



— BUREAU OF —
RECLAMATION

Near-term Colorado River Operations

Draft Supplemental Environmental Impact Statement

April 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 economically sound manner in the interest of the American public.

Photo of Lake Mead with a calcium carbonate ring and Hoover Dam and its intake towers. Photo taken in May 2022 when Lake Mead was in a level 2 shortage condition (1,025' to 1,500' feet above sea level).
Photo by Bureau of Reclamation Christopher Clark.

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 winter of 2022–2023 and 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 need to 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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Appendixes

A	Overview of Colorado River Operations
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C	CRMMS Model Documentation
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Acronyms and Abbreviations

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
AMSL	(above) mean sea level
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
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
CO ₂ e	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
Dam Fund	Colorado River Dam Fund
DCP	Drought Contingency Plan

DCPA	2019 Colorado River Drought Contingency Plan Authorization Act
Development Fund	Colorado River Basin Development Fund
DO	dissolved oxygen
DOI	United States Department of the Interior
DROA	Drought Response Operations Agreement
EA	Environmental Assessment
EC	Extraordinary Conservation
EIA	United States Energy Information Administration
EIS	Environmental Impact Statement
EOCY	End-of-Calendar-Year
EOWY	End-of-Water-Year
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
GTM _{Max}	Generation and Transmission Maximization Model
GWh	giga-watt 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-Tribe Council of Arizona
LCR MSCP	Lower Colorado River Multi-Species Conservation Plan
LMNRA	Lake Mead National Recreation Area
Lower Division States	Lower Division States
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
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
SUIT	Southern Ute Indian Tribe
TCP	traditional cultural property
TDS	total dissolved solids
THPO	Tribal Historic Preservation Officers

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 southwestern United States and northwestern United Mexican States (Mexico). 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 (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 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.

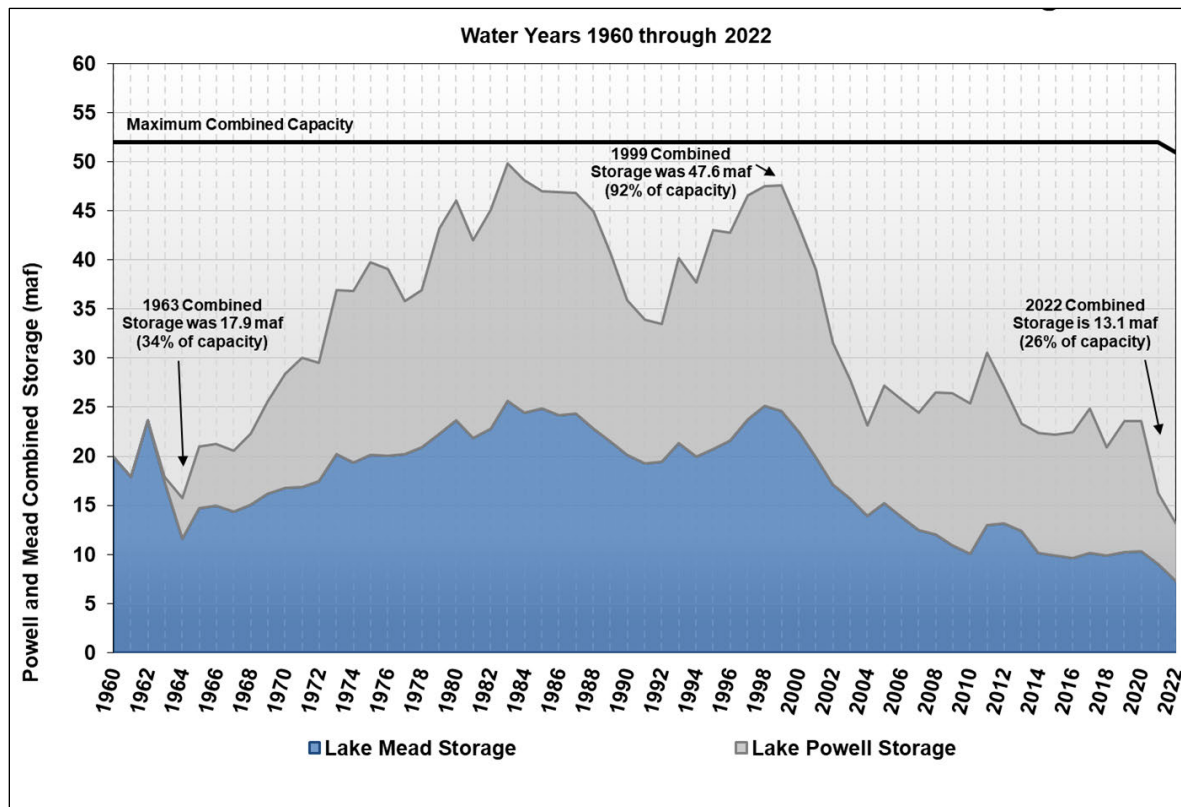
The Department of the Interior’s (Department) Bureau of Reclamation (Reclamation) is tasked with operating the Colorado River system in both the Upper and Lower Basins. Reclamation operates four major dams and various irrigation and diversion structures along the mainstream river, along with five dams 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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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.



Map 1-1
Colorado River Basin and Glen Canyon and Hoover Dams

- 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 is because the SEIS is not considering alternative actions that would change water deliveries to Mexico. The provisions of the 1944 Water Treaty and implementing Minutes are not affected by this SEIS.

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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 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 Environmental Impact Statement (2007 FEIS; Reclamation 2007).

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 Pilot Program and Memorandum of Understanding (MOU) for Lower Basin Drought Response Actions:** 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

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>.

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.

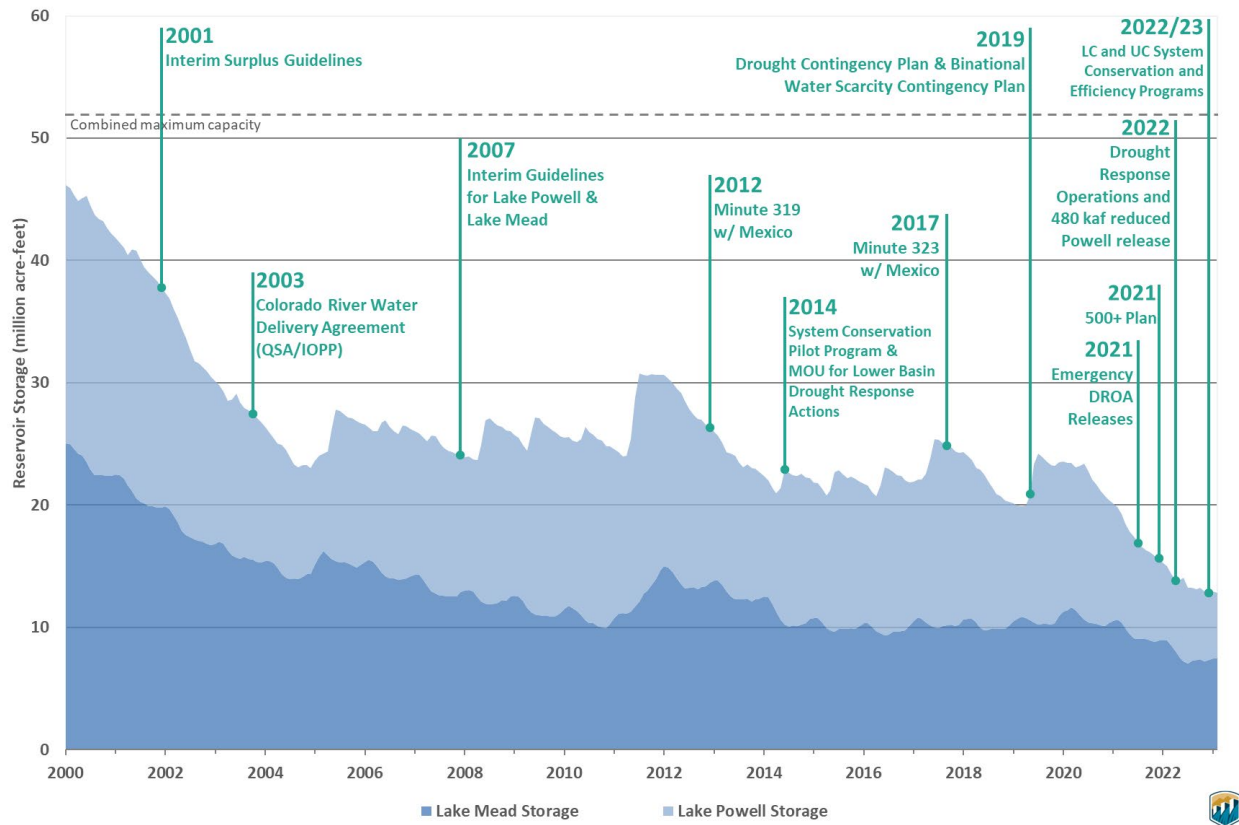
- **2019 – Drought Contingency Plans:** As approved by Congress, the DCPs provide a framework for additional actions to help the Basin adapt to drought. The Upper Basin DCP is designed to reduce the risk of reaching critical elevations at Lake Powell, help assure continued compliance with the Compact, 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.
- **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 acre-feet 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 are approximately 500,000 af of water to be released from Flaming Gorge Reservoir under the DROA and 480,000 af to be held 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>

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. 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 Notice of Intent (NOI) in the *Federal Register* on November 17, 2022. The NOI provided the public

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.

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 post-2026 operational planning; 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 revising the 2007 Interim Guidelines for the near-term operation of Glen Canyon and Hoover Dams beginning in the 2024 operating year (beginning October 1, 2023) to address the potential for continued low-runoff conditions in the Basin.⁸ Reclamation has concluded that the potential impacts of low-runoff conditions in the winter of 2022–2023 and the remainder of the interim period pose unacceptable risks to routine operations of Glen Canyon and Hoover Dams during the remainder of the interim period (prior to Jan. 1, 2027) and that modified operating guidelines need to be expeditiously developed. Development of modified operating guidelines would also inform potential operations in 2025–2026; however, due to the critically low current reservoir conditions and the potential for worsening drought, the Department recognizes that operational strategies for 2024 may need to be revisited for subsequent operating years to potentially address, for example, 2023 and 2024 hydrology; evaporation, seepage, and system losses; determinations of beneficial use, and additional public health and safety considerations. Given the potential risks to infrastructure⁹ and public health and safety, through this SEIS the Department will promptly identify and analyze modified operating guidelines to address current and foreseeable hydrologic conditions. The proposed action would modify the following

⁸ The 2024 operating year for Glen Canyon Dam begins Oct. 1, 2023; the 2024 operating year for Hoover Dam begins Jan. 1, 2024.

⁹ In recent months, a primary concern for the Department has been to identify and implement actions to ensure that Glen Canyon Dam continues to provide downstream water deliveries as designed and intended (i.e., 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 operational risk for downstream releases). This would create a risk of water supply interruptions to users that rely on Lake Powell for drinking water supplies; 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 risk of Lake Mead declining to critically low levels and threatening water deliveries to those that rely on Lake Mead for water supplies.

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; and Section 7. Implementation of Guidelines. Reclamation has already begun efforts that will lead to preparation of an additional Environmental Impact Statement (EIS) effort for operating guidelines after 2026. See 87 *Federal Register* 37884 (June 24, 2022).

This National Environmental Policy Act of 1969 (NEPA) document 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 where reservoir operations can 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 Basin (Lake Powell and Lake Mead) and the other system reservoirs (both upstream of Lake Powell and downstream of Lake Mead).

In the absence of consensus among all entities affected by changed operations, 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. In short, every potential option involves difficult water management impacts and unprecedented reductions for entities in 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 downstream water releases, 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.

The International Boundary and Water Commission, United States and Mexico (IBWC) 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, which 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 proposing operations that are specifically designed to manage the respective reservoirs at lower elevations in order to more reliably maintain congressionally authorized infrastructure, operations, water deliveries, and power generation, and to avoid dead pool conditions as possible.

The hydrologic modeling performed for this SEIS examines scenarios based on flows in the Basin over the past 30 years, which includes 23 consecutive 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 from 2024 to 2026. The SEIS does not include any changes to other operational agreements, such as LTEMP, DCPs, DROA, or Minute 323; operations 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 USBWC). All public comment letters, along with a scoping summary report (Reclamation 2023), 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).

¹⁰ Project website: <https://www.usbr.gov/ColoradoRiverBasin/SEIS.html>

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
Physical Resources		
Air Quality	Yes	Fugitive dust and exposure of reservoir 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 (historical 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, reptiles, raptors, mammals, waterfowl
Special Status Species	Yes	Threatened and endangered species, state and Tribal sensitive species

Resource	Potentially Significant	Issue Areas
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 No Action Alternative, as well as a range of reasonable action 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 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, Action Alternative 1, and Action Alternative 2, below, discuss how each alternative would modify these sections. The action alternatives provide operations that are specifically designed to manage the respective reservoirs at lower elevations in order to more reliably maintain congressionally authorized infrastructure, operations, water deliveries, and power generation, and to avoid dead pool conditions as possible.

Reclamation developed two action alternatives for analysis in this SEIS. As noted in the November 17, 2022, NOI, the Final SEIS is anticipated to be available with a ROD, as appropriate, in late summer 2023. The NOI (87 *Federal Register* 69045) further provided that:

In addressing operations for 2023–24, Reclamation is committed to using the best available information to develop near-term operating guidelines while longer-term approaches are developed. Reclamation anticipates using the work and analysis from this SEIS process to also inform operating guidelines for the 2025–2026 period, which will undergo any additional NEPA analysis as required.

Accordingly, the alternatives developed in this SEIS are focused, as an initial matter, on the 2024 operating year, and recognize that further refinements to operating guidelines for the 2025–2026 period may be required.

These action alternatives reflect input from Reclamation, the cooperating agencies, stakeholders, and other interested parties, including comments submitted during the SEIS public scoping period. To date, no submission has garnered complete consensus across the Basin. However, among the input received, Reclamation received written proposals for alternatives, or components thereof, that met the proposed federal action's purpose and need. Specifically, 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.

While no external proposals have been carried forward as full alternatives in this SEIS, several of these proposals have been analyzed in **Appendix B**, Hydrologic Modeling of External Proposals, in terms of their hydrologic performance over the remainder of the interim period. As noted in more detail in **Appendix B**, the action alternatives identified in this SEIS more closely mimic the full range of the states' submissions for the 2025–2026 period, given the larger Lower Basin reductions discussed below in each action alternative.

A description of each alternative, including elements common to all alternatives, follows.

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 (43 Code of Federal Regulations [CFR] 1502.14(e)).

2.3 Environmentally Preferable Alternative

In accordance with CEQ NEPA regulations (43 CFR 1502.2(b)), Reclamation will identify the environmentally preferable alternative in the ROD for this SEIS.

2.4 Implementation

The Department anticipates adopting modified guidelines prior to determining operations for the 2024 operating year. For Glen Canyon Dam and the other Upper Basin reservoirs, operations for the 2024 operating year begin October 1, 2023; for Hoover Dam, they 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. The Department may select different parts of any of the alternatives to best meet the purpose and need. The action alternatives provide operational tools for continued low-flow conditions in light of the fact that current operating guidelines provide insufficient protection against reservoirs declining to critically low elevations.

The analysis in the SEIS has a primary, but not exclusive, focus on implementation of each alternative for the 2024 operating year. The focus on this 2024 operating year time frame is based on the need to promptly develop additional operational tools in light of historically low reservoir elevations. The alternatives also describe operations for 2025–2026. The SEIS analyzes the alternatives for the 2025–2026 time frame across affected resource areas to the extent that information is available. There is more uncertainty in the 2025–2026 analysis (both from a

hydrologic and resource impact standpoint); accordingly, the Department may select an alternative to apply in the 2024 operating year, with future analysis, as needed, to be performed before potentially revising the selected alternative for 2025–2026 operations.

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 Equalization and Upper Elevation Balancing Tiers for determining the annual Lake Powell release, based on the volume of water in storage or the corresponding elevation of Lake Powell and Lake Mead, 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 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 reasonably foreseeable that Lake Powell may decline below this critical elevation during the 2024–2026 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 routine maintenance.

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 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 and effectiveness of these essential 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, beginning in the 2024 operating year.

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 in calendar year 2024. 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 calendar year.¹

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

Lake Mead Elevation (feet)	No Action Alternative		
	2007 ROD** Shortage (1,000 af)	2019 DCP Contributions (1,000 af)	Total Shortage + 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 – 1,000	500	600	1,100
<1,000 – 975	500	600	1,100
<975 – 950	500	600	1,100
<950	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.

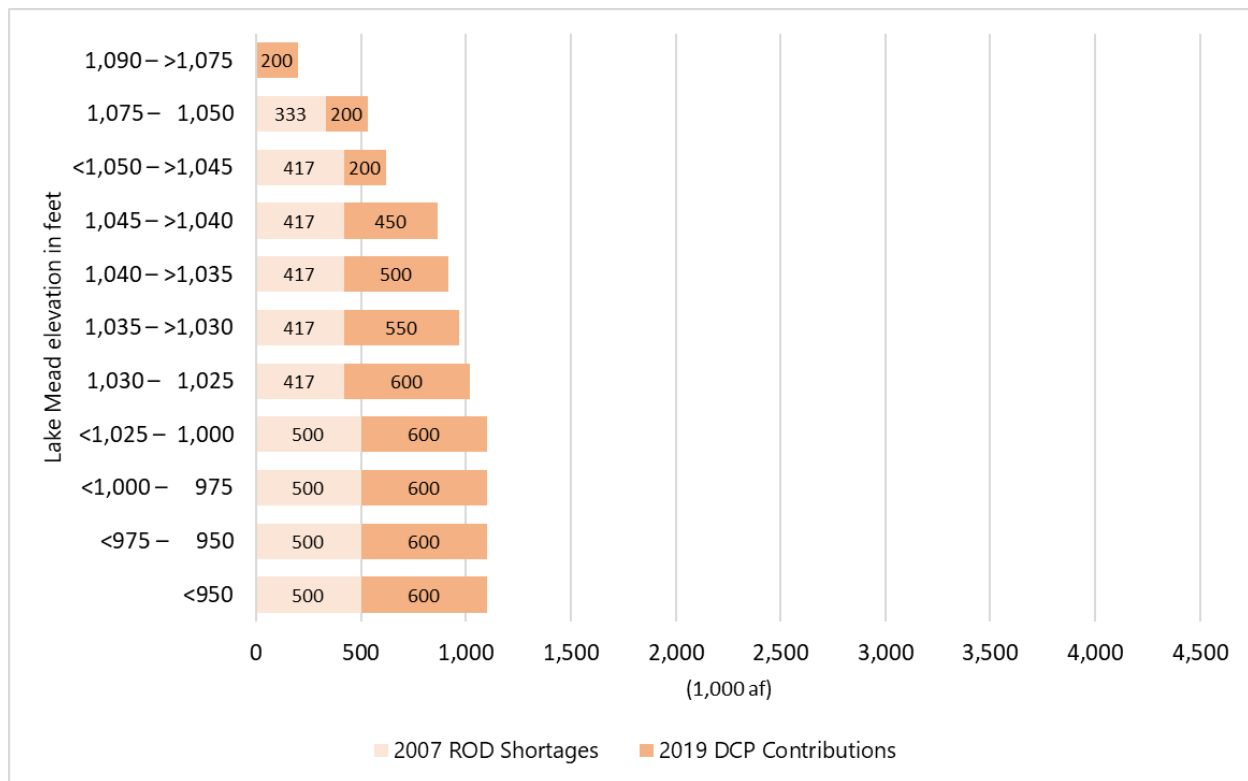
** Shortages listed in the 2007 ROD

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

These same assumptions for Lower Basin shortages, DCP contributions, and deliveries to Mexico under the 1944 Water Treaty and Minute 323 were modeled in calendar years 2025 and 2026.

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 elevation of Lake Powell and Lake Mead, as described in the operational tiers below (see **Table 2-2**). 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.

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.

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	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)	<hr style="border-top: 1px dashed black;"/> 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	<hr style="border-top: 1px dashed black;"/> Mid-Elevation Release Tier Release 7.48 maf; if Lake Mead < 1,025 feet, release 8.23 maf	8.90
3,525	<hr style="border-top: 1px dashed black;"/> Lower Elevation Balancing Tier Balance contents with a minimum/maximum release of 7.0/9.5 maf	5.55
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 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 Plan

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 to dead pool, thereby preventing operation of Glen Canyon Dam or Hoover Dam, or both, to provide water supplies in the Basin. In such reasonably foreseeable circumstances, the No Action Alternative would not meet the purpose of and need for the federal action because it would not “ensure that Glen Canyon Dam continues to operate under its intended design” and would not “protect Hoover Dam operations, system integrity, and public health and safety ” (see **Section 1.3**, Purpose of and Need for Action).

2.7 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.² 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.³

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,

² 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.

³ 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.”

2.7.1 Shortage Guidelines

Table 2-3 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 2-4**. Reclamation may consider additional shortages in Shortage Condition Year 2025 and 2026 (see **Table 2-5**). This consideration would occur as part of the future analysis referenced in **Section 1.2** before the 2025 operating year operating condition determination.

Figure 2-2 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.

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 2-3
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 2-4
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 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.

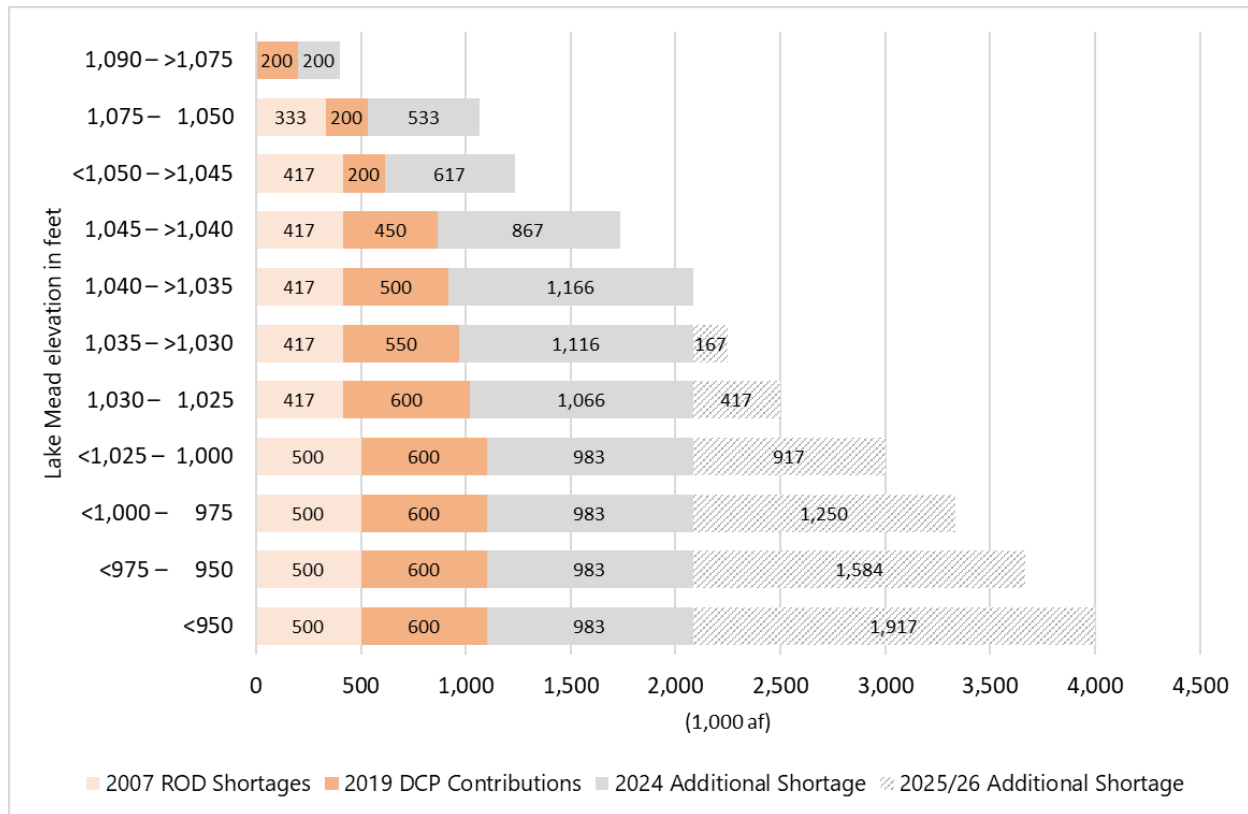
Table 2-5
Lower Division States' Shortages and DCP Contributions, Action Alternatives 1 and 2
(2025–2026)*

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 2-2
Modeled Lower Basin Shortages and DCP Contributions, Action Alternatives 1 and 2



2.7.2 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 2-6**). 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.

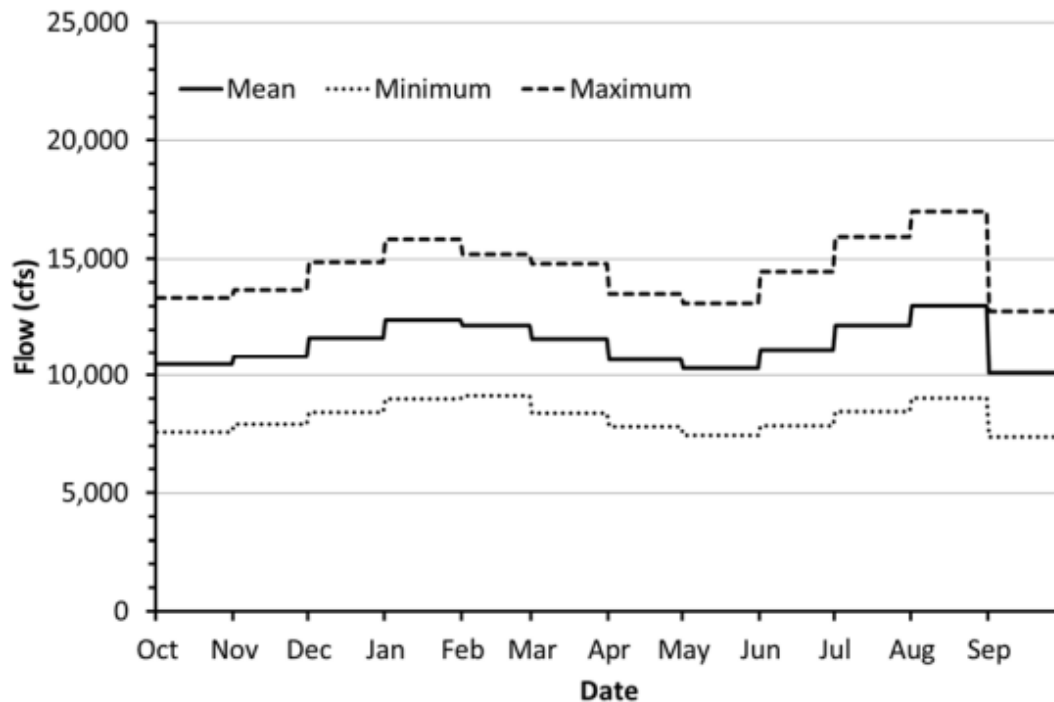
Hourly, daily, and monthly releases from Lake Powell for coordinated operations would be consistent with the parameters of the ROD for the LTEMP EIS (Reclamation and NPS 2016). Monthly releases from Glen Canyon Dam would be distributed proportionally across months for annual releases below 7.0 maf (see **Figure 2-3** 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 2-6
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: 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	8.90
3,500	----- 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	4.22
3,370		0

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

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 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 river⁴ 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.
- 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.

⁴ 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 3,550 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.

2.7.3 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.

2.8 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.^{5 6} Total additional shortage volumes for the Lower Basin are the same under Action Alternative 2 as under Action Alternative 1.

⁵ 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.

⁶ 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.

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.”

2.8.1 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 2-3** and **Table 2-5** 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).

Table 2-7 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 2-5**). This consideration would occur as part of the future analysis referenced in **Section 1.2** before the 2025 operating year operating condition determination.

Figure 2-2 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 2-7
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

2.8.2 Coordinated Reservoir Operations

The modifications to annual Lake Powell releases and operational tiers are the same as those under Action Alternative 1.

2.8.3 Implementation of Guidelines

The provisions for a mid-year review are the same as those under Action Alternative 1.

2.9 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 action alternatives; or 3) are infeasible or inconsistent with the basic policy objectives for Colorado River operations, including consistency with applicable federal laws. In addition to the SEIS action alternatives, Reclamation is considering and analyzing other actions to improve dam operations separately from this SEIS. These actions are not discussed in this SEIS.

2.9.1 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 proposed action (which focuses on the critically low elevations impacting operations of both Glen Canyon and Hoover Dams during the interim period). 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.

2.9.2 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 to further goals of 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 proposed action’s purpose (which focuses on the critically low elevations impacting operations of both Glen Canyon and Hoover Dams during the interim period) and need (which is based on the potential that continued low-runoff conditions in the could lead Lake Powell and Lake Mead to decline to critically low elevations impacting operations in 2024). Congress authorized 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.

2.9.3 Fill Lake Mead First

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 proposed action’s purpose (which focuses on the critically low elevations impacting operations of both Glen Canyon and Hoover Dams during the interim period) 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 impacting operations in 2024).

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.

2.9.4 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.

2.9.5 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 alternatives considered in detail contemplate similar shortage amounts to those that would be assessed based on evaporation, seepage, and system loss calculations in the proposals received. However, the shortage amounts are implemented at different elevations and timing compared with the six Basin States proposal. The six Basin States proposal, which incorporates evaporation, seepage, and system losses, is analyzed further in **Appendix B**.

Reclamation anticipates publishing—separate from this SEIS process—an informational report in 2023 addressing potential methodologies to support assessments for evaporation, seepage, and other system losses in the Basin.

2.9.6 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 implementing water conservation measures in the Lower Basin. 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 proposed 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. Apart from concepts of beneficial-use determinations, Reclamation does not have the authority to mandate water conservation measures in the Lower Basin. The alternatives considered in detail do include additional shortages for the Lower Basin, as suggested by the proponents of this alternative.

2.9.7 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.

Each action alternative analyzed in this SEIS acknowledges the possibility of operating Glen Canyon and Hoover Dams in a situation where the inflow minus losses equals outflow, subject to run-of-the-river conditions. This represents a worst-case scenario that would occur if elevations in Lake Powell or Lake Mead dropped below critically low levels approaching or reaching dead pool. The range of hydrologic modeling scenarios analyzed includes multiple hydrology sequences in which this type of operation would be necessary. 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).

Reclamation believes this range of hydrology scenarios 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 in 2024, and potentially in 2025 and 2026, 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.

2.9.8 Hydropower Prioritization Alternative

Comments suggested an alternative that includes elevation levels prioritizing preservation of the 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 alternatives considered in detail contemplate protection of critical reservoir levels, and the continued resulting water deliveries that accordingly also relate to the resulting 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 would also need to be assessed for consistency with governing authorities. Finally, inclusion of similar protection elevations in the alternatives considered in detail provides adequate opportunity for analysis.

2.9.9 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.

2.10 Summary Comparison of Alternatives

Summary comparisons of the alternatives identified and analyzed in the SEIS are provided in **Table 2-8** as a matrix of alternatives and their approach for addressing 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 2-9** provides a comparison of the shortage guidelines elements of the alternatives (Section 2. Determination of Lake Mead Operation during the Interim Period). **Table 2-10** 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).

**Table 2-8
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	<ul style="list-style-type: none"> • 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. 	<ul style="list-style-type: none"> • Below 3,575 feet at Lake Powell, either reduce Lake Powell releases or balance volumes depending on elevations at Lake Powell and Lake Mead. 	<ul style="list-style-type: none"> • 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).
Action Alternative 1	<ul style="list-style-type: none"> • 2024 shortages from Lake Mead and DCP contributions of 400,000 af at 1,090 feet to 2.083 maf at or below 1,040 feet • 2025–2026 shortages from Lake Mead and DCP contributions of 400,000 af at 1,090 feet to 4.000 maf below 950 feet • Shortages are distributed across Lower Basin water users according to priority. 	<ul style="list-style-type: none"> • Below 3,575 feet at Lake Powell, set initial release at 6.0 maf and adjust to as high as 8.23 maf based on the April end-of-water-year elevation projection. • Below 3,500 feet at Lake Powell in any month, reduce releases (gains equals losses) such that Lake Powell ends the operating year at 3,500 feet. 	<ul style="list-style-type: none"> • Mid-year review may adjust the Lake Powell operational tier up or down or reduce or increase shortages from Lake Mead (allow additional or reduced deliveries to Lower Basin water users).
Action Alternative 2	<ul style="list-style-type: none"> • Total shortages and DCP contributions for Lower Basin water users are the same as under Action Alternative 1. • Shortages are distributed in the same percentage across all Lower Basin water users. 	<ul style="list-style-type: none"> • Same as Action Alternative 1 	<ul style="list-style-type: none"> • Same as Action Alternative 1

Table 2-9
Comparison of Shortage Guidelines by Alternative (volumes in 1,000 af)*

Lake Mead Elevation (feet)	No Action Alternative (Total Shortages and DCP Contributions)	Action Alternatives 1 and 2 (Total Shortages and DCP Contributions 2024 / 2025–2026)
1,090 – >1,075	200	400 / 400
1,075 – 1,050	533	1,066 / 1,066
<1,050 – >1,045	617	1,234 / 1,234
1,045 – >1,040	867	1,734 / 1,734
1,040 – >1,035	917	2,083 / 2,083
1,035 – >1,030	967	2,083 / 2,250
1,030 – 1,025	1,017	2,083 / 2,500
<1,025 – 1,000	1,100	2,083 / 3,000
<1,000 – 975	1,100	2,083 / 3,333
<975 – 950	1,100	2,083 / 3,667
<950	1,100	2,083 / 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.

Table 2-10
Comparison of Coordinated Reservoir Operations by Alternative

Lake Powell Elevation (feet)	No Action Alternative	Action Alternatives 1 and 2	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	Lower Elevation Release Tier Set initial release: 6.0 maf; adjust releases based on 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	8.90
3,525	Lower Elevation Balancing Tier Balance contents with a minimum/maximum release of 7.0/9.5 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	5.55
3,500		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	4.22
3,370			0

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

2.11 Summary of Potential Effects

Table 2-11 presents a summary of the potential effects of the alternatives. **Chapter 3, Affected Environment and Environmental Consequences**, contains detailed descriptions of these effects.

Table 2-11
Summary of Potential Effects of the Alternatives

SEIS Section	Affected Resource	Alternatives		
		No Action	Action Alternative 1	Action Alternative 2
3.6	Hydrologic Resources			
	Reservoir elevations for Lake Powell	There is a higher likelihood of monthly pool elevations dropping below the critical elevation of 3,490 feet than under either of the two action alternatives. Modeled end-of-water-year pool elevations result in lower median and wider range of values than the action alternatives. This suggests the lack of the ability to recover reservoir elevations above critical elevations once they are reached.	The operational modification designed to protect a Lake Powell elevation of 3,500 feet is effective at minimizing instances of falling below 3,490 feet in 2024 and eliminating this outcome for all modeled traces by 2026. The median monthly elevation of Lake Powell for the action alternatives remains higher than the No Action Alternative through 2026.	Same impact as Action Alternative 1 with a minor variation in model traces due to assumptions for potential DROA contributions.
	Reservoir elevations for Lake Mead	In 2026, 7 percent of traces under the No Action Alternative approached dead pool, and the reservoir does not recover for the rest of the period of analysis.	In 2024, there would initially be lower Lake Mead elevations than under the No Action Alternative. One percent of traces reach dead pool in April 2025 before recovering for the next 10 months.	In 2024, there would initially be lower Lake Mead elevations than under the No Action Alternative. One percent of traces reach dead pool for 3 months in 2026, and then elevations recover.

SEIS Section	Affected Resource	Alternatives		
		No Action	Action Alternative 1	Action Alternative 2
3.6 (cont.)	Reservoir releases for Glen Canyon Dam (at Lake Powell)	Median annual releases for the No Action Alternative increase from 2024 to 2026. Median annual releases for the No Action Alternative are higher than for the action alternatives with less variability, except in 2026. During the driest 25 percent of traces, the No Action Alternative releases continue to be larger than the action alternatives' releases, resulting in decreasing Lake Powell elevations.	The new Lower Elevation Release Tier results in lower (median) monthly releases for the first half of the water year and then higher (median) monthly releases for April through September, as compared with the No Action Alternative. Median annual releases increase from 2024 to 2026. During the driest 25 percent of traces, Action Alternatives 1 and 2 have lower and more variable releases than the No Action Alternative.	There would be similar impacts as under Action Alternative 1 with minor variations in model traces. For example, Action Alternative 2 has higher releases in some model traces due to assumptions for potential DROA contributions.
	Reservoir releases for Hoover Dam (at Lake Mead)	Median annual releases for the No Action Alternative decrease slightly from 2024 to 2026. The median annual releases are higher than under the action alternatives with less variability, except for 2026 when 5 percent of No Action Alternative model traces are associated with dead pool elevations.	Median annual releases are lower than under the No Action Alternative and are more variable. Median annual releases decrease in 2025 and begin to recover in 2026.	There would be the same impact as described under Action Alternative 1 with a minor variation in model traces due to assumptions for potential DROA contributions.
	River flows	River flows for all alternatives decline over time. Flows under the No Action Alternative decline at a slower rate than the action alternatives and have less variation.	River flows for the various reaches are lower than they would be under the No Action Alternative with a wider variation of possible flows based on the model traces. Median annual river flows are typically the lowest in 2025 and recover slightly in 2026.	There would be the same impact as under Action Alternative 1 with a minor variation in model traces due to assumptions for potential DROA contributions.
	Groundwater	Certain portions of the river are anticipated to have decreased groundwater elevations due to decreasing river flows and shallower river stages.	Groundwater elevations are anticipated to decrease more than they would under the No Action Alternative due to lower river flows.	There would be the same impacts as under Action Alternative 1.

SEIS Section	Affected Resource	Alternatives		
		No Action	Action Alternative 1	Action Alternative 2
3.7	Water Deliveries			
	Apportionments in the Upper Division States	No impact.	No impact.	No impact.
	Apportionments and water entitlements to and within the Lower Division States	No impact.	No impact.	No impact.
	Lower Division State water supply determinations	Initially, there would be fewer impacts; however, there would be increased combined shortages, DCP contributions, and impacts on water supply determinations as reservoir levels decrease.	Initially, there would be greater impacts from increased combined shortages and DCP contributions; however, impacts would decrease over time as Lake Mead's elevation stabilizes and increases over time. There would be greater impacts on Arizona and Nevada and fewer on California relative to Action Alternative 2.	There would be similar combined impacts on Lower Division States as under Action Alternative 1; however, there would be greater impacts on California and fewer impacts on Arizona and Nevada relative to Action Alternative 1.
	Total water deliveries to Lower Division States	Initially, there would be fewer impacts; however, there would be increased impacts on deliveries as reservoir levels decrease and greater frequency of system shortages occurs.	Initially, there would be greater impacts, but impacts decrease over time as Lake Mead's elevations stabilize and system shortages are reduced, relative to the No Action Alternative. There would be greater impacts on Arizona and Nevada and fewer impacts on California, relative to Action Alternative 2.	There would be similar impacts on combined Lower Division States as under Action Alternative 1; however, there would be greater impacts on California and fewer impacts on Arizona and Nevada, relative to Action Alternative 1.

SEIS Section	Affected Resource	Alternatives		
		No Action	Action Alternative 1	Action Alternative 2
3.7 (cont.)	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 and if dead pool is reached.	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 and if dead pool is reached. Initially, there would be greater impacts on modeled deliveries, then decreased impacts as Lake Mead elevations stabilize and increase.	This SEIS does not consider actions for Mexico. Same impacts as Action Alternative 1.
	Modeled distribution of shortages to and within the Lower Division States	Initially, there would be fewer impacts but increased impacts on shortages 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.	As total shortages increase, there would be a corresponding increase in shortages allocated to Arizona 4th-priority entitlement holders and Nevada 8th-priority contractors. California would continue to make DCP contributions but would not be affected by additional shortages.	There would be similar impacts on combined Lower Division States as under Action Alternative 1; however, due to additional shortages, there would be greater impacts on California and fewer impacts on Arizona and Nevada, relative to Action Alternative 1.
3.8	Water Quality			
	Salinity	Higher lake levels result in marginally lower salinity concentrations. Under the No Action Alternative, Lake Powell is much more likely to reach dead pool (3,370 feet). If Lake Powell were to reach dead pool, it would lead to an increase in salinity.	Higher lake levels result in marginally lower salinity concentrations.	Same impact as under Action Alternative 1.

SEIS Section	Affected Resource	Alternatives		
		No Action	Action Alternative 1	Action Alternative 2
3.8 (cont.)	Temperature	There are slightly lower probabilities of exceeding 16°C and much lower probabilities of exceeding 20°C than under the action alternatives. Release temperatures are coldest when reservoir elevations are highest. This may result in lower temperatures. However, under this alternative, Lake Powell is much more likely to reach dead pool, which would lead to a large increase in temperatures.	There are slightly higher probabilities of exceeding 16°C and much higher probabilities of exceeding 20°C than under the No Action Alternative. Release temperatures are coldest when reservoir elevations are highest.	Same as Action Alternative 1.
	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, spring HFEs would only be triggered for approximately 15 percent of the time, and fall HFEs would be triggered approximately 70 percent of the time, each year between 2024 and 2026. 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 and through 2026.	Same as the No Action Alternative, except this alternative would reduce the potential of elevations below the Protection Level (below 3,500 feet). This increases the probability of HFE implementation, compared with the No Action Alternative.	Same as Action Alternative 1.
	Nutrients and algae	Lake Powell would be more likely to reach dead pool, which would raise temperatures and opportunities for algal growth. Bypass only scenarios would also likely result in more algal growth.	Slightly higher temperatures would provide more opportunities for algal growth. An increased probability of low DO would create more bioavailable phosphorus, which may provide more opportunities for algal growth.	Same as Action Alternative 1.

SEIS Section	Affected Resource	Alternatives		
		No Action	Action Alternative 1	Action Alternative 2
3.8 (cont.)	Dissolved oxygen	The releases from Glen Canyon Dam mean it would be less probable for the August–October DO levels to drop below 5mg/L, compared with under the action alternatives. The use of river outlet works aerates releases. Lake Powell is more likely to reach dead pool under the No Action Alternative.	The releases from Glen Canyon Dam mean it would be more probable for August–October DO levels to drop below 5mg/L, compared with under the No Action Alternative.	Same as Action Alternative 1.
	Metals	The No Action Alternative would be unlikely to reduce dilution capacity significantly. Lake Powell would be more likely to reach dead pool, which may affect metals' concentrations as elevations would continue to decrease.	Action Alternative 1 would be unlikely to reduce dilution capacity significantly.	Same as Action Alternative 1.
3.9	Air Quality			
	Shoreline exposure fugitive dust	Increased shoreline exposure would result 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 most potential for increased fugitive dust emissions.	Shoreline exposure is anticipated to decrease compared with the No Action Alternative.	Similar to Action Alternative 1, with the potential for even less shoreline exposure due to potential DROA releases.
	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 the most potential for alternative power and therefore the most potential for increased greenhouse gas emissions.	Hydropower is anticipated to increase compared with under the No Action Alternative.	Same as Action Alternative 1.

SEIS Section	Affected Resource	Alternatives		
		No Action	Action Alternative 1	Action Alternative 2
3.10	Visual Resources			
	Visibility of attraction features	Cathedral in the Desert would be visible and accessible. More of the upstream side of Glen Canyon and Hoover Dams would be visible.	Impacts would be similar to those under the No Action Alternative, except less of the upstream side of Glen Canyon and Hoover Dams would be visible.	Same as Action Alternative 1.
	Lake Powell maximum height of calcium carbonate ring, 10th percentile, 2025	204 feet	200 feet	158 feet
	Lake Mead maximum height of calcium carbonate ring, 10th percentile, 2025	233 feet	224 feet	220 feet
	Colorado River landscape character	Initially, there would be less impacts; however, if Lake Powell reaches dead pool, impacts would be extensive and immediate.	Lower releases would result in increased initial impacts; however, based on protecting 3,500 feet, this alternative would temper the more extensive impacts associated with the No Action Alternative by maintaining consistent flows along the Colorado River.	The impacts would be similar to those under Action Alternative 1, except based on potential releases from Upper Basin reservoirs, this alternative would result in decreased impacts on the landscape character.
	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 water supply adjustments to temper impacts, initial shortages would be focused within Arizona and Nevada with shortages identified for California if Lake Powell drops below 1,040 feet.	The impacts would be similar to those under Action Alternative 1, except water shortages would be distributed across all three Lower Division States. This would result in more widely distributed, but less intense, impacts on the landscape character.

SEIS Section	Affected Resource	Alternatives		
		No Action	Action Alternative 1	Action Alternative 2
3.11	Cultural Resources			
	Low lake elevations exposing cultural resources	Low lake levels at Lake Mead and Lake Powell would expose resources to increased wave action, wet/dry cycling, and visitation.	Projected higher lake levels would expose fewer resources.	Same as Action Alternative 1.
	Low river levels exposing cultural resources	Low river levels would expose more resources to visitation, but they would increase available sediment for wind transport to protect some resources.	Projected higher river levels would expose fewer resources, but they would make less sediment available for wind transport to protect some resources.	Same as Action Alternative 1.
	Alterations to traditional cultural places	Visitation to archaeological sites may increase as resources are exposed. Plant habitat would increase for nonnative species and decrease for native species.	Projected higher river levels would expose less sites, and there would be a decline in nonnative plant species.	Same as Action Alternative 1.
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.	Projected higher lake levels would expose fewer paleontological resources to potential impacts from wave action, erosion, wet/dry cycling, visitation, and unauthorized collecting.	Same as Action Alternative 1.
	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 they may make less sediment available for wind transport to protect some resources.	Same as Action Alternative 1.

SEIS Section	Affected Resource	Alternatives		
		No Action	Action Alternative 1	Action Alternative 2
3.13	Biological Resources			
	Vegetation	Water elevations are predicted to decrease over time, resulting in short-term changes to riparian vegetation, including an increase of invasive plant species and loss of suitable habitat for native plant species.	At Lake Powell and Lake Mead, fewer acres have the potential to be invaded by nonnative species, as compared with under the No Action Alternative. Impacts on riparian vegetation would be greater as compared with the No Action Alternative, as water flows are reduced to maintain higher water elevations in Lake Powell and Lake Mead.	Same as Action Alternative 1.
	Wildlife	Water elevations are predicted to decrease over time with the potential to reach dead pool in Lake Mead. This would result in impacts on wildlife from decreased flows and the reduction of lake levels.	There would be similar impacts as those described under the No Action Alternative, with a lesser magnitude due to contingencies in place to protect elevations at Lake Mead and ensure flowing water in all sections.	Same as Action Alternative 1.
	Special status species	Water elevations are predicted to decrease over time with the potential to reach dead pool in Lake Mead. This would result in impacts on special status species from decreased flows and the reduction of lake levels.	There would be similar impacts as those described under the No Action Alternative, with a lesser magnitude due to contingencies in place to protect elevations at Lake Mead and ensure flowing water in all sections.	Same as Action Alternative 1.

SEIS Section	Affected Resource	Alternatives		
		No Action	Action Alternative 1	Action Alternative 2
3.14	Recreation			
	Recreation at Lake Powell	Projected Lake Powell elevations would be 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 would be unavailable from the Rainbow Bridge National Monument shoreline. Declining pool elevations would expose additional areas of Glen Canyon, creating new visitation patterns and resource protection challenges. Sport fish populations are not expected to be impacted.	There would be similar impacts as those described under the No Action Alternative, with a lesser magnitude due to Action Alternative 1 preserving more water in Lake Powell and reducing overall variability in water surface elevations.	Same as Action Alternative 1.
	Recreation from Glen Canyon Dam to Lake Mead	Daytime flows would 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, it would lead to a large increase in water temperature, which would lead to potentially lethal conditions for rainbow trout.	There would be similar impacts on whitewater boating as described under the No Action Alternative. Predicted release temperatures have higher temperature magnitudes than under the No Action Alternative, which could result in a greater likelihood that temperatures would reach or exceed the 23°C threshold at which rainbow trout stop growing. However, Action Alternative 1 would reduce water temperatures beyond 2026 compared with the No Action Alternative, thereby benefiting rainbow trout.	Same as Action Alternative 1.

SEIS Section	Affected Resource	Alternatives		
		No Action	Action Alternative 1	Action Alternative 2
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 would necessitate boat launch facilities be closed or relocated. The projected median pool elevation for Lake Mead would likely result in boaters encountering boating navigational hazards. Projected surface water temperatures would not be anticipated to impact sport fish.	There would be similar impacts as those described under the No Action Alternative; however, the slight rebound in Lake Mead pool elevations under Action Alternative 1 could marginally help limit the closure or relocation of boat launch facilities in 2026.	Same as Action Alternative 1.
	Recreation from Hoover Dam to SIB	Flow releases from Hoover Dam, Davis Dam, Parker Dam, and Imperial Dam would be within the historical operating range; therefore, there would be 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 would not be expected to affect warmwater sport fish.	Same as the No Action Alternative.	Same as the No Action Alternative.
3.15	Electrical Power Resources			
	<i>Glen Canyon Powerplant</i>			
	Average annual generation	2,192,899 MWh	+1,433,796 MWh	+1,528,935 MWh
	Average August capacity	394 MW	+96 MW	+117 MW
	Average annual total hydropower value	\$469,595,000	+\$117,442,000	+\$124,769,000

SEIS Section	Affected Resource	Alternatives		
		No Action	Action Alternative 1	Action Alternative 2
3.15 (cont.)	<i>Hoover Powerplant</i>			
	Average annual generation	2,459,590 MWh	-623,173 MWh	-598,550 MWh
	Average August capacity	868 MW	+33 MW	+36 MW
	Average annual total hydropower value	\$976,746,000	\$909,310,000	\$913,140,000
	<i>Parker and Davis Powerplants</i>			
	Average annual generation	1,427,805 MWh	-388,284 MWh	-448,560 MWh
	Average August capacity	Negligible impacts on the Parker and Davis Powerplants	Negligible impacts on the Parker and Davis Powerplants	Negligible impacts on the Parker and Davis Powerplants
	Average annual total hydropower value	\$433,953,000	\$393,953,000	\$386,271,000
	Changes in the total hydropower value impact on the various power funds	Reduced total hydropower value at Glen Canyon Powerplant would result in reduced contributions to the Basin Fund. Reduced total hydropower value at Hoover, Parker, and Davis Powerplants would result in reduced contributions to the Development Fund. Continued revenue from surcharges at Hoover, Parker, and Davis Powerplants would result in minor impacts on the Dam Fund.	Continued positive total hydropower value would result in continued contributions to the Basin Fund. Reduced total hydropower value at Hoover, Parker, and Davis Powerplants would result in reduced contributions to the Development Fund. Continued revenue from surcharges at Hoover, Parker, and Davis Powerplants would result in minor impacts on the Dam Fund.	Same as Action Alternative 1 with slightly higher contributions to the Basin Fund and Development Fund. Same as Action Alternative 1 for the Dam Fund.
	The basin funds' impacts on other governmental programs	Reduced cash in the Basin Fund and Development Fund would result in less contributions to associated government programs. Continued financial resources in the Dam Fund would have minor impacts on the associated government programs.	Continued financial resources in the Basin Fund would result in continued contributions to associated government programs. Reduced cash in the Development Fund would result in less contributions to the associated programs. Continued financial resources in the Dam Fund would have minor impacts on the associated programs.	Same as Action Alternative 1 with slightly higher contributions to the government programs associated with the Basin Fund and Development Fund. Same as Action Alternative 1 for government programs associated with the Dam Fund.

SEIS Section	Affected Resource	Alternatives		
		No Action	Action Alternative 1	Action Alternative 2
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	<p>Arizona:</p> <p>Production: \$100–\$116 million loss</p> <p>Jobs: 657–1,613 lost</p> <p>Income: \$60–\$108 million loss</p> <p>Tax revenue: \$10–\$23 million loss</p> <p>California:</p> <p>No impacts</p> <p>Nevada:</p> <p>No impacts</p>	<p>Arizona:</p> <p>Production: \$82–\$257 million loss</p> <p>Jobs: 1,060– 7,078 lost</p> <p>Income: \$87–\$452 million loss</p> <p>Tax revenue: \$15–\$92 million loss</p> <p>California:</p> <p>Production: \$0–\$486 million loss</p> <p>Jobs: 0–2,924 lost</p> <p>Income: \$0–\$185 million loss</p> <p>Tax revenue: \$0–\$66 million loss</p> <p>Nevada:</p> <p>No impacts</p>	<p>Arizona:</p> <p>Production: \$79–\$264 million loss</p> <p>Jobs: 889–4,410 lost</p> <p>Income: \$81–\$290 million loss</p> <p>Tax revenue: \$15–\$50 million loss</p> <p>California:</p> <p>Production: \$23–\$338 million loss</p> <p>Jobs: 110–2,439 lost</p> <p>Income: \$9–\$165 million loss</p> <p>Tax revenue: \$3–\$60 million loss</p> <p>Nevada:</p> <p>Production: \$23,000–\$316,000 loss</p>
	Recreation economic contributions	Economic contributions from recreation in Lake Powell and Lake Mead, river-based recreation, and adjacent land-based recreation 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 would be supported under all alternatives due to minimum flow requirements; however, the recreational experience would be impacted by the variation in flow	There would be the continued potential for a decrease in economic contributions from water-based recreation, similar to under the No Action Alternative. Impacts on water-based recreation economic contributions may be moderated by a reduction on the overall variability in water elevation in the long term.	Same as Action Alternative 1.

SEIS Section	Affected Resource	Alternatives		
		No Action	Action Alternative 1	Action Alternative 2
3.16 (cont.)	Municipal and industrial water social and economic contributions	Under all alternatives, allocated water shortages for different water elevations in Lake Mead would 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 would be 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).	Under Action Alternative 1, impacts would be realized at the lowest shortage level (400,000-af scenario) for Arizona and Nevada entitlement holders, while California would experience impacts starting at the 2.083-maf scenario. The lowest levels of shortage (at which the respective state would begin to experience impacts) would result in domestic water shortages of 58,316 af in Arizona, 16,000 af in Nevada, and 261,593 af in California. The maximum levels of shortage (4.000-maf shortage scenario) would result in domestic water shortages of 741,409 af in Arizona, 160,000 af in Nevada, and 843,052 af in California.	Under Action Alternative 2, impacts would be realized at all shortage scenarios for all three states. The lowest levels of shortage would result in domestic water shortages of 1,402 af in Arizona, 15,919 af in Nevada, and 25,827 af in California. The maximum levels of shortage (4.000-maf shortage scenario) would result in domestic water shortages of 603,284 af in Arizona, 144,825 af in Nevada, and 724,491 af in California.

SEIS Section	Affected Resource	Alternatives		
		No Action	Action Alternative 1	Action Alternative 2
3.17	Environmental Justice			
	Environmental justice communities	Initially, there would be fewer impacts; however, there would be an increased potential of disproportionate impacts on environmental justice communities as reservoir levels decrease. The available water supply would 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 includes two Tribes.	The available water supply would be reduced for the same priorities as under the No Action Alternative and additional Arizona priorities located within the following Arizona environmental justice study area counties: Coconino, Gila, La Paz, Mohave, Pima, Pinal, and Yuma' this includes eight Tribes. Potential disproportionate impacts on environmental justice communities would be more concentrated and severe compared with under the No Action Alternative.	Compared with Action Alternative 1, the available water supply would be reduced to zero for the same water users within the following Arizona environmental justice study area counties: Pinal and Pima; this includes two Tribes. There would be the potential for disproportionate impacts on a range of users within environmental justice communities; however, impacts would be less concentrated and severe, compared with Action Alternative 1.
3.18	Indian Trust Assets			
	Water rights and allocations	Tribal water rights are a matter of settled law; however, annual water deliveries may change as a result of shortages. Water deliveries and shortages would be shared based on priority.	Impacts would be similar to those under the No Action Alternative. The number of Tribes affected (and how they are affected) varies because water deliveries are based on priority. However, long-term water deliveries are projected to be more reliable as compared with the No Action Alternative.	The number of Tribes affected (and how they are affected) varies because additional shortages are distributed based on the same percentage for all water users. However, long-term water deliveries are projected to be more reliable as compared with the No Action Alternative.
	Cultural and biological resources	Low river levels would expose more resources to visitation. As water elevations decrease, there would be short-term changes to riparian vegetation, including an increase of invasive plant species and the loss of suitable habitat for native plant species.	Projected higher river levels would expose less sites, and there would be a decline in nonnative plant species.	Same as Action Alternative 1.

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 Alternative and Action Alternatives 1 and 2, as described in **Chapter 2**. The analysis is issue-based, meaning it addresses 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 resource section of **Chapter 3**.

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 f (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 is not affected by the proposed alternatives.

In addition to the potential impacts that may occur within the main stem Colorado River corridor, the SEIS alternatives may also affect the water supply that is available to specific Colorado River water users in the Lower Basin due to the allocation of reductions in the proposed alternatives. The following water agency service areas are included in the geographic scope of analysis:

- Arizona water users and Tribes, particularly the water users in the Central Arizona Project (CAP) service area
- The SNWA service area
- The MWD service area

The environmental consequences analysis focuses on the period between operating years 2024 and 2026 during which the alternatives considered would be implemented, as described in **Section 2.4, Implementation**. The focus on the 2024 operating year is based on the need to promptly develop additional operational tools in light of historically low reservoir elevations. The alternatives also describe operations for 2025–2026. The SEIS analyzes the alternatives for the 2025–2026 time frame across affected resource areas to the extent that information is available. There is more uncertainty in the 2025–2026 analysis (both from a hydrologic and resource impact standpoint); accordingly, the Department may select an alternative to apply in the 2024 operating year with future analysis, as needed, to be performed before potentially revising the selected alternative for 2025–2026 operations. Although impacts of the proposed alternatives would extend beyond 2026, the analysis does not examine impacts beyond 2026. This is because Reclamation is in the process of preparing a separate EIS to develop the post-2026 operational strategies. This post-2026 EIS will analyze a full range of alternatives along with the 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 each action alternative. 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.

Hydrologic modeling also provided the basis for analyzing potential effects of each alternative on other environmental resources, such as recreation, biology, energy, etc. The potential effects on specific resource issues are identified and analyzed for each action alternative and compared to 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 action alternatives.

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 C**, Colorado River Mid-term Modeling System (CRMMS) Model Documentation, and **Appendix D**, 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

Two action alternatives 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; Sections 6.C, Mid-Elevation Release Tier, and 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 this section; **Appendix C**, CRMMS Model Documentation; and **Appendix D**, Shortage Allocation Model Documentation.

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 action alternatives were simulated using 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 five years as opposed to the longer-term outlooks projected using CRSS.

CRMMS simulates the 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, releases from the dams, the amount of water flowing at various points throughout the system, and the diversions to and return flows from the 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, 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 C**. The model was used to project the future conditions of the Colorado River system on a monthly time-step for the period September 2022 through December 2026.

The input data for the model includes monthly unregulated inflow forecasts based on the September 2022 forecast, various physical process parameters such as the evaporation rates for each reservoir, initial reservoir conditions as of August 31, 2022, 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

¹ In addition, Reclamation analyzed external proposals for alternatives, or components thereof, in **Appendix B**, as further described in **Section 2.1**, Development of the Alternatives.

purposes of 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 C**.

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 September 2022 unregulated inflow forecast, allowing Reclamation to explore a wider range of low-flow hydrologic scenarios beyond those experienced during the recent 30 years (1991–2020). See **Appendix C** 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 C**, CRMMS Model Documentation; **Appendix D**, 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 that are common to all alternatives.

CRMMS Assumptions for All Alternatives

Detailed assumptions for CRMMS can be found in **Appendix C** and are summarized here. Assumptions with regard to reduction of deliveries to the Lower Division States under each alternative are described in **Sections 2.7 and 2.8**, as well as **Section 3.3.9**, below.

- All simulations were performed with a start date of September 2022 and an end date of December 2026.
- If the pool elevation at 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 any associated maintenance activities. Reclamation believes this is a conservative and prudent estimation given the historical and future operations and maintenance requirements for the river outlet works.
- DCP contributions and intentionally created surplus (ICS) assumptions are consistent with the official September 2022 CRMMS simulation.
- 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.

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

- Hourly, daily, and monthly releases from Lake Powell will be consistent with the LTEMP so long as sufficient water is available for annual releases. 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 the LTEMP.
- The DROA releases from Flaming Gorge—projected 500 kaf for May 2022 through April 2023³—are included in the tier determination and balancing releases, as are the 2021 DROA releases (which totaled 161 kaf from Flaming Gorge and Aspinall), consistent with the official September 2022 CRMMS simulation.
- 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 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. 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, reductions under low-elevation reservoir conditions, BWSCP contributions per Minute 323, and/or additional shortages in the action alternatives.
- 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.
- For the purpose 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 at dead pool, or “system shortages.”⁴ Combined, shortages and system shortages may be referred to as “total shortages.”

Shortage Allocation Model Assumptions for All Alternatives

Detailed assumptions for the Shortage Allocation Models can be found in **Appendix D** and are summarized here.

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 include:

CRMMS

- The No Action Alternative includes the continued implementation of the 2007 Interim Guidelines, the 2016 ROD for the Glen Canyon Dam LTEMP and Glen Canyon Dam

³ The projected 500 kaf DROA release was reduced in March 2023 but is not reflected in the modeling assumptions. It may be updated for the Final SEIS.

⁴ System shortages are reported as a total for the entire Lower Basin because there are no explicit assumptions made in the CRMMS associated with how these shortages would be distributed in the Lower Basin. This results in users being shorted “hydrologically” (that is, upstream users access water before downstream users); however, it does not reflect potential implementation of such system shortages.

Operating Criteria, Minute 323, and the 2019 DCPs for operations of Glen Canyon and Hoover Dams.

- 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 September 2022 CRMMS simulation.
- Lake Powell and Lake Mead operations are modeled “as if” 480 kaf of water had been delivered to Lake Mead⁵.

Shortage Allocation Model

- The No Action Alternative Shortage Allocation Model assumes a maximum analyzed shortage of 1.1 maf.
- Shortages are characterized by two stages, Stage 1 and Stage 2. In Stage 1, shortages are imposed only upon Arizona and Nevada⁶ and continue until the deliveries to the post-1968 water rights holders in Arizona (including the CAP) are reduced to zero. In Stage 2, after deliveries to the fourth-priority entitlements within Arizona are expected to be reduced to zero, additional reductions would be applied to Arizona, California, and Nevada according to Stage 2 ratios. However, the maximum shortage volume simulated in the No Action Shortage Allocation Model does not exceed Stage 1 shortage amounts. 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 Action Alternative 1

Section 2.7 describes Action Alternative 1 in detail. An overview of assumptions for Action Alternative 1 include:

CRMMS

- 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 the No Action Alternative.

⁵ The reduction of releases from Lake Powell from 7.48 maf 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 the 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 operating determinations for 2023 and it was accounted for “as if” this volume of water had been delivered to Lake Mead.

⁶ Note that this is consistent with an Arizona-Nevada Shortage Sharing Agreement dated February 9, 2007, which covers shortage declarations up to 500 kaf during an Interim Period (ending December 31, 2025). In that agreement, shortage declarations exceeding 500 kaf would be consulted upon by the Secretary, triggered by Lake Mead water surface elevations at or below 1,025 feet.

- The Mid-Elevation Release Tier and Lower Elevation Balancing Tier in Lake Powell are replaced with the Lower Elevation Release Tier.
- 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 hydrology. Releases may be further reduced to prevent Lake Powell from dropping below 3,500 feet.
- Physical elevations are used for tier determinations and balancing releases for operating years 2024 through 2026 with no assumptions for the repayment of the 480,000-af reduced delivery from Lake Powell in operating year 2022.
- Deliveries to the Lower Division States during Shortage Condition Year 2024 are different from Shortage Condition Years 2025–2026; these are described in **Section 2.7** and **Section 3.3.9**, respectively.
- Shortage reductions in excess of the 2007 ROD and 2019 DCPs are distributed to the Lower Basin based on priority.
- DCP contributions and ICS assumptions are consistent with the official September 2022 CRMMS simulation.

Shortage Allocation Model

- The Action Alternative 1 Shortage Allocation Model assumes a maximum analyzed shortage of 2.083 maf in 2024 and 4.0 maf in 2025 and 2026.
- Shortages are characterized by two stages, Stage 1 and Stage 2. The model distributes available water first among states and subsequently among the entitlement holders within each state based on priority.

Modeling Assumptions for Action Alternative 2

Section 2.8 describes Action Alternative 2 in detail. An overview of assumptions for Action Alternative 2 include:

CRMMS

- 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 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, operated the same way as in Action Alternative 1.
- This alternative includes modeling assumptions regarding contributions from the Upper Initial Units of releases from zero to 500,000 af per DROA Year (May 1–April 30), which will conform to the DROA and its implementing documents and will be made only to help protect a Lake Powell elevation of 3,500 feet. The analysis refers to these as “potential DROA contributions.”
- Physical elevations are used for tier determinations and balancing releases for operating years 2024 through 2026 with no assumptions for the repayment of the 480 kaf reduced delivery from Lake Powell in operating year 2022.

- Deliveries to the Lower Division States during Shortage Condition Year 2024 are different from Shortage Condition Years 2025–2026 and are described in **Section 2.8**.
- Shortage reductions in excess of the 2007 ROD and 2019 DCPs 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 September 2022 CRMMS simulation.

Shortage Allocation Model

- The Action Alternative 2 Shortage Allocation Model assumes a maximum analyzed shortage of 2.083 maf in 2024 and 4.0 maf in 2025 and 2026.
- The Shortage Allocation Model for Action Alternative 2 distributes shortage reductions in addition to the 2007 ROD and 2019 DCPs distributed in the same percentage across all Lower Basin water users based on 2021 adjusted consumptive use.

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 the distribution of shortages by state for 2024, was provided in **Sections 2.7** and **2.8**.

As described in **Section 3.2**, Reclamation anticipates that there may be additional analysis and outreach before implementing additional changes to the 2007 Interim Guidelines for the 2025 and 2026 operating years. However, for purposes of modeling and analysis of potential environmental consequences from the alternatives in 2025 and 2026 in this SEIS, Reclamation has made assumptions about how additional shortage volumes from Lake Mead considered under Action Alternatives 1 and 2 would be distributed among Lower Division States and individual users (see **Table 3-1** and **Table 3-2** and **Appendix C** and **Appendix D**). The assumptions are based on the methodologies for distributing additional shortages by priority, for Action Alternative 1, or in the same percentage, for Action Alternative 2, as described in **Sections 2.7** and **2.8**. These assumed shortage volumes are subject to further revision based on any subsequent analyses and outreach after completion of this SEIS.

Table 3-1
Lower Division States' Shortages and Contributions by State, Action Alternative 1
(2025–2026)
(All volumes in 1,000 af)

Lake Mead Elevation (feet)	2007 ROD Shortage + 2019 DCP Contributions				2025–2026 Action Alternative 1 Additional Shortage*				2025–2026 Total Shortages and Contributions			
	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	1,131	63	89	1,131	1,771	90	389	2,250
1,030 – 1,025	640	27	350	1,017	1,180	73	230	1,180	1,820	100	580	2,500
<1,025 – 1,000	720	30	350	1,100	1,198	90	612	1,900	1,918	120	962	3,000
<1,000 - 975	720	30	350	1,100	1,263	103	867	2,233	1,983	133	1,217	3,333
<975 - 950	720	30	350	1,100	1,329	117	1,122	2,567	2,049	147	1,472	3,667
<950	720	30	350	1,100	1,394	130	1,376	2,900	2,114	160	1,726	4,000

*The additional shortage volumes decrease at elevation 1,025 feet because the shortages under the 2007 ROD increase by the same amount. Therefore, the additional shortage amounts necessary to get to the 2.083 maf total are lower.

**The first increment of shortage volumes required by Action Alternative 1 is satisfied by 2019 DCP contributions. In this elevation tier, the 2019 DCP contributions for California exceed the 2024 shortage volume under Action Alternative 1, which follows the priority system.

***The state distributions in the 2025–2026 Total Shortage columns reflect Action Alternative 1 shortages plus remaining contributions to satisfy the 2019 DCPs. In this elevation tier, the California DCP contribution when added to the total shortage exceeds the total volume of Action Alternative 1.

Table 3-2
Lower Division States' Shortages and Contributions by State, Action Alternative 2
(2025–2026)
(All volumes in 1,000 af)

Lake Mead Elevation (feet)	2007 ROD Shortage + 2019 DCP Contributions				2025–2026 Action Alternative 2 Additional Shortage					2025–2026 Total Shortages and Contributions			
	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	17.11%	479	51	753	1,283	1,119	78	1,053	2,250
1,030 – 1,025	640	27	350	1,017	19.77%	554	59	870	1,483	1,194	86	1,220	2,500
<1,025 – 1,000	720	30	350	1,100	25.33%	709	76	1,115	1,900	1,429	106	1,465	3,000
<1,000 - 975	720	30	350	1,100	29.77%	834	89	1,310	2,233	1,554	119	1,660	3,333
<975 - 950	720	30	350	1,100	34.23%	958	103	1,506	2,567	1,678	133	1,856	3,667
<950	720	30	350	1,100	38.67%	1,083	116	1,701	2,900	1,803	146	2,051	4,000

*Percentage of 2021 consumptive use.

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

The CEQ's regulations (40 CFR 1500 through 1508) implementing the procedural provisions of NEPA defines cumulative impacts as the following:

“...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 either through 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 future state conservation projects, but did not bring them forward for cumulative impacts analysis. This is because the projects were too speculative at this time to be considered reasonably foreseeable, did 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 Glen Canyon Dam/Smallmouth Bass Flow Options

Reclamation's Upper Colorado Basin Region is preparing an environmental assessment (EA) regarding experimental operations at the Glen Canyon Dam to prevent smallmouth bass from establishing. 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. If smallmouth bass successfully spawn and establish below Glen Canyon Dam and then 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 proposed action is to prevent the establishment of smallmouth bass below the Glen Canyon Dam using dam operations to reduce water release temperatures.

Reclamation is considering two alternatives, one of which includes four experimental flow options that are designed to reduce the temperature of the water released through the dam to prevent smallmouth bass from establishing below the dam. All four options would include releases of water through the river outlet works, which are lower. This means the water release temperature would be colder; however, power is only generated when water is released through the penstocks, which would result in impacts on hydropower generation. The flow options would not result in any changes to monthly or yearly release volumes but would instead change how and when those releases took place.

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. These same hydrologic resources have the potential to be affected by the proposed alternatives evaluated in this SEIS; these resources include:

- Reservoir storage, reservoir releases, and corresponding changes in Colorado River flows downstream of the reservoirs
- Groundwater within the Colorado River corridor and/or offstream

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 in the US have affected hydrologic resources in the Basin since issuance of the 2007 FEIS:

- 1) Interim Guidelines were established in December 2007 from the FEIS Preferred Alternative and 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 of 2019, the DCPs were signed to address ongoing historic drought in the Basin. In May 2019, components of the Lower Basin DCP were implemented and the Lower Basin DCP was fully implemented 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 DCPs.
- 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.

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 through 2022 to better describe evolving characteristics of hydrologic resources within the affected environment. The updated information for these resources, by river reach, captures the implementation of the 2007 Interim Guidelines, 2019 DCPs, Minute 323, and drought conditions within the Basin. The updated hydrologic conditions 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 the Basin contains. 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 the Upper Basin DCP and Lower Basin DCP. The Colorado River Basin Climate and Hydrology: State of the Science (State of the Science) (Lukas, J. and Payton, E. 2020) report provided a comprehensive assessment of Basin hydroclimate conditions and trends through 2019. Key findings from the report are summarized below, updated through 2022, where appropriate.

Since 2000, the Basin has experienced persistent drought conditions, exacerbated by a warming climate, leading to a 20 percent decrease in average annual Upper Basin (at Lee Ferry) natural flows (Reclamation 2022c). 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 of about 70 maf relative to twentieth-century conditions (Reclamation 2022c). Approximately 92 percent of the natural Basin streamflow originates from the Upper Basin, with snowmelt being 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.



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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
- Imperial Dam to Northerly International Boundary (NIB)
- 8 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 is because the SEIS is not considering alternative actions that would change water deliveries to Mexico. The provisions of the 1944 Water Treaty and implementing Minutes are not affected by this SEIS.

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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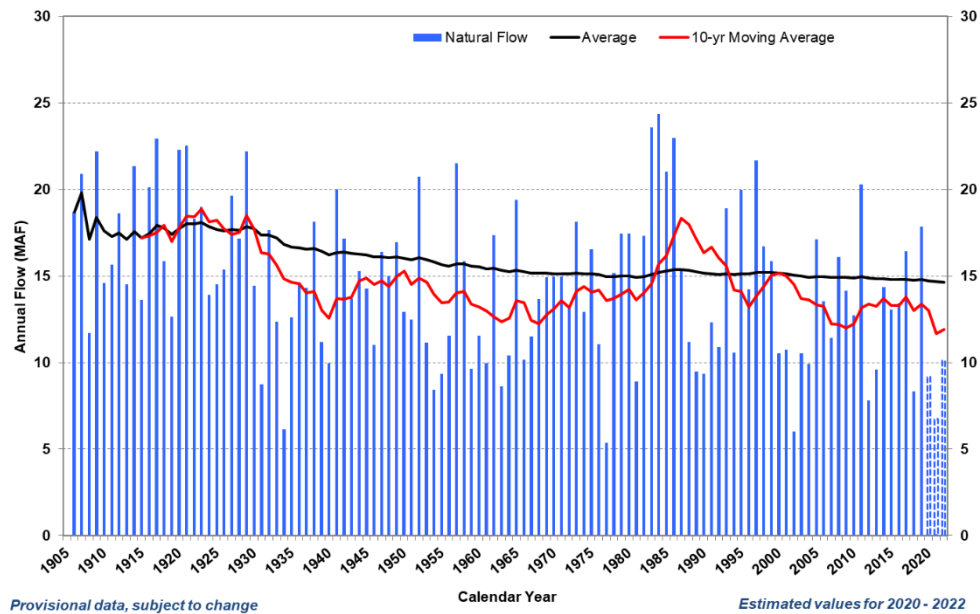
In addition, annual water use in the Basin has exceeded the annual inflows in most years since 2000. This resulted in a depletion of storage down to 26 percent of the total combined capacity of Lake Powell and Lake Mead by the end of operating year 2022 (Reclamation 2023d). Since issuance of the 2007 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 two degrees Fahrenheit warmer than the twentieth-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 non-significant) precipitation trend was noted over the period from 1980 to 2019. During the 1980 to 2019 period, precipitation over the cold season (October through March), which typically falls as snow, showed a greater declining trend than precipitation over the warm-season months. 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 calculated to be 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 were calculated based on observed (gage) flow, and they were corrected for upstream reservoir changes in storage and release, losses including evaporation, and depletions due to agriculture 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 calculated at the Lees Ferry Gaging Station for 1922 through 2022.

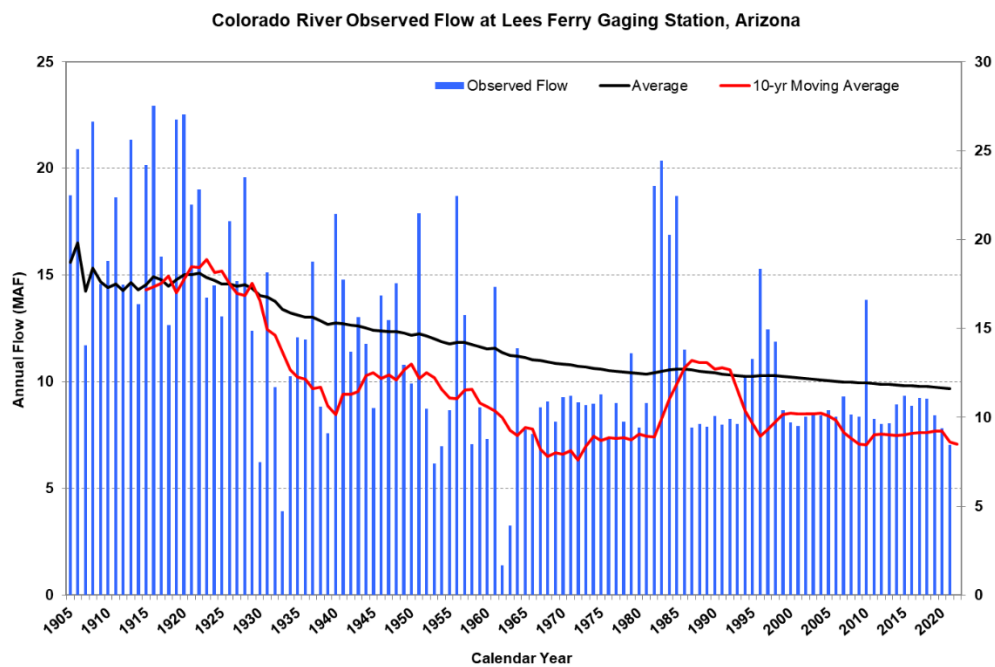
Beginning in 2008, annual observed flows (which do not account for the above-mentioned factors) at the Lees Ferry Gaging Station have decreased. The annual observed flow at Lees Ferry during the historical period since the Glen Canyon Dam was built (1963–2007) ranged from 1.383 maf (when the dam was built in 1963) to 20.374 maf (1984) with an average of 9.691 maf. Since the implementation of the 2007 Interim Guidelines (2008 to 2022), 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. According to the 2020 State of the Science report, a 2-year average flow of less than 15 maf at Lees Ferry is considered a streamflow deficit. The maximum annual observed flow of 13.846 maf occurred in 2011, and it 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 1922 through 2022.

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



Source: Reclamation 2023e

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



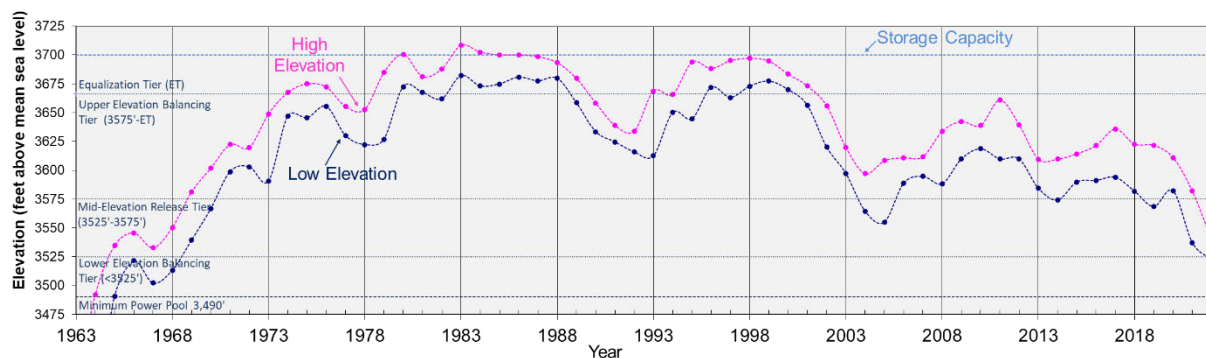
Source: Reclamation 2023e

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 the years 2008 through 2022 from Reclamation's Upper Basin Hydrologic dataset. The operating range during this period was between 3,522.2 feet (occurring in 2022) and 3,660.9 feet (occurring in 2011). The average operating elevation was 3,602.3 feet, which is well below the average elevation throughout the 1980s and late 1990s.

Since 2017, the annual average water surface elevation at Lake Powell has declined approximately 87 feet. Lake Powell's annual high-water elevation and annual low-water elevation 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.⁷ 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 alternatives 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 2023e

The 2007 FEIS did not consider effects to groundwater elevations in the vicinity of Lake Powell. Fluctuations of reservoir levels may impact adjacent groundwater levels. Declining reservoir elevations since the 2007 FEIS may be mirrored in declining groundwater elevations.

Glen Canyon Dam to Lake Mead

As described in the 2007 FEIS, flows in the river reach between Glen Canyon Dam and 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 the implementation of the 2007 Interim Guidelines (2008 to 2022), annual

⁷ ROD for the Glen Canyon Dam LTEMP FEIS, December 2016. Internet website: https://ltempis.anl.gov/documents/docs/LTEMP_ROD.pdf.

inflow from the Little Colorado River ranged from 204,300 to 392,900 af, averaging 274,600 af. During the same period, the annual inflow from the Paria River ranged from 8,100 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 River and Little Colorado River 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.

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 (through 2022), the Upper Elevation Balancing Tier has been the most common operation type, allowing releases between 7.0 and 9.0 maf (see **Table 3-3**). Glen Canyon Dam releases for this period have ranged from 7.04 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 alternatives are further discussed in **Section 3.6.2**, Environmental Consequences below.

Table 3-3
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

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
2015	Upper Elevation Balancing	Balancing	106	9.00	—	Normal/ICS Surplus
2016	Upper Elevation Balancing	Balancing	100	9.00	—	Normal/ICS Surplus
2017	Upper Elevation Balancing	Balancing	124	9.00	—	Normal/ICS Surplus
2018	Upper Elevation Balancing	Balancing	48	9.00	—	Normal/ICS Surplus
2019	Upper Elevation Balancing	Balancing	135	9.00	—	Normal/ICS Surplus
2020 ⁴	Upper Elevation Balancing	None	61	8.23	—	Normal/ICS Surplus DCP Contributions
2021 ⁵	Upper Elevation Balancing	None	36	8.23	—	Normal/ICS Surplus DCP Contributions
2022	Mid-Elevation Release Tier	Adjusted in May 2022 ⁶	63	7.00	—	Level 1 Shortage 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 acre-feet 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 2021c).

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 \(usbr.gov\)](https://www.usbr.gov/pressroom/2022/04/2022-Glen-Canyon-Dam-Operations-Decision-Letter).

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

As stated in the 2007 FEIS, this reach is within 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 is lost as seepage around the Glen Canyon Dam. The incised nature of this river corridor has remained relatively unchanged since issuance of the 2007 FEIS. 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, it is assumed that groundwater levels have remained the same since 2007 for this reach.

The 2007 FEIS did not consider effects on groundwater elevations in the vicinity of Lake Mead. Fluctuations of reservoir levels may impact adjacent groundwater levels. Declining reservoir elevations since the 2007 FEIS may be mirrored in declining 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 operations at lower water levels. The new turbines updated the minimum power pool elevation to 950 feet. Water surface elevations above 895 feet can still allow releases through the intake towers.

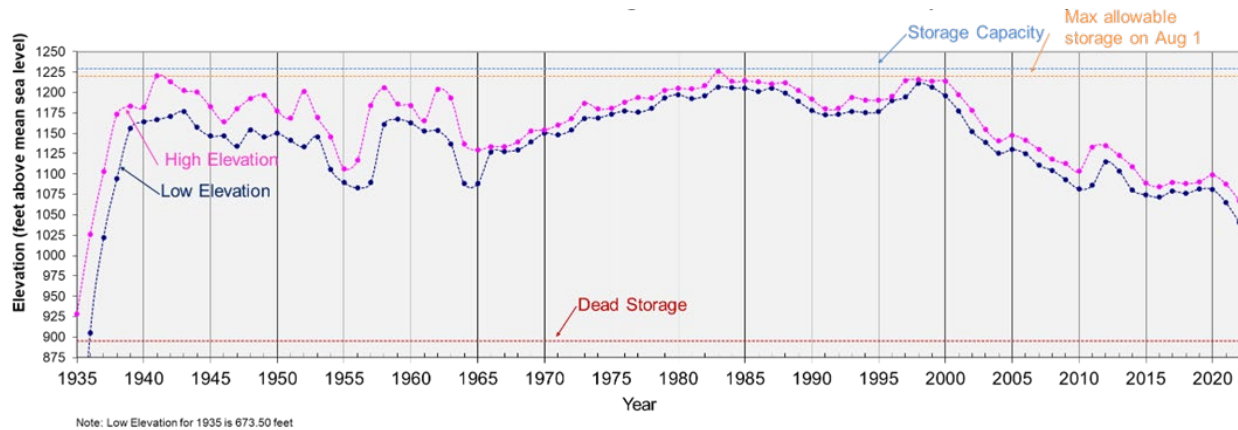
Since the construction of the Hoover Dam in 1935, it took Lake Mead approximately 4 years to fill up to an average annual water surface elevation of 1,172 feet. The water surface elevation of Lake Mead was highly variable from 1939 until the Glen Canyon Dam at Lake Powell came online in 1963, fluctuating from 1,098 feet to 1,195 feet. 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 steadily 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 (occurring in 2022) and 1,134.5 feet (occurring in 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.

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 alternatives 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**.

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



Source: Reclamation 2023f

Since the issuance of the 2007 FEIS, Lake Mead operated in a normal/ICS condition each year 2008 through 2021 and in a Level 1 shortage condition in 2022 (see **Table 3-3**). In addition, contributions under the Lower Basin DCP were required in the years 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 for the period from 1996 through 2007. With the 2007 Interim Guidelines in place since issuance 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 issuance 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 1.01 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 and 9 maf, 40.5 percent for releases between 9.01 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 and 9 maf occurred approximately 27 percent of the time, add releases between 9.01 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 for the 2008 to 2022 time period were different than the modeled probabilities for the 2007 FEIS federal alternative.

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

The 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 the same, at approximately 640.9 feet. The average storage in Lake Mohave has remained 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 the same in this reach since 2007. The lower portion of the reach is dominated by Lake Mohave. The 2007 FEIS did not consider effects to 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.

The 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. This is 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 for 1906 through 2007. Annual Alamo Dam releases since 2008 (through 2022) have ranged from 15.4 to 501,900 af and averaged 105,000 af. Contributions to Lake Havasu from the Bill Williams River have remained unchanged since the 2007 Interim Guidelines.

Reclamation has continued to operate 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 up 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 the same, at 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 the 2007 Interim Guidelines would result in decreased groundwater elevations of approximately 0.25 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 the reach is the Chemehuevi Valley groundwater basin, which is dominated by Lake Havasu. 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 assumes that groundwater levels have remained the same 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.

The 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 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 to 6.7 maf and averaged 6.4 maf. This is a decrease of 1.0 maf in average annual releases.

The operations of the Headgate Rock Dam and Palo Verde Diversion Dam have remained unchanged since issuance 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 to 0.30 feet. Therefore, Reclamation assumes that groundwater levels in this reach have decreased by approximately that much 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 US' 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, but annual releases have decreased since their 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 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 to 18,751 cfs and averaged 7,632 cfs. This is a decrease of average flow rates of 1,299 cfs.

The 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 analyses performed in the 2007 FEIS, 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 federal action 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. During the period 1974 through 2012, the average flows to Mexico in excess of scheduled deliveries was 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 the analyses performed in the 2007 FEIS, the 2007 Interim Guidelines were not anticipated to affect gaining or losing sections of this reach.

3.6.2 Environmental Consequences

Methodology

This section examines the potential effects on hydrologic resources under the No Action Alternative (baseline condition) and the action alternatives. CRMMS, as described in **Section 3.3**, was used to analyze hydrologic resources across these alternatives. Modeling details for each alternative are described in **Section 3.3.8** and **Appendix C**, CRMMS Model Documentation.

Assumptions

(Please refer to **Section 3.3.8**, **Appendix C**, CRMMS Model Documentation, and **Appendix D**, 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 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

For all alternatives evaluated, 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, Action Alternative 1, and Action Alternative 2 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 in 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 elevation 3,490 feet is critical for preserving infrastructure ensuring Glen Canyon Dam continues to operate under its intended design for purposes of downstream water releases. Under the No Action Alternative, the median percentile of traces is at a minimum elevation of 3,505 feet in 2024 and at a maximum elevation of 3,555 feet in 2025. However, the range of modeled elevations under the No Action Alternative is wide with 30 to 35 percent of traces falling below an elevation of 3,490 feet throughout the period of analysis. Under Action Alternative 1 and Action Alternative 2, which show almost identical results to each other throughout time in all metrics, the medians of Lake Powell pool elevations range from a minimum of 3,520 feet in 2024 to a maximum of 3,576 feet in 2026. The percent of traces falling below 3,490 feet under the two action alternatives goes from 8 percent in 2024 to 0 percent in 2026. The median monthly pool elevation for the two action alternatives remain higher than the No Action Alternative 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 either of the two action alternatives.

With respect to modeled end-of-water-year Lake Powell pool elevations, the distribution of elevations under the No Action Alternative results in a lower median and wider range than the action alternatives throughout the period of analysis. In 2024 and 2025, the median September 30th elevations range between 3,541 and 3,546 feet under the No Action Alternative and the interquartile ranges span a range of approximately 55 feet in 2024 to a range of 100 feet in 2026. The medians September 30th elevations for the action alternatives are approximately 3,555 feet in 2024 to 3,565 feet in 2026, and the interquartile ranges remain relatively consistent between 35 and 50 feet.

Throughout the period of analysis, the No Action Alternative results in a large number of traces falling below critical elevations; exhibits declining predictability in response to a wide range of potential hydrologic futures; and suggests lacking the ability to recover reservoir elevations above critical elevations once they are reached.

The operational modification included in Action Alternative 1 and Action Alternative 2 designed to protect Lake Powell elevation 3,500 feet is effective at minimizing instances of falling below 3,490 feet in 2024 and eliminating this outcome for all modeled traces by 2026. Actions would not take effect until 2024, which could result in traces ending 2023 and starting 2024 below 3,490 feet. The new Lower Elevation Release Tier created in both action alternatives provides the ability for Lake Powell elevations to gain a buffer against critical elevations under many modeled traces, thus reducing risk even further.

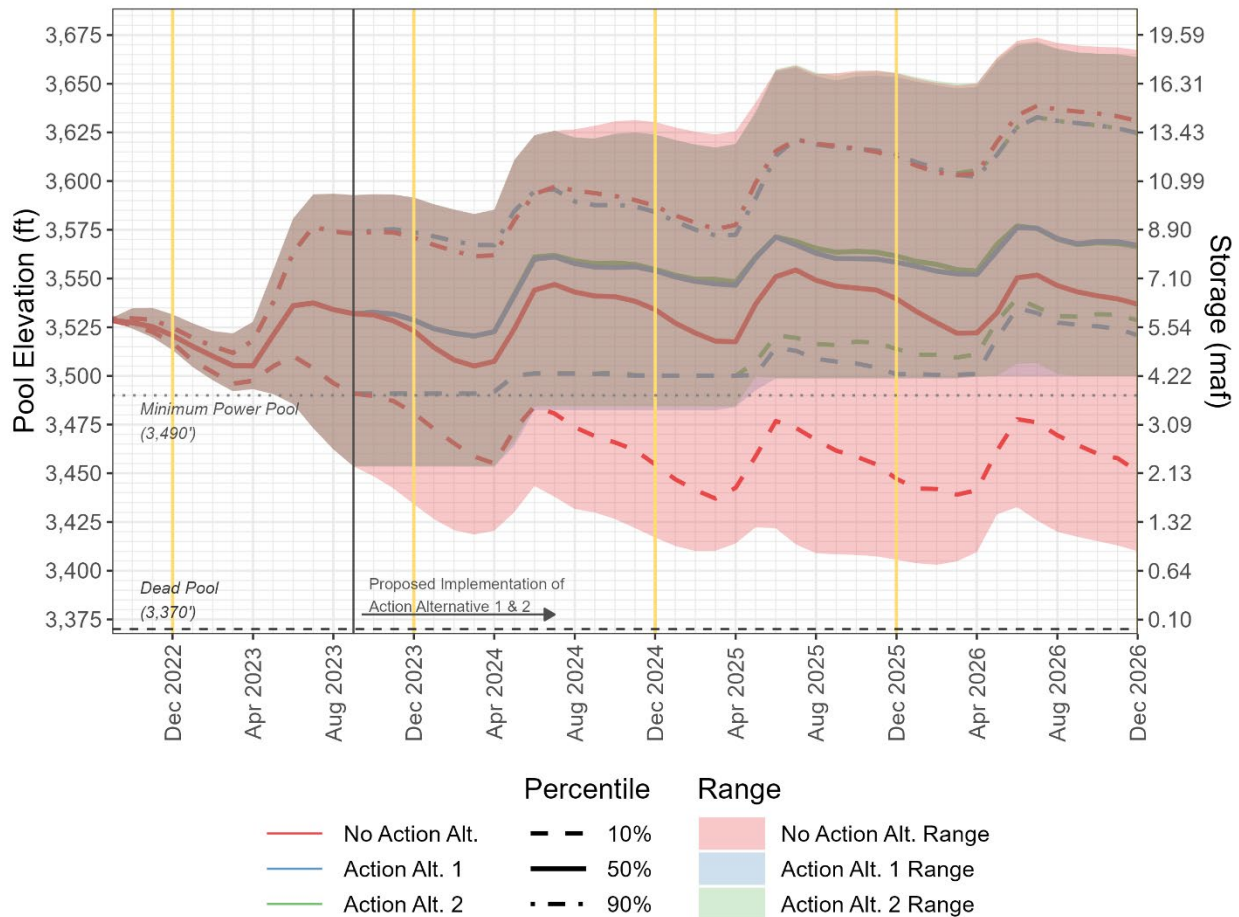
Monthly Pool Elevations

Figure 3-5 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 all three alternatives through 2026.

The range of modeled Lake Powell elevations resulting from the No Action Alternative is shown by the red cloud in **Figure 3-5**, which spans from 3,417 to 3,631 feet in 2024, with fluctuations corresponding to seasonal reservoir levels. The bottom of the No Action Alternative cloud falls as low as 3,403 feet in 2026 and reaches as high as 3,674 feet in 2026, consistent with increasing uncertainty over time. The clouds for Action Alternative 1 (blue) and Action Alternative 2 (green) are nearly completely overlapping each other and are contained within the range of the No Action Alternative cloud. The clear distinction between the No Action Alternatives and the two action alternatives is that the lower boundaries of the ranges for the two action alternatives are considerably higher; in 2024, the minimum modeled elevation for Action Alternative 1 and Action Alternative 2 is 3,453 feet, or 36 feet higher than the lowest Lake Powell pool elevation modeled in the No Action Alternative. The minimum elevation of the action alternatives in 2026 is 3,500 feet, or 97 feet higher than the No Action Alternative. The ranges for the action alternatives stabilize at 3,500 feet because releases are calculated to explicitly protect that elevation.

In **Figure 3-5**, the 50th percentile, or median, of the modeled elevations for the No Action Alternative ranges between 3,505 and 3,547 feet in 2024, with minimums increasing slightly through 2026. The median elevations for the action alternatives are nearly identical, and they are approximately 5 to 20 feet higher than the median of the No Action Alternative throughout 2024.

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



By 2026, the median modeled pool elevations for the two action alternatives are 15 to 25 feet higher than the median of the No Action Alternative. The 90th percentiles of all three alternatives are similar, consistent with the overlap at the high ends of the three clouds.

The differences in the 10th percentile lines in **Figure 3-5** show the potential impacts that the action alternatives could have in dry conditions. The No Action Alternative 10th percentile line falls below Lake Powell's minimum power pool (3,490 feet) in November of 2023, and it does not go above minimum power pool at any time through 2026. This means that 10 percent or more of the modeled traces were at or below minimum power pool throughout the analysis period under this alternative. The 10th percentiles of the modeled Lake Powell elevations for the two action alternatives are nearly identical through April 2025, and they do not ever go below minimum power pool, remaining constant at elevation 3,500 feet until they diverge slightly. By 2026, the 10th percentiles of both alternatives climb above 3,525 feet. The small differences between the action alternatives are due to the different modeling assumptions for potential DROA contributions; Action Alternative 2 includes an assumption for up to 500,000 af/year when Lake Powell is below 3,525 feet, which slightly increases Lake Powell's elevations.

Percentages of Traces Below Critical Elevations

Figure 3-6 shows the percent of modeled traces that fell below Lake Powell elevation 3,490 feet at any time during a year for the period of analysis. Remaining above 3,490 feet is critical for protecting infrastructure.

Figure 3-6 shows that in 2024, 38 percent of the modeled traces fall below Lake Powell elevation 3,490 feet at some point during the operating year under the No Action Alternative, while only 9 percent of traces do so under the two action alternatives. In 2025 and 2026, the No Action Alternative results in 31 percent and 34 percent of traces falling below 3,490 feet, respectively, while 2 percent and 0 percent of the action alternatives' traces do so.

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

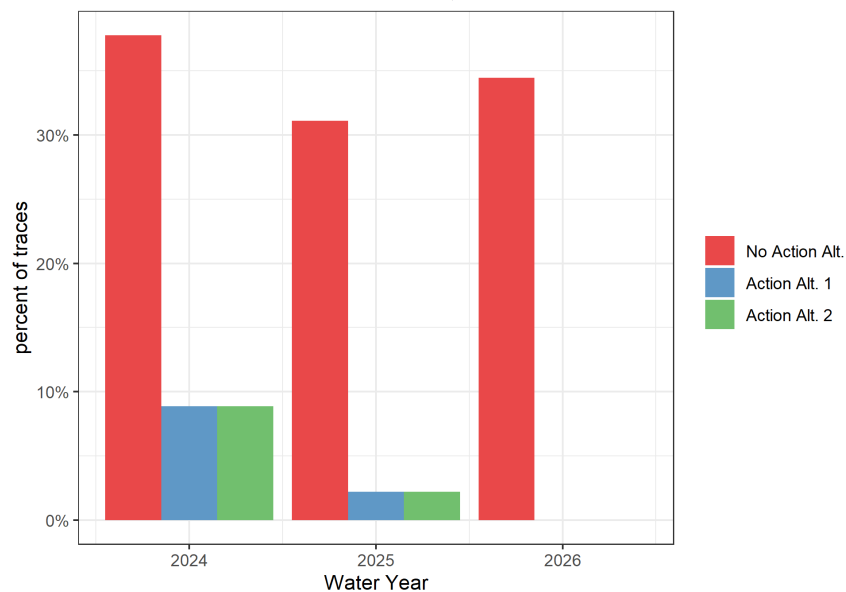
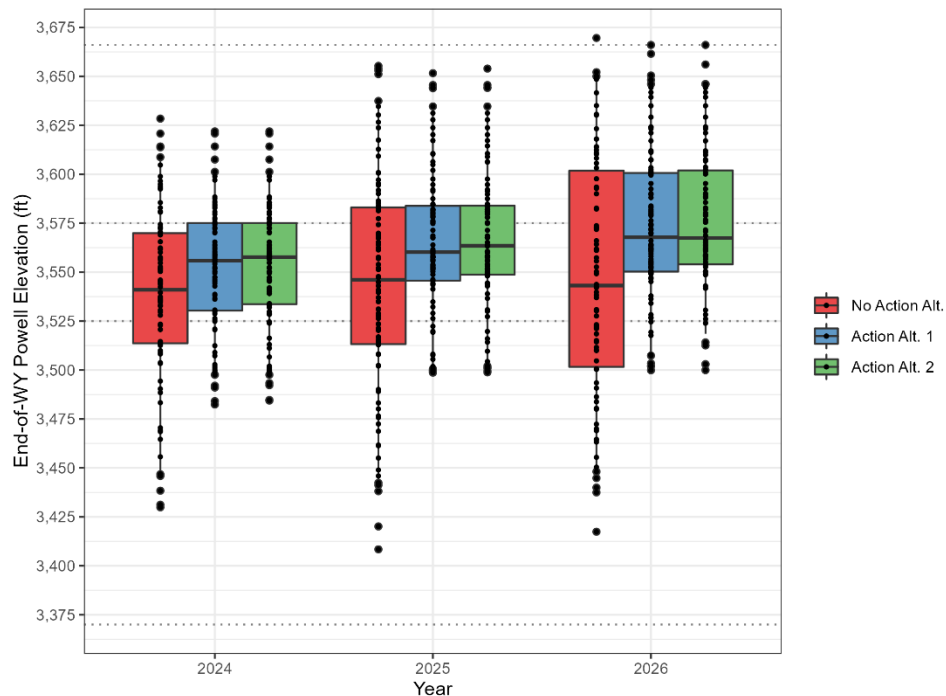
*Annual Pool Elevations*

Figure 3-7 shows the distributions of modeled Lake Powell elevations on September 30 in 2024, 2025, and 2026. Each dot is the end-of-water year elevation produced by a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile 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 boxplots in **Figure 3-7** show how a wide range of modeled end-of-Water Year pool elevations at Lake Powell are distributed; while the medians of the elevations are relatively stable around 3,530 to 3,540 feet, the interquartile ranges increase through time as do the whiskers and outliers. In comparison, the action alternatives have median end-of-water-year elevations approximately 15 feet higher in 2024 and 2025 and approximately 25 feet higher in 2026.

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



The interquartile and full ranges for the two action alternatives are smaller than those of the No Action Alternative, with Action Alternative 2 having slightly higher modeled elevation ranges due to the different assumptions for potential DROA contributions.

Lake Mead

Summary of Alternatives Comparison

The conclusions in this section are drawn from analyses in 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 differences between the No Action Alternative and the two action alternatives vary in 2024 when compared to the differences in 2025 and 2026. In 2024, modeling of the driest hydrologic traces with Action Alternative 1 and Action Alternative 2 result in lower Lake Mead elevations than the No Action Alternative. This discrepancy is the result of both Lake Powell and Lake Mead modeled operations. The modeled Lake Powell operations in the action alternatives result in projected releases below 7.0 maf, which occur immediately in 2024 in the driest traces, while releases from the No Action Alternative do not become constrained by Glen Canyon Dam infrastructure limitations until later in the period of analysis (refer to *Issue 2*). Modeled Lower Basin total shortages and contributions are constrained to 2.083 maf in 2024; however, modeled Lower Basin shortages and contributions increase in 2025 and 2026 when larger additional shortages are modeled below elevation 1,040 feet. As a result, through 2026 the modeled action alternatives are significantly more effective in all traces than the No Action Alternative.

In terms of monthly Lake Mead pool elevations, the bottoms of the modeled ranges under the action alternatives decline more steeply than the No Action Alternative in 2024 and the first half of 2025 with Action Alternative 1 reaching 895 feet, or dead pool (the elevation at which Lake Mead can no longer regularly release water), in April 2025 before recovering for the next 10 months. Action Alternative 2 falls to dead pool for three months in 2026 and recovers, while the No Action Alternative reaches dead pool in January 2026 and it does not recover for the rest of the period of analysis. The median elevations across the three alternatives do not exhibit such large differences in 2024, and in April 2025 the relative performance between the action alternatives and the No Action Alternative switches, and by 2026 the peak median Lake Mead elevations for the action alternatives is approximately 1,040 feet and the peak for the No Action Alternative is approximately 1,015 feet.

Risks of falling below critical elevations exhibit similar patterns over the period of analysis across all thresholds analyzed: in 2024 the percentages of modeled traces falling below the specific Lake Mead elevation threshold are between 0 and 5 percent higher in the action alternatives compared to the No Action Alternative; in 2025 percentages of traces are generally increasing for the No Action Alternative and decreasing for the action alternatives; and by 2026 the percentages of traces violating a critical threshold under the No Action Alternative are significantly higher than the percentages of both action alternatives. The most important result is that in 2026, 8 percent of traces under the No Action Alternative approached dead pool while only 1 percent did so under the two action alternatives. At dead pool, only flows that reach the reservoir, less any diversions or losses, could be released downstream through the Glen Canyon Dam. Below this elevation water could not be released through the Glen Canyon Dam via gravity.

A comparison of modeled December 31st Lake Mead pool elevations across alternatives shows that in 2024 the action alternatives exhibit slightly lower medians than the No Action Alternative and more variability. In 2025 and 2026, the median elevations of the action alternatives are approximately 20 and 30 feet higher, respectively, than the medians of the No Action Alternative. In 2026, all of the alternatives have similar magnitudes of variability, but the distributions of elevations under the action alternatives are shifted higher. The median pool elevation of the No Action Alternative in 2026 is approximately 1,010 feet and the medians of the action alternatives are approximately 1,040 feet.

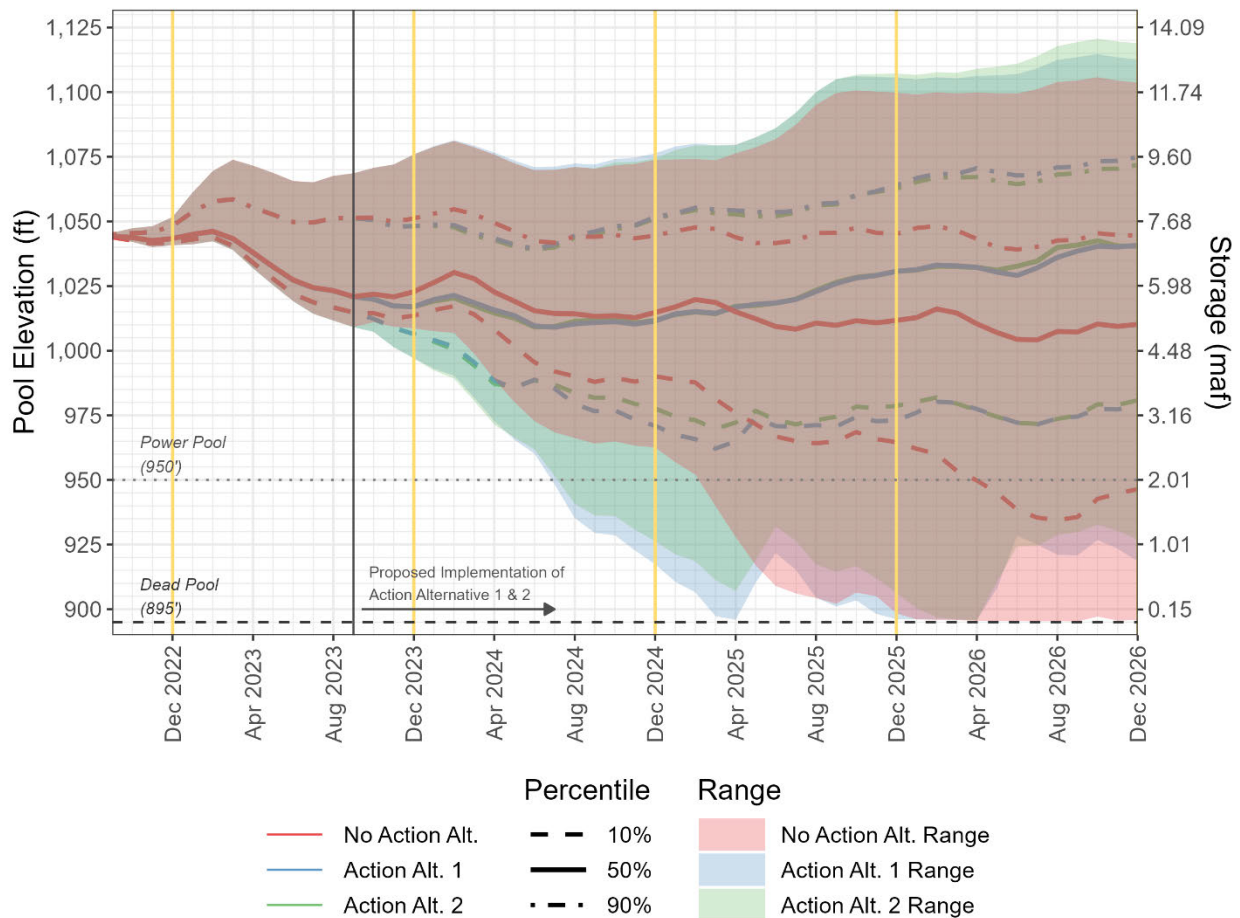
Throughout the period of analysis, the No Action Alternative exhibits generally declining Lake Mead elevations and significant increases in risks of falling below critical elevations.

In 2024, the driest modeled traces result in significant declines in Lake Mead elevations under Action Alternative 1 and Action Alternative 2 as a result of immediate and in some cases significant reductions in releases from Lake Powell. However, in the majority of modeled traces, elevations stabilized and increased in 2025 and 2026. The additional shortage reductions were effective at greatly reducing the risk of reaching the most critical elevations by 2026.

Monthly Pool Elevations

Figure 3-8 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 all three alternatives through 2026.

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



The 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 963 to 1,081 feet in 2024, with fluctuations corresponding to seasonal reservoir levels. The bottom of the No Action Alternative cloud falls to 898 feet in 2025 and it reaches 895 feet, or dead pool, in January 2026 with essentially no recovery. At dead pool, only flows that reach the reservoir, less any diversions or losses, could be released downstream through Glen Canyon Dam. Below this elevation, water could not be released through dam via gravity. The high range of Lake Mead elevations under the No Action Alternative goes from 1,081 feet in 2024 to 1,106 feet in 2026. This increasing range is consistent with increasing uncertainty over time. The clouds for Action Alternative 1 (blue) and Action Alternative 2 (green) are similar throughout the period of analysis, though when differences occur, it is Action Alternative 2 showing slightly higher modeled elevations than Action Alternative 1. This occurs because of the different assumptions for potential DROA contributions modeled under Action Alternative 2, which sometimes result in larger releases to Lake Mead, and the distribution of shortages among Lower Basin users can have minor effects on elevations. The most significant difference between the ranges across all alternatives is that under the driest hydrology, the action alternatives drop more steeply than the No Action Alternative in 2024, with Action Alternative 1 reaching dead pool in

April 2025 (but recovering the next month). The action alternatives decline more steeply because operations explicitly designate annual releases below 6.0 maf from Glen Canyon Dam to protect elevation 3,500 feet at Lake Powell. Both action alternatives eventually reach dead pool, but they recover for some periods while the No Action Alternative does not. The periods of recovery in 2025 and 2026 are in part due to the additional shortage volumes below 1,035 feet that take effect in these years. At the high end of the range of modeled Lake Mead pool elevations, the action alternatives show slightly greater increases than the No Action Alternative through 2026.

In **Figure 3-8**, the median of the modeled Lake Mead elevations for the No Action Alternative ranges between 1,013 feet and 1,030 feet in 2024 and it exhibits a downward trend throughout the period of analysis. The medians of the action alternatives are nearly identical and in 2024 they range from 1,009 feet to 1,020 feet. While this is lower than the range for the No Action Alternative, the median modeled elevations for the action alternatives exhibit an upward trend that begins in late 2024 and continues through 2026 due to the increases in shortages that take effect after 2024. In December 2026, the median elevations under the two action alternatives are at 1,041 feet and the median under the No Action Alternative is at Lake Mead elevation 1,010 feet.

For the 90th percentiles of modeled Lake Mead elevations in **Figure 3-8**, the No Action Alternative and the action alternatives show a similar range in 2024, and the action alternatives trend upward while the No Action Alternative has a slight downward trend. The 10th percentiles of elevations for the two action alternatives are consistently lower than the 10th percentile of the No Action Alternative in 2024, but as with the medians, those relative positions switch in 2025 and the action alternatives stabilize around 975 feet through the remainder of the period of analysis while the No Action Alternative falls to 934 feet in 2026.

Percentages of Traces Below Critical Elevations

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

Figure 3-9 shows that in 2024, 68 percent of the modeled traces under the No Action Alternative fall below Lake Mead elevation 1,020 feet, and slightly more traces do so under the two action alternatives: 71 percent under Action Alternative 1 and 72 percent under Action Alternative 2. (While Action Alternative 2 generally performs slightly better than Action Alternative 1 for reasons described above, very small elevation differences in a single month due to shortage distributions can push traces into or out of the categories in this metric.) Under the No Action Alternative, the percent of traces increases through 2026, at which point 77 percent of traces fall below 1,020 feet. The percentages of traces decline identically through 2026 under both action alternatives: in 2025, 64 percent of traces fall below 1,020 feet and in 2026, 48 percent do so.

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

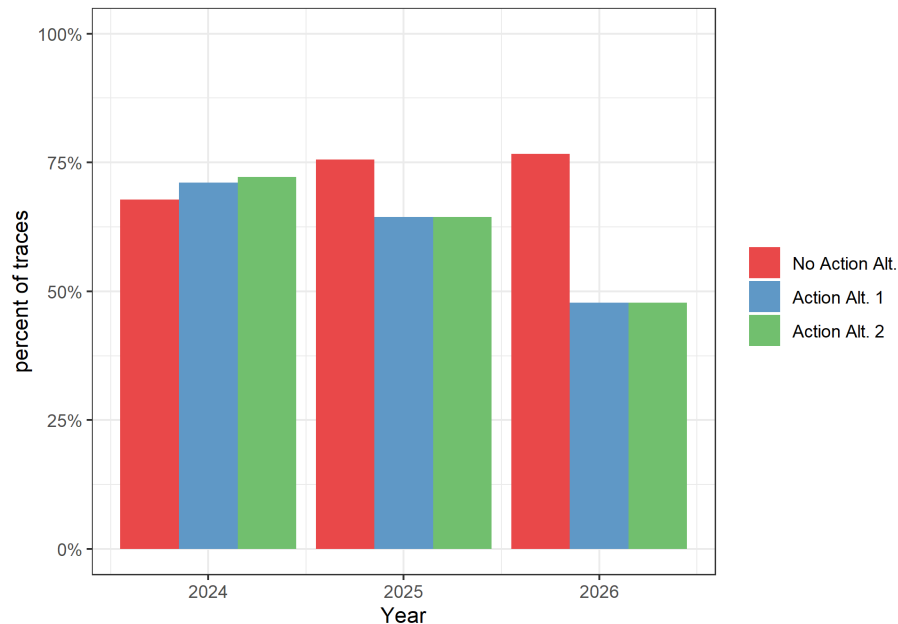


Figure 3-10 shows the percent of modeled traces that fell below Lake Mead elevation 950 feet at any time during a year for the period of analysis. Elevation 950 feet is a critical elevation because it is the lowest elevation at which Hoover Dam can generate hydropower.

As shown in **Figure 3-10**, the No Action Alternative does not result in any traces falling below 950 feet at Lake Mead at any time during 2024, while under Action Alternative 1, 6 percent of traces do and under Action Alternative 2, 3 percent of traces do. In 2025, the alternatives have similar percentages of traces falling below 950 feet – 9 percent for the No Action Alternative and Action Alternative 1 and 8 percent for Action Alternative 2. In 2026, the percentage reaches 14 percent for the No Action Alternative while the Action Alternative 1 and Action Alternative 2 percentages decline to 7 percent and 4 percent, respectively.

Figure 3-11 shows the percent of modeled traces that fell below Lake Mead elevation 900 feet at any time during a year for the period of analysis. Elevation 900 feet is a critical elevation because it is approaching 895 feet, which is dead pool at Lake Mead.

Figure 3-11 shows that in 2024, no traces in any alternatives approach dead pool in Lake Mead. In 2025, 1 percent of traces under the No Action Alternative and 2 percent under Action Alternative 1 approach dead pool. In 2026, 8 percent of traces under the No Action Alternative approach dead pool and 1 percent of traces in both action alternatives do so.

Figure 3-10
Lake Mead Minimum Annual Elevation, Percent of Traces Less than Elevation 950 feet

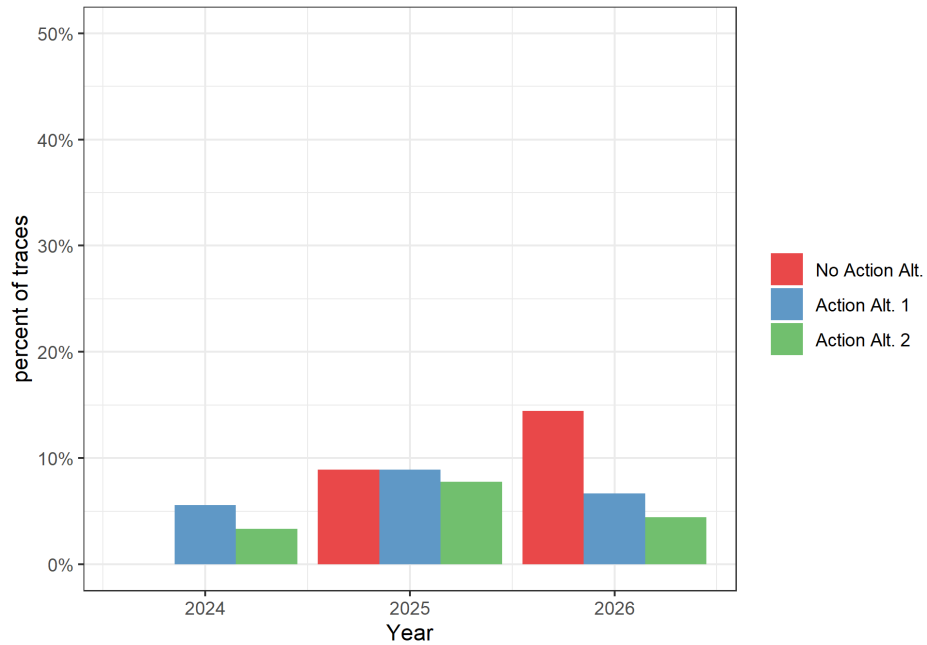
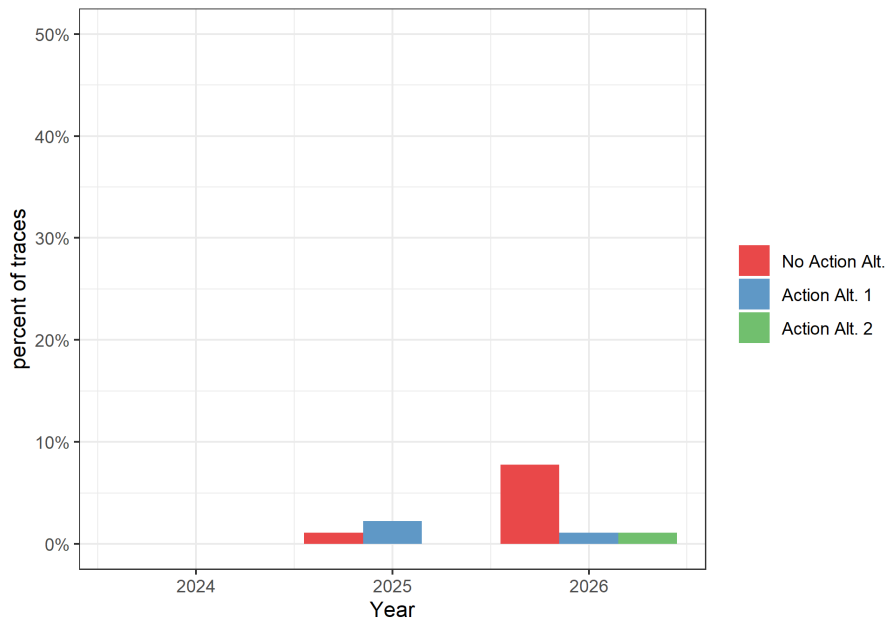


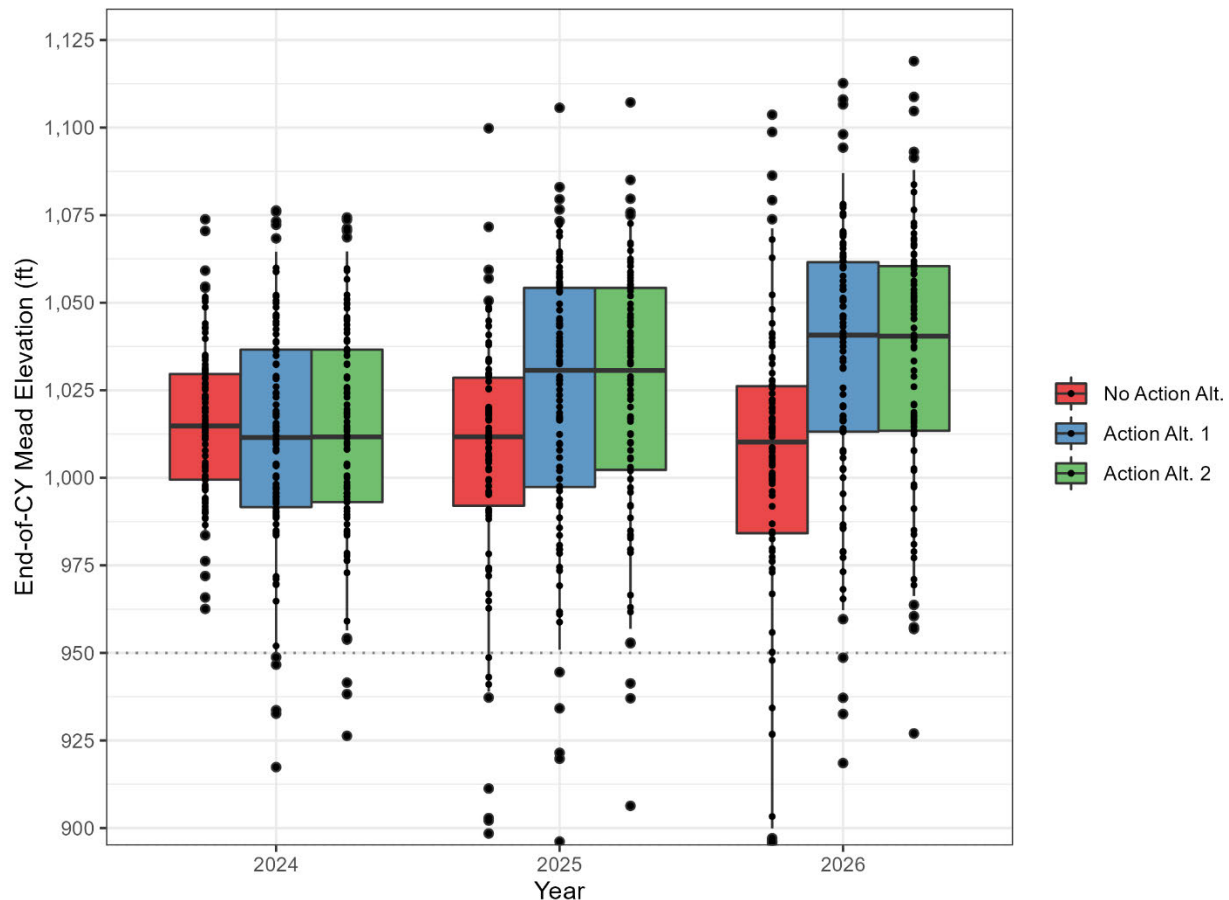
Figure 3-11
Lake Mead Minimum Annual Elevation, Percent of Traces Less than Elevation 900 feet



Annual Pool Elevations

Figure 3-12 shows the distributions of modeled December 31st Lake Mead elevations in 2024, 2025, and 2026. This end-of-calendar-year elevation is used to determine shortage conditions for the following calendar year. Each dot is the end-of-calendar year elevation produced by a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines.

Figure 3-12
Mead End-of-Calendar-Year Elevation



The No Action Alternative boxplots in **Figure 3-12** show how a wide range of modeled end-of-calendar-year Lake Mead elevations are distributed from the minimum at 963 feet to the maximum of 1,074 feet in 2024 and a median of 1,015 feet. The median elevations decline slightly through 2026, as do the interquartile ranges, but the high and especially the low ends of the distributions of traces expand. The increasing frequency of lower extremes occurs because the release capacity of Glen Canyon Dam when Lake Powell is below 3,490 feet becomes constrained. The two action alternatives have similar distributions of modeled Lake Mead elevations from 2024 through 2026, with the slight discrepancies due mostly to the impacts of different modeling assumptions for the potential DROA contributions represented in Action Alternative 2 that can increase Lake Powell's

release volumes. Compared to the 2024 distribution of elevations under the No Action Alternative, the action alternatives produced a wider range, particularly at the low end due to the explicit allowance of Lake Powell releases below 7.0 maf (whether determined by the Lower Elevation Release Tier or as protection of elevation 3,500 feet). The medians of the action alternatives are at approximately 1,011 feet, or 4 feet lower than the median of the No Action Alternative. In 2025 and 2026, the medians of the action alternatives' modeled elevations increase significantly – by over 20 feet in 2025 and an additional 10 feet in 2026 when the medians are approximately 1,040 feet. The ranges of modeled elevations increase slightly in 2025 before contracting and shifting up in 2026.

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 it would apply to operations under any of the action alternatives. Therefore, future Lake Mohave and Lake Havasu elevations would be expected to be similar between the action alternatives and the No Action Alternative.

Cumulative Effects

Implementation of one of the Glen Canyon Dam/Smallmouth Bass flow options would not result in annual or monthly changes to reservoir levels in Lake Powell or Lake Mead. The operating tiers established by this SEIS will inform flow rates and volumes if flow options are implemented.

Therefore, no additive cumulative effects would occur on reservoir levels due to proposed operational changes evaluated in the EA.

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, Action Alternative 1, and Action Alternative 2 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, operating year Glen Canyon Dam Releases, monthly Glen Canyon Dam releases, and the 10-year running sum of Lees Ferry flows. Detailed comparisons of the alternatives follow in subsequent sections.

Throughout the period of analysis, the action alternatives result in more traces shifting into higher operational tiers than the No Action Alternative: in 2026, 21 percent of traces modeled under the No Action Alternative operate in either the Upper Elevation Balancing Tier or Equalization Tier, while approximately 40 percent of traces under the action alternatives operate in these tiers. While this is partially because the action alternatives assume that the 480,000 af stored in Lake Powell instead of Lake Mead since 2022 is no longer operationally neutral, the majority of this difference is the result of increasing elevations at Lake Powell.

The upward shifts in operational tiers are reflected in operating year Glen Canyon Dam releases, which show that the median modeled release volumes under all alternatives are within 500,000 af of each other throughout the period of analysis, ranging between 7.0 and 7.7 maf. The differences between the No Action Alternative and the action alternatives are larger in the bottom half, and especially the bottom 25 percent, of the distributions in 2024 and 2025: under the No Action Alternative, the driest 25 percent of modeled traces result in releases that range from 5.9 to 7.0 maf in 2024 and 5.1 to 7.48 maf in 2025; under the action alternatives, the ranges are similar to each other spanning approximately 3.6 to 6.0 maf in 2024 and approximately 3.0 to 6.2 maf in 2025. (Releases below 6.0 maf are required to protect elevation 3,500 feet.) In 2026, the ranges of modeled operating year releases from Glen Canyon Dam all alternatives are similar, though the inclusion of different assumptions for potential DROA contributions in Action Alternative 2 increases the releases under the driest modeled traces.

The differences between modeled monthly Glen Canyon Dam releases under the No Action Alternative and the action alternatives have two different patterns. In the first half of the operating year, releases under the action alternatives are lower at the medians and have greater low-end variability than the No Action Alternative. During the second half of the operating year, median releases under the action alternatives are higher than median releases under the No Action Alternative and the variability is greater in both the interquartile and full ranges. This is due to how the Lower Elevation Release Tier in the action alternatives is modeled: start in October with a 6.0 maf release pattern and then adjust upward in April if warranted by runoff conditions. Throughout the operating year, approximately 5 to 10 percent of the traces modeled under the two action alternatives fall below the estimated daily minimum flow threshold specified by LTEMP. Under the No Action Alternative, fewer than 5 percent of traces fall below the threshold. However, when Lake Powell is below 3,490 feet, as it is in more than 30 percent of traces every year under the No Action Alternative, monthly and daily releases from Glen Canyon Dam are highly uncertain.

With respect to the modeled 10-year running sums of flows at Lees Ferry gage, the medians under all alternatives decline over the period of analysis. The median flows of the action alternatives are always lower than the medians of the No Action Alternative, with the differences increasing over time. In 2024, the median flow volumes under the No Action Alternative were just under 85 maf and the medians of the action alternatives were approximately 84 maf. In 2026, the median of the No Action Alternative is 82.9 maf, and the medians under the action alternatives are approximately 81.5 maf. Twenty-five percent of modeled 10-year Lees Ferry gage flows are below 82.3 maf under all alternatives in 2026, and under Action Alternative 1 and Action Alternative 2, 10 percent and 5 percent, respectively, are below 75 maf.

Lake Powell Operating Tiers

Figure 3-13 shows the percent of modeled traces that were within each operational tier for the period of analysis. (Note that the Mid-Elevation Release Tier and the Lower Elevation Balancing Tier of the No Action Alternative are encompassed and replaced by one tier in the action alternatives, the new Lower Elevation Release Tier.)

Figure 3-13
Lake Powell - Percent of Modeled Traces within each Operational Tier

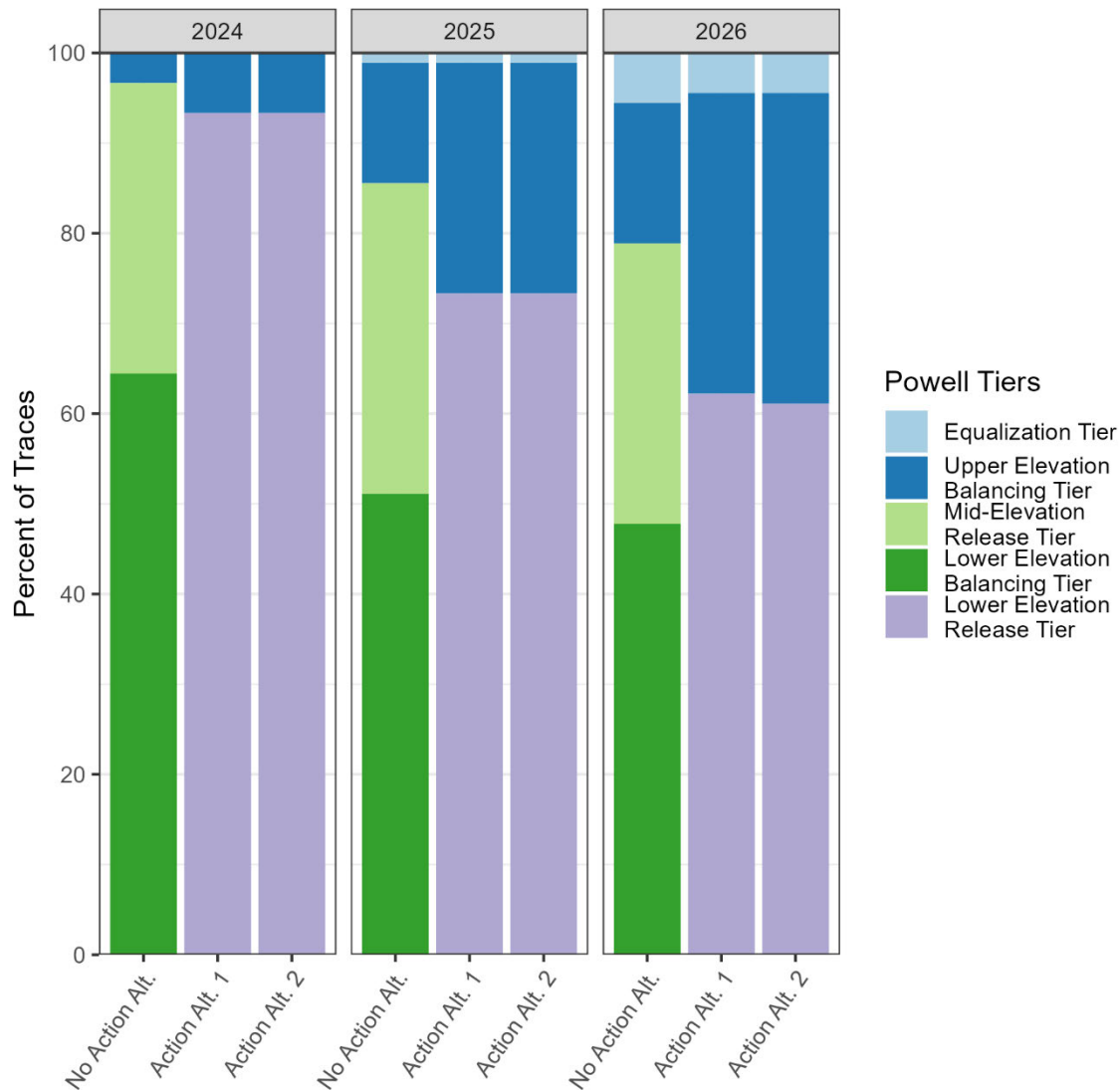
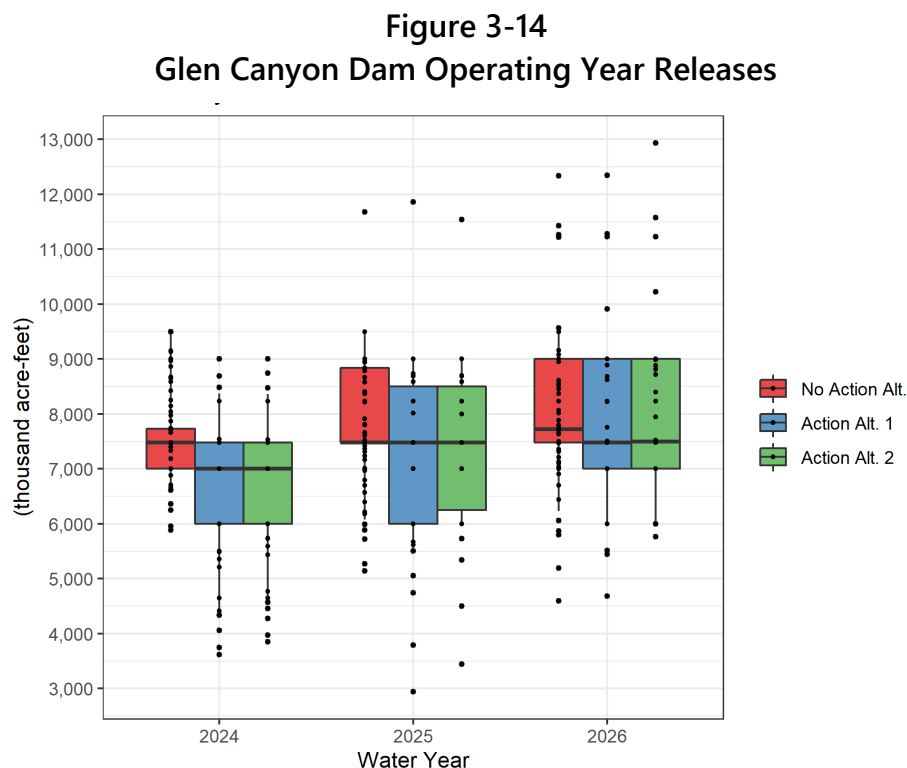


Figure 3-13 shows that in 2024, in the No Action Alternative, 64 percent of modeled traces operated in the Lower Elevation Balancing Tier, in which annual releases range from 7.0 maf to 9.5 maf (unless infrastructure limitations below Lake Powell elevation 3,490 feet reduce the volume that can be released), and the number of traces in this tier decreases to 48 percent through 2026. Approximately 30 percent of traces under the No Action Alternative are in the Mid-Elevation Release Tier in all years, in which the release is either 7.48 or 8.23 maf. The percent of traces in the Upper Elevation Balancing Tier, in which releases range from 7.0 to 9.0 maf, increases from 3 percent in 2024 to 16 percent by 2026. By 2026, 6 percent of traces operate in the Equalization Tier for the No Action Alternative. This shift toward higher tiers is a result of the wide range of hydrology traces used and it is reflected in the elevations seen in **Figure 3-5**.

Figure 3-13 shows that Action Alternative 1 and Action Alternative 2 have identical distributions across tiers until 2026. In 2024, 6 percent of modeled traces are in Upper Elevation Balancing Tier. (The elevations delineating this tier are common among all alternatives, and the reason there are more traces operating in it for the action alternatives is that they eliminate operational neutrality for 480,000 af, meaning that it is included in Lake Powell’s tier determination in the action alternatives while it is treated “as if” it is in Lake Mead for tier determinations in the No Action Alternative.) In 2024, 93 percent of traces for the action alternatives operate in the new Lower Elevation Release Tier, in which annual releases range from 6.0 to 8.23 maf (unless releases are further reduced to protect Lake Powell elevation 3,500 feet), and, similarly to the No Action Alternative, the distribution of modeled traces shifts to higher tiers through the period of analysis. In 2026, Action Alternative 1 has 33 percent of traces in Upper Elevation Balancing Tier and Action Alternative 2 has 34 percent in that tier, and both have 4 percent in the Equalization Tier. The slight difference in the modeled projections of the two action alternatives is due to the different assumptions for potential DROA contributions in Action Alternative 2 that affect some traces. Both action alternatives have approximately twice as many traces as the No Action Alternative in the Upper Elevation Balancing Tier in 2025 and 2026.

Annual Release Volumes

Figure 3-14 shows the distributions of modeled operating year 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. Each dot is the operating year releases produced by a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines.



The boxplots for the No Action Alternative in **Figure 3-14** show that median of modeled release from Glen Canyon Dam was 7.48 maf in 2024 and that 9 percent were lower than 7.0 maf, indicating that infrastructure limitations below Lake Powell elevation 3,490 feet impacted releases in these traces. In 2025 and 2026, median modeled releases from Glen Canyon Dam under the No Action Alternative were 7.48 and approximately 7.70 maf, respectively, and 13 percent and 9 percent of traces released less than 7.0 maf, respectively. Throughout the period of analysis, the minimum releases under the No Action Alternative decrease from approximately 5.9 maf in 2024 to 4.6 maf in 2026.

The distributions of operating year releases for the two action alternatives shown in **Figure 3-14** show nearly identical distributions, with the minor variations due to the different modeling assumptions for potential DROA contributions in Action Alternative 2 that results in higher releases in some traces. In 2024, the medians of the modeled releases for the two action alternatives are 7.0 maf, and 88 percent of releases are 6.0 maf or higher. The remaining 12 percent of modeled releases range from 3.6 to 5.5 maf under Action Alternative 1 and 3.8 to 5.7 maf under Action Alternative 2. Median modeled annual Glen Canyon Dam releases increase to 7.48 maf in 2025 and 2026 under both action alternatives, with increased variability around the median in both interquartile ranges and outliers. Minimum releases are lowest in 2025, when Action Alternative 1 results in a release of 2.9 maf from Glen Canyon Dam and Action Alternative 2 results in a 3.4 maf release to protect 3,500 feet at Lake Powell. The ranges of releases for both action alternatives increase significantly in 2026, when they are similar to the range of annual releases under the No Action Alternative.

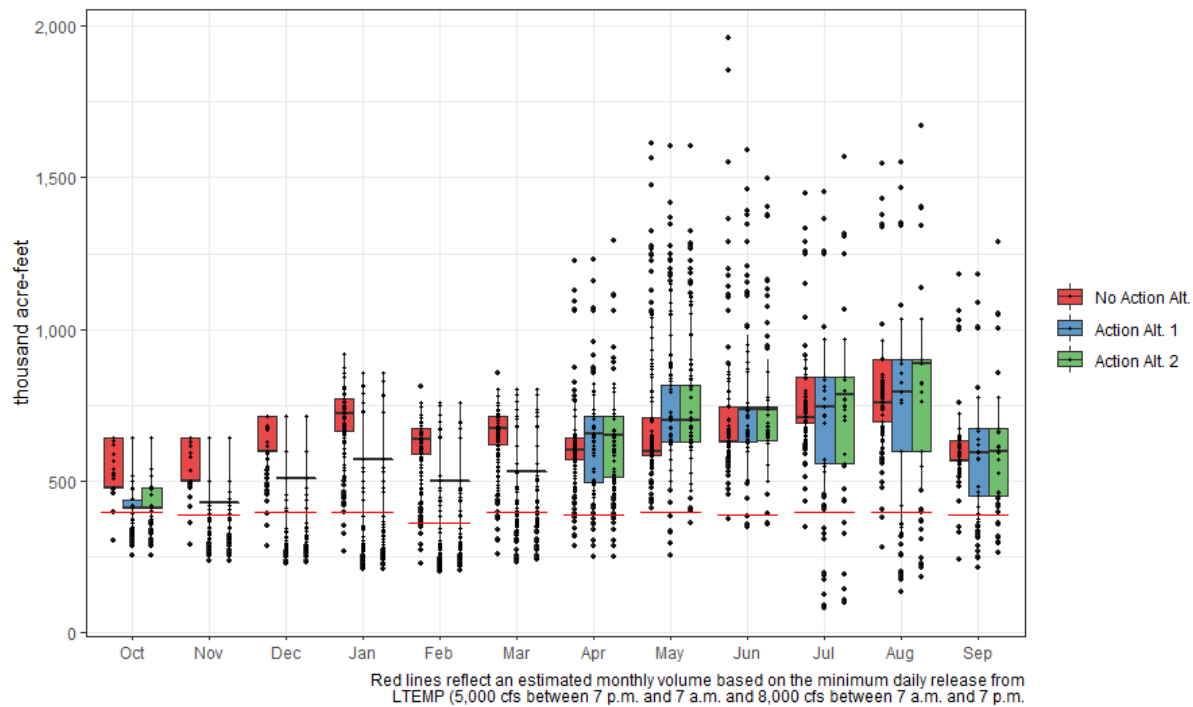
Monthly Release Volumes

Figure 3-15 shows the distributions of modeled monthly release volumes in operating years 2024, 2025, and 2026, oriented to the operating year (October through September) on which Lake Powell operates. 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** for more information about these modeling assumptions.

Each dot in **Figure 3-15** represents the monthly releases produced by a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile 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 LTEMP (5,000 cfs between 7 p.m. and 7 a.m. and 8,000 cfs between 7 a.m. and 7 p.m.).

The boxplots of monthly modeled Glen Canyon Dam release volumes under the action alternatives in **Figure 3-15** demonstrate the impacts of the new Lower Elevation Release Tier. For the first half of the operating year, the action alternatives have lower releases than the No Action Alternative, mostly because 60 to 95 percent of the traces under that action alternatives operate in the new Lower Elevation Release Tier, which is modeled to start the year with a 6.0 maf release pattern with an optional upward April adjustment based on hydrologic conditions. This is also the cause of the wide variability from April to September under the action alternatives.

Figure 3-15
Lake Powell Monthly Release, Operating Years 2024–2026



From April through September, **Figure 3-15** shows that the differences in median modeled monthly releases from Glen Canyon Dam are reversed: medians of the action alternatives are higher than those of the No Action Alternative, though the magnitudes vary across months because of large variability in the releases under the action alternatives. The monthly releases on the lower end of the distributions under the action alternatives tend to be lower or significantly lower than those under the No Action Alternative.

Per **Figure 3-15**, 5 percent or fewer traces modeled under the No Action Alternative exceed the estimated daily minimum flow target in every month. However, when Lake Powell is below 3,490 feet, as it is in more than 30 percent of traces every year under the No Action Alternative, monthly and daily release from Glen Canyon Dam are highly uncertain. Under the two action alternatives, more than 10 percent of traces fall below the target during the first half of the operating year due to the 6.0 maf release pattern. In the second half of the operating year, fewer than 5 percent of traces modeled under Action Alternative 2 fall below the target, and under Action Alternative 1, between 5 and 10 percent of the traces fall below the estimated minimum daily flow target volume.

Ten-Year Lees Ferry Gage Flows

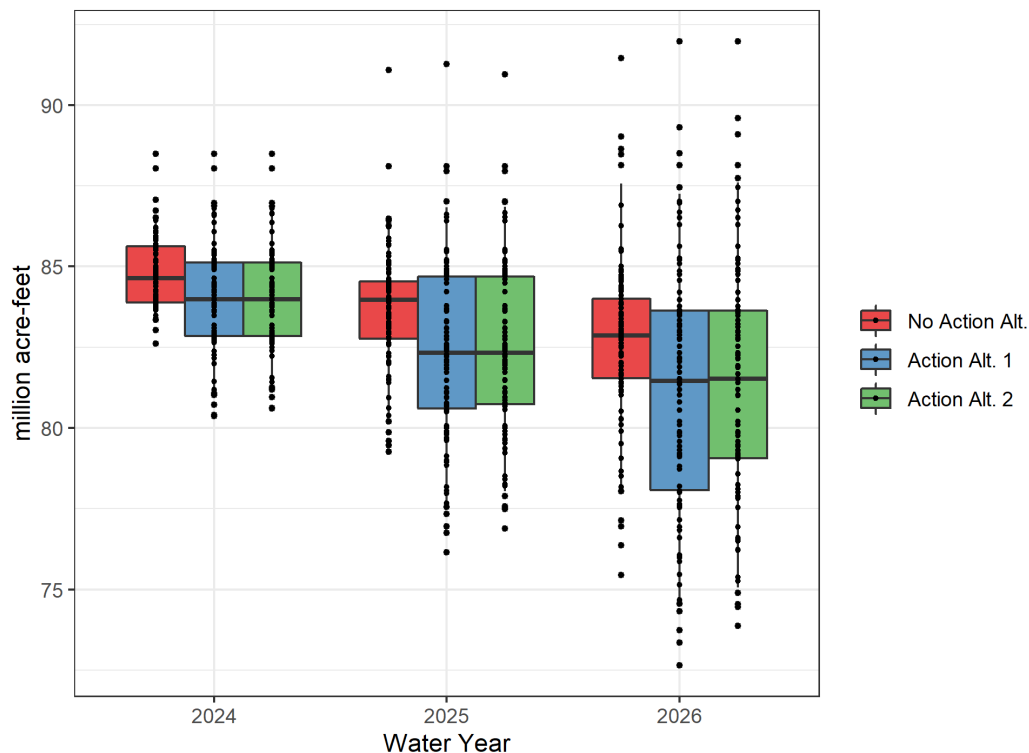
Figure 3-16 shows the distribution of modeled 10-year running sums of Lees Ferry gage flows in 2024, 2025, and 2026. The modeled 2024 flow is calculated using the observed deliveries from 2015 through 2022 and a modeled delivery volume in 2023. There is some variability in the 2023 volume, but it is common to all alternatives so it does not impact relative performance among alternatives.

The modeled 2025 volume drops the 2015 observed volume, and the modeled 2026 volume drops 2015 and 2016.

Each dot is the 10-year volume resulting from a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines.

The distributions of modeled 10-year running sums in **Figure 3-16** show that the median volumes decline over time for all alternatives and the interquartile and full ranges increase, with the ranges of the two action alternatives increasing more and toward the lower end compared to the No Action Alternative. In 2024, the median flow under the No Action Alternative is 84.6 maf and it decreases to 82.9 maf by 2026. In 2026, approximately 25 percent of modeled traces result in a flow volume less than 82.3 maf under the No Action Alternative. The minimum 10-year Lees Ferry flow volume resulting from the No Action Alternative is just above 75 maf in 2026.

Figure 3-16
Lees Ferry Gage 10-Year Running Total



The median modeled 10-year flows under the action alternatives are nearly identical throughout the period of performance, starting at 84 maf in 2024 and declining to 82.3 maf in 2025. In 2026, the medians under the action alternatives are 81.5 maf, meaning that more than half of modeled traces result in delivery volumes lower than 82.3 maf. The minimum delivery volume in 2026 under Action Alternative 1 is slightly above 72.6 maf, and the minimum for Action Alternative 2 is approximately

73.9 maf. The differences in modeled projections in the two action alternatives are greatest at the low end of the distributions in 2026, and they are a result of the different modeling assumptions for potential DROA contributions in Action Alternative 2 that can result in greater Lake Powell elevations and subsequent Glen Canyon Dam releases in some years. In 2026, approximately 10 percent of modeled deliveries under Action Alternative 1 and approximately 5 percent of Action Alternative 2 are below 75 maf.

Hoover Dam

Summary of Alternatives Comparison

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

Under the No Action Alternative, the median modeled release from Hoover Dam is 8.5 maf in 2024, declining only slightly to 8.4 maf in 2026. The ranges around these medians for each year are relatively consistent, except in 2026 when the driest modeled traces result in Lake Mead reaching dead pool and Hoover Dam releases go as low as 5.3 maf.

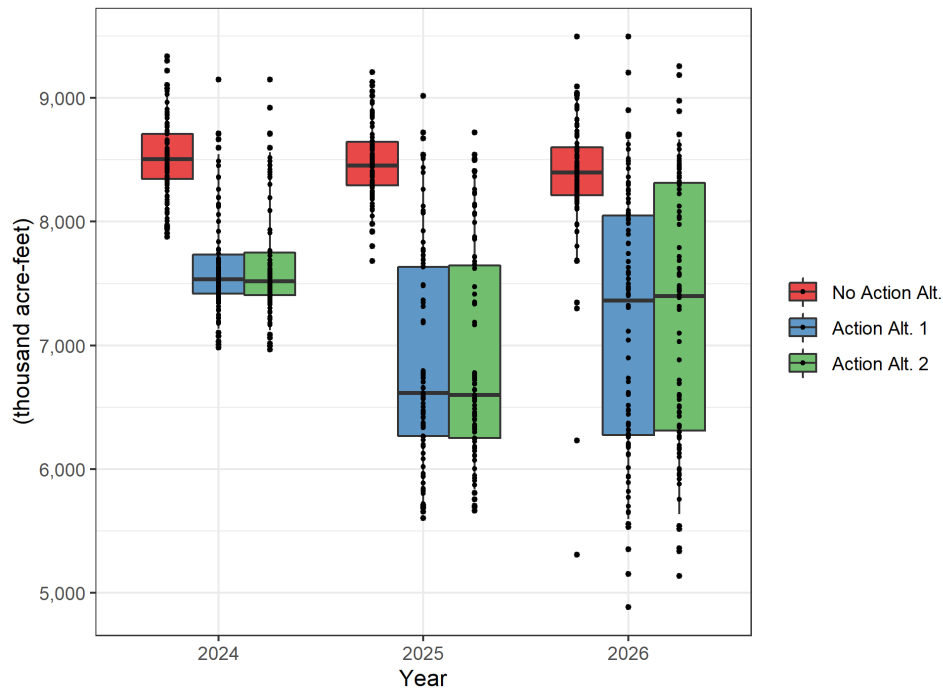
The median modeled annual Hoover Dam releases under the action alternatives are between 1 maf lower (2024) and 1.9 maf lower (2025) than the No Action Alternative. They also exhibit greater variability than the releases under the No Action Alternative: in 2026, the interquartile ranges for the action alternatives are more than 1.5 maf, while the interquartile range under the No Action Alternative is approximately 0.4 maf. The increased additional shortage volumes that are modeled in 2025 result in the lowest median releases of approximately 6.6 maf in 2025, but the shortages are effective at increasing Lake Mead elevations and they result in median modeled releases from Hoover Dam of approximately 7.4 maf in 2026.

Annual Release Volumes

Figure 3-17 shows the distributions of modeled calendar year release volumes from Hoover Dam in 2024, 2025, and 2026. Each dot is the annual volume produced by a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers represented as dots beyond these lines.

Figure 3-17 shows that under the No Action Alternative, the overall distribution of releases declines slightly from 2024 to 2026, where the median releases are 8.5 maf and 8.4 maf, respectively. The variability around the medians remains similar except in 2026, when approximately 5 percent of releases are below 7.5 maf and the minimum release is 5.3 maf. These extreme low releases occur in modeled traces when Lake Mead is at dead pool.

Figure 3-17
Hoover Dam Calendar Year Annual Release



Under the two action alternatives, **Figure 3-17** shows that the medians, ranges, and variability are very similar throughout the period of analysis. In 2024, 2025, and 2026, the medians of modeled Hoover Dam releases are approximately 7.5, 6.6, and 7.4 maf, respectively, and the ranges under both action alternatives more than doubles compared to 2024. The large decline in 2025 medians occurs because of the increases in additional shortage volumes applied below Lake Mead elevation 1,040 feet, and the subsequent increase in median modeled releases in 2026 occurs because the additional shortages act to increase the elevation in Lake Mead in many modeled traces. The minimum modeled release volumes occur in 2026 when Action Alternative 1 releases slightly less than 5 maf and Action Alternative 2 releases slightly more than 5 maf. The differences across the modeled projections of the two action alternatives are caused by their different assumptions about the distribution of additional shortage reductions and the different modeling assumptions for potential DROA contributions.

Davis Dam

Summary

The conclusions in this section are drawn from analyses of calendar 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 are relatively consistent, with slight declines in the medians from 8.2 maf in 2024 to 8.1 maf in 2026. The variability around these medians is also consistent, except in 2026 when releases from Hoover Dam are limited in traces where Lake Mead reaches dead pool. The median annual releases from Davis Dam under the

two action alternatives are lower and the ranges much wider than under the No Action Alternative. In 2024, 2025, and 2026, the medians are approximately 7.2, 6.3, and 7.0 maf, respectively. Increased additional shortage reduction volumes that are modeled in 2025 lead to increased 2026 elevations in Lake Mead and, therefore, increased releases from Hoover Dam relative to 2025.

Annual Release Volumes

Figure 3-18 shows the distributions of modeled calendar year release volumes from Davis Dam in 2024, 2025, and 2026. Each dot is the volume produced by a single hydrologic trace, and dots may be plotted on top of one another. The boxes capture the 25th to 75th percentile of the modeled elevations and the whiskers extend to the 5th and 95th percentiles, with outliers represented as dots beyond these lines.

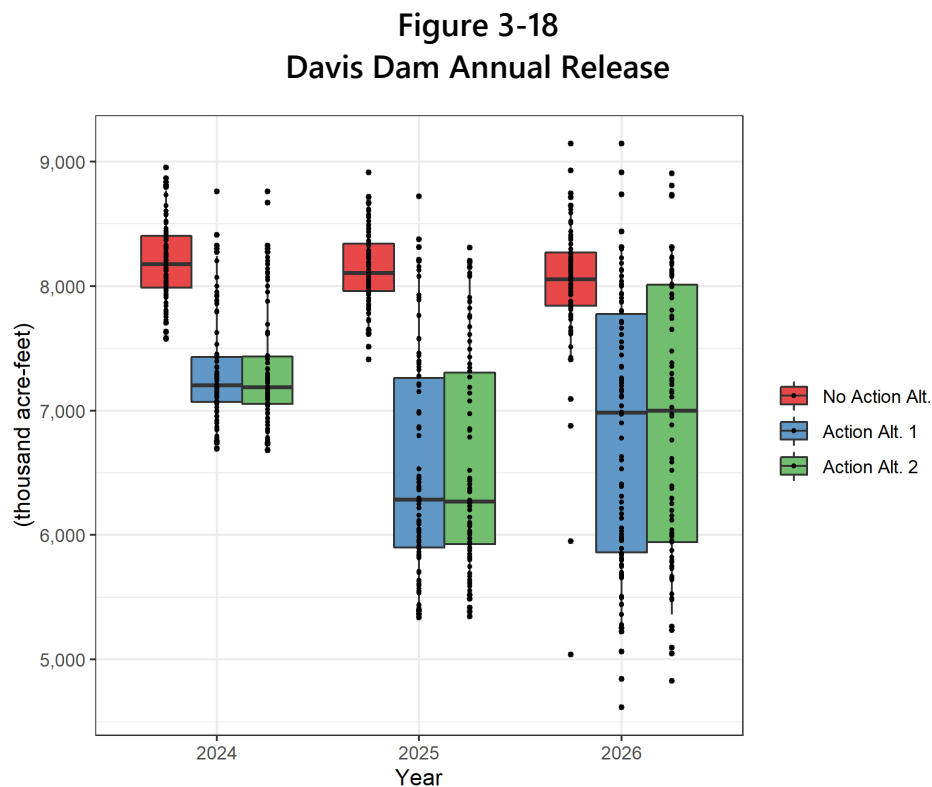


Figure 3-18 shows that, under all alternatives, the distributions of modeled annual releases from Davis Dam follow the same pattern as the releases from Hoover Dam because Hoover Dam releases are impounded in Lake Mohave and released from Davis Dam to generate hydropower. The median releases under the No Action Alternative are 8.2, 8.1, and 8.05 maf in 2024, 2025, and 2026, respectively, and the ranges stay relatively consistent except in 2026, when the driest modeled traces result in limited releases from Hoover Dam because Lake Mead has reached dead pool. The median releases from Davis Dam under the two action alternatives are approximately 7.2, 6.3, and 7.0 maf in 2024, 2025, and 2026, respectively. The ranges in 2025 and 2026 under the action alternatives are more than twice as wide as the ranges under the No Action Alternative. The minor differences in the modeled projections of the two action alternatives are caused by their different assumptions

about the distribution of additional shortage reductions and the different modeling assumptions for potential DROA contributions.

Parker Dam

Summary

The conclusions in this section are drawn from analyses of calendar 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 6.3 maf. There are also only minimal variations in the range of releases under the No Action Alternative, with the exception of 2026 when four of the modeled traces result in limited releases from Hoover Dam because Lake Mead is at dead pool. In 2026, the minimum Parker Dam release under the No Action Alternative is 3.3 maf.

The medians and ranges of modeled annual releases from Parker Dam are lower under the action alternatives compared to the No Action Alternative, but unlike in analyses of effects upstream, the different assumptions about the distribution of additional shortage reductions cause significant variation between the two alternatives. The median annual releases under Action Alternative 2 are 500,000 to 700,000 af lower than those of Action Alternative 1 every year, and ranges for both action alternatives are commensurate with the differences in medians. The minimum releases in 2026 (also the minimums for entire period of analysis) deviate from this, as under both action alternatives, the minimum modeled annual releases from Parker Dam are approximately 4.2 maf.

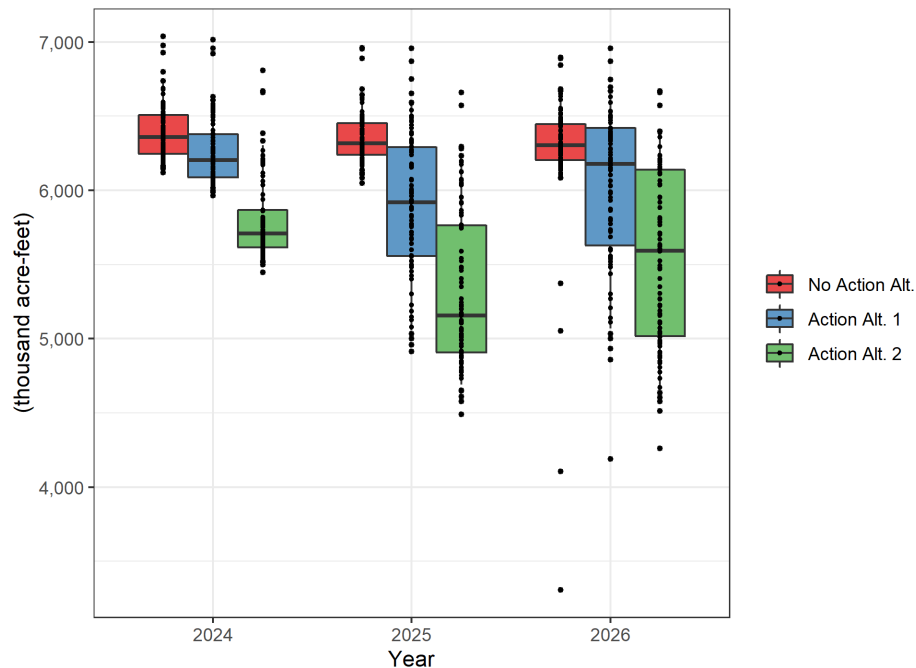
Annual Release Volumes

Figure 3-19 shows the distributions of modeled calendar year release volumes from Parker Dam in 2024, 2025, and 2026. Each dot is the volume produced by a single hydrologic trace, and dots may be plotted on top of one another. The boxes capture the 25th to 75th percentile of the modeled elevations and the whiskers extend to the 5th and 95th percentiles, with outliers represented as dots beyond these lines.

Figure 3-19 shows that under the No Action Alternative, modeled annual releases from Parker Dam do not vary significantly across years in either the medians, which are all approximately 6.3 maf or the ranges. The exceptions to these observations occur in 2026, when the modeled releases are as low as 3.3 maf because Lake Mead is at dead pool and releases from Hoover Dam are limited.

The medians and ranges of modeled annual releases from Parker Dam are lower under the two action alternatives, but unlike in analyses of upstream releases, the different assumptions about the distribution of additional shortage reductions cause significant differences. In 2024, 2025, and 2026, the median releases under Action Alternative 1 are 6.2, 5.9, and 6.2 maf, respectively. The median annual releases from Parker Dam under Action Alternative 2 are 500,000 to 700,000 af lower each year, at 5.7, 5.2, and 5.6 maf, respectively. The ranges for each year under each action alternative vary similarly to the medians, except for the 2026 minimum releases of approximately 4.2 maf for both alternatives (which are also the minimums for the period of analysis).

Figure 3-19
Parker Dam Annual Release



Cumulative Effects

Implementation of one of the Glen Canyon Dam/Smallmouth Bass flow options would not result in changes to annual reservoir releases from Glen Canyon Dam (Lake Powell) or Hoover Dam (Lake Mead). The operating tiers and corresponding volumes of annual Glen Canyon Dam releases established by this SEIS would determine sub-annual timing of Glen Canyon Dam releases (hourly, daily, monthly, and experimental), including potential flows associated with the flow options. Therefore, no additive cumulative effects would occur to reservoir releases due to proposed operational changes evaluated in the EA.

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

This section presents a comparison of river flows under the No Action Alternative, Action Alternative 1, and Action Alternative 2 in various metrics, including annual, monthly, and daily release volumes. Because in most cases the river flows in each reach are mainly made up of upstream reservoir releases, most discussion below will refer to figures in *Issue 2*.

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 very short periods of time, and they would not be affected by the proposed alternatives. However, future annual and the monthly distribution of releases from Glen Canyon Dam may be affected by the proposed alternatives (see *Issue 2*).

With respect to annual flows, **Figure 3-14** shows modeled distributions of operating year releases from Glen Canyon Dam for the period of analysis. In general, both action alternatives result in nearly identical distributions of releases and they have slightly lower median release volumes than the No Action Alternative, but the releases resulting from dryer traces can be significantly lower. (See *Issue 2* for additional discussion.)

Distributions of modeled monthly flows between Glen Canyon Dam and Lake Mead for all alternatives are presented in **Figure 3-15**. Compared to the No Action Alternative, the two action alternatives have lower releases in October through March, with less variability, and higher and more variable releases compared to the No Action Alternative in April through September. This is a function of operations in the new Lower Elevation Release Tier, which is modeled to begin the operating year with a 6.0 maf release pattern with an optional upward April adjustment. (See *Issue 2* for additional discussion.)

Daily flows were not estimated for this SEIS. However, a table of estimates can be found in Section 4.3.3.1 of the 2007 FEIS. **Figure 3-15** shows how monthly releases from Glen Canyon Dam compare to an estimate of how daily minimum flows specified by LTEMP would sum to a monthly volume. With respect to beach habitat-building flows in the Grand Canyon, monthly flows are likely to have more effects on sediment. **Section 3.8** of this SEIS addresses the effects of high-flow experiments (HFEs) and monthly volume releases in the Grand Canyon. The timing of releases is also 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 proposed alternatives. However, due to the presence of Lake Mohave immediately downstream, 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 3-17**. In general, the action alternatives result in nearly identical distributions of releases, and their median annual releases from Hoover Dam are significantly lower than releases under the No Action Alternative. The action alternatives also exhibit significantly more variability than the No Action Alternative. The minimum annual releases under all alternatives occur in 2026, and they are 5.3, 4.9, and 5.1 maf for the No Action Alternative, Action Alternative 1, and Action Alternative 2, respectively. (See *Issue 2* for additional discussion.) With lower modeled annual releases from Hoover Dam in the action alternatives compared to 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 3-18**. In general, the action alternatives result in nearly identical distributions of releases and their median annual releases from Davis Dam are significantly lower than releases under the No Action Alternative. The action alternatives also exhibit significantly more variability than the No Action Alternative. The minimum annual releases under all alternatives occur in 2026, and they are 5.0, 4.6, and 4.8 maf for the No Action Alternative, Action Alternative 1, and Action Alternative 2, respectively. (See *Issue 2* for additional discussion.) With lower annual releases from Davis Dam in the action alternatives compared to 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 of the 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 this reach are essentially the releases from Parker Dam. **Figure 3-19** shows the distributions of modeled annual releases from Parker Dam for all alternatives. In general, the action alternatives result in lower median annual releases than the No Action Alternative and also significantly wider ranges in 2025 and 2026. The medians and ranges of the two action alternatives are significantly different from each other due to different assumptions about the distribution of additional shortage reductions, with modeled annual releases from Parker Dam under Action Alternative 2 being lower than those under Action Alternative 1. The minimum annual releases under all alternatives occur in 2026, and they are 3.3, 4.2, and 4.25 maf for the No Action Alternative, Action Alternative 1, and Action Alternative 2, respectively. (See *Issue 2* for additional discussion.)

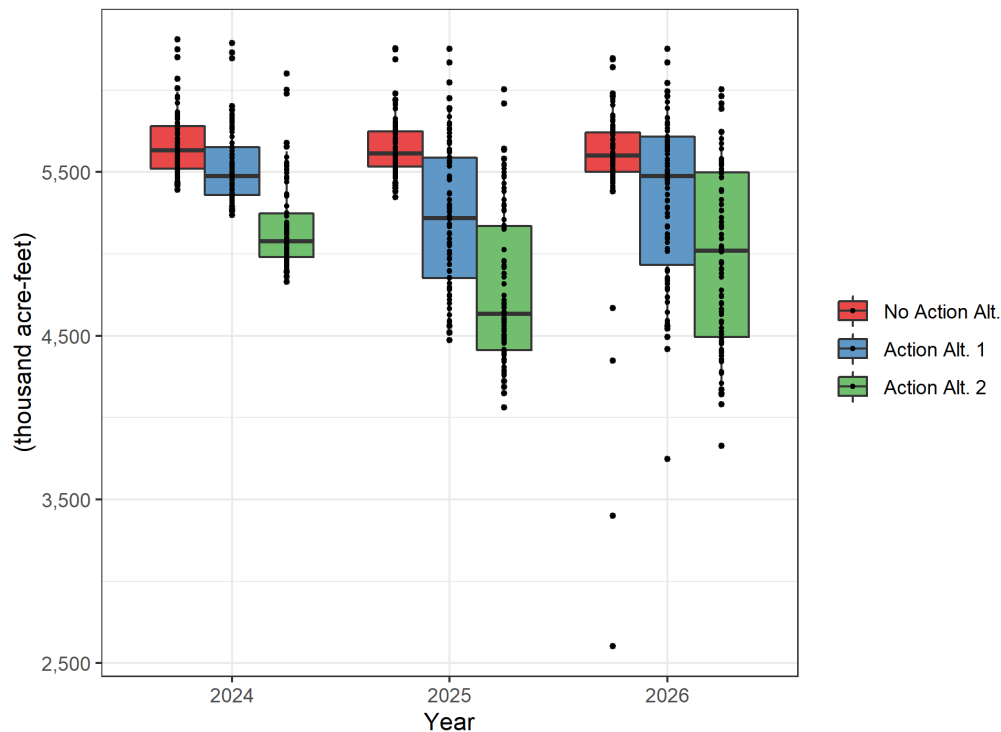
Two other points on the Colorado River are used to analyze flows in the reach between Parker Dam and Imperial Dam: flows near the Colorado River Indian Reservation (CRIR) and flows downstream of the Palo Verde Diversion Dam. The CRIR diversion is located at Headgate Rock Dam, approximately 14 miles downstream 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 that was 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 3-20 shows the distributions of modeled calendar year release volumes downstream of the Palo Verde Diversion Dam in 2024, 2025, and 2026. Each dot is the volume produced by a single hydrologic trace, and dots may be plotted on top of one another. The boxes capture the 25th to 75th percentile of the modeled elevations and the whiskers extend to the 5th and 95th percentiles, with outliers represented as dots beyond these lines.

In **Figure 3-20**, 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 3-19**: medians and variability in the No Action Alternative remain stable throughout the period of analysis, Action Alternative 1 has lower median flows and wider ranges than the No Action Alternative, and Action Alternative 2 has lower median flows than Action Alternative 1 due to different assumptions about the distribution of additional shortage reductions. As was discussed in previous analyses, the No Action Alternative has traces that modeled flow volumes far below the rest of the distribution because of the limitations in Hoover Dam releases when Lake Mead is at dead pool. The minimum annual flows under all alternatives occur in 2026, and they are 2.6, 3.75, and 3.8 maf for the No Action Alternative, Action Alternative 1, and Action Alternative 2, respectively.

Figure 3-20
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 of the 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 alternatives will not alter operation of these diversions and wasteways and, therefore, will not have an effect on this river reach.

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. Therefore, neither the No Action Alternative nor either action alternative projects any flood control releases from 2023–2026. Additionally, deliveries to Mexico are outside the scope of this SEIS and, therefore, further analysis is not required.

Cumulative Effects

Implementation of one of the Glen Canyon Dam/Smallmouth Bass flow options EA would not result in changes to reservoir releases from Glen Canyon Dam (Lake Powell) or Hoover Dam (Lake Mead). The operating tiers established by this SEIS would inform the Glen Canyon Dam flow rates and volumes. Therefore, no additive cumulative effects would occur on flow rates within the various reaches of the Colorado River due to proposed operational changes evaluated in the EA.

Issue 4: How would operational activities affect groundwater?

Based on the modeling assumptions discussed previously, and considering the proposed alternatives, this section presents resulting differences associated with groundwater within specific reaches along the Colorado River for the No Action Alternative, Action Alternative 1, and Action Alternative 2. This qualitative analysis is informed by the assumptions, analyses, and findings of the 2007 FEIS. Further declines to groundwater levels as a result of potential reduced flows are assumed by Reclamation to be similar to those declines calculated 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*, the No Action Alternative results in a lower monthly median reservoir elevation at Lake Powell and a larger number of model traces falling below critical elevations as compared to Action Alternative 1 and Action Alternative 2. Decreases in groundwater elevation adjacent to Lake Powell are anticipated to be larger under the No Action Alternative, as compared with the action alternatives.

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, there are assumed by Reclamation to be no differences between the No Action Alternative, Action Alternative 1, and Action Alternative 2. The alternatives are 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 declining median elevations through the analysis period and a large number of model traces falling below critical elevations as compared to Action Alternative 1 and Action Alternative 2, which generally decline through 2024 and then begin to recover in 2025 and 2026. Groundwater elevations adjacent to Lake Mead may fluctuate throughout the analysis period. At the end of 2026, decreases in groundwater elevation adjacent to Lake Mead are anticipated to be larger under the No Action Alternative, as compared with the action alternatives.

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 that is dominated by Lake Mohave. There are assumed by Reclamation to be 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 proposed alternatives. As discussed in *Issue 3*, river flows could decrease. Decreasing river flows and shallower river stages in this reach have historically resulted in decreased groundwater elevations. Decreases in the groundwater elevation in the upper portion of this reach are anticipated to be larger under the Action Alternatives 1 and 2, as compared with the No Action Alternative. This is because the Action Alternative 1 and Action Alternative 2 experiences lower flow rates through this portion of the Colorado River due to the shortage allocations.

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 proposed alternatives. As discussed in *Issue 3*, river flows could decrease. Decreasing river flows and shallower river stages in this reach have historically resulted in decreased groundwater elevations. Decreases in the groundwater elevation are anticipated to be larger under Action Alternative 1 and Action Alternative 2, as compared with the No Action Alternative. This is because Action Alternative 1 and Action Alternative 2 experience lower flow rates through this portion of the Colorado River due to the shortage allocations.

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 it is diverted to the All-American Canal. There are assumed by Reclamation to be 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 Action Alternative 1 and Action Alternative 2 alter the flow in the Lower Basin reaches differently than the No Action Alternative, impacts on groundwater levels are not anticipated within this reach across all alternatives.

Cumulative Effects

Implementation of one of the Glen Canyon Dam/Smallmouth Bass flow options would not result in changes to reservoir releases from Glen Canyon Dam (Lake Powell) or Hoover Dam (Lake Mead). The operating tiers established by this SEIS will inform the upcoming Glen Canyon Dam EA flow rates and volumes. Therefore, no additive cumulative effects would occur on groundwater levels within the various reaches of the Colorado River due to proposed operational changes evaluated in the EA.

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 issuance of the 2007 FEIS, deliveries to the Lower Basin states have been adjusted to meet the 2007 Interim Guidelines under certain conditions (Shortage Condition Years) and the Lower Basin DCP (Reclamation 2019b). The Upper Basin DCP also has been implemented since issuance of the 2007 FEIS with the goal of moving water within the Upper Basin to keep the pool elevation in Lake Powell above critical levels. 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 Basin and Lower Basin, 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 allow for the reduction 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. Further details on the Upper Division States' apportionments and depletion schedules can be found in the 2007 FEIS. The state's apportionments are listed in **Table 3-4**. The 2007 Interim Guidelines do not affect the apportionments of the Upper Division States.

Table 3-4
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 the apportionments of water to the Lower Division States. Details on these states' apportionments can be found in the 2007 FEIS. The states' apportionments are listed in **Table 3-5**.

Table 3-5
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 the apportionments of water to the Lower Division States. Therefore, further discussion of these schedules is not warranted; additional detail can be found in the 2007 FEIS.

Water Delivery Entitlements to Entities in the Lower Division States

As stated in the 2007 FEIS, the Lower Basin states' apportioned water is further allocated through entitlements, in accordance with the BCPA and Consolidated Decree.⁸ Approximately 10,000 af of Arizona's lower Colorado River water apportionment has not been allocated. The 2007 Interim Guidelines do not affect the entitlements in the Lower Division States; additional details on these entitlements can be found in the 2007 FEIS.

Additionally, the 2007 Interim Guidelines created ICS. This allows Lower Basin contractors to store unused portions of their entitlements in Lake Mead. Special conservation programs must be used to allocate water through this storage credit. ICS creation and deliveries are subject to constraints as defined in the 2007 ROD and 2019 DCPs (specifically Exhibit 1).

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 elevations of Lake Powell and Lake Mead. 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.C.1 of the 2007 Interim Guidelines. Similarly, Reclamation has set the condition governing operation of Lake Mead for each calendar year consistent with Section 2.D.1 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. The water supply condition for each year since 2008 has been normal/ICS surplus in accordance with the 2007 Interim Guidelines, with the exception of 2022 and 2023. Inflow projections and reservoir elevations led to a water supply determination for 2022 as a Shortage Condition Year, and water deliveries to the Lower Basin states were reduced to 7.167 maf. The water supply determination for 2023 was a Shortage Condition Year, and water deliveries will be limited to 7.083 maf and further adjusted for required DCP contributions.

⁸ 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).

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 impacted.

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. The proposed updates being considered (Action Alternative 1 and Action Alternative 2), 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 2021 is shown in **Table 3-6**. 2008 was selected since that is when the 2007 Interim Guidelines were implemented. At the time of this report, data was not available after 2021. Total annual diversions to the Lower Basin have declined on average from 2008 to 2020.

Table 3-6
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
2021	2,425,736	4,404,727	242,168	7,072,631

Source: Reclamation 2022d

Projected depletion schedules have been modified since the 2007 FEIS. **Appendix C**, CRMMS Model Documentation, outlines the current depletion schedules used in normal and surplus⁹ 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

The specifics of the allotment 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 calendar year has been set in accordance with the 1944 Water Treaty and IBWC 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 at a later 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 issuance of the 2007 FEIS.

In the 2007 FEIS, the maximum volume of domestic shortages analyzed were 2.083 maf. As such, the total shortages in 2024, as modeled in this SEIS, are limited to 2.083 maf, 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. While shortages greater than 2.083 maf are modeled in 2025 and 2026 as part of this SEIS, analyzing 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 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, 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 3-7** below presents this breakdown.

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

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

Table 3-7
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 distributed through entitlements. A priority system was established for the delivery of mainstream Colorado River water. The following table (**Table 3-8**) from the 2007 FEIS outlines Arizona's priority system.

As outlined 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 3-8
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

Priority	Rights to Be Satisfied
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 3-9** below from the 2007 FEIS outlines the priority system.

Table 3-9
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) Imperial Irrigation District (IID) and Coachella Valley Water District (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 Coachella Valley Water District (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.

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.

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 3-10**, updated from the 2007 FEIS, outlines the priority system.

Table 3-10
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

3.7.2 Environmental Consequences

Methodology

This section compares water deliveries from the Colorado River mainstream under the No Action Alternative (baseline condition) and the action alternatives. 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 3.3.8** and **Appendix C**, CRMMS Model Documentation.

Additionally, as described in **Section 3.3**, Shortage Allocation Models were used in addition to CRMMS to analyze the potential impacts of each alternative on individual water users within each Lower Division State. The Shortage Allocation Models were used to estimate delivery of water to Colorado River water users within the Lower Division States under varying levels of shortage for each alternative. Modeling assumptions for the Shortage Allocation Models are summarized in **Section 3.3.8** and detailed in **Appendix D**, Shortage Allocation Model Documentation, 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 3.3.8**, **Appendix C**, and **Appendix D** 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 being used:

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

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

The proposed alternatives will 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 proposed alternatives will 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?

Summary of Alternatives

As discussed in **Chapter 2** and **Appendix C**, CRMMS Model Documentation, shortage and DCP contribution determinations for all alternatives were determined in response to Lake Mead elevations, outlined in **Table 3-11**, **Table 3-12**, and **Table 3-13**. As shown in **Figure 3-21**, all modeled traces, apart from one trace of the wettest hydrology scenario in 2026, experience December Lake Mead starting elevations below the threshold for shortages or DCP contributions (1,090 feet).

Table 3-11
Lower Division States' Shortages and DCP Contributions, No Action Alternative*
(Volumes in 1,000 af)

Lake Mead Elevation (feet)	No Action Alternative		
	2007 ROD Shortage	2019 DCP Contributions	Total Shortages and Contributions
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	1017
< 1,025 – 1,000	500	600	1100
< 1,000 – 975	500	600	1100
< 975 – 950	500	600	1100
< 950	500	600	1100

* 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.

Table 3-12
Lower Division States' Shortages and DCP Contributions, Action Alternatives 1 and 2
(2024)*
(Volumes in 1,000 af)

Lake Mead Elevation (feet)	No Action Alternative			Action Alternatives 1 and 2 (2024)	
	2007 ROD Shortage	2019 DCP Contributions	No Action Total	2024 Additional Shortage	2024 Total Shortages + Contributions
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	1100	983	2083
< 950	500	600	1100	983	2083

* 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.

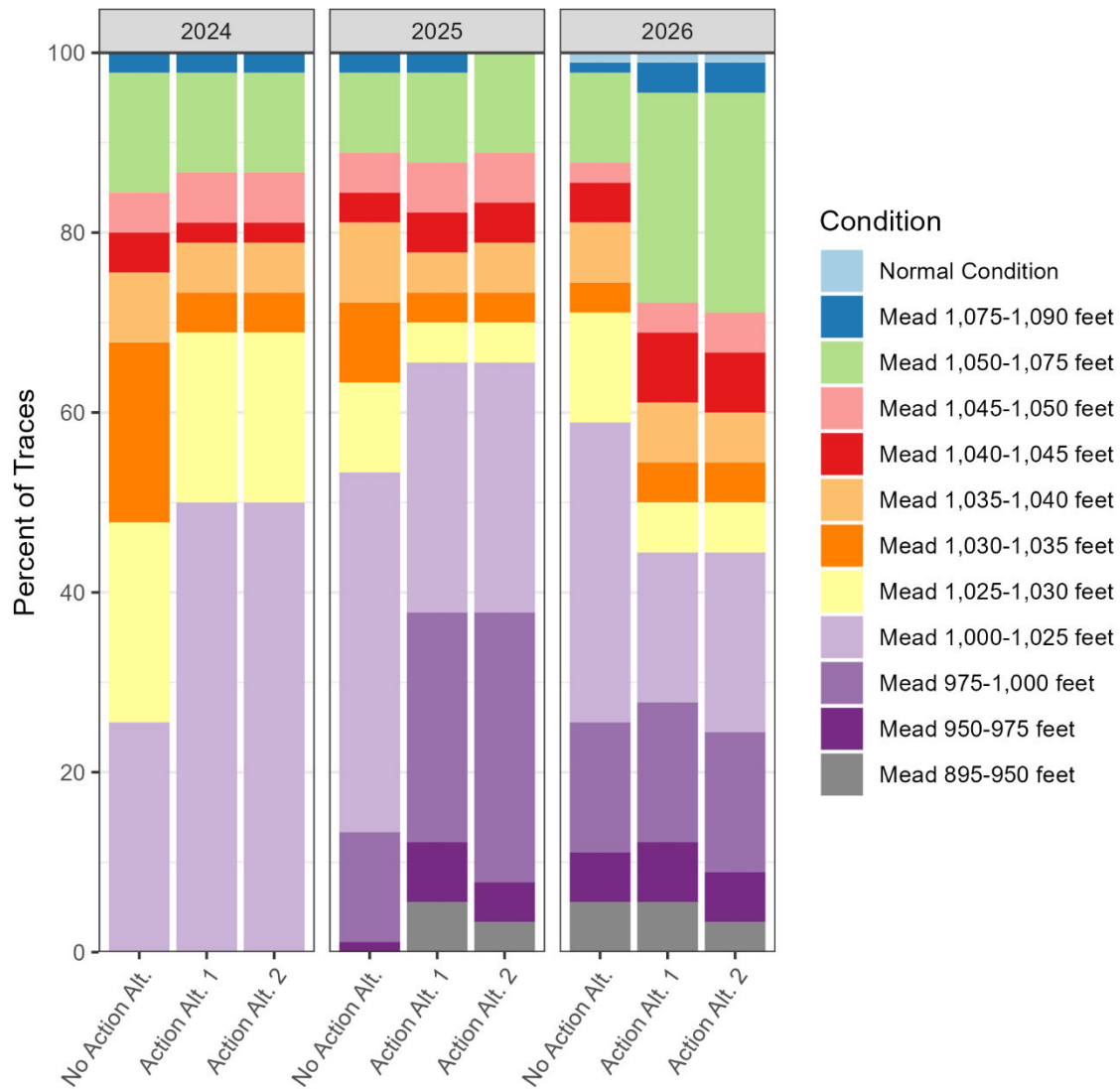
Table 3-13
Lower Division States' Shortages and DCP Contributions, Action Alternatives 1 and 2
(2025-2026)* (Volumes in 1,000 af)

Lake Mead Elevation (feet)	No Action Alternative			Additional Shortages under Action Alternatives 1 and 2 (2025- 2026)	
	2007 ROD Shortage	2019 DCP Contributions	No Action Total	2025-2026 Additional Shortage**	2025-2026 Total Shortages + Contributions
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 BWSCP 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 3-21
Percent of Traces with Lower Division Shortage and DCP Tiers*

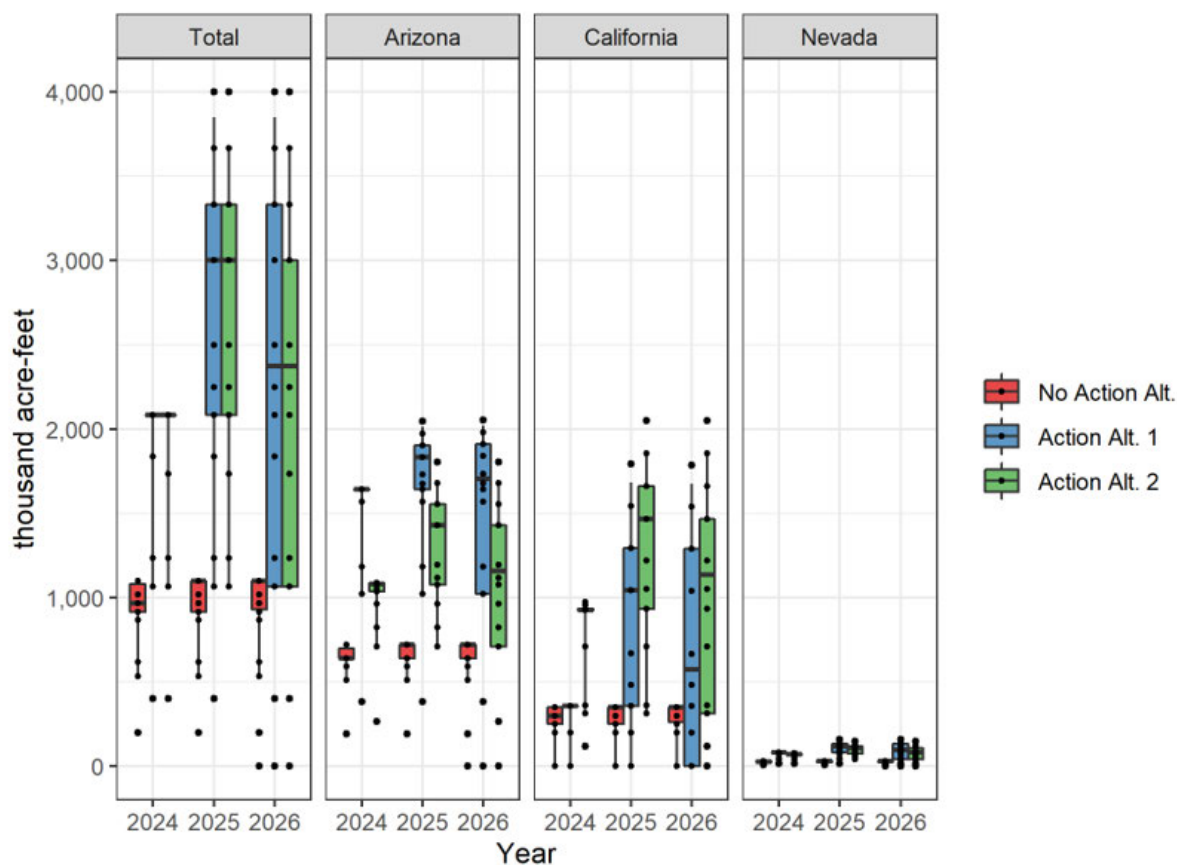


*Tiers for the No Action Alternative are based on effective pool elevation, while elevations for the action alternatives are based on physical elevation because the action alternatives model removing operational neutrality.

Under the No Action Alternative, combined shortages and DCP contributions for the Lower Division States are less than the action alternatives (the action alternatives increase shortages when Lake Mead is below elevation 1,090 feet), as shown in **Figure 3-22**. Total shortages and DCP contributions tend to increase over time under the No Action Alternative as reservoir elevations decrease; however, both action alternatives show total shortage and DCP contributions increasing through 2025 and then decreasing in 2026. This is because the larger modeled shortage volumes in 2025 and 2026 start to stabilize and increase Lake Mead elevations by 2026.

Figure 3-22 shows the distributions of Lower Division Shortages and DCP contributions for each state in 2024, 2025, and 2026. Each dot is the shortage volume produced by a single hydrologic trace, and dots may be plotted on top of one another. The boxes capture the 25th to 75th percentile of the modeled elevations and the whiskers extend to the 5th and 95th percentiles, with outliers represented as dots beyond these lines.

Figure 3-22
Distribution of Lower Division Shortages and DCP Contributions



Both action alternatives result in the same shortage tiers for the Lower Division States in 2024 and similar tiers in 2025 and 2026, as shown in **Figure 3-21**; however, the distribution of shortages among Lower Division States and water users changes according to the action alternative. When comparing the action alternatives, the two alternatives result in nearly the same total Lower Basin shortage; however, Action Alternative 1 results in greater combined total shortages and DCP contributions for Arizona and Nevada and reduced combined shortages and DCP contributions to California relative to Action Alternative 2. Equivalently, Action Alternative 2 results in greater combined total shortages and DCP contributions for California, thereby reducing combined shortages and DCP contributions for Arizona and Nevada relative to Action Alternative 1.

No Action Alternative

Figure 3-8 in **Section 3.6.2** shows the projected end-of-month pool elevations for Lake Mead from 2024 through 2026 for each alternative. The median pool elevation for the No Action Alternative begins below 1,025 feet under current policies. Under this alternative, the elevations of Lake Mead fluctuate, but they generally decline with an ending median elevation of 1,010 feet and minimum elevation reaching dead pool at 895 feet. The median elevation stays below 1,025 feet for the duration of the analysis period.

Combined specified shortage volumes and DCP contributions for the combined Lower Division States can be found in **Table 3-12** and **Table 3-13**. Combined specified shortage volumes and DCP contributions broken down by Lower Division State can be found in **Table 2-4** in **Section 2.7.1** for calendar year 2024 and **Table 3-1** for calendar years 2025-2026. The distribution of total modeled combined shortage volumes and DCP contributions throughout this analysis period is shown in **Figure 3-22**. For calendar years 2024-2026, Arizona experiences maximum modeled combined annual shortage volumes and DCP contributions of 720,000 af, California experiences 350,000 af in annual DCP contributions, and Nevada experiences 30,000 af in combined shortage volumes and DCP contributions. The maximum total specified and modeled Lower Division State combined shortage volumes and DCP contributions for calendar years 2024-2026 for the No Action Alternative is 1.100 maf.

Action Alternative 1

Action Alternative 1 includes reduced releases from Glen Canyon Dam, the use of physical elevations for tier determinations, and additional shortage volumes when Lake Mead is below 1,090 feet based exclusively on the concept of priority. Modeling assumptions for Action Alternative 1 are stated in **Section 3.3.8** and described in detail in **Appendix C**, CRMMS Model Documentation.

The median pool elevation for this alternative begins below 1,025 feet under current policies as shown in **Figure 3-8** in **Section 3.6.2**. Under Action Alternative 1, the median elevation of Lake Mead continues to generally decline through the end of 2024. From 2025 through 2026, the median elevation generally increases, reaching a median value of 1,039 feet in 2026. The range of all modeled traces shows a maximum monthly elevation in Lake Mead of 1,141 feet and a minimum of 895 feet, reaching dead pool.

Combined specified shortage volumes and DCP contributions for the combined Lower Division States can be found in **Table 3-12** and **Table 3-13**. Combined specified shortage volumes and DCP

contributions broken down by Lower Division State can be found in **Table 2-4** in **Section 2.7.1** for calendar year 2024 and **Table 3-1** for calendar years 2025-2026. The distribution of total modeled combined shortage volumes and DCP contributions throughout this analysis period is shown in **Figure 3-22**. In calendar years 2024–2026, Arizona would experience maximum modeled annual shortage volumes and DCP contributions of 1.642 maf, 2.045 maf, and 2.053 maf, respectively. In 2024, California would experience a maximum of 357,000 af in annual DCP contributions, and in 2025–2026 it would experience combined annual DCP contributions and shortage volumes of 1.795 maf and 1.787 maf, respectively. In 2024, Nevada would experience a maximum of 83,000 af, and in both 2025 and 2026 it would experience a maximum of 160,000 af in combined shortage volumes and DCP contributions. The maximum total specified and total modeled Lower Division State combined shortage volumes and DCP contributions for calendar year 2024 for Action Alternative 1 is 2.083 maf and it does not include the full DCP contributions required of California. In 2025 and 2026, the total potential Lower Division State combined shortage volumes and DCP contributions for Action Alternative 1 is 4.000 maf a year.

Action Alternative 2

Action Alternative 2 includes reduced releases from Glen Canyon Dam; the use of physical elevations for tier determinations; additional shortage volumes when Lake Mead is below 1,090 feet that are distributed in the same percentage across all Lower Basin water users; and the potential for additional inflow to Lake Powell based on potential DROA contribution modeling assumptions. Modeling assumptions for Action Alternative 2 are stated in **Section 3.3.8** and described in detail in **Appendix C**.

Total shortage volumes and DCP contributions for the Lower Division States remain the same as under Action Alternative 1; however, the distribution of shortages among the Lower Division States changes. Under Action Alternative 2, the additional shortages are distributed at the same percentage across all Lower Basin water users, rather than based on priority. The range of total shortages and DCP contributions is nearly identical to those under Action Alternative 1. The only differences are due to small changes in Lake Mead’s elevations that are related to how the assumptions for potential DROA contributions included in Action Alternative 2 affect Lake Powell’s release. The distribution of total modeled combined shortage volumes and DCP contributions throughout this analysis period is shown in **Figure 3-22**.

In calendar year 2024, Arizona would experience maximum modeled annual combined shortage volumes and DCP contributions of 1,087,000 af, and in both 2025 and 2026, would experience combined annual DCP contributions and shortage volumes of 1.803 maf. In 2024, California would experience a maximum of 975,000 af in annual DCP contributions, and in both 2025 and 2026, would experience combined annual DCP contributions and shortage volumes of 2.051 maf. In 2024, Nevada would experience a maximum of 74,000 af, and in both 2025 and 2026, it would experience a maximum of 146,000 af in combined shortage volumes and DCP contributions. The maximum total specified and total modeled Lower Basin combined shortage volumes and DCP contributions for calendar year 2024 for Action Alternative 2 would be 2.083 maf. In 2025 and 2026, the total potential Lower Division State combined shortage volumes and DCP contributions for Action Alternative 2 would be 4.000 maf a year.

Cumulative Effects

If one of the Glen Canyon Dam/Smallmouth Bass flow options were implemented, there would be no changes to water supply determinations. The operating tiers established by this SEIS would inform the Glen Canyon Dam flow rates and volumes. Therefore, no additive cumulative effects would occur on water supply determinations for Lower Division States due to operational changes evaluated in the EA.

Issue 4: How would changes to operational activities affect total water deliveries to the Lower Division States?

This section presents the 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.

In addition to conditions encountered under the 2007 FEIS, more extreme hydrologic conditions may result in limitations on deliveries due to physical constraints on reservoir outflow capabilities at low-water elevations. Specifically, system shortages occur when Lake Mead's elevation reaches dead pool (elevation 895 feet). Under the extreme low elevation reservoir conditions, Lake Mead may not be able to meet all downstream demands.

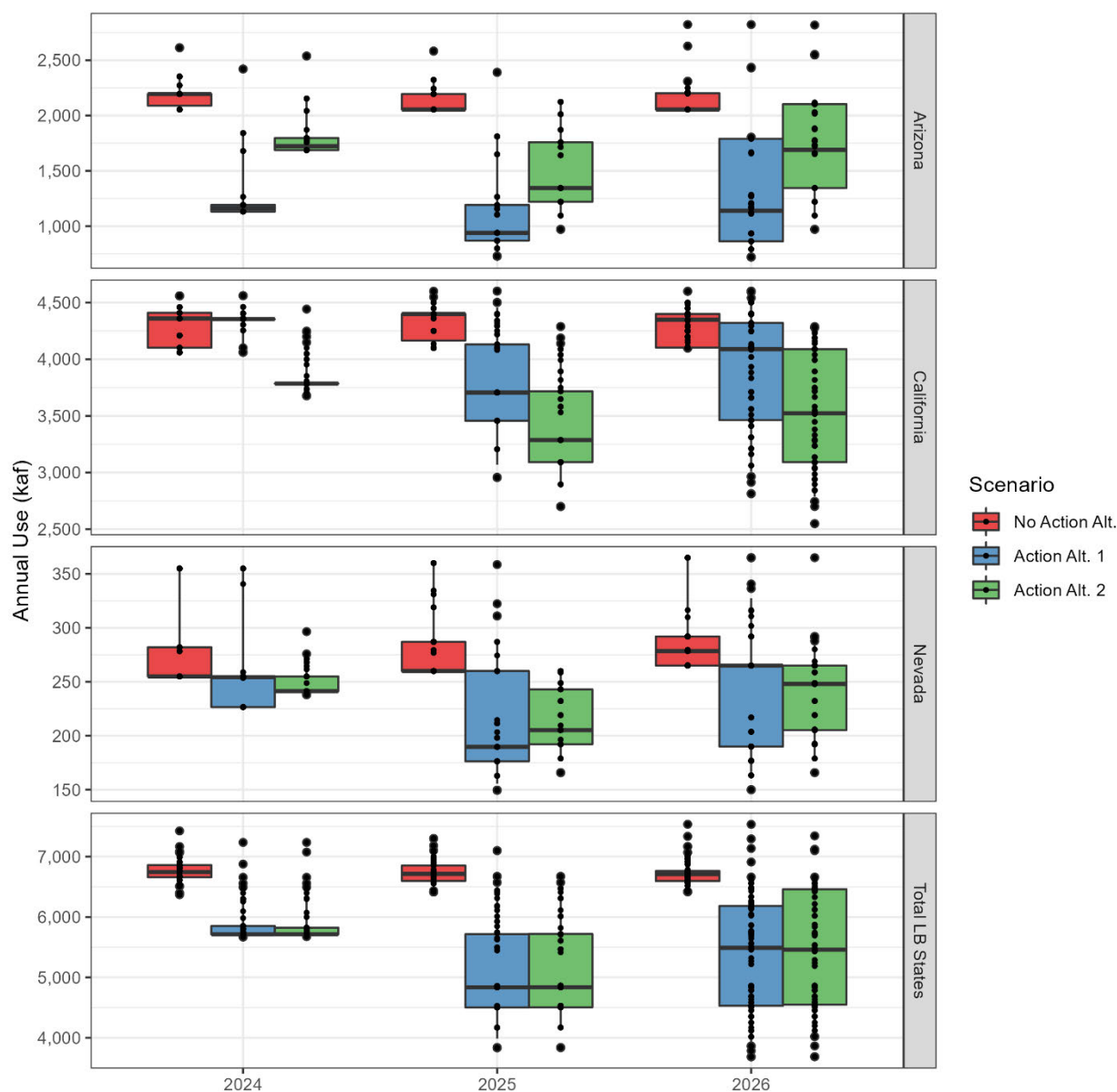
Summary of Alternatives

Under the No Action Alternative, the median modeled depletions remain relatively similar with little variability because Lake Mead is typically projected to be below 1,025 feet with the maximum shortage and DCP contributions occurring below this elevation. The action alternatives almost always result in lower modeled depletions to Lower Division States than the No Action Alternative. However, it is important to note that these depletions do not take into account system shortages discussed below. In the action alternatives, median modeled depletions to the Lower Division States decrease through 2025 and then increase in 2026 (see **Figure 3-23**) as Lake Mead's elevation is stabilized and then it begins to increase in 2026.

Figure 3-23 shows the modeled depletions for the Lower Division States in 2024, 2025, and 2026. Each dot is the annual use volume produced by a single hydrologic trace, and dots may be plotted on top of one another. The boxes capture the 25th to 75th percentile of the modeled elevations and the whiskers extend to the 5th and 95th percentiles, with outliers represented as dots beyond these lines.

Comparing the modeled depletions between Action Alternative 1 and Action Alternative 2 across states shows the effects of distributing shortages based on priority (Action Alternative 1) versus distributing shortages based on an equal percentage (Action Alternative 2). Action Alternative 1 results in lower modeled depletions for Arizona and Nevada and higher modeled depletions to California relative to Action Alternative 2. Equivalently, Action Alternative 2 results in lower modeled depletions for California and higher modeled depletions for Arizona and Nevada relative to Action Alternative 1.

Figure 3-23
Lower Division State Modeled Depletions¹¹



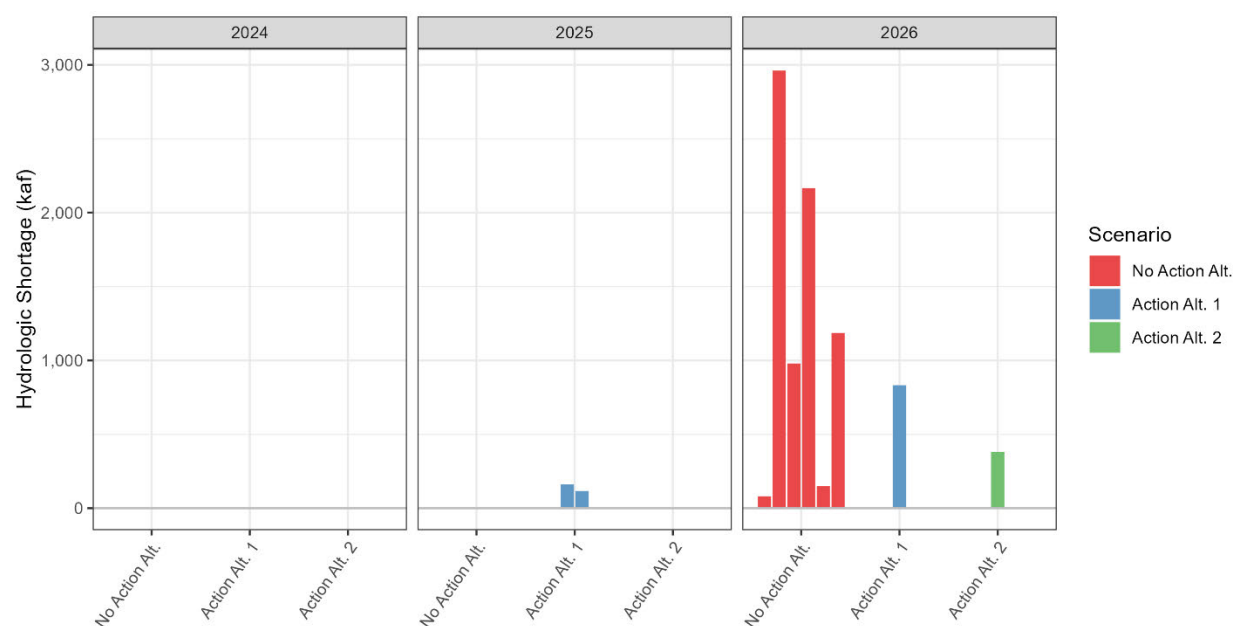
Importantly, both action alternatives decrease the frequency (**Table 3-14**) and magnitude (**Figure 3-24**) of system shortages, relative to the No Action Alternative. In 2026, 6.7 percent of No Action Alternative traces have a system shortage, which is reduced to 1.1 percent of traces in both action alternatives. When a system shortage does occur, the maximum volume exceeds 2.5 maf in the No Action Alternative, but it is only 830,000 af in Action Alternative 1 and 380,000 af in Action Alternative 2. In the No Action Alternative, system shortages would be expected to increase in frequency into the future as the elevation of Lake Mead continues to decline and not recover.

¹¹ Depletions modeled without system shortages.

Table 3-14
Percentage of Traces with System Shortages (Percent)

Year	No Action	Action Alternative 1	Action Alternative 2
2024	0	0	0
2025	0	2.2	0
2026	6.7	1.1	1.1

Figure 3-24
Range of Lower Basin System Shortages



No Action Alternative

The No Action Alternative assumes a continuation of the 2007 Interim Guidelines and 2019 DCPs. Shortages and DCP contributions are dependent on the projected January 1 Lake Mead elevation. **Table 3-11** includes total shortages and DCP contributions to the Lower Division States under all alternatives. Assumptions for ICS creation and delivery (see **Appendix C**) can also affect the modeled deliveries to the Lower Division States.

Figure 3-23 provides a comparison of Arizona, Nevada, and California's modeled depletions under the No Action Alternative and the action alternatives. In 2024–2026, the median total modeled depletions for the Lower Division States are 6.810 maf, 6.714 maf, and 6.682 maf, respectively. Total modeled depletions for Lower Division States under the No Action Alternative do not exhibit much variability, as over half the traces each year are below 1,025 feet at Lake Mead where the maximum combined shortage and DCP contributions of 1.1 maf occur. There are slightly fewer traces with larger depletions each year, as Lake Mead's elevation also exhibits a downward trend from 2023–2026. Deliveries lower than the modeled depletions shown in **Figure 3-23** can occur when Lake

Mead is at dead pool and it cannot meet all downstream demands. In these cases, system shortages are reported as a total for the entire Lower Basin. **Table 3-14** shows the percentage of traces in which a system shortage occurs under each alternative, with this occurring in 6.7 percent of traces in 2026 in the No Action Alternative. **Figure 3-24** shows the range of volumes of system shortage for 2024–2026 under each alternative across the entire Lower Basin, which can exceed 2,500 maf in 2026 under the No Action Alternative. Based on the projected trends, system shortages would be expected to increase in frequency into the future as the elevation of Lake Mead continues to decline and not recover.

Total Deliveries to Arizona

Water deliveries to Arizona are projected to fluctuate throughout the 3-year period of analysis; these fluctuations reflect variations in hydrologic conditions and the physical constraints of Lake Powell and Lake Mead. Under the No Action Alternative, modeled annual depletions for Arizona are shown in **Figure 3-23**. In 2024, the median modeled depletions total 2.195 maf, and in 2025 and 2026, the median modeled depletions total 2.055 maf. The model indicates a similar pattern to that of the entire Lower Basin; deliveries will be greater initially, but they will decline as less water is available in storage and more traces fall below 1,025 feet.

Total Deliveries to Nevada

Water deliveries to Nevada are projected to fluctuate throughout the 3-year period of analysis; these fluctuations reflect variations in hydrologic conditions and the physical constraints of Lake Powell and Lake Mead. Under the No Action Alternative, modeled annual depletions for Nevada are shown in **Figure 3-23**. In 2024–2026, the median deliveries are 255,000 maf, 260,000 maf and 278,000 maf, respectively. The model indicates a similar pattern for Nevada as for that of the entire Lower Basin; deliveries will initially be greater, but they will decline as less water is available in storage and more traces fall below 1,025 feet.

Total Deliveries to California

Water deliveries to California are not expected to be impacted greatly under the No Action Alternative. However, the model indicates deliveries will fluctuate throughout the 3-year period of analysis; these fluctuations reflect variations in hydrologic conditions and the physical constraints of Lake Powell and Lake Mead. Under the No Action Alternative, modeled annual depletions for California are shown in **Figure 3-23**. In 2024–2026, the median deliveries are 4.360 maf, 4.400 maf and 4.349 maf, respectively. The model indicates a similar pattern to that of the entire Lower Basin, although the magnitude of impacts is less. This is because California does not make DCP contributions until Lake Mead is below 1,040 feet and these contributions are modeled to be made through ICS conversion, when possible. Most of the variability in California's deliveries in the No Action Alternative are due to modeled ICS creation and delivery.

Action Alternative 1

Action Alternative 1 includes reduced releases from Glen Canyon Dam, the use of physical elevations for tier determinations, and additional shortage volumes when Lake Mead is below 1,090 feet based exclusively on the concept of priority. Modeling assumptions for Action Alternative 1 are stated in **Section 3.3.8** and described in detail in **Appendix C**, CRMMS Model Documentation. Assumptions for ICS creation and delivery (see **Appendix C**) can also affect the modeled deliveries

to the Lower Division States. **Table 3-11** includes total shortages and DCP contributions to the Lower Division States under all alternatives.

In 2024–2026, the median total deliveries modeled to the Lower Division States under Action Alternative 1 are 5.771 maf, 4.836 maf, and 5.494 maf, respectively. Modeled deliveries to the Lower Division States are reduced relative to the No Action Alternative, due to the additional shortages included in Action Alternative 1. Modeling the distributing of shortages exclusively based on the concept of priority results in Arizona (and Nevada to a lesser extent) incurring the bulk of the additional shortages. However, reservoir elevations remain higher, resulting in more reliable deliveries farther in the time horizon, as shown by the reduced chance of system shortages due to reaching dead pool at Lake Mead. 2.2 percent of traces in 2025 and 1.1 percent of traces in 2026 experience system shortages under Action Alternative 1, as shown in **Table 3-14**. **Figure 3-24** shows the range of volumes of system shortage for 2024–2026 under each alternative across the entire Lower Basin. No system shortages are modeled in 2024, while in 2025 system shortages range from 117,000 to 161,000 af, and in 2026 only one trace shows a system shortage of 832,000 af.

Total Deliveries to Arizona

Under Action Alternative 1, modeled water deliveries to Arizona are projected to fluctuate throughout the 3-year period of analysis. These fluctuations reflect variations in hydrologic conditions, the physical constraints of Lake Powell and Lake Mead, and the shortage condition and DCP contributions based on the projected Lake Mead elevation. Modeled annual depletions for Arizona for Action Alternative 1 are shown in **Figure 3-23**. In 2024–2026, the median deliveries are 1.162 maf, 940,000 af, and 1.799 maf, respectively. Under Action Alternative 1, modeled deliveries to Arizona are limited by increased shortages, compared to the No Action Alternative; however, deliveries are more reliable later in the time horizon relative to the No Action Alternative due to a decrease in the frequency and volume of system shortages. This is because the additional shortages in Action Alternative 1 help stabilize and then increase Lake Mead’s elevation.

Total Deliveries to Nevada

Under Action Alternative 1, modeled water deliveries to Nevada are projected to fluctuate throughout the 3-year period of analysis. These fluctuations reflect variations in hydrologic conditions, the physical constraints of Lake Powell and Lake Mead, and the shortage tier and DCP contributions based on the projected Lake Mead elevation. Modeled annual depletions for Nevada for Action Alternative 1 are shown in **Figure 3-23**. In 2024–2026, the median deliveries are 254,000 af, 190,000 af, and 265,000 af, respectively. Under Action Alternative 1, modeled deliveries to Nevada are limited by increased shortages, compared with the No Action Alternative; however, deliveries are more reliable later in the time horizon relative to the No Action Alternative, due to a decrease in the frequency and volume of system shortages. This is because the additional shortages in Action Alternative 1 help stabilize and then increase Lake Mead’s elevation.

Total Deliveries to California

Under Action Alternative 1, modeled water deliveries to California are projected to fluctuate throughout the 3-year period of analysis. These fluctuations reflect variations in hydrologic conditions, the physical constraints of Lake Powell and Lake Mead, and the shortage tier and DCP contributions based on the projected Lake Mead elevation. Modeled annual depletions for California

for Action Alternative 1 are shown in **Figure 3-23**. In 2024–2026, the median deliveries are 4.354 maf, 3.707 maf, and 4.089 maf, respectively. Under Action Alternative 1, modeled deliveries to California are limited by increased shortages, compared with the No Action Alternative, especially for 2025–2026. In 2024, the total Lower Basin shortages and DCP contributions are limited to 2.083 maf; at this level only a small portion of the additional shortage at certain elevations (see *Issue 6*) is applied to California. In 2025–2026, the modeled additional shortages increase beyond 2.083 maf to a maximum of 4.0 maf when Lake Mead is below 950 feet. At these larger levels of shortage, some of the additional shortage volume is applied to California, which is responsible for the approximately 650,000 af reduction in median delivery between 2024 and 2025. Deliveries are more reliable later in the time horizon relative to the No Action Alternative due to a decrease in the frequency and volume of system shortages. This is because the additional shortages in Action Alternative 1 help stabilize and then increase Lake Mead’s elevation. Under Action Alternative 1, modeled impacts on deliveries to California (particularly in 2024) are lower in magnitude than they are for Arizona and Nevada. This is due to the priority-based shortage allocations that result in California incurring a lesser magnitude of shortages.

Action Alternative 2

Action Alternative 2 includes reduced releases from Glen Canyon Dam, the use of physical elevations for tier determinations, additional shortage volumes when Lake Mead is below 1,090 feet that are distributed in the same percentage across all Lower Basin water users, and the potential for additional inflow to Lake Powell based on potential DROA contributions modeling assumptions. Modeling assumptions for Action Alternative 2 are stated in **Section 3.3.8** and described in detail in **Appendix C**, CRMMS Model Documentation. Assumptions for ICS creation and delivery (see **Appendix C**) can also affect the modeled deliveries to the Lower Division States. **Table 3-11** includes total shortages and DCP contributions to the Lower Division States under all alternatives.

In 2024–2026, the median total deliveries modeled to the Lower Division States under Action Alternative 2 are 5.749 maf, 4.837 maf, and 5.461 maf, respectively. Modeled depletions for the Lower Basin are less in 2025–2026 for all states because of the additional shortages modeled in these years. Reservoir elevations remain higher than the No Action Alternative, particularly in 2026, due to the increased additional shortages in 2025–2026, resulting in more reliable deliveries further in the time horizon with a minimized chance of system shortages related to reaching dead pool at Lake Mead. Also, deliveries are projected to be greater in Action Alternative 2 due to how model assumptions for potential DROA releases affect Lake Powell releases which, in turn, can affect Lake Mead’s operating condition. **Table 3-14** shows the percentage of traces in which a system shortage occurs under each alternative, with this occurring in 1.1 percent of traces in 2026, under Action Alternative 1. **Figure 3-24** shows the range of volumes of system shortage for 2024–2026 under each alternative across the entire Lower Basin. No system shortages are experienced in 2024 or 2025 under Action Alternative 2, while 380,000 af of system shortages are experienced in 2026.

Total Deliveries to Arizona

Under Action Alternative 2, modeled water deliveries to Arizona are projected to fluctuate throughout the 3-year period of analysis. These fluctuations reflect variations in hydrologic conditions, the physical constraints of Lake Powell and Lake Mead, and the shortage condition and DCP contributions based on the projected Lake Mead elevation. Modeled annual depletions for

Arizona for Action Alternative 2 are shown in **Figure 3-23**. In 2024–2026, the median deliveries are 1.723 maf, 1.345 maf, and 1.690 maf, respectively. Under Action Alternative 2, modeled deliveries to Arizona are limited by increased shortages, compared to the No Action Alternative; however, deliveries are more reliable later in the time horizon relative to the No Action Alternative due to a decrease in the frequency and volume of system shortages. This is because the additional shortages in Action Alternative 2 help stabilize and then increase Lake Mead’s elevation.

Total Deliveries to Nevada

Under Action Alternative 2, modeled water deliveries to Nevada are projected to fluctuate throughout the 3-year period of analysis. These fluctuations reflect variations in hydrologic conditions, the physical constraints of Lake Powell and Lake Mead, and the shortage condition and DCP contributions based on the projected Lake Mead elevation. Modeled annual depletions for Nevada for Action Alternative 2 are shown in **Figure 3-23**. In 2024–2026, the median deliveries are 241,000 af, 205,000 af, and 248,000 af, respectively. Under Action Alternative 2, modeled deliveries to Nevada are limited by increased shortages, compared with the No Action Alternative; however, deliveries are more reliable later in the time horizon relative to the No Action Alternative due to a decrease in the frequency and volume of system shortages. This is because the additional shortages in Action Alternative 2 help stabilize and then increase Lake Mead’s elevation.

Total Deliveries to California

Under Action Alternative 2, modeled water deliveries to California are projected to fluctuate throughout the 3-year period of analysis. These fluctuations reflect variations in hydrologic conditions, the physical constraints of Lake Powell and Lake Mead, and the shortage condition and DCP contributions based on the projected Lake Mead elevation. Modeled annual depletions for California for Action Alternative 2 are shown in **Figure 3-23**. In 2024–2026, the median deliveries are 3.785 maf, 3.287 maf, and 3.523 maf, respectively. Under Action Alternative 2, modeled deliveries to California are limited by increased shortages, compared with the No Action Alternative, especially for 2025–2026.

Deliveries are more reliable later in the time horizon relative to the No Action Alternative due to a decrease in the frequency and volume of system shortages. This is because the additional shortages under Action Alternative 2 help stabilize and then increase Lake Mead’s elevation. Under Action Alternative 1, modeled impacts on deliveries to California (particularly in 2024) are greater in magnitude than they are for Arizona and Nevada. This is due to additional shortage volumes being distributed in the same percentage across all Lower Basin water users.

Cumulative Effects

If one of the Glen Canyon Dam/Smallmouth Bass flow options were implemented, there would be no additional changes to water deliveries. The operating tiers established by this SEIS would inform the Glen Canyon Dam flow rates and volumes. Therefore, no additive cumulative effects would occur on water deliveries for Lower Division States due to the flow options.

Issue 5: How would changes to operational activities affect deliveries to Mexico?

As stated above, Mexico’s reductions and recoverable savings are per Minute 323, with a maximum of 275,000 af (of their 1,500,000 af annual water allotment), when Lake Mead is below elevation

1,025 feet. 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 calendar 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 action alternatives do affect projected Lake Mead elevations (through modeled changes to Lake Powell's release and increased Lower Division State shortages). These differences in Lake Mead elevation can result in different modeled reductions and recoverable savings for Mexico.

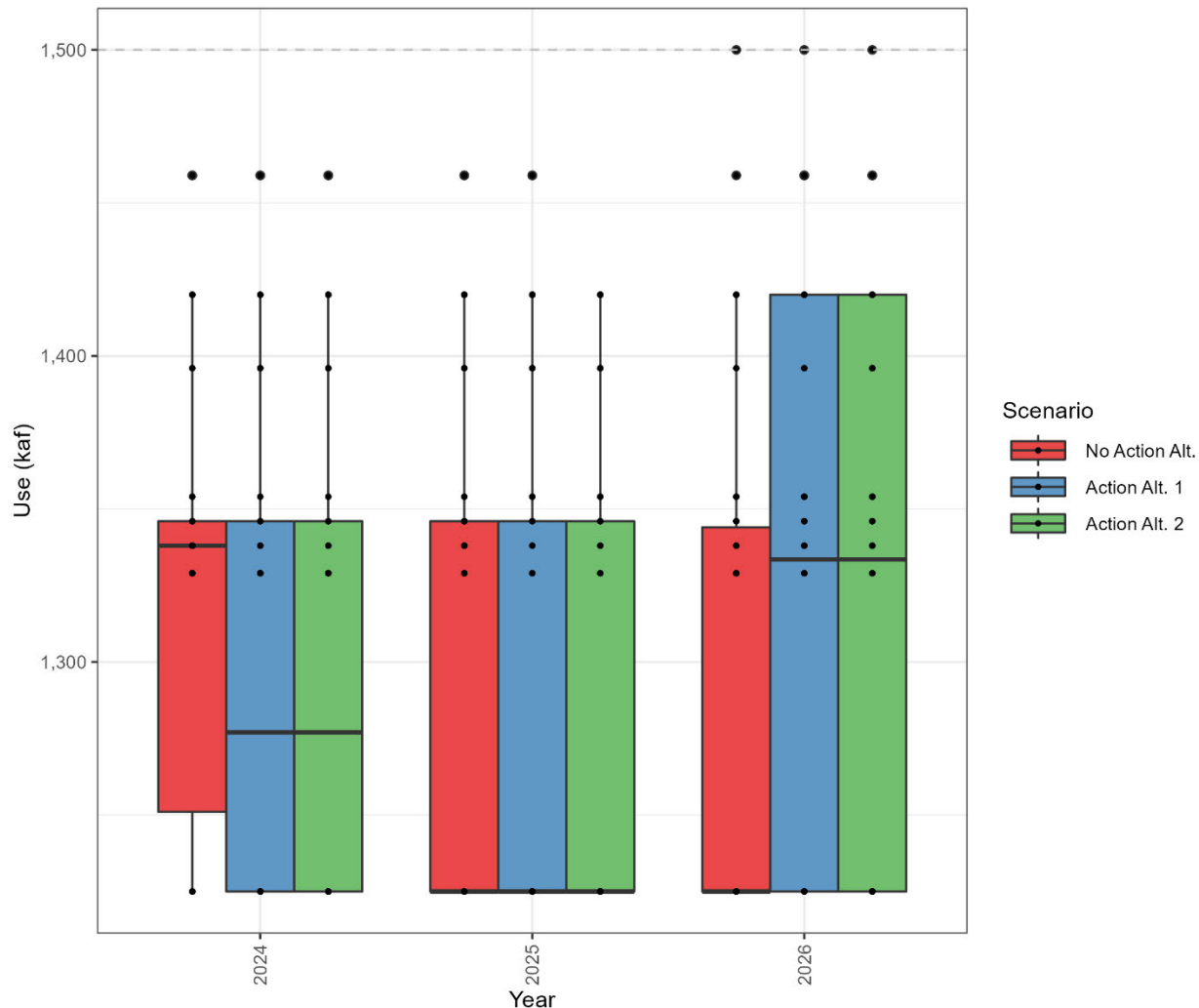
Figure 3-25 compares the modeled deliveries to Mexico for the No Action and action alternatives. The No Action Alternative shows a median delivery to Mexico of 1.338 maf in 2024, decreasing to 1.225 maf in 2025 and 2026. Both action alternatives show median deliveries to Mexico of approximately 1.275 maf in 2024, 1.225 maf in 2025, and approximately 1.334 maf in 2026. These deliveries are consistent with the Lake Mead elevations shown in **Figure 3-8**, which shows lower elevations in the action alternatives in 2024, but higher elevations by 2026. Deliveries lower than the modeled depletions shown in **Figure 3-23** could occur if Lake Mead is at dead pool and it cannot meet all downstream demands. In these cases, system shortages at dead pool are reported as a total for the entire Lower Basin (**Figure 3-24**).

Figure 3-25 shows the modeled deliveries to Mexico for the No Action Alternative and action alternatives in 2024, 2025, and 2026. Each dot is the annual delivery volume produced by a single hydrologic trace, and dots may be plotted on top of one another. The boxes capture the 25th to 75th percentile of the modeled elevations and the whiskers extend to the 5th and 95th percentiles, with outliers represented as dots beyond these lines.

Cumulative Effects

If one of the Glen Canyon Dam/Smallmouth Bass flow options were implemented, there would be no changes to water deliveries to Mexico. The operating tiers established by this SEIS would inform the Glen Canyon Dam flow rates and volumes. Therefore, no additive cumulative effects would occur on water deliveries for Lower Division States due to operational changes evaluated in the EA.

Figure 3-25
Modeled Range of Deliveries to Mexico after Minute 323 Reductions and Savings



Issue 6: How would changes to operational activities affect the modeled distribution of shortages 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 Models to quantify estimated shortage distributions. Overall, the No Action Alternative does not analyze the same magnitude of shortage as Action Alternative 1 and Action Alternative 2. Both action alternatives apply to 2007 Interim Guidelines shortages and 2019 DCPs contributions; however, additional shortages, as modeled in this SEIS, are applied differently in the action alternatives. Action Alternative 1 models additional shortages based on priority, both among the Lower Division States and within each state, and Action Alternative 2 models the distribution of additional shortages using the same percentage across all Lower Basin water users. Total Lower Division States' shortages of up to 1,100 maf were analyzed under the No Action Alternative. Under Action Alternative 1 and Action Alternative 2, total Lower Division States' shortages of up to 2,083

maf were analyzed for 2024. Under Action Alternative 1 and Action Alternative 2, up to 4,000 maf of shortage was analyzed for 2025 and 2026. Modeling details for each alternative are described in **Section 3.3.8** and **Appendix D**, Shortage Allocation Model Documentation.

Under the No Action Alternative, the maximum total volume of 2007 Interim Guidelines shortages and 2019 DCP contributions modeled was 1.1 maf in 2024–2026. The maximum shortage and DCP contributions for Arizona and Nevada are 720,000 af and 30,000 af, respectively. The maximum DCP contributions for California are 350,000 af.

Under Action Alternative 1, the total volume of the 2007 Interim Guidelines shortages and 2019 DCP contributions modeled was 2.083 maf in 2024. The maximum shortage and DCP contributions modeled under Action Alternative 1 for Arizona was 1.74 maf reducing the total available water for the Arizona 4th priority to 0. The maximum shortage and DCP contributions modeled under Action Alternative 1 for Nevada was 83,000 af. The maximum shortage and DCP contributions modeled under Action Alternative 1 for California was 261,000 af.

Under Action Alternative 2, the total volume of 2007 Interim Guidelines shortages, 2019 DCP contributions, and additional shortage modeled was 2.083 maf in 2024. The maximum shortage and DCP contributions modeled under Action Alternative 2 for Arizona was 1.09 maf. The maximum shortage and DCP contributions modeled under Action Alternative 2 for Nevada were 69,300 af. The maximum shortage and DCP contributions modeled under Action Alternative 2 for California was 926,000 af.

No Action Alternative

The No Action Alternative models shortages and contributions, consistent with the 2007 Interim Guidelines and 2019 DCPs, among the Lower Division States. There is a different assumption, as compared to the 2007 FEIS, for how shortage distribution can be modeled that takes into consideration fulfilling PPRs before distributing shortage among the Lower Division States. Additional information on the differences can be found in **Appendix B** and **Appendix D**, Shortage Allocation Model Documentation. (Refer to **Section 3.17.2** for specific Tribal allocations under the No Action Alternative.)

Distribution of Shortages within Arizona

Table 3-15 provides a summary of the total shortage impacts modeled for Arizona, broken out by the range of analyzed shortage volumes under the No Action Alternative for 2024–2026. Total basin shortage volumes analyzed under the No Action Alternative 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 shortages for Arizona in accordance with the 2007 Interim Guidelines and 2019 DCPs. As the total shortage analyzed increases, there is a corresponding increase in shortages allocated to Arizona 4th-priority entitlement holders including CAP contracts and subcontracts. The maximum shortage volume simulated does not exceed Stage 1 shortage amounts. (Refer to **Appendix D**, Shortage Allocation Model Documentation for additional information.)

Table 3-15
No Action Alternative - 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 D**, Shortage Allocation Model Documentation for additional information.

¹Water 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. Agricultural and other CAP 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.

Distribution of Shortages within Nevada

Table 3-16 provides a summary of the total shortage impacts modeled for Nevada, broken out by the range of analyzed shortage volumes under the No Action Alternative for 2024–2026. Total basin shortage volumes analyzed under the No Action Alternative 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 shortages for Nevada in accordance with the 2007 Interim Guidelines and 2019 DCPs. There is a corresponding increase in shortages allocated to Nevada (up to 30,000 af), but only at the 8th-priority level. The maximum shortage volume simulated does not exceed Stage 1 shortage amounts. (Refer to **Appendix D**, Shortage Allocation Model Documentation for additional information.)

Distribution of Shortages within California

Table 3-17 provides a summary of the total shortage impacts modeled for California broken out by the range of analyzed shortage volumes under the No Action Alternative for 2024–2026. Total basin shortage volumes analyzed under the No Action Alternative for the Lower Division States ranged from 200,000 af to 1.1 maf. This resulted in 0 af to 350,000 af in shortages for California, which are attributed to only 2019 DCP contributions. (Refer to **Appendix D**, Shortage Allocation Model Documentation for additional information.)

Action Alternative 1

The Action Alternative 1 Shortage Allocation Model calculated total shortages and the distribution of shortage within the priority system among and within the Lower Division States. The model analyzed shortage volumes of up to 2.083 maf for 2024. Under Action Alternative 1, available water is distributed first among states and subsequently among the entitlement holders based on priority within each state. Under this alternative, shortages are characterized by two stages, Stage 1 and Stage 2. (Refer to modeling assumptions in **Section 3.3.8** for descriptions on Stage 1 and Stage 2 shortages.) There is a different assumption, as compared to the 2007 FEIS, for how shortage distribution can be modeled that takes into consideration fulfilling PPRs before distributing shortage among the Lower Division States. Additional information on these assumptions can be found in **Appendix B** and **Appendix D**, Shortage Allocation Model Documentation. (Refer to **Section 3.17.2** for specific Tribal allocations under Action Alternative 1.)

Table 3-16
No Action Alternative-- 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
8 th Priority (SNWA – Balance and Unused)	8,000	21,000	25,000	27,000	27,000	27,000	27,000	30,000
8 th Priority (SNWA and Big Bend)	0	0	0	0	0	0	0	0
7 th Priority (Boy Scouts, Reclamation, and Nevada Department of Wildlife)	0	0	0	0	0	0	0	0
6 th Priority (Las Vegas Valley Water District)	0	0	0	0	0	0	0	0
5 th Priority (PABCO and Lakeview Company)	0	0	0	0	0	0	0	0
4 th Priority (Henderson and Basic Management)	0	0	0	0	0	0	0	0
3 rd Priority (Boulder City)	0	0	0	0	0	0	0	0
2 nd Priority (LMNRA)	0	0	0	0	0	0	0	0
1 st 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 D**, 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 3-17
No Action Alternative - 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							
	200,000	533,000	617,000	867,000	917,000	967,000	1,017,000	1,100,000
California – Priority								
4th Priority (MWD)	0	0	0	200,000	250,000	300,000	350,000	350,000
3rd Priority (IID, Coachella Valley Water District, Palo Verde Irrigation District, and QSA Diversions by MWD)	0	0	0	0	0	0	0	0
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 D**, 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.

Distribution of Shortages within Arizona

Table 3-18 displays Lower Division States' shortage volumes for 2024 and the portions of these shortage amounts that were assumed by Reclamation to be distributed to Arizona. Available water within Arizona is distributed among a number of water users based on Arizona's Colorado River priority system.

Under Action Alternative 1, the total Basin shortage volumes modeled for the Lower Division States ranged from 400,000 af to 2.083 maf for 2024. This results in 384,000 af to 1.738 maf in shortages for Arizona. At the first tier of shortage analyzed (400,000 af), shortages are distributed to CAP NIA priority long-term contracts, with no water available for Arizona 5th and 6th priority entitlement holders, entitlement holders for unused CAP water, and CAP agricultural and other excess entitlement holders. As the total shortage analyzed increases, there is a corresponding increase in shortages allocated to Arizona and its 4th-priority entitlement holders. The allocation of shortages to individual users within the CAP is affected by the priority system within the CAP. (Refer to **Appendix D** for additional information regarding CAP shortages.)

As total shortages to the Lower Division States increase, the impact of a given shortage to the CAP increasingly impacts the higher-priority Indian and M&I priority contractors and subcontractors, and the shortage cannot be absorbed by the lower priorities. Shortages to the Lower Division States that total approximately 1.734 maf or greater result in shortages to Arizona 2nd- and 3rd-priority entitlement holders. These shortages are characterized as Stage 1 (where Arizona is assigned 96 percent up to 1.67 maf) and Stage 2 (where Arizona is assigned 19.6 percent of additional shortages).

Distribution of Shortages within Nevada

Table 3-19 shows Lower Division States' shortage volumes and the portion of the shortage that is allocated to Nevada for 2024. The total Basin shortage volumes analyzed for the Lower Division States ranged from 400,000 af to 2.083 maf for 2024. This results in 16,000 af to 83,300 af in shortages for Nevada. These shortages are borne, as described in the No Action Alternative above, but with increasing volumes of shortage imposed on 8th Priority entitlement holders.

Nevada bears a reduction of 4.0 percent of the total Lower Division States shortage volume under Stage 1 shortage. In addition to its Stage 1 shortage, Nevada bears 4.0 percent of the Stage 2 Shortage.

Distribution of Shortages within California

Table 3-20 shows different Lower Division States' shortage volumes and the portion of the shortage that is allocated to California for 2024. At the 2.083¹² maf analyzed shortage volume, the shortage allocation to California represents approximately 12.6 percent of the total Lower Division States' shortage amount in 2024. This shortage is only borne by 4th Priority entitlement holders.

¹² Refer to **Section 2.7** for additional information. Because the 2019 DCP contributions for California exceed the 2024 total shortage and contribution volume as modeled by the Shortage Allocation Model, the sum of the three states' totals exceeds the total shortage and contribution volume. While 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 2024.

Table 3-18
Action Alternative 1 - Summary of Shortages for Arizona 2024

Summary of Wet Water Shortage Impacts by State and Priority		Range of Analyzed Volumes of Total Shortage to Lower Division States*				
		400,000	1,066,000	1,234,000	1,734,000	2,083,000
Arizona	Priority					
	5th, 6th, and CAP Agricultural and Other Excess	286,465	333,921	339,609	351,774	365,748
	4th Priority i (Mainstream)	0	32,228	39,643	63,122	63,445
	4th Priority ii (CAP) ¹					
	NIA Priority	97,535	245,633	245,633	245,633	245,633
	M&I Priority	0	265,389	360,827	602,601	602,601
	Indian Priority	0	146,189	198,928	332,533	332,533
	2nd and 3rd Priorities	0	0	0	68,977	128,127
	1st Priority (PPRs)	0	0	0	0	0
	Subtotal	384,000	1,023,360	1,184,640	1,664,640	1,738,087

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

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

¹Water 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. Agricultural and other CAP 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 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 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 cannot replicate the precision required of that process.

Table 3-19
Action Alternative 1 - Summary of Modeled Shortages for Nevada 2024

Summary of Wet Water Shortage Impacts by State and Priority		Range of Analyzed Volumes of Total Shortage to Lower Division States*				
		400,000	1,066,000	1,234,000	1,734,000	2,083,000
Nevada	Priority					
	8th Priority (SNWA - Balance & Unused)	16,000	42,640	49,360	69,360	83,320
	8th Priority (SNWA and Big Bend)	0	0	0	0	0
	7th Priority (Boy Scouts, Reclamation, and Nevada Department of Wildlife)	0	0	0	0	0
	6th Priority (Las Vegas Valley Water District)	0	0	0	0	0
	5th Priority (PABCO and Lakeview Company)	0	0	0	0	0
	4th Priority (Henderson and Basic Management)	0	0	0	0	0
	3rd Priority (Boulder City)	0	0	0	0	0
	2nd Priority (LMNRA)	0	0	0	0	0
	1st Priority (PPRs: LMNRA and Fort Mojave Indian Reservation)	0	0	0	0	0
	Subtotal	16,000	42,640	49,360	69,360	83,320

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

Disclaimer: These modeling results (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 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 they cannot replicate the precision required of that process.

Table 3-20
Action Alternative 1 - Summary of Shortages for California for 2024

Summary of Wet Water Shortage Impacts by State and Priority		Range of Analyzed Volumes of Total Shortage to Lower Division States				
		400,000	1,066,000	1,234,000	1,734,000	2,083,000
California ¹	Priority					
	4th Priority (MWD)	0	0	0	0	261,593
	3rd Priority (IID, Coachella Valley Water District, Palo Verde Irrigation District, and QSA Transfers to MWD)	0	0	0	0	0
	2nd Priority (Yuma Project Reservation Division)	0	0	0	0	0
	1st Priority (Palo Verde Irrigation District)	0	0	0	0	0
	PPRs	0	0	0	0	0
	Subtotal	0	0	0	0	261,593

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

¹The first increment of shortage volumes required by Action Alternative 1 is satisfied by 2019 DCP contributions. In some elevation tiers, the 2019 DCP contributions for California exceed the 2024 shortage volume under Action Alternative 1, which follows the priority system. In these instances, the Shortage Allocation Model for the No Action Alternative will show higher shortages to California than the Shortage Allocation Model for Action Alternative 1.

Disclaimer: These modeling results (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 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 they cannot replicate the precision required of that process.

Action Alternative 2

The Action Alternative 2 Shortage Allocation Model calculated total shortages and the effects of distributing shortages using the same percentage across all Lower Basin water users within the Lower Division States. The model analyzed shortage volumes to the Lower Division States beginning at 400,000 af and going up to 2.083 maf for 2024. **Table 3-21** summarizes the range of shortage volumes analyzed, the range of total additional shortage analyzed, and the percentage reduction to each water user. Under Action Alternative 2, shortages are in addition to current commitments (2007 Interim Guidelines shortages and 2019 DCP contributions) and they are distributed in the same percentage across all Lower Basin water users based on 2021 consumptive use (and conservation), and volumes of water available are calculated relative to that baseline. Under this alternative, first, the 2007 Interim Guidelines shortages and 2019 DCP contributions are applied assuming that they are borne by the major junior priority diverter in each state and second, the additional shortages are applied to all Lower Basin water users using the same percentage; this percentage reduction is shown in the tables below. The reductions for each state are broken out as irrigation, domestic, and Tribal user group totals in **Table 3-22** through **Table 3-24**. (Refer to **Appendix D**, Shortage Allocation Model Documentation for additional information regarding how shortages are distributed and for a full list of water users.) (Refer to **Section 3.17.2** for specific Tribal allocations under Action Alternative 2.)

Distribution of Shortages within Arizona

Table 3-22 summarizes Lower Division States' shortage volumes and the portions of these shortage amounts that were assumed by Reclamation to be distributed to Arizona. The total Basin shortage volumes analyzed for the Lower Division States ranged from 400,000 af to 2.083 maf. This results in 266,000 af to 1.075 maf in shortages for Arizona. As the volume of additional shortage analyzed increases, there is a corresponding increase in the reductions to each water user group.

Distribution of Shortages within Nevada

Table 3-23 provides Lower Division States' shortage volumes and the portions of these shortage amounts that were assumed by Reclamation to be distributed to Nevada. Under Action Alternative 2, the total Basin shortage volumes analyzed for the Lower Division States ranged from 400,000 af to 2.083 maf. This results in 16,000 af to 74,000 af in shortages for Nevada. As the volume of additional shortage analyzed increases, there is a corresponding increase, on average, in the reductions to each water user group.

Distribution of Shortages within California

Table 3-24 provides Lower Division States' shortage volumes and the portions of these shortage amounts that were assumed by Reclamation to be distributed to California. Under Action Alternative 2, the total Basin shortage volumes analyzed for the Lower Division States ranged from 400,000 af to 2.083 maf. This results in 117,000 af to 934,000 af in shortages for California. As the volume of additional shortage analyzed increases, there is a corresponding increase, on average, in the reductions to each water user group.

Table 3-21
Action Alternative 2 - Summary of Shortage Impacts

	Range of Analyzed Volumes							
Range of Analyzed Volumes of Total Shortage to Lower Division States (af)	400,000	1,066,000	1,234,000	1,734,000	2,083,000	2,083,000	2,083,000	2,083,000
Range of Analyzed Volumes of Total Additional Shortage to Lower Division States (af)	200,000	533,000	617,000	867,000	983,000	1,066,000	1,116,000	1,166,000
Percentage Reduction to Each Water User's 2021 Adjusted Consumptive Use	2.67%	7.11%	8.23%	11.56%	13.11%	14.21%	14.88%	15.55%

Source: Reclamation 2023g

Disclaimer: These modeling results (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 agency position with respect to contract or statutory interpretation, and 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 3-22
Action Alternative 2 -Summary of Shortages for Arizona

		Range of Analyzed Volumes							
		400,000	1,066,000	1,234,000	1,734,000	2,083,000	2,083,000	2,083,000	2,083,000
Arizona	Percentage Reduction	2.67%	7.11%	8.23%	11.56%	13.11%	14.21%	14.88%	15.55%
	Irrigation ¹	256,590	382,819	390,887	420,840	429,640	435,715	441,984	448,253
	Domestic (Includes Interim Guidelines and DCPs) ¹	1,402	131,899	198,120	261,644	330,406	293,925	300,453	306,980
	Tribal ¹	8,675	196,269	233,339	281,195	326,941	308,333	314,203	320,073
Subtotal		266,667	710,987	822,347	963,680	1,086,987	1,037,973	1,056,640	1,075,307

¹ 2007 Interim Guidelines shortages, DCP contributions, and additional reductions are distributed among irrigation, domestic, and Tribal users as part of the CAP priority system. In California and Nevada, 2007 Interim Guidelines shortages and DCP contributions are attributed to the junior priority domestic diverter.

Disclaimer: These modeling results (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 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 they cannot replicate the precision required of that process.

Table 3-23
Action Alternative 2 -Summary of Shortages for Nevada

		Range of Analyzed Volumes							
		400,000	1,066,000	1,234,000	1,734,000	2,083,000	2,083,000	2,083,000	2,083,000
Nevada	Percentage Reduction	2.67%	7.11%	8.23%	11.56%	13.11%	14.21%	14.88%	15.55%
	Irrigation	0	0	0	0	0	0	0	0
	Domestic (Includes Interim Guidelines and DCPs) ¹	15,919	42,104	49,430	61,329	68,922	69,208	71,188	73,168
	Tribal	81	216	250	351	398	432	452	472
Subtotal		16,000	42,320	49,680	61,680	69,320	69,640	71,640	73,640

¹ 2007 Interim Guidelines shortages, DCP contributions, and additional reductions are distributed among irrigation, domestic, and Tribal users as part of the CAP priority system. In California and Nevada, 2007 Interim Guidelines shortages and DCP contributions are attributed to the junior priority domestic diverter.

Disclaimer: These modeling results (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 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 of that process.

Table 3-24
Action Alternative 2 -Summary of Shortages for California

		Range of Analyzed Volumes							
		400,000	1,066,000	1,234,000	1,734,000	2,083,000	2,083,000	2,083,000	2,083,000
California	Percentage Reduction	2.67%	7.11%	8.23%	11.56%	13.11%	14.21%	14.88%	15.55%
	Irrigation	91,233	243,135	281,452	395,493	448,408	486,269	509,077	531,886
	Domestic (Includes Interim Guidelines and DCPs) ¹	25,827	68,829	79,676	311,960	476,939	487,658	444,114	400,571
	Tribal	274	730	845	1,187	1,346	1,460	1,528	1,597
Subtotal		117,333	312,693	361,973	708,640	926,693	975,387	954,720	934,053

¹ 2007 Interim Guidelines shortages, DCP contributions, and additional reductions are distributed among irrigation, domestic, and Tribal users as part of the CAP priority system. In California and Nevada, 2007 Interim Guidelines shortages and DCP contributions are attributed to the junior priority domestic diverter.

Disclaimer: These modeling results (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 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 of that process.

Cumulative Effects

If one of the Glen Canyon Dam/Smallmouth Bass flow options were implemented, there would be no additional changes to the distribution of shortages. The operating tiers established by this SEIS would inform the Glen Canyon Dam flow rates and volumes. Therefore, no additive cumulative effects would occur on water deliveries for Lower Division States due to operational changes evaluated in the EA.

3.8 Water Quality

3.8.1 Affected Environment

This section describes the water quality constituents that could potentially 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 historic 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 and 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 recommendations for the salinity criteria for the Colorado River every 3 years (Colorado River Basin Salinity Control Forum 2020). **Table 3-25** shows the current salinity criteria for the Colorado River.

While salinity in the Colorado River has generally decreased over the past century (USGS 2021), salinity has only slightly decreased since 2007. Salinity control results from the implementation of measures on private agricultural lands. 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 2022a). Despite these

salinity control efforts, there has been a consistent slowing of downward trends since 2000 (Rumsey 2021).

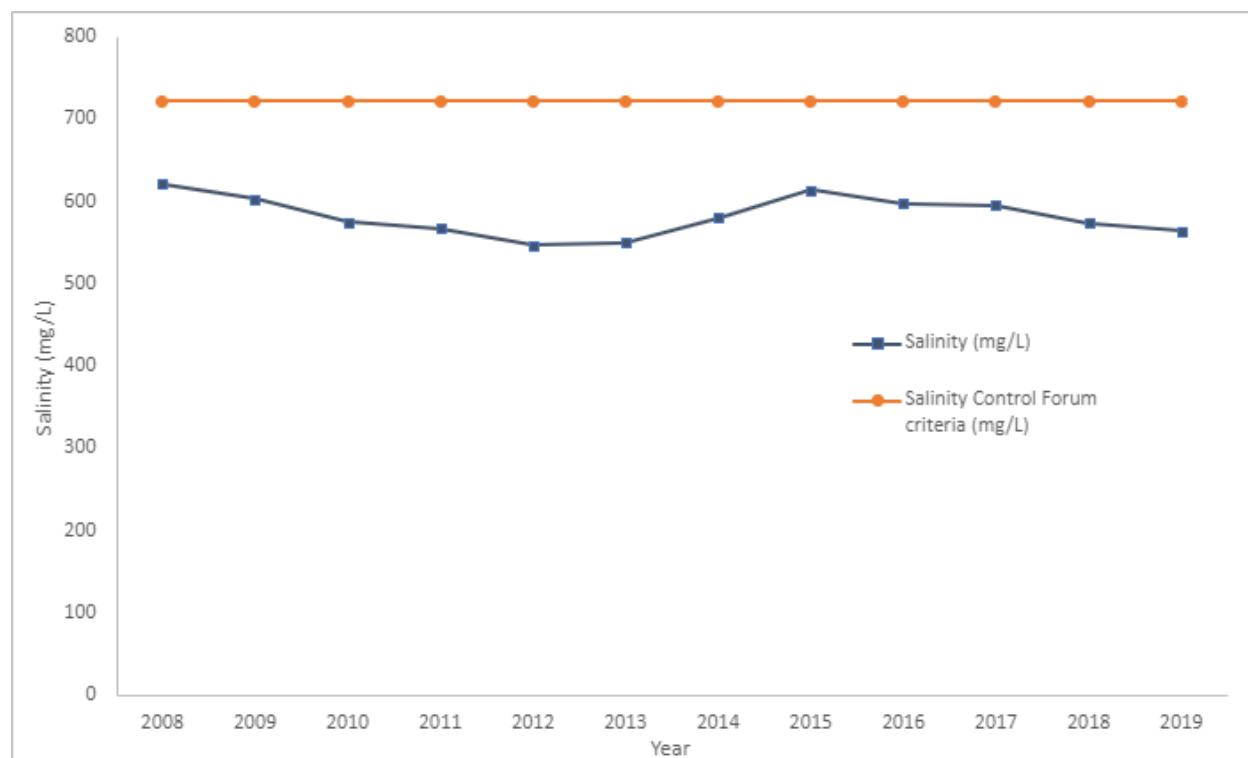
When the 2007 FEIS was released, salinity downstream of Glen Canyon Dam varied between 390 milligrams per liter (mg/L) to 660 mg/L; while, more recently, salinity has varied between 300 mg/L to 600 mg/L (Reclamation and NPS 2016). It is important to note that releases from lower elevations in Lake Powell are cooler and more saline compared to releases from higher 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 is described in **Table 3-25**. At the time of this report, data was not available after 2019 (Reclamation 2019a). (See **Figure 3-26**, **Figure 3-27**, and **Figure 3-28** for more information and historical salinity concentrations in the Lower Basin.)

Table 3-25
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

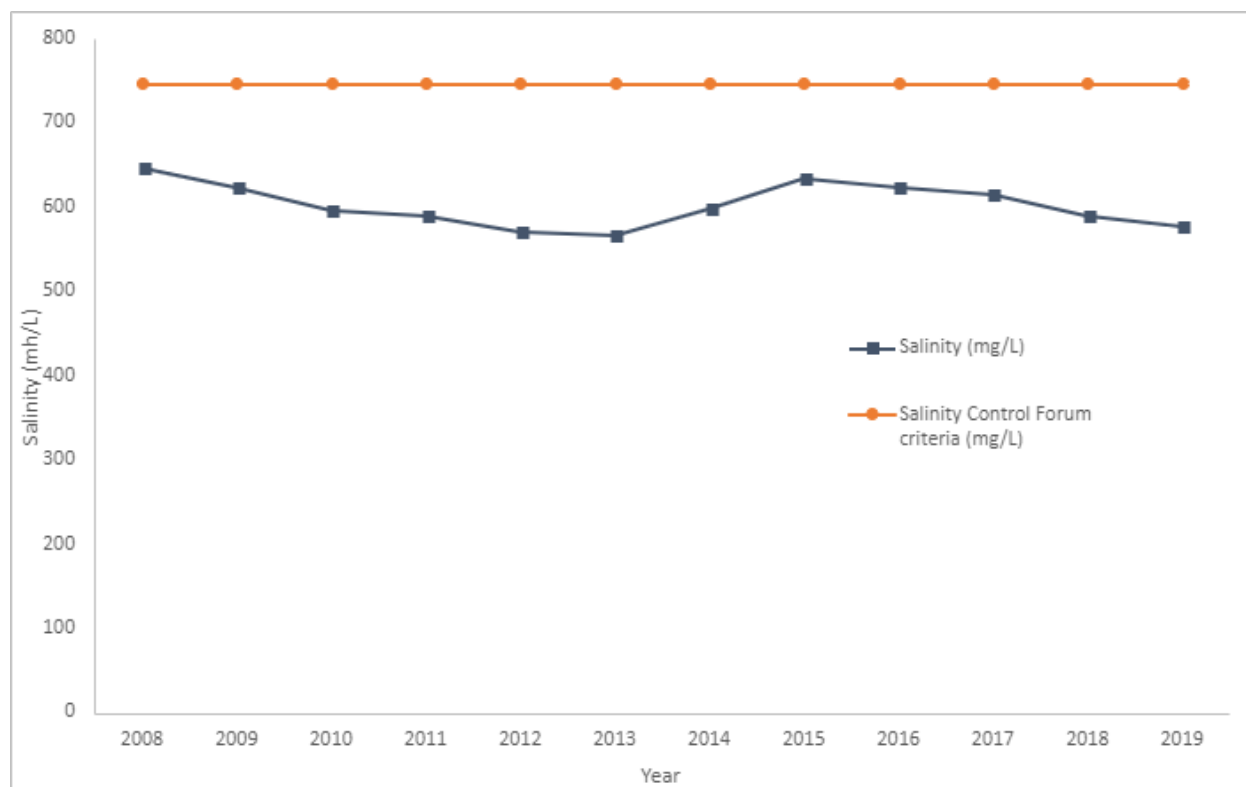
Source: Colorado River Salinity Control Forum 2020.

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



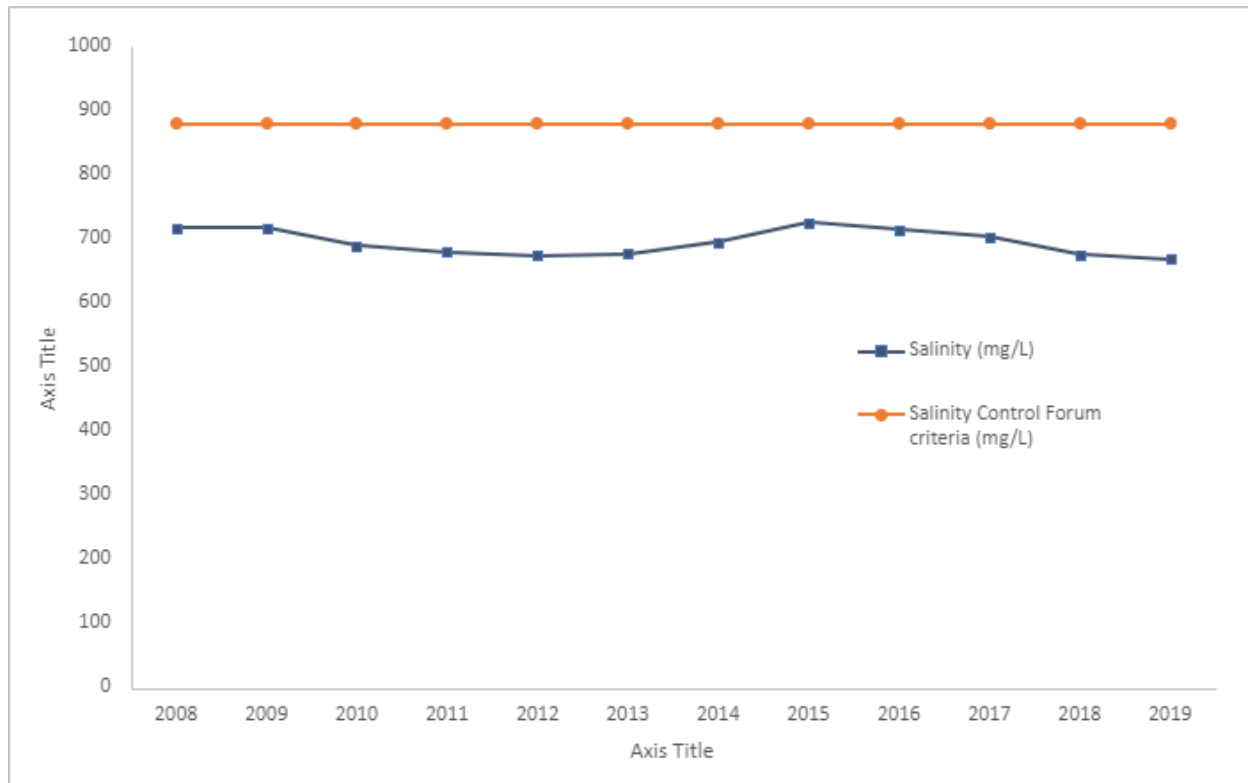
Source: Colorado River Basin Salinity Control Forum 2020

Figure 3-27
Colorado River Salinity Concentrations and Flows Downstream of Parker Dam 2007–2019



Source: Colorado River Basin Salinity Control Forum 2020

Figure 3-28
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 the Glen Canyon Dam (Reclamation and NPS 2016). Temperatures in the Colorado River in Grand Canyon are highly variable over space and time, and they 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 (e.g., below RM 88), the influence of release discharge 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 degree Celsius (°C) 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, which means that Lake Powell is arranged into layers with distinct temperatures and chemical characteristics. Generally, Lake Powell's epilimnion, or uppermost layer, ranges from 25°C-30°C in the summer and may drop to 6°C-10°C in the winter. Lake Powell's hypolimnion, or deeper layer, ranges from 6°C-9°C. In the winter, the thermal stratification breaks down and Lake Powell experiences turnover,

where the higher stratified layers mix with deeper waters. Full turnover does not occur every year, but partial turnover does. 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).

Lake Mead is also thermally stratified. The temperature that enters Lake Mead is influenced by the temperature of water released from Lake Powell (Reclamation and NPS 2016). Lake Mead's hypolimnion, or deepest layer, is around 12°C year-round. Lake Mead's epilimnion, or uppermost layer, ranges from about 14°C-29°C in the spring, summer, and early fall, then drops to about 13°C-15°C 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 the turbidity (cloudiness); a water quality measure that affects light penetration and photosynthesis for aquatic species. (See **Section 3.13.2** for a description of the effects of turbidity on fish.)

Downstream of Hoover Dam, large and 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 Dam and upstream of Laguna Dam to remove accumulated sediment and ensure efficient delivery of Colorado River water to downstream users (Reclamation 2021a and USGS 2022).

Sediment in the reach from Lake Powell to Lake Mead is dependent 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 wind transport that may help protect archaeological resources (Sankey et al. 2022). In addition, beaches provide camping areas for river and backcountry users (Hazel et al. 2022).

Sandbars 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 that are necessary for sandbar deposition (increased sandbar size), and sandbars erode between these events (Hazel et al. 2022). Reservoir drawdown and low flows, in conjunction with reduced sand deposition in eddies and on sandbars, have resulted and continue to result in net erosion of sand in this reach (USGS 2011 and USGS 2018).

River stage also affects the area of sand available for aeolian (wind) 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 three consecutive days, that sand is approximately as mobile as the sand which 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 Final EIS, turbidity increases due to erosion during HFEs are temporary and any observed fluctuations recover quickly when flows return to those less than those of an HFE magnitude (Reclamation and NPS 2016). These trends would continue under all the alternatives.

Nutrients and Algae

The 2007 FEIS described how deeper or hypolimnetic releases from Glen Canyon Dam are relatively nutrient rich, whereas epilimnetic or higher releases may cause a reduction of nutrients available to the downstream ecosystem. 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, but 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). Within 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, the increases in the temperatures of water entering Lake Mead led to a harmful algal bloom caused by a cyanobacteria, *Microcystis*, which may produce toxins that are harmful to humans, pets, and wildlife (Reclamation and NPS 2016). (See **Section 3.14** for information about harmful algal blooms impacts on recreation.)

No new TMDLs 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 Colorado River above Lee Ferry have been lower than historical levels in certain months over the last few years, but they are still within a similar average. Suspended sediment reduces DO in the inflow plume. This occurs whenever large sediment inputs occur and when sediment erodes from the reservoir banks. The Colorado River below Lee Ferry becomes oxygen saturated with mixing. The Colorado River DO increases approximately 1 mg/L between Glen Canyon Dam and Lee 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 3.5 mg/L in the fall and rising as high as 9mg/L-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, which are less than 5 mg/L, have become more common due to lower lake elevations that expose sediment to erosion and resuspension.

Generally, Lake Powell DO concentrations are at their highest near the surface of the reservoir in the spring to early summer when inflows are well oxygenated and photosynthetic activities, atmospheric reaeration, and wind-induced mixing are high. As the year progresses, DO concentrations decrease during the summer into the fall, as a result of organic matter decomposition. 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. The resulting discharged waters may eventually lead to higher DO in the downstream reach. Notably, when water is discharged through the river outlet works, such as during HFEs or the flow options evaluated here, it becomes well-aerated and increases the DO level. This aeration also occurs downstream of the Glen Canyon Dam in stretches of rapids (Reclamation and NPS 2016).

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, the more decomposition and low oxygen 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 described the sources of various metals, including selenium and mercury, within the planning area. Selenium and mercury are toxic to fish and wildlife and they can accumulate in the food web (Walters 2015). The Environmental Protection Agency (EPA) drinking water maximum contaminant level for mercury has not been updated since the 2007 FEIS; the MCL is 0.002 mg/L. The Lower Basin's selenium standard is 2 micrograms per liter (µg/L). The selenium in the Colorado River is about 1µg/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 described 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 & Electric Compressor Station near Needles, California. Since 2007, mitigation efforts and plume monitoring have been ongoing. The latest groundwater monitoring data indicates 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 Ave. and Holly Ave. 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).

Perchlorate

The 2007 FEIS described 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).

3.8.2 Environmental Consequences

Methodology

To understand the drivers of water quality change in Lake Powell, a 2D hydrodynamic model has been developed using CE-QUAL-W2 (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, and it is a similar constituent as 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 hydrological 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 hydrological information is 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, and it was still being calibrated for other constituents. Lake Powell modeling for the 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. Salinity inputs to the CE-QUAL-W2 Lake Powell model were generated using historic data and building Weighted Regressions on Time Discharge and Season models with a Kalman filter (Zhang and Hirsch 2019). Modeling with CE-QUAL-W2 was available for Glen Canyon Dam at the time of this report but additional modeling results from CE-QUAL-W2 and linear regression for Hoover Dam, Imperial Dam, and Parker Dam were not available at the time of this report.

A limited number of CRMMS traces were simulated due to time constraints associated with model run durations. Traces were identified that represented a range of different Lake Powell elevations, and they provided unique cases to test in the model. These cases included (1) the lowest elevation, (2) the lowest average elevation of traces that stay above power pool (3,490 feet), and (3) the highest

elevation. These cases were determined for the No Action Alternative, Action Alternative 1, and Action Alternative 2 scenarios independently, but selected traces were paired between each scenario to allow for direct comparison among models. This resulted in a total of six pairs of traces that were run in CE-QUAL-W2.

The traces simulated with CE-QUAL-W2 were further compared against release temperature projections made with the Small Mouth Bass temperature model. The temperature modeling for smallmouth bass was carried out using a model that resamples daily Glen Canyon Dam forebay profiles projected by CE-QUAL-W2 between 2010 and 2023, herein referred to as the Small Mouth Bass model. The Small Mouth Bass model accounts for effects of reservoir elevation, inflow magnitude, and month of year when resampling temperatures from forebay profiles.

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 were used to model and project DO concentration within a 10-meter envelope of the penstock depth for the 180 hydrological 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 the months of August, September, and October (1967-2022) were used to calculate yearly mean late summer/early fall DO concentrations in six 10-meter 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 hydrological traces being examined here (6 to <16 meters, 16 to <26 meters, 26 to <36 meters, 36 to <46 meters, 46 to <56 meters, and 56 to <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, the volume of the spring inflow, which were calculated as the inflow from April-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. 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. For the Sand Routing Model, USGS ran each hydrology trace with 22 possible Paria River sediment loads (the Paria River is a significant sediment source and tributary to the Colorado River), each associated with a 5-year period. The Sandbar Model was run with a subset of three Paria traces (1993–2003, 2011–2016, and 2017–2022), representing a large range of potential cumulative Paria sand load values. The Sandbar Model was calibrated to a set of the nine most dynamic sandbars out of the forty-five sandbars that are monitored long-term. The calibration period was 2015–2022. Historic and current (observation) data for sediment and flows from river mile (RM) 30 gage were used as inputs for the Sandbar model. Observation data for Paria sediment load time series from RM30, RM61, and RM87 were used as inputs for the Sand Routing Model. For future projections, projected hourly flow releases from the WAPA Generation and Transmission Maximization Model (GTMax) Model and the Paria sediment load traces were used as inputs for the Sand Routing model. Sediment and flow data obtained from the Sand Routing Model at RM30 were then used to calculate the Sandbar Model future projections.

Assumptions

Under the CE-QUAL-W2 model, the testing of the “new” Lake Powell water quality model was carried out over a 12-year 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 was 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) was used to evaluate model projections.

Release temperatures were evaluated based on 16°C and 20°C thresholds. When temperatures exceed a 16°C threshold for extended periods of time, the likelihood that smallmouth bass and other warmwater nonnatives increase in abundance is much higher, while when temperatures exceed 20 °C for longer periods of time it is 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, while rainbow trout are a desired species for the Blue Ribbon fishery in the tailwater segment of Glen Canyon Dam. See **Section 3.13** for more information.

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 <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 that has been 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 the Glen Canyon Dam, so we consider 8 mg/L DO 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. Future work to constrain the relationship between bypass spill rate and reaeration would help to more accurately model outflow DO concentrations resulting from bypass spill. 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 was observed in 2021.

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 assumes a constant exponential erosion rate that is independent of discharge. It does 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 hydrology traces include 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 (20,000–30,000 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.

Impact Indicators

For all alternatives evaluated, the following indicators were used to assess impacts.

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

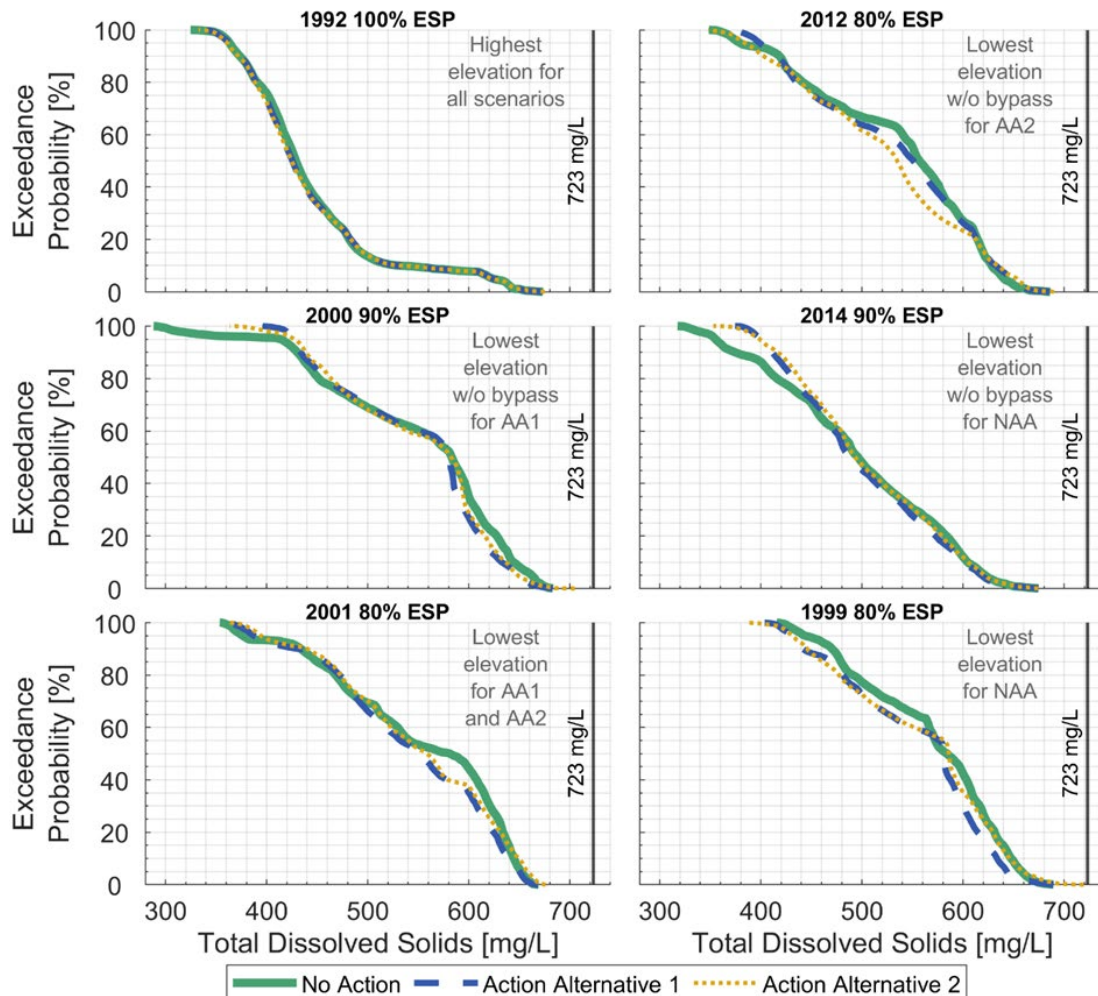
Issue 1: How would elevation protection and low-flow conditions affect salinity within each reach?

Summary

There is no limit for salinity concentration in waters released from Glen Canyon Dam; however, Hoover Dam has a limit of 723 mg/L as seen in **Table 3-25**. There is cyclical relationship between the salinity of inflows to Lake Powell and the salinity of waters below Hoover Dam that typically follows a two-year lag. These salinity levels are a major factor driving salinity in Lake Mead (Tillman et al. 2019). While this report cannot speak to modeled salinity concentrations in Lake Mead and releases from Hoover Dam, as seen in **Figure 3-29**, under every alternative, future salinity of Glen Canyon Dam releases would not exceed the numeric salinity criteria set for Hoover Dam. The CE-QUAL-W2 2D hydrodynamic model results also illustrated a general trend between Lake Powell elevation and salinity concentrations. Generally, when Lake Powell's elevations were high (trace 1992 100 percent ESP), salinity releases were lowest. Conversely, Lake Powell's elevations at 3,500 feet or lower resulted in high projected salinity concentrations as seen in **Figure 3-29**. (For a description of the six traces chosen, see the *Methodology* section.)

Under the No Action Alternative, Lake Powell is much more likely to reach dead pool, 3,370 feet. If Lake Powell were to reach dead pool, it would lead to an increase in salinity. (See **Section 3.4**, Hydrologic Resources, for more information.)

Figure 3-29
Exceedance Probability for Salinity*Concentrations in Glen Canyon Dam Releases



Source: USGS 2023a

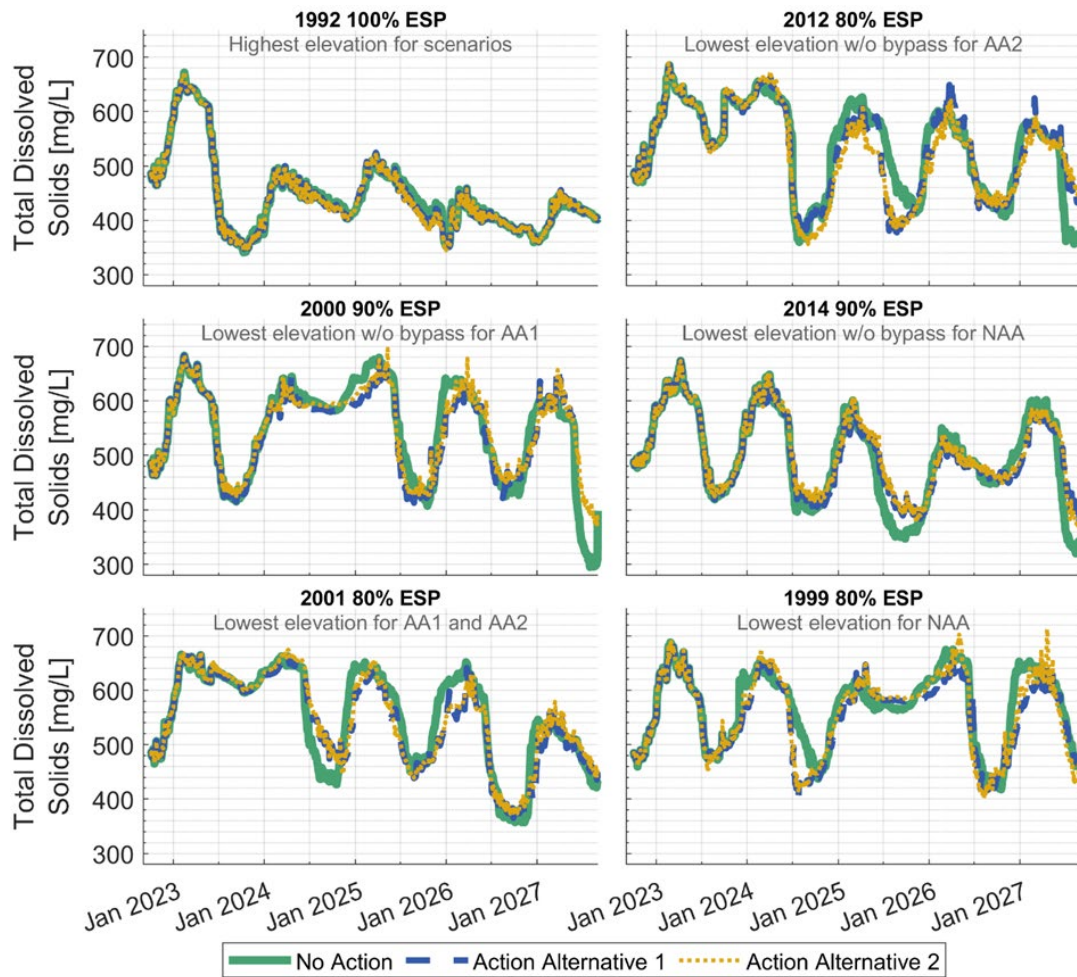
* Salinity is the measure of the amount of dissolved salt in water, where TDS measures all dissolved solids in a water sample, and it is a similar constituent as it estimates the level of salt within a water sample. TDS was used in the CE-QUAL-W2 model as a proxy for salinity.

No Action Alternative

Under the No Action Alternative, salinity concentrations in waters released from Glen Canyon Dam would not exceed 723 mg/L, which is the numeric salinity criteria for Hoover Dam as seen in **Figure 3-29**. 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 3-30 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 3-30
Projected Release Salinity* Concentration (mg/L) from Glen Canyon Dam Over the 5-
Year Simulation Period



Source: USGS 2023a

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

Action Alternative 1

Under Action Alternative 1, salinity concentrations in waters released from Glen Canyon Dam would not exceed 723 mg/L, which is the numeric salinity criteria for Hoover Dam as seen in **Figure 3-29**. 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 3-30 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.

Action Alternative 2

Under Action Alternative 2, salinity concentrations in waters released from Glen Canyon Dam would not exceed 723 mg/L, which is the numeric salinity criteria for Hoover Dam as seen in **Figure 3-29**. 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.

The CE-QUAL-W2 results for Action Alternative 2 also illustrated a general trend between Lake Powell elevation and salinity concentrations. Generally, when lake elevations were high (trace 1992 100 percent ESP), salinity releases were lowest. Conversely, lake elevations at 3,500 feet or lower resulted in high projected salinity concentrations as seen in **Figure 3-29**. **Figure 3-30** 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.

Cumulative Effects

If one of the Glen Canyon Dam/Smallmouth Bass flow options were implemented, Reclamation would change how and when releases from Glen Canyon Dam took place. Each of these flow options includes releasing water through the river outlet works, which are lower than the penstocks 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.

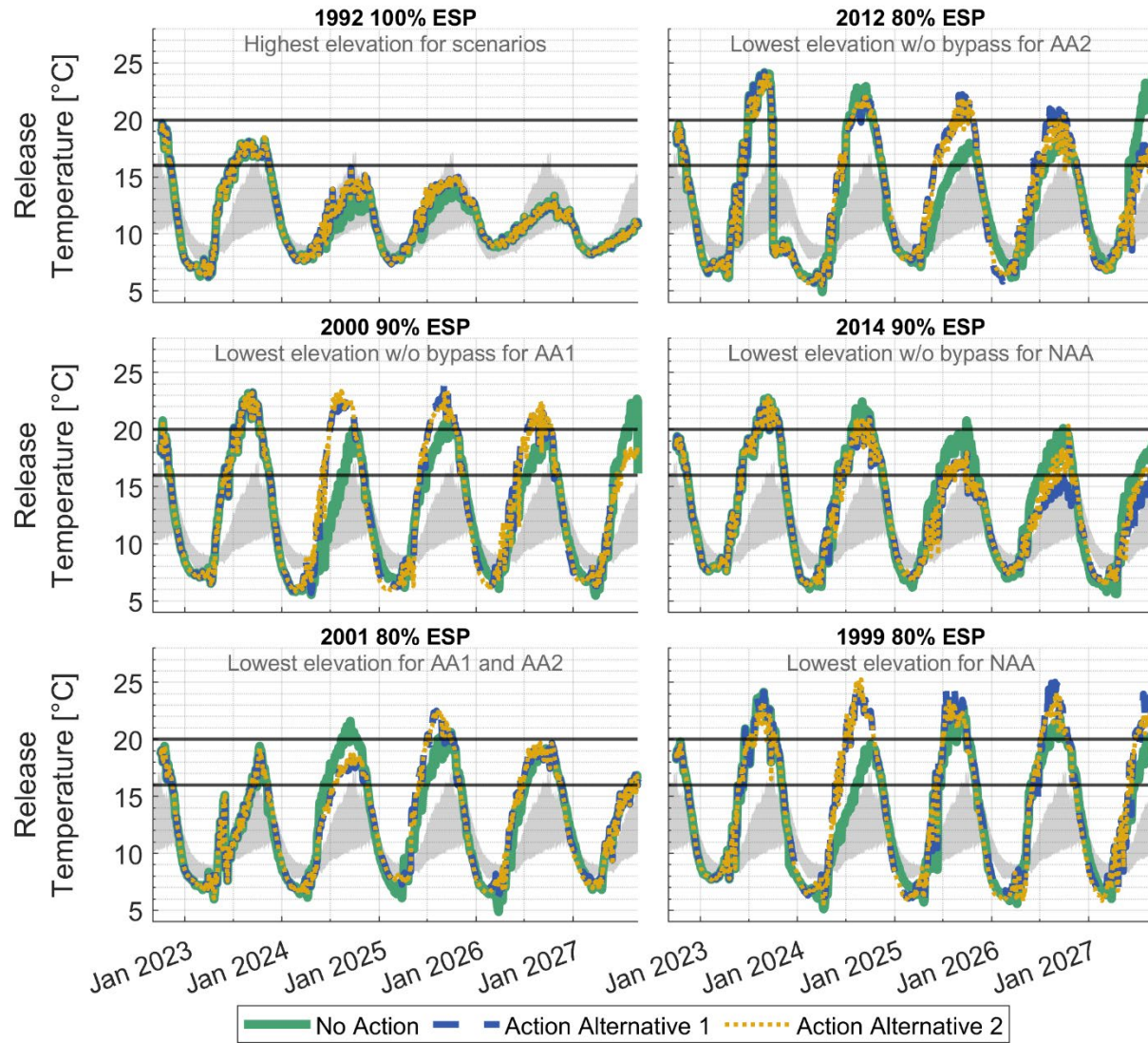
Issue 2: How would elevation protection and low-flow conditions affect temperature within each reach?

Summary

As seen in **Figure 3-31**, projected temperature releases varied greatly among different scenarios. (For a description of the six 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 is 3,490 feet, or from the river outlet works, which is 3,370 feet.

As seen in the CE-QUAL-W2 model results for Glen Canyon Dam releases in **Figure 3-31**, warmest temperatures were observed in trace 1999 80 percent ESP for the action alternatives, where pool elevation hovered near 3,500 feet just above power pool and released from the penstocks from 2023-2026. Conversely, under the No Action Alternative, the selected traces show a cooling over time due to water being released from colder hypolimnetic waters adjacent to the river outlet works. This is due to elevations dropping below minimum power pool where releases through the river outlet works are necessary. Release temperatures were coldest when reservoir elevations were highest under all alternatives. This last point is critical to consider as the No Action Alternative may result in lower temperatures from 2023 through 2026, but under the No Action Alternative, Lake Powell is much more likely to reach dead pool, which is 3,370 feet. If Lake Powell were to reach dead pool, it would lead to a large increase in temperature.

Figure 3-31
Projected Release Temperatures from Glen Canyon Dam Over the 5-Year Simulation
Period for Each Selected Trace and Management Scenario*



Source: USGS 2023a

*Hourly projections from the model were averaged to daily values for illustrative purposes. Horizontal black lines represent 16 °C and 20 °C temperature thresholds. The grey shaded area represents historical daily average temperatures within the 10th and 90th percentiles from 2010 to present.

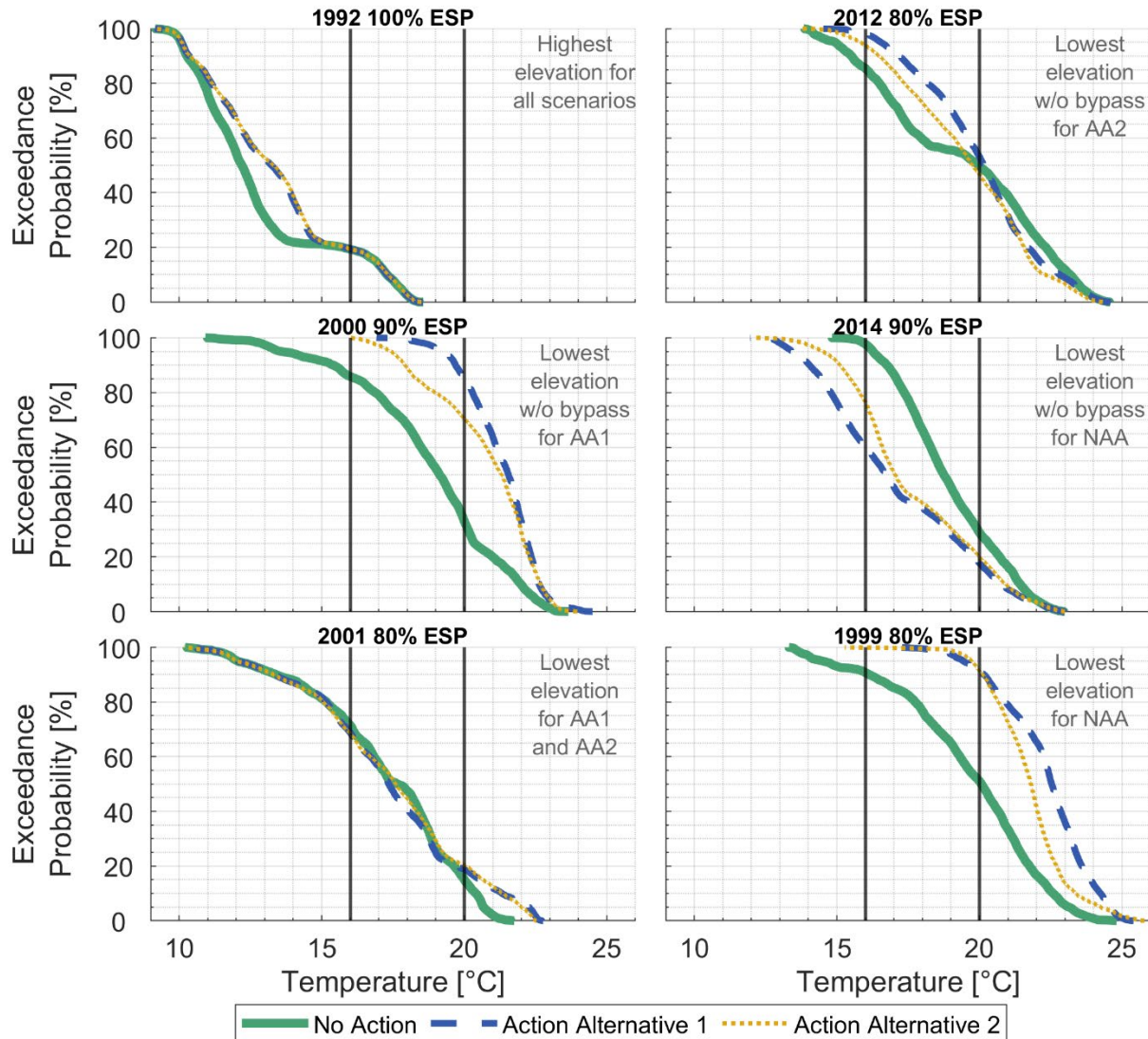
As seen in **Figure 3-32**, the temperature of Lake Powell releases was evaluated based on important temperature thresholds for smallmouth bass and rainbow trout. Smallmouth bass are a concern because the Service's 2018 species status assessment listed this invasive predator as one of the biggest threats to the federally listed humpback chub in the Grand Canyon. When temperatures exceed 16°C, the likelihood that smallmouth bass and other warmwater nonnatives increase in abundance is much higher, while when temperatures exceed 20°C for longer periods of time it is expected to negatively impact salmonids. See **Section 3.13** for more information. In the six traces modeled, the highest probability of release temperature exceeding 16°C was 98 percent for the No Action Alternative in trace 2014 and 90 percent and 100 percent for both action alternatives in traces 2000 90 percent ESP and 1999 80 percent. In the six traces modeled, the highest probability of release temperatures exceeding the 20°C threshold was 51 percent for the No Action Alternative under trace 1999 80 percent ESP, 92 percent for Action Alternative 1 in trace 1999 80 percent ESP, and 91 percent for Action Alternative 2 in trace 1999 80 percent ESP. Release temperatures are strongly tied to where water would be released from which impacted the probability of the No Action Alternative as releases from the river outlet works would be necessary.

Generally, there is good agreement between release temperature projections from the Small Mouth Bass and CE-QUAL-W2 Lake Powell models among all selected traces and management alternatives (**Figure 3-33**). The Small Mouth Bass and CE-QUAL-W2 models had the best agreement in trace 2014 90 percent ESP for both the No Action Alternative and Action Alternative 1 and trace 1992 100 percent ESP for Action Alternative 2 based on reported RMSE values. There is also good model agreement for trace 1999 80 percent ESP under Action Alternative 1 and Action Alternative 2 based on R2 values, both of which had similar Lake Powell elevations, both hovering around 3,500 feet over the 5-year simulation period. The greatest disagreement between models occurred in traces that drop below power pool, especially under the No Action Alternative where 4 of the 6 traces were below power pool for most of the 5-year simulation period.

In examining the full ensemble of hydrologic traces generated by CRMMS using the smallmouth bass model, Action Alternative 1 and Action Alternative 2 would lead to slightly fewer days above 16°C and 20°C on average when compared to the No Action Alternative (**Figure 3-34** and **Figure 3-35**).

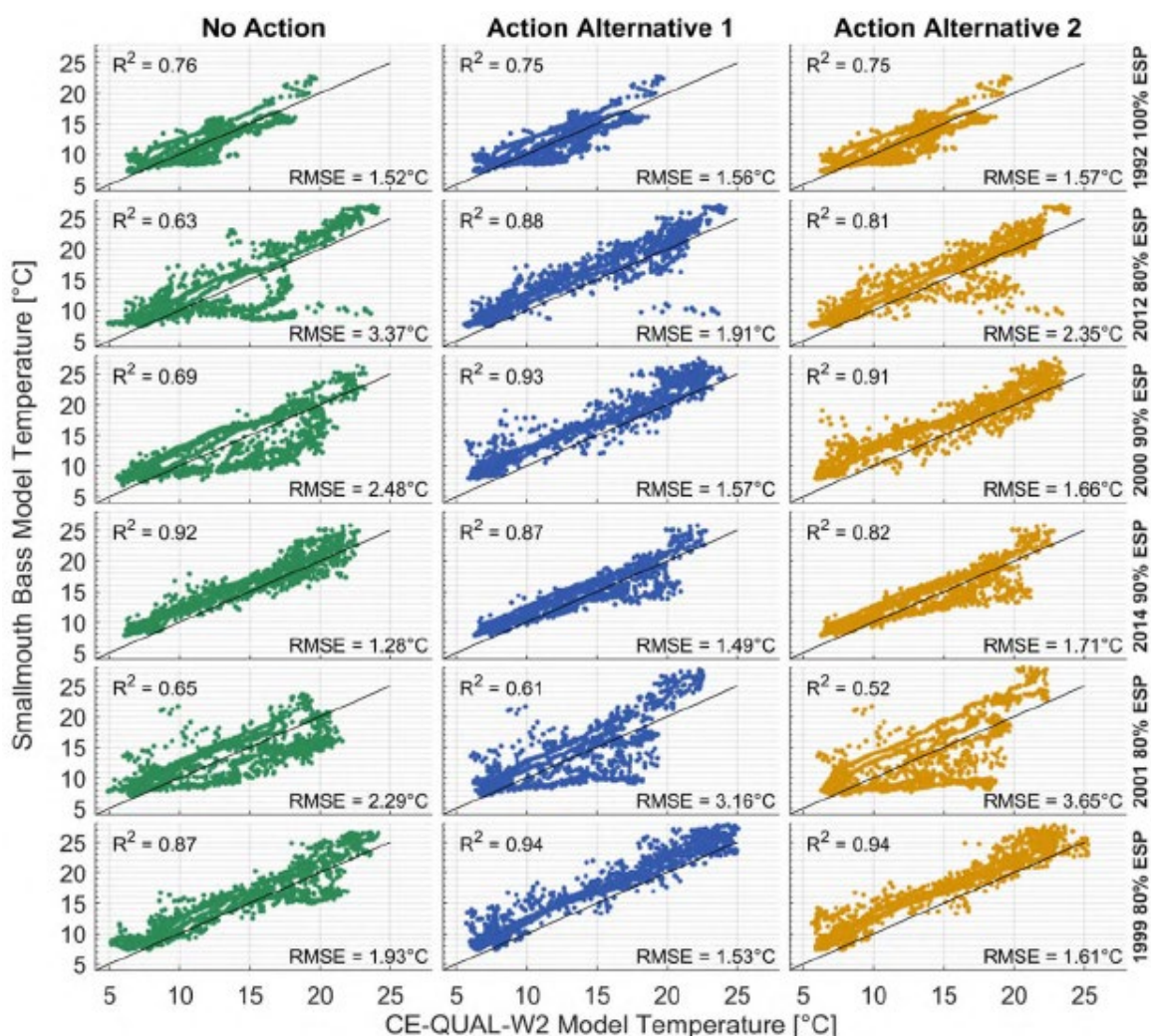
Glen Canyon Dam release temperatures are related to Hoover Dam release temperatures, but this analysis cannot speak to the release temperatures of Hoover Dam without more modeling.

Figure 3-32
Percent Probability of Summertime (July, August, and September) Release
Temperatures Exceeding Temperature Thresholds from Glen Canyon Dam Over the 5-
Year Simulation Period for Each Selected Trace and Management Scenario



Source: USGS 2023a

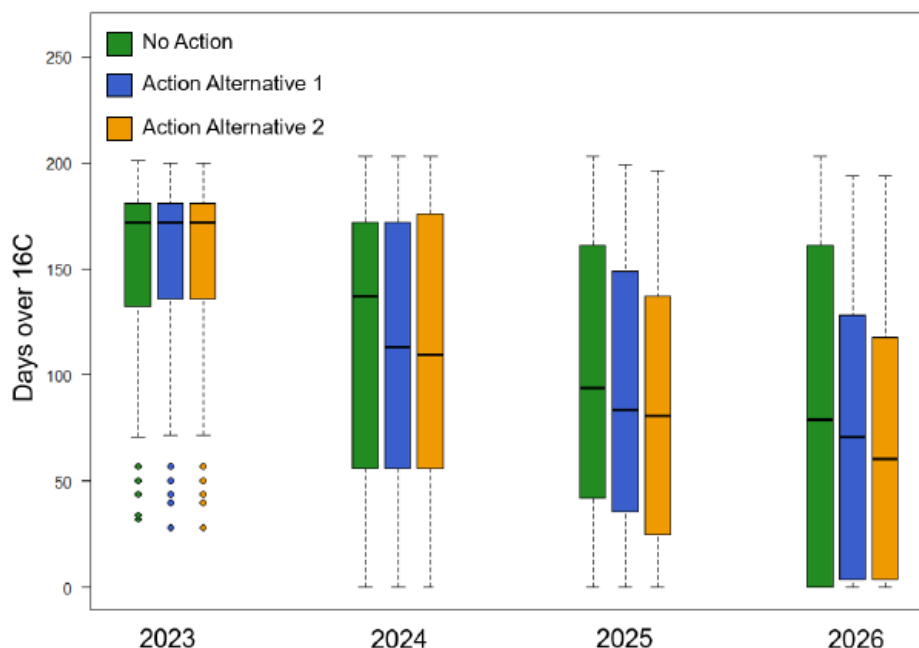
Figure 3-33
Scatter Plots Comparing CE-QUAL-W2 and Small Mouth Bass Model Daily Average
Release Temperature Projections for Each Selected Trace*



Source: USGS 2023a

*Trace names are shown on the right-hand side of each row of plots. The diagonal black lines indicate a 1:1 relationship.

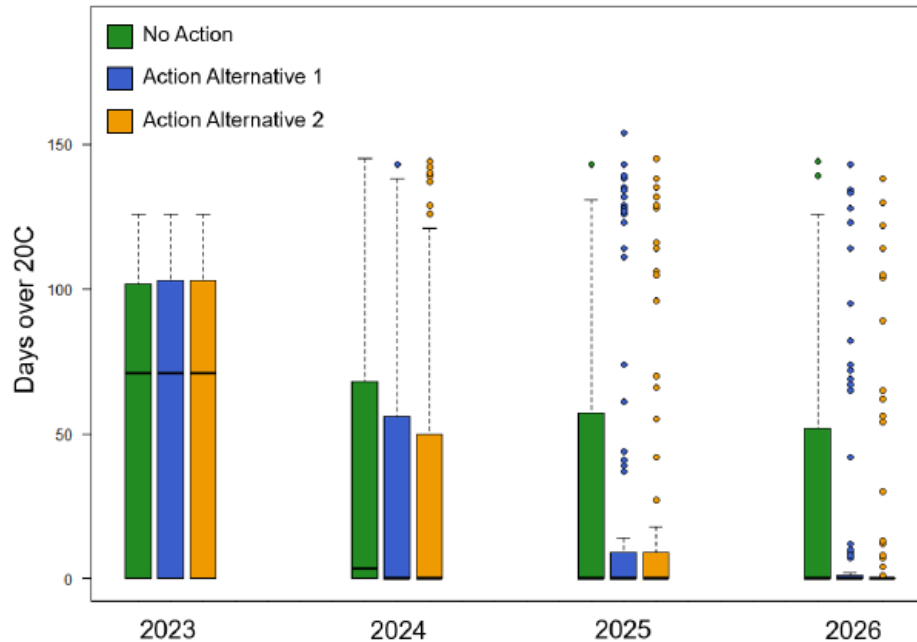
Figure 3-34
Box Plots Showing the Number of Days with an Average Glen Canyon Dam Release Temperature over 16 °C for all CRMMS Traces and each Alternative for Operating Years 2023–2026*



Source: USGS 2023a

* 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.

Figure 3-35
Box Plots Showing the Number of Days with an Average Glen Canyon Dam Release Temperature over 20°C for all CRMMS Traces and each Alternative for Operating Years 2023–2026*



Source: USGS 2023a

* 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.

No Action Alternative

As seen in the CE-QUAL-W2 model results for Glen Canyon Dam releases in **Figure 3-31**, water temperature releases were high in trace 1999 80 percent ESP when lake elevations were just above power pool in July 2023 and after elevations dropped closer to the bypass elevation of 3,370 feet in July 2025 and subsequent years. The coldest release temperatures occurred when reservoir elevations were the highest.

In the six traces examined using CE-QUAL-W2, for the No Action Alternative, trace 2014 90 percent ESP had the highest probability of dam releases exceeding the 16°C threshold with a 98 percent probability of occurring. The probability of exceeding the 20°C threshold under the No Action Alternative was 51 percent in trace 1999 80 percent ESP. Release temperatures are 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.

Release temperatures were coldest when reservoir elevations were highest. This last point is critical to consider as the No Action Alternative may result in lower temperatures. However, under the No Action Alternative, Lake Powell is much more likely to reach dead pool. If Lake Powell were to reach dead pool, 3,370 feet, it would lead to a large increase in temperatures.

Action Alternative 1

Action Alternative 1 scenarios resulted in higher temperatures relative to the No Action Alternative where pool elevation hovered near 3,500 feet just above power pool and water would be released from the penstocks. As seen in **Figure 3-31**, the warmest water release temperatures were observed in trace 1999 80 percent ESP where pool elevation hovered around 3,500 feet from 2023-2026. The minimum elevation trace, 2001 80 percent ESP, for Action Alternative 1 had relatively lower water temperatures compared to the 1999 80 percent ESP trace.

The coldest release temperatures occurred when reservoir elevations were the highest.

For Action Alternative 1, in the six traces examined using CE-QUAL-W2, 2000 90 percent ESP and 1999 80 percent ESP traces had the highest probability of release temperatures exceeding 16°C at 100 percent. The probability of exceeding the 20°C threshold under Action Alternative 1 was 92 percent in trace 1999 80 percent ESP.

Action Alternative 2

Action Alternative 2 scenarios resulted in higher temperatures relative to the No Action Alternative where pool elevation hovered near 3500 feet just above power pool and water would be released from the penstocks. As seen in **Figure 3-31**, the warmest water release temperatures were observed in trace 1999 80 percent ESP where pool elevation hovered around 3,500 feet from 2023-2026. The minimum elevation trace, 2001 80 percent ESP, for Action Alternative 2 had relatively lower water temperatures compared to the 1999 80 percent ESP trace. The coldest release temperatures occurred when reservoir elevations were the highest.

For Action Alternative 2, in the six traces examined using CE-QUAL-W2, 2000 90 percent ESP and 1999 80 percent ESP traces had the highest probability of release temperatures exceeding 16°C at 100 percent. The probability of exceeding the 20°C threshold under Action Alternative 2 was 91 percent in trace 1999 80 percent ESP.

Cumulative Effects

If one of the Glen Canyon Dam/Smallmouth Bass flow options were implemented, Reclamation would change how and when releases from Glen Canyon Dam would take place. Each of these flow options includes releasing water through the river outlet works, which are lower than the penstocks 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.

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

Summary

Under all alternatives, HFEs in the reach between Lake Powell and Lake Mead (in Marble and Grand Canyons) would not be implemented when Lake Powell elevations are below the Protection Level (3,500 feet). Under all alternatives and given the current LTEMP protocols, the modeling results indicate that spring HFEs would only be triggered for approximately 15 percent of the time

and fall HFEs would be triggered approximately 70 percent of the time, each year, between 2024 and 2026 (see **Figure 3-36**). Net erosion of sandbars would occur, and sandbar building would decrease, if HFEs cannot be implemented (see **Figure 3-37**). However, Action Alternatives 1 and 2 would reduce the potential of elevations below the Protection Level, and, therefore, would increase the probability of HFE implementation compared with the No Action Alternative.

In **Figure 3-36**, the blue (leftmost) “sediment-triggered” bars 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 accounting window. The orange (middle) “volume constraint” bars 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 3-26**). The yellow (rightmost) bars represent the probability an HFE of the indicated duration could be implemented given the volume constraint combined with the Lake Powell Protection Level (greater than 3,500 feet) constraint. 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 3-26
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

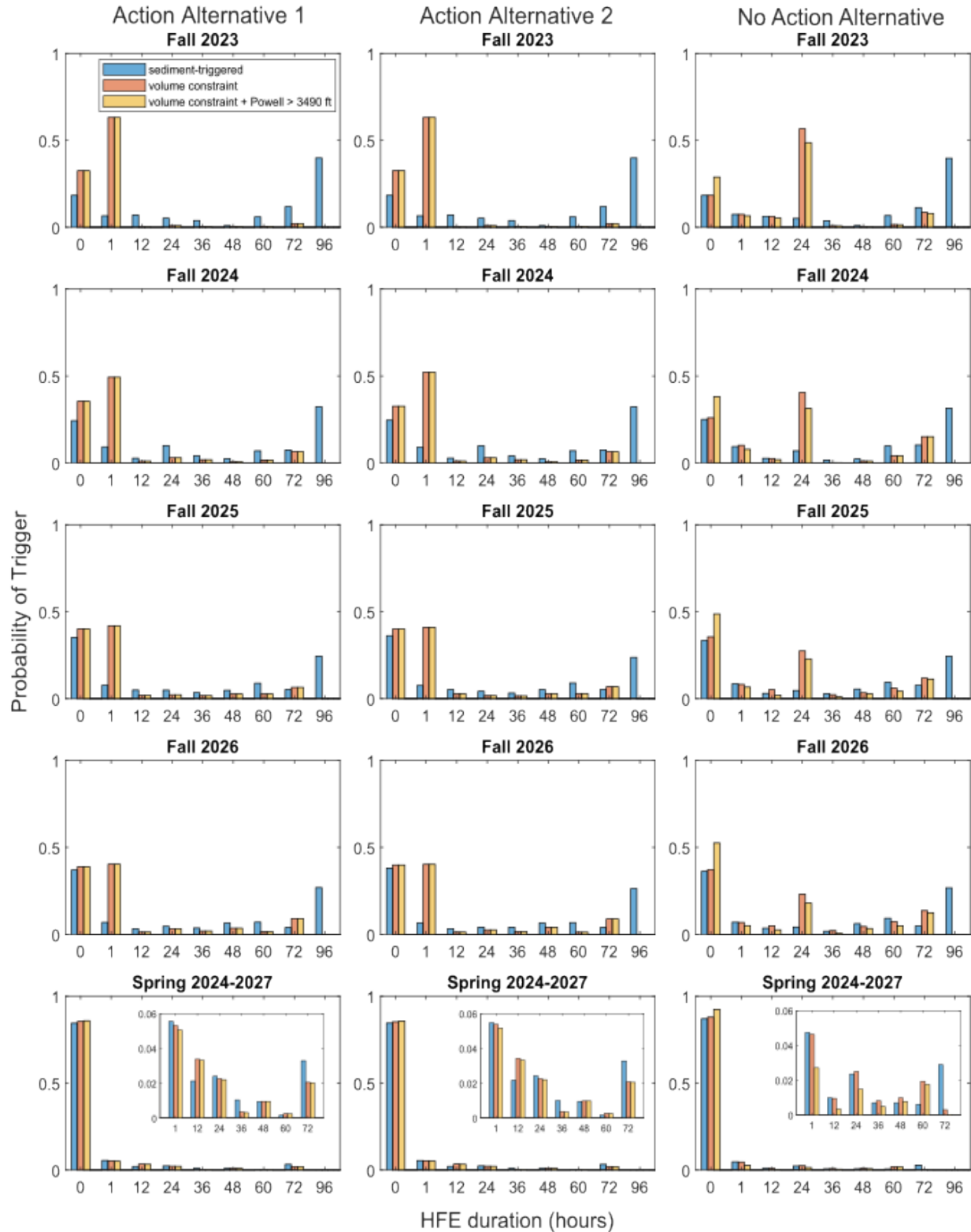
Source: Salter and Grams 2023

¹Total 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 and volume constraint combined with the Lake Powell Protection Level constraint would cause HFEs of longer duration (12 to 96 hours) to be substituted with one-hour HFEs (see **Figure 3-36**). Based on the Mueller and Grams (2021) sandbar model, a one-hour HFE is projected to be less than 5 percent as effective as a 96-hour HFE. 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 the LTEMP to be implemented when there was insufficient sediment available for longer duration HFEs (Reclamation and NPS 2016).

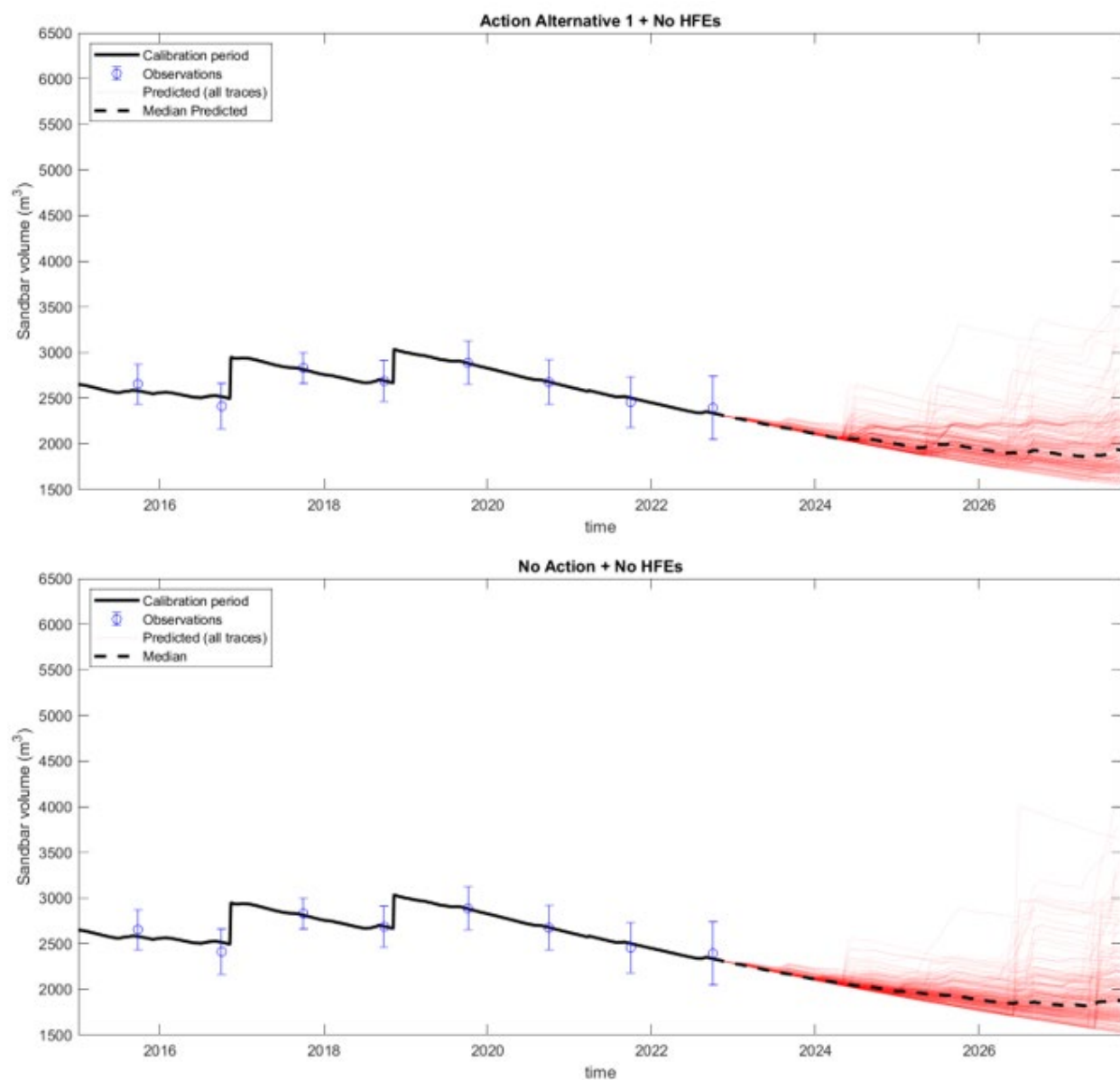
Sediment dredging projects in the reach below the Hoover Dam that ensure water delivery to downstream users would continue under all alternatives.

Figure 3-36
Probabilities of HFE Trigger under LTEMP Sediment Accounting Windows



Source: Salter and Grams 2023

Figure 3-37
Observed and Predicated Sandbar Volume with no HFE Implementation



Source: Salter and Grams 2023

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 deposition in the Marble and Grand Canyons would be insufficient to build sandbars. In addition, sandbars would progressively erode between current conditions and through 2026 (see **Figure 3-37**).

Under the No Action Alternative, current modeling demonstrates that spring HFEs would only be triggered for approximately 15 percent of the time and fall HFEs would be triggered approximately 70 percent of the time, each year, between 2024 and 2026 under the LTEMP protocols (see **Figure 3-36**). 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 hydrology inputs and slightly different sediment assumptions (Reclamation and NPS 2016). It should be noted that there has not been an HFE since 2018. If neither spring or fall HFEs can be implemented, net erosion of sandbars would continue, and existing sandbars would erode (Salter and Grams 2023).

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

Action Alternative 1

According to the modeling results, fall and spring HFEs under Action Alternative 1 would be triggered for approximately the same occurrence (15 percent of the time for spring HFEs and 70 percent of the time for fall HFEs) as the No Action Alternative (see **Figure 3-36**). Impacts on sediment in the reach between Lake Powell and Lake Mead when Lake Powell elevations are below the Protection Level (3,500 feet) would be the same as described under the No Action Alternative. However, the potential for the elevation to drop below this level would decrease under Action Alternative 1. This would increase the potential for HFE implementation compared with the No Action Alternative. If neither spring or fall HFEs can be implemented, net erosion of sandbars would continue, and existing sandbars would erode (Salter and Grams 2023).

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

Action Alternative 2

There are negligible differences between the modeling results for Action Alternatives 1 and 2 (see **Figure 3-36**). Therefore, impacts on sediment in the reach between Lake Powell and Lake Mead would be the same as those described under Action Alternative 1.

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

Cumulative Effects

If one of the Glen Canyon Dam/Smallmouth Bass flow options were implemented this would change how and when releases from Glen Canyon Dam occur. Each of these flow options 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 have a greater influence on the probability of triggering an HFE. The probability would likely decrease. Action Alternatives 1 and 2 would reduce this cumulative effect, compared with the No Action Alternative, because these alternatives would reduce the potential for Lake Powell elevation dropping below the Protection Level. 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.

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

Summary

As Action Alternative 1 and 2 would lead to slightly higher temperatures, these may provide more opportunities for algal growth. Declining water levels in Lake Powell could promote cyanobacteria blooms, but this remains to be studied (Yang et al. 2016). However, while the No Action Alternative may result in lower temperatures, under the No Action Alternative, Lake Powell is much more likely to reach dead pool, which is 3,370 feet. If Lake Powell were to reach dead pool, temperatures would be expected to rise. This increase in temperature would create more opportunities for algal growth.

Additionally, an increased probability of low DO events would create more bioavailable phosphorus, which may also provide more opportunities for algal growth under Action Alternatives 1 and 2 as seen in **Figure 3-38**. DO is discussed in more detail under *Issue 5*.

Lower flows under Action Alternatives 1 and 2 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; 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 slightly cooler temperatures than Action Alternatives 1 or 2, as discussed under *Issue 2*.

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 2023).

Figure 3-38
Projections of mean August-October DO concentrations in Glen Canyon Dam outflows for each projection year under Action Alternative 1, Action Alternative 2, and No Action Alternative



Source: USGS 2023b

Under the No Action Alternative, low DO events occur in 68 percent of years as shown in **Figure 3-38**. This occurs in the late summer and early fall, which could lead to more bioavailable phosphorus and opportunities for algal growth.

Action Alternative 1

A key determinant of release temperature is Lake Powell's reservoir elevation relative to where water is being released, either from the penstocks at 3,490 feet or from the river outlet works at 3,370 feet. Due to water levels being held just above power pool for extended periods of time in the Action Alternative 1, these scenarios resulted in higher temperatures relative to the No Action Alternative.

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 Action Alternative 1, low DO events would occur in 91 percent of years as shown in **Figure 3-38**. There is an increased probability of decreased DO concentrations in the late summer and early fall, which could lead to more bioavailable phosphorus and opportunities for algal growth.

Action Alternative 2

A key determinant of release temperature is Lake Powell's reservoir elevation relative to where water is being released, either from the penstocks at 3,490 feet or from the river outlet works at 3,370 feet. Due to water levels being held just above power pool for extended periods of time in the Action Alternative 2, these scenarios resulted in higher temperatures relative to the No Action Alternative.

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 Action Alternative 2, low DO events would occur 91 percent of years as shown in **Figure 3-38**. There is an increased probability of decreased DO concentrations in the late summer and early fall, which could lead to more bioavailable phosphorus and opportunities for algal growth.

Cumulative Effects

If one of the Glen Canyon Dam/Smallmouth Bass flow options were implemented, Reclamation would change how and when releases from Glen Canyon Dam took place. Each of these flow options includes releasing water through the river outlet works, which are lower than the penstocks 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.

Issue 5: 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 metalimnion¹³ in September or early October but have been observed as early as August in response to large spring inflows, such as from snowmelt.

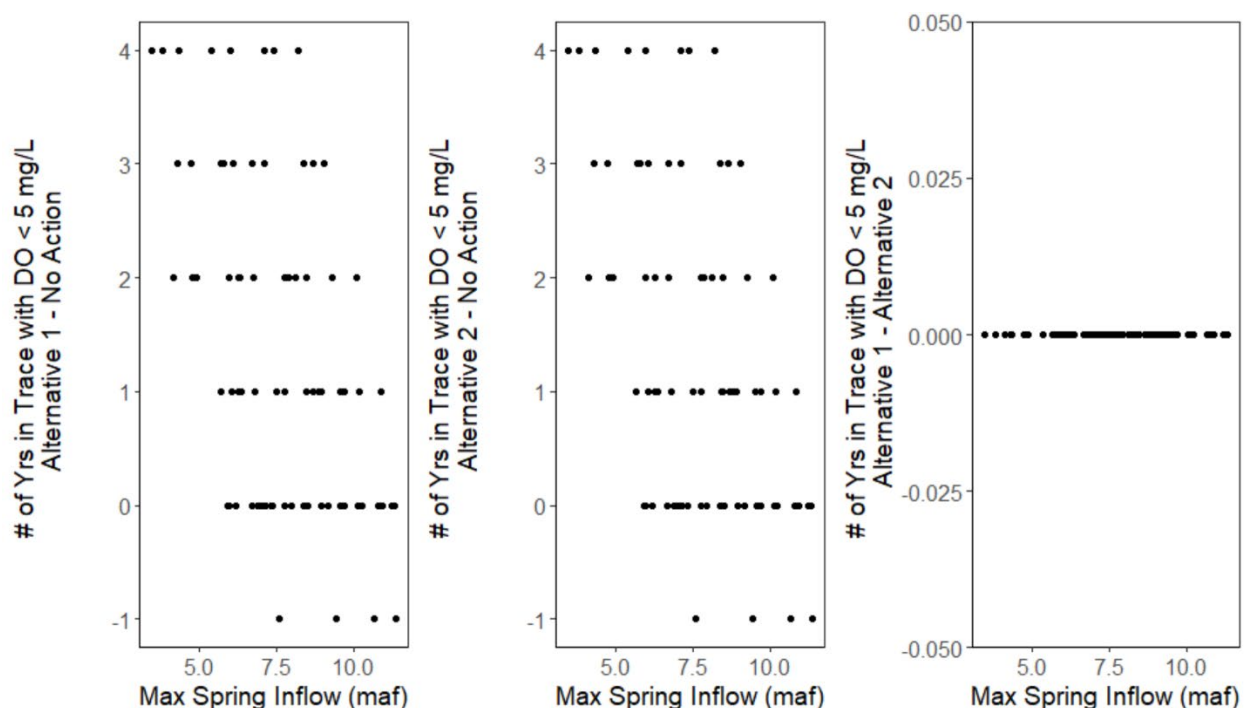
As seen in **Figure 3-38**, across all alternatives, mean August to October DO ^{50%} in Lake Powell is projected to drop below 5 mg/L in 83 percent of traces. The probability of low DO events occurring in the tailwater would be more likely under the action alternatives than the No Action Alternative. This difference increases during later years due to the use of the river outlet works

¹³ The metalimnion is the middle layer in a thermally stratified lake or reservoir.

under the No Action Alternative, which provides aeration. **Figure 3-38** shows a dashed red line for 5mg/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 8mg/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).

As seen in **Figure 3-39**, there were no differences in the modeled probability of low DO events between the action alternatives.

Figure 3-39
Differences in the Number of Years Within Each Trace Likely to Have a Low DO Event
As a Function of Maximum Spring Inflow in the Trace



Source: USGS 2023b

No Action Alternative

Under the No Action Alternative, Glen Canyon Dam releases mean August-October DO levels would drop below 5 mg/L in 68 percent of years. DO also has an increasing trend over time on an August-October time period as release through the river outlet works is predicted to increase under this alternative, especially in later years. **Figure 3-38** shows the modeled mean August-October DO concentrations in Glen Canyon Dam outflows for each model year under the No Action Alternative in blue.

Action Alternative 1

Under Action Alternative 1, Glen Canyon Dam releases mean August-October DO levels would drop below 5 mg/L in 91 percent of years. **Figure 3-38** shows the projections of mean August-

October DO concentrations in Glen Canyon Dam releases for each projection year under Action Alternative 1 in pink.

Under Action Alternative 1, it would be more likely that the tailwater¹⁴ below Glen Canyon Dam would have more low DO events than under the No Action Alternative because of the No Action Alternative's increased use of the river outlet works which aerate the releases.

Action Alternative 2

Under Action Alternative 2, Glen Canyon Dam releases mean August-October DO levels would drop below 5 mg/L in 91 percent of years. **Figure 3-38** shows the projections of mean August-October DO concentrations in Glen Canyon Dam releases for each projection year under Action Alternative 2 in green.

Under Action Alternative 2, it would be more likely that the tailwater below Glen Canyon Dam would have more low DO events than under the No Action Alternative because of the No Action Alternative's increased use of the river outlet works which aerate the releases.

Cumulative Effects

If one of the Glen Canyon Dam/Smallmouth Bass flow options were implemented, Reclamation would change how and when releases from Glen Canyon Dam took place. Each of these flow options includes releasing water through the river outlet works which are lower than the penstocks where water is typically released when hydropower is generated. However, passage through the river outlet works would also aerate the water so this likely would not lead to a cumulative effect on DO.

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, but they would not be expected to result in any significant decrease in dilution capacity or increase in 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 because dilution capacity is not likely to reduce significantly. However, without more specific modeling, it is difficult to project the quantified water quality impacts.

Under the No Action Alternative, Lake Powell is much more likely to reach dead pool, which is 3,370 feet. (See **Section 3.6**, Hydrologic Resources, for more information.) This may affect metals'

¹⁴ Tailwater is the water below the reservoir that would be more similar to reservoir waters than downstream waters.

concentrations as elevations would continue to decrease, but impacts cannot be assessed without quantified impacts.

Action Alternative 1

Under Action Alternative 1, the likelihood of drawing down below 1,000 feet would be small, 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.

Action Alternative 2

Under Action Alternative 2, shortage reductions in excess of previous commitments would be distributed as a percentage reduction based on 2021 consumptive use. Therefore, the likelihood of drawing down below 1,000 feet would be small, like 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 and 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

If one of the Glen Canyon Dam/Smallmouth Bass flow options were implemented, Reclamation would change how and when releases from Glen Canyon Dam took place. This would not result in any changes to monthly or annual release volumes, but it would change how and when those releases took place. Therefore, there is not an expected change to elevation that would impact metals' concentrations.

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 potential for fugitive dust emissions is limited by the extent of the area containing fine sediment having the potential to generate dust.

The other air quality issue, which was not addressed in the 2007 FEIS, is 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. The 2016 LTEMP (Reclamation and NPS 2016, Table 3.15-3) presents criteria pollutant, volatile organic compounds, and GHG emissions over the 11-state area within the Western Interconnection.

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, 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, 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, and 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 (primary now 12 µg/m³ reduce from 15 µg/m³; secondary standard is 15 µg/m³).

EPA is currently proposing to retain the current PM₁₀ 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/m³ to within the range of 9.0 to 10.0 µg/m³. 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 PM₁₀ 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/m³ and the annual PM₁₀ standard has been removed; and
- 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 provides a qualitative characterization of a reach, as compliant with the standards and attainment characterizes the specific pollutant as not a significant concern within the reach. 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 PM₁₀ was redesignated from non-attainment 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 PM₁₀ NAAQS, the remaining county, including Lake Mead, is in attainment of the standard. Mohave County, Arizona, adjacent to Lake Mead, is also in attainment of the PM₁₀ 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 PM₁₀ levels at Lake Mead reached 116 µg/m³, which is about 77 percent of the 150 µg/m³ NAAQS. The State of Nevada started a regulatory PM₁₀ monitor in Boulder City, Nevada, in 2021. In this first year of monitoring, 24-hour PM₁₀ levels exceeded the 24-hour NAAQS at 190 µg/m³, 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.

3.9.2 Environmental Consequences

This section analyzes the potential effects of the 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 action alternatives and the No Action Alternative. 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 park 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 has not been determined due to 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 located at or near heavily visited marinas and beaches. Both parks advocate for deployment of air quality monitoring equipment, sediment testing, and modeling activities 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 hydrology scenario provided by Reclamation; this shows the ranges for elevations at Lake Powell and Lake Mead (NPS 2023m). In addition, geographic information system (GIS) acreage information was prepared utilizing the United States Geological Survey's (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 4-year period was utilized 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 2021b). 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, 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. 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 action alternatives on electrical power resources of the Colorado River system that included all major facilities. Reclamation's CRMMS helped develop potential releases, reservoir elevations, and power generation from the action alternatives. 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 hour for the alternatives and conversion emission factors for coal and natural gas from the US Energy Information Administration (EIA) energy conversion calculator, the estimated metric tons (MT) of carbon dioxide equivalent (CO₂e) 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 because 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.

The analysis area includes every major hydropower facility along the Colorado River, from Lake Powell to the southern international border. 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 action alternatives 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 hydrology 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 (approximately 7,000 cfs year-round steady). For a conservative assessment, the lowest extent of the 10th percentile for the 80 percent ESP hydrology 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 hydrology 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 hydrology scenario.
- All calculations were completed using the North American Datum 1983 (2011) Universal Transverse Mercator Zone 12N projected coordinate system.
- Exposed shoreline acres are two-dimensional estimates.

The method for assessing potential increased GHG emissions from decreased hydropower includes several assumptions made during the modeling process. The assumptions from the CRMMS of the Upper and Lower Basin are covered in **Section 3.3**, Methodology, with additional information in **Section 3.6**, Hydrologic Resources. Following the 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 one week each month and then replicated for every week of the month. The 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 CRMSS/GTMax modeling were utilized and using the EIA energy conversion calculators, the amount of coal and natural gas necessary to produce the same amount of power was determined. Then, the EPA emission factors for GHG inventories were utilized to determine the metric tons per year (MT/year) of CO₂e for both natural gas and coal for each 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 controls 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 potential exposed shoreline and fugitive dust?

Summary

The projected exposed shoreline acreages under Action Alternative 1 and Action Alternative 2 are less than that projected under the No Action Alternative at Lake Powell. The projected exposed shoreline acreages under Action Alternative 1 and Action Alternative 2 are also less than that projected under the No Action Alternative at Lake Mead. Although Action Alternative 2 was not analyzed with exposed shoreline acreages, due to potential additional DROA releases, Action Alternative 2 would likely result in less exposed shoreline acreages than the No Action Alternative and Action Alternative 1.

As reservoir elevations decrease and more shoreline is exposed, the potential for increased fugitive dust emissions increases. However, an increase in fugitive emissions from increased exposed shoreline would potentially be limited at Lake Powell. This is because the increased exposure of acreage could be comprised largely of sandstone, which is not conducive to generating PM₁₀ standard fugitive dust emissions. There is also a significant potential for local “dust devils” and/or regional haboobs (intense dust storms), exposure to toxins in dust, and 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 the 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 the 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 3,522 feet, which is 57,454 acres of Lake Powell surface. Snowpack and hydrology would 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 hydrology scenario (2023–2026), increased dust would be noted with much larger shorelines at Lake Powell, with an estimated exposed 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 is 10,636 acres of Lake Mead surface. Snowpack and hydrology will change water levels and exposed shorelines dramatically over a broad range. In the case of no action 10th percentile for the 80 percent ESP hydrology 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 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).

Action Alternative 1

Lake Powell and Glen Canyon Dam

Under Action Alternative 1, shoreline exposures may still vary significantly. For the Action Alternative 1 10th percentile for the 80 percent ESP hydrology scenario (2023–2026), increased dust would remain an issue, with an estimated exposed additional 8,000 acres at Lake Powell. The Action Alternative 1 10th percentile low-end elevation is 3,500 feet, which is 49,388 acres of Lake Powell surface. For Action Alternative 1, this would result in a decrease of about 70 percent in exposed shoreline compared with the No Action Alternative. Action Alternative 1 would yield the higher potential to reduce dust emissions and less impacts on air quality. However, there would still be an

increase in exposed shoreline, and this increase would potentially have a negative effect on air quality. As sediment comprises a small percentage of the shoreline, the increase in acreage susceptible to wind erosion would be reduced and would not exceed the PSD Class II threshold or the state or national AAQS.

Glen Canyon Dam to Lake Mead, Lake Mead, and Hoover Dam

Under Action Alternative 1, shoreline exposures may still vary significantly. For the Action Alternative 1 10th percentile for the 80 percent ESP hydrology scenario (2023–2026), increased dust would remain an issue, with an estimated exposed additional 74,350 acres at Lake Mead. The Action Alternative 1 10th percentile low-end elevation is 950 feet, which is 30,636 acres of Lake Mead surface. For Action Alternative 1, this would result in a decrease of about 20 percent in exposed shoreline compared with the No Action Alternative. Action Alternative 1 would yield the higher potential to reduce dust emissions and less impacts on air quality. However, there would still be an increase in exposed shoreline, and this increase would potentially have a negative effect on air quality. The increase in acreage susceptible to wind erosion could potentially contribute to an exceedance of the PSD Class II threshold or the state or national AAQS.

Action Alternative 2

Lake Powell and Glen Canyon Dam

Action Alternative 2 includes potential additional DROA releases; otherwise, it would be similar to the air quality effects of Action Alternative 1, which was analyzed in detail above. Under Action Alternative 2, shoreline exposures may still vary significantly. For Action Alternative 2, increased dust would remain an issue, although the 10th percentile for the 80 percent ESP hydrology scenario (2023–2026) was not calculated to determine an estimated exposed additional acreage at Lake Powell. However, there would still be a decrease in exposed shoreline compared with the No Action Alternative. As stated, with potential for additional DROA releases, Action Alternative 2 could even yield the higher potential to reduce dust emissions and less impacts on air quality, compared with the No Action Alternative and Action Alternative 1. However, Reclamation would still anticipate an increase in exposed shoreline, and this increase would potentially have a negative effect on air quality. As sediment comprises a small percentage of the shoreline, the increase in acreage susceptible to wind erosion would be reduced and would not exceed the PSD Class II threshold or the state or national AAQS.

Glen Canyon Dam to Lake Mead, Lake Mead and Hoover Dam

Action Alternative 2 includes potential additional DROA releases; otherwise, it would be similar to the air quality effects of Action Alternative 1, which was analyzed in detail above. Under Action Alternative 2, shoreline exposures may still vary significantly. For Action Alternative 2, increased dust would remain an issue, although the 10th percentile for the 80 percent ESP hydrology scenario (2023–2026) was not calculated to determine an estimated exposed additional acreage at Lake Mead. However, there would still be a decrease in exposed shoreline compared with the No Action Alternative. As stated, with potential for additional DROA releases, Action Alternative 2 could even yield the higher potential to reduce dust emissions and less impacts on air quality compared with the No Action Alternative and Action Alternative 1. However, Reclamation would still anticipate an increase in exposed shoreline, and this increase would potentially have a negative effect on air

quality. The increase in acreage susceptible to wind erosion would be reduced and would not exceed the PSD Class II threshold or the state or national AAQS.

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 Glen Canyon Dam/Smallmouth Bass 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.

Issue 2: How would lake reservoir elevations and releases impact power generation and GHG emissions?

Summary

Action Alternatives 1 and 2 result in significantly more power generation at Glen Canyon Powerplant compared with the No Action Alternative under low hydrology scenarios. This is particularly true in 2025–2026 when lake elevations under the No Action Alternative could drop below minimum power pool. Annual releases at Lake Mead are higher under the No Action Alternative, leading to less power generation at Hoover Powerplant under Action Alternative 1 across most hydrologic scenarios. Action Alternative 2 shows greater generation compared with the No Action Alternative due to the potential additional DROA releases. The difference is more varied at higher hydrologic scenarios due to the possibility of the dams releasing under different operational tiers.

Because Action Alternatives 1 and 2 result in significantly more power generation at Glen Canyon Powerplant compared with the No Action Alternative under low hydrology scenarios, the difference between the power generated for the No Action Alternative and Action Alternative 2 are compared. This difference is 1,293,755 megawatt hour (MWh) and the GHG emissions under the No Action Alternative for both coal and natural gas were calculated and 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 3-27**). Increases in GHG emissions for the No Action Alternative compared with Action Alternative 2 would be small, at approximately 442,360.81 MT/year of CO₂e for coal and 255,216.75 MT/year of CO₂e for natural gas. However, the totality of climate change impacts is not attributable to any single action. Albeit a small contribution, this project-related emission, in combination with a variety of GHG emission sources around the world, could exacerbate climate-related impacts.

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 tier, as outlined in the 2007 Interim Guidelines. At these rates, the likelihood of water elevations dropping below the minimum power pool at Lake Powell and Lake Mead rises drastically, 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 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 3-27**, below, presents the estimated increase of GHGs for the No Action Alternative.

Table 3-27
Reduction of Annual Energy Generation and Associated GHG Emissions

Measure	No Action Alternative 10th Percentile	Action Alternative 1 10th Percentile	Action Alternative 2 10th Percentile
2024 Total - Glen Canyon, Hoover, and Parker-Davis Generation MWh	4,549,905	4,865,379	4,892,220
2025 Total - Glen Canyon, Hoover, and Parker-Davis Generation MWh	3,507,459	4,555,799	4,615,470
2026 Total - Glen Canyon, Hoover, and Parker-Davis Generation MWh	2,268,589	4,622,749	4,711,292
Largest Difference in MWh from Action Alternative 2	2,442,703	N/A	N/A
Coal - Mixed (Electric Power Source) (MT/year CO ₂ e)	835,209	N/A	N/A
% of 11-State GHG Emissions	0.07	N/A	N/A
% of US GHG Emissions	0.01	N/A	N/A
Natural Gas (MT/year CO ₂ e)	481,868	N/A	N/A
% of 11-State GHG Emissions	0.04	N/A	N/A
% of US GHG Emissions	0.007	N/A	N/A

The calculated GHG emissions under the No Action Alternative can also be 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 3-27**). Under the No Action Alternative, the reduction of hydropower could result in GHG emissions of 835,209 MT/year (0.835 million MT/year) with coal as the replacement power source, or 481,868 MT/year (0.482 million MT/year) with natural gas as the replacement power source. Differences in GHG emissions from the No Action Alternative range from 0.07 percent (coal) to 0.04 percent (natural gas) relative

to total 11-state GHG emissions, and from 0.01 percent (coal) to 0.007 percent (natural gas) relative to total US GHG emissions.

Action Alternative 1

Under Action Alternative 1, elevations at Lake Powell would be protected at 3,500 feet allowing hydroelectric generation to continue at Glen Canyon Power Plant. This would result in a considerably smaller chance of dropping below the minimum power pool. However, protecting elevations at Lake Powell could result in a decrease in elevation at Lake Mead. This would lead to significantly less generation at Hoover Power Plant. These results show continued power generation at Glen Canyon Power Plant with impacts on generation at Hoover Power Plant. Overall, power generation across these facilities is higher compared with the No Action Alternative. Therefore, there would be no increase in GHG emissions due to alternative power sources for Action Alternative 1 compared with the No Action Alternative.

Action Alternative 2

Under Action Alternative 2, different allocations would redirect water below Hoover Power Plant. This would have no impact on hydroelectric generation at Glen Canyon and Hoover Power Plants compared with Action Alternative 1. There would be slight changes in impacts on generation at Parker and Davis Power Plants compared with Action Alternative 1. The potential additional releases from the Upper Basin under DROA would result in higher lake elevations and releases at Lake Powell and Lake Mead. These conditions would lead to greater capacity and generation potential at Glen Canyon and Hoover Powerplants. The additional potential DROA releases would have slight impacts on Parker and Davis Powerplants. However, these slight impacts would not increase GHG emissions due to alternative power sources for Action Alternative 2. Therefore, there would be no increase in GHG emissions due to alternative power sources for Action Alternative 2 compared with the No Action Alternative; however, the No Action Alternative would require alternative power and would increase 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 Glen Canyon Dam/Smallmouth Bass flow options were implemented, water would be released through the river outlet works that do not include power generation, resulting in a decrease in power generation. The potential operational changes included in the Glen Canyon Dam would result in a decrease in power generation at the Glen Canyon Powerplant. This 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. 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.

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 action alternatives:

- 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's physiographic province (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 the visitation of 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, may not be boatable at reservoir elevations below 3,525 feet.

- **Glen Canyon Dam:** The American Society of Civil Engineers considers it 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. Motorists would view the calcium carbonate ring on Utah State Route 95 (near Hite, Utah), boaters would view it on Lake Powell, recreationists would see it at developed and undeveloped recreation areas (for example, Hite, Bullfrog, Halls Crossing, Antelope Point, and Wahweap), and hikers would 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), scenic overlooks adjacent to these inflow areas, and water-based recreationists on Lake Powell.

Glen Canyon to Lake Mead

Attraction Features

This portion of the river, including GCNP, are heavily visited. It includes world-renowned whitewater rafting and other recreation 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 (e.g., 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 is mostly comprised of riparian species such as native willows, nonnative and invasive tamarisk (salt cedar), and isolated areas of cottonwoods as well as 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 HFEs from Glen Canyon Dam, to recreate natural floods common before the construction of the Glen Canyon Dam, have allowed for the transportation and deposition of sand, resulting in the formation of natural sandbars along the river. In some areas, these HFEs can strip vegetation along the existing sandbars, including tamarisk (salt cedar), allowing 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). As described in the 2007 FEIS, one attraction feature was identified:

- **Hoover Dam:** A major destination and national landmark with high levels of visitation, in 1955, it was selected as one of the seven engineering wonders in the United States by the American Society of Civil Engineers. Since the Hoover Dam is located 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. Motorists would view the calcium carbonate ring on US Highway 93 (between Boulder City, Nevada, and Hoover Dam), boaters would view it on Lake Mead, and hikers would 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, and 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.

3.10.2 Environmental Consequences

Methodology

Similar methods were used for the analysis of potential impacts on visual resources as in the 2007 FEIS for the assessment of effects on attraction features, extent of 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 would be visible (and accessible) if these supplemental interim guidelines needed to be implemented. The assessment of effects on landscape character adjacent to Lake Powell and Lake Mead used the same methods identified in the 2007 FEIS. This includes using the latest 80 percent ESP analysis's 10th percentile reservoir elevations, developed by Reclamation using the 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 elevation and tiers to the analysis conducted in the 2007 FEIS.

Two new analysis items, Colorado River Landscape Character and Broader Landscape Character, were added based on changes in hydrological conditions associated with the No Action Alternative as well as management direction associated with the action alternatives. To assess potential changes to 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 as well as the potential inability to conduct HFE from Glen Canyon Dam. This analysis considers and references 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 the different 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 visual character in irrigated landscapes including those associated with agricultural production. 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, but based on the typical threshold between the foreground-middleground visual distance zone and background visual distance zone 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 scope area were considered, where appropriate, including the effects on the broader landscape character associated with potential decreased water availability for the Lower Division States.

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 assumed this would occur for all alternatives if these supplemental interim guidelines would need to be implemented.
- Decreasing flow rates along the Colorado River, and the inability to conduct HFE from Glen Canyon Dam, would modify the river corridor's natural, visual character though limiting natural flooding processes including through the Grand Canyon.
- Decreasing water availability for the Lower Division States would result in large-scale changes to 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 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 ring 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:** Qualitatively describe the effect associated with proposed flow rates and the potential to conduct HFE 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:** Qualitatively describe 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.

Issue 1: How would management of reservoir elevations affect visibility of attraction features?

Summary

Visibility and access to Cathedral in the Desert would be similar among all 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 both action alternatives.

No Action Alternative

Under the No Action Alternative, Lake Powell would likely remain below 3,550 feet through the end of 2026. Based on this elevation, Cathedral in the Desert would be visible and accessible under the No Action Alternative through the planning period. This same modeling projects pool elevations for Lake Powell could drop below 3,450 feet in 2024, 2025, and 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 900 feet in 2026.

Action Alternative 1

Similar to the No Action Alternative, Cathedral in the Desert would 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, the management of water levels within Lake Mead would remain above 925 feet through 2026 resulting in less of the upstream side of Hoover Dam becoming visible under this alternative compared with the No Action Alternative.

Action Alternative 2

Similar to the No Action Alternative and Action Alternative 1, Cathedral in the Desert would be visible and accessible under this alternative. Similar to Action Alternative 1, less of the upstream side of Glen Canyon Dam and Hoover Dam would be exposed as compared with the No Action Alternative.

Cumulative Effects

If one of the Glen Canyon Dam/Smallmouth Bass flow options were implemented, there would be no changes to lake levels in Lake Powell or Lake Mead. 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, 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.

Issue 2: How would management of reservoir elevations affect landscape character including visibility of calcium carbonate rings and sediment deltas?

Summary

The effects on landscape character associated with visibility of calcium carbonate rings and sediment deltas would be most prominent associated with the No Action Alternative based on taller calcium carbonate rings and more extensive sediment deltas, which would become populated by vegetation including tamarisk, introducing bright greens into the landscape contrasting 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. Due to the addition of potential DROA releases each year (up to 500,000 af to help protect Lake Powell elevation of 3,500 feet) under Action Alternative 2, water levels in Lake Powell

and Lake Mead would be higher resulting in shorter calcium carbonate rings and less expansive sediment deltas than the No Action Alternative and Action Alternative 1.

No Action Alternative

Modeled reservoir elevations for March 2025 indicate a low Lake Powell reservoir elevation of 3,496 feet under the No Action Alternative, which would create a potential calcium carbonate ring of 204 feet in height. Modeled reservoir elevations for September 2025 indicate a low Lake Mead reservoir elevation of 988 feet under the No Action Alternative, which would create a potential calcium carbonate ring of 233 feet in height. As described in the 2007 FEIS, sediment deltas would continue to build up over time and would be visible as reservoir elevations drop, including under the current No Action Alternative. The expanding sediment deltas would become populated by vegetation, including tamarisk, which would introduce bright greens into the landscape, contrasting 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 with these modifications 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 with these modifications being 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.

Action Alternative 1

Modeled reservoir elevations for March 2025 indicate a low Lake Powell reservoir elevation of 3,500 feet under Action Alternative 1, which would create a potential calcium carbonate ring 200 feet in height. Modeled reservoir elevations for September 2025 indicate a low Lake Mead reservoir elevation of 997 feet under Action Alternative 1, which would create a potential calcium carbonate ring of 224 feet in height. Based on potential higher lake elevations associated with 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, Action Alternative 1 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.

Action Alternative 2

Modeled reservoir elevations for March 2025 indicate a low Lake Powell reservoir elevation of 3,542 feet under Action Alternative 2, which would create a potential calcium carbonate ring of 158 feet in height. Modeled reservoir elevations for September 2025 indicate a low Lake Mead reservoir elevation of 1,001 feet under Action Alternative 2, which would create a potential calcium carbonate ring of 220 feet in height. Based on potential higher lake elevations associated with this alternative, the sediment deltas would be less extensive than under the No Action Alternative and Action Alternative 1. Due to the shorter calcium carbonate ring and less extensive sediment deltas, Action Alternative 2 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 or Action Alternative 1.

Cumulative Effects

If one of the Glen Canyon Dam/Smallmouth Bass flow options were implemented, there would be no changes to lake levels in Lake Powell or Lake Mead. Therefore, no additive cumulative effects would occur on 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.

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 action alternatives, as 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 Action Alternatives 1 and 2. Under Action Alternative 1, 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. Action Alternative 2 would result in similar impacts as Action Alternative 1, except due to potential releases from Upper Basin reservoirs, would likely result in higher levels in Lake Powell and higher flows from Glen Canyon Dam. This would result in lower impacts on the landscape character associated with Action Alternative 2 along the Colorado River compared with Action Alternative 1.

No Action Alternative

The No Action Alternative includes lowering releases from Glen Canyon Dam, as Lake Powell elevations drop, resulting 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). 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 that 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**; for impacts on recreation, including visibility of river features, refer to **Section 3.14**.)

Action Alternative 1

Action Alternative 1, as part of the Lower Elevation Release Tier (below 3,575 feet), includes a series of thresholds to reduce releases from Glen Canyon Dam. These thresholds are tied to lower Lake Powell elevations with an initial release set at 6.0 maf with increases based on the April elevation projection. 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 potentially 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 April elevation projection identifies that Lake Powell would be above 3,525 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. It would also avoid the increased impacts associated with the lower 6.0 maf releases from Glen Canyon Dam. Through management to maintain Lake Powell elevations above dead pool (3,370 feet), by reducing releases to balance gains and losses starting below 3,500 feet (potentially resulting in releases of less than 6.0 maf), impacts on the landscape character associated with the flowing, turbulent Colorado River and its effect on bank armoring and visibility of river features would increase and may include the inability to conduct HFEs from Glen Canyon Dam. (For more information on the impacts on riparian vegetation under Action Alternative 1, refer to **Section 3.13**; for impacts on recreation, including visibility of river features, refer to **Section 3.14**.)

Action Alternative 2

Impacts would be similar to those described for Action Alternative 1, but with the addition of potential water releases each year from Upper Basin reservoirs to help protect Lake Powell elevation 3,500 feet, up to 500,000 af, water levels in Lake Powell would likely remain higher under this alternative. Based on higher water levels in Lake Powell, the decreased releases from Glen Canyon Dam and its effects on landscape character associated with Action Alternative 1 would be tempered by this additional inflow of water into Lake Powell under this alternative. (For more information on the impacts on riparian vegetation under Action Alternative 2, refer to **Section 3.13**; for impacts on recreation, including visibility of river features, refer to **Section 3.14**.)

Cumulative Effects

If one of the Glen Canyon Dam/Smallmouth Bass flow options were implemented, there would be no changes to release amounts from Glen Canyon Dam. Therefore, no additive cumulative effects would occur on landscape character along the Colorado River downstream of Glen Canyon Dam, 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.

Issue 4: How would management of water availability for the Lower Division States affect 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 both action alternatives. As the elevation of Lake Mead continues to drop toward dead pool, under the No Action Alternative dramatic decreases in water availability could occur and it would affect all three Lower Division States. Both action alternatives establish a series of water supply adjustments based on lower elevations of Lake Mead to temper these impacts with Action Alternative 1 initially focusing shortages in Arizona and Nevada with potential further decreases for California if Lake Powell drops below 1,040 feet. Action Alternative 2 would have similar impacts; however, it would distribute water shortages 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.

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. As elevations in Lake Mead continue to drop toward dead pool (895 feet), the 80 percent ESP analysis identifies that lake levels could approach this threshold in 2026, and flows from Lake Mead could 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, diminishing 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, resulting 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).

Action Alternative 1

Action Alternative 1 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. In 2024, if water levels drop below 1,040 feet, all three states would receive less water from the Colorado River under this alternative, with Arizona and Nevada experiencing the largest shortage. For 2025 and 2026, more reductions to water supplies could occur with all three states likely receiving lower deliveries associated with each lowering reservoir elevation tier.

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 would occur. These include further reductions in water deliveries based on extraordinary circumstances, as described in Section 7(D) of the 2007 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, but they would occur more gradually. The influence of the Colorado River into adjacent lands would begin to narrow, especially in Arizona and Nevada where larger water shortages are anticipated, 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 Action Alternative 1, refer to **Section 3.16, Socioeconomics**).

Action Alternative 2

Similar to Action Alternative 1, the same series of proposed water supply adjustments for the Lower Division States, based on lower elevations of Lake Mead, would occur. Under Action Alternative 2, all three Lower Division States would receive less water with shortages distributed between all users in these areas. Impacts on landscape character would be similar to those described for Action Alternative 1 except these effects would be distributed across the Lower Division States reducing effects in Arizona and Nevada while increasing effects on irrigated and agricultural landscapes in California. (For more information on the impacts on agricultural operations under Action Alternative 2, refer to **Section 3.16, Socioeconomics**).

Cumulative Effects

If one of the Glen Canyon Dam/Smallmouth Bass flow options were implemented, there would be 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.

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 was 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 that are listed on or eligible for listing on the National Register of Historic Places (NRHP) and includes 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 (which includes Lake Powell) for recreation and resource protection. Reclamation manages water operations. The cultural resources in the portion of GCNRA below the Glen Canyon Dam and the cultural resources in the Grand Canyon are protected under the GCPA. The GCNP is also a designated United Nations Educational, Scientific, and Cultural Organization World Heritage Area.

Both agencies 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: “Archeological and historic 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) The LTEMP for the operations of the Glen Canyon Dam includes a Reclamation programmatic agreement (PA) to mitigate 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. Additional, and more recent, data were provided by the NPS (NPS 2023k). Because the majority of the 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 will consult with the Arizona, Nevada, Utah, and California 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. 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 per 36

CFR 800.6. 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.

Glen Canyon Dam to Lake Mead

This reach extends from the GCNRA into the 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 operations of the dam; 313 were determined eligible, 14 ineligible, and 9 as unevaluated for listing on the NRHP. 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 2023j).

As discussed in LTEMP Section 3.8, research has shown that sediment within the active river channel and/or deposited by HFEs can be transported by the wind to terraces and source bordering aeolian deposits that contain historic properties (East et al. 2016). That wind-deposited sediment can help stabilize and preserve the archaeological properties in place (East et al. 2016). If used correctly, HFEs could benefit sediment deposition to keep archaeological resources that would otherwise be exposed through erosion. Current dam operations and the absence of 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 in 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 2023k). Over 50 resources are below 1,083 feet and may retain integrity (NPS 2023k). 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 integrity. An NRHP-listed traditional cultural place (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-age 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-period Chemehuevi Indian villages are known to have been located along the river in the Chemehuevi Valley. Resources within the lake's current or historic 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

Limited inventories have been conducted in this reach. Only 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). However, more cultural resources are likely present in this reach.

Imperial Dam to SIB

Very little data are available for the Imperial Dam to SIB reach. Two resources within the reach are listed on the NRHP: the Ocean-to-Ocean Bridge and the Yuma Crossing and Associated Sites NHL (Reclamation 2007). Because of the lack of inventories for this reach, currently unknown resources may be present.

Ethnographic Resources and Traditional Cultural Places

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. The Hualapai Tribe (Coulam 2011), the Hopi Tribe (Hopi CPO 2001), the Navajo Nation (Maldonado 2011), and the Pueblo of Zuni (Dongoske 2011) have all 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 state 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, the majority of impacts within the reaches were assessed by comparing anticipated flows between alternatives.

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 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. 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 consultation under the NHPA Section 106 process (36 CFR 800).

Impacts Analysis Area

The impacts analysis area for cultural resources is consistent with that used by the 2007 FEIS. It consists of the reaches of the Colorado River from Lake Powell to Imperial Dam and 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.

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.

Impact Indicators

Impact indicators for this analysis are:

- Projected lake elevations that fall below levels previously analyzed by 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 the LTEMP that may contribute to erosion and exposure of resources
- 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/balancing Lake Mead and Lake Powell affect previously submerged archaeological sites, as well as those at the lake margins?

Summary

All the 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. Both Action Alternative 1 and Action Alternative 2 would have fewer negative impacts on cultural resources at Lake Powell and Lake Mead than the No Action Alternative. Action Alternative 2 could have slightly fewer negative impacts on cultural resources than Action Alternative 1. Under the two action alternatives, lake levels would remain at least at or above the minimum power pool for Lake Powell and Lake Mead. This would protect those cultural resources below that level. 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 places would be resolved through land management agency using existing mitigation documents and the NHPA Section 106 process.

No Action Alternative

Under the No Action Alternative, Lake Powell's projected pool elevation for the 10th percentile through 2024 is 3,450 feet, which is below the minimum power pool. In 2025 through 2026, pool elevations for the 10th percentile are projected to dip below 3,450 feet and remain under the minimum power pool for the future. Newly exposed resources below 3,496 feet would likely be exposed for an extended period of time and may be prone to increased visitation; most of these resources are in canyons that are difficult to reach on foot but may be accessible via canyoneering. Negative impacts from wave action and wet/dry cycles may occur on newly exposed resources at lower elevations.

Lake Mead pool elevations are currently below 1,080 feet and, for the 10th percentile, are projected to dip under 1,000 feet by the end of 2024. Between 2025 and 2026, the 10th-percentile scenario is for the pool elevation at Lake Mead to dip below the power pool level of 950 feet by 2026, which would continue into the future. Known resources below 1,080 feet are primarily prehistoric sites recorded prior to the inundation of the lake; these would also be exposed for an extended period of

time. These sites could be affected by wave action at the lake margins and wet/dry cycles, and they could see increased visitation from hikers.

Action Alternative 1

Under Action Alternative 1, Lake Powell's pool elevations at the 10th percentile could dip to the minimum power pool of 3,490 feet in 2024; however, the minimum power pool elevation of 3,490 feet would be protected except under extraordinary circumstances. Pool elevations are projected at the 10th percentile to be at or above 3,500 feet through 2025–2026 and beyond. Overall, pool elevations would be higher than they would be for the No Action Alternative, and they would remain above the minimum power pool. Therefore, impacts on cultural resources at Lake Powell for Action Alternative 1 are fewer than those for the No Action Alternative because fewer resources would be exposed for a shorter amount of time.

For Lake Mead, the pool elevations are projected at the 10th percentile to be as low as 960 feet in 2025 but around 975 feet in late 2025 and into 2026. The minimum power pool would be protected except under extraordinary circumstances. Because the power pool level of 950 feet would be maintained and fewer resources would be exposed, impacts on cultural resources under Action Alternative 1 would be less than those under the No Action Alternative.

Action Alternative 2

Impacts on cultural resources at Lake Powell and Lake Mead for Action Alternative 2 would be the same as those for Action Alternative 1. However, potential additional DROA contributions implemented to protect the 3,500-foot elevation of Lake Powell could lessen impacts on cultural resources at Lake Powell. If these releases moved Lake Powell to an elevation that allowed for higher releases—and resulting higher elevations at Lake Mead—impacts on cultural resources at Lake Mead could also be lessened.

Cumulative Effects

Reclamation has identified one reasonably foreseeable future project that may, in conjunction with the proposed near-term Colorado River operations, contribute to cumulative effects on cultural resources; this project is the Glen Canyon Dam/Smallmouth Bass flow options. Reclamation is proposing specific flow adjustments in water releases from the Glen Canyon Dam to control smallmouth bass establishment. All proposed flow options in the EA adhere to operational and regulatory constraints as outlined in the LTEMP FEIS. 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 (which includes TCPs) or its contributing elements, those effects will be resolved under the LTEMP PA and the Nonnative Fish MOA, which is in development. If potential adverse effects can be mitigated, the project should not contribute to cumulative impacts in conjunction with the proposed near-term Colorado River operations.

Issue 2: How would changes in river flows from water releases from Lake Mead and from equalizing/balancing Lake Mead and Lake Powell affect archaeological sites along the river?**Summary**

Both Action Alternative 1 and Action Alternative 2 would have fewer negative impacts on cultural resources than the No Action Alternative. Under the two action alternatives, water releases would occur and thus would provide protection for resources at very low elevations or presently protected by river sediment. However, resources could be subjected to additional visitation along the river due to the lower river levels. Adverse effects on historic properties would be resolved through the LTEMP PA or land management agency NHPA agreements. If no agreements exist, the normal NHPA Section 106 process would be undertaken.

No Action Alternative

Under the No Action Alternative, releases from Glen Canyon Dam could fall below levels analyzed under the LTEMP. The higher releases under the No Action Alternative could result in dead pool and associated declines in flows.

For the No Action Alternative, the median acreage of available sediment for windblown transport ranges from 1,643,222 square meters (m²) at the 80th percentile to 1,575,186 m² at the 100th percentile. Lower river flows would result in the most sediment available in late 2024, again in late 2025, and again in late 2027 at the 100th percentile. Increases in available sediment are a beneficial impact of low river flows and could help cover archaeological sites with sediment.

If reduced releases result in a very low river level, then there would be increased access to previously inundated or buried precontact archaeological sites¹⁵ between Lake Powell and Lake Mead. For sites with increased access, there may be deterioration of site integrity due to increased visitation or vandalism.

Flows, and therefore river levels, from Lake Mead downstream would initially be higher until Lake Mead drops to dead pool when they will drop precipitously. The drop in flows and river level may expose previously inundated cultural resources. These resources would then be exposed for a longer duration of time because it would be more difficult to increase flows back up to their previous levels.

Action Alternative 1

Under Action Alternative 1, releases from Lake Powell would be consistent with those approved and analyzed under the LTEMP while conditions permit. If insufficient water is available, releases would be coordinated to protect Lake Powell's 3,500-foot elevation. Projected releases below the LTEMP minimum for Action Alternative 1 would be less likely than for the No Action Alternative and would be designed to prevent dead pool at Lake Powell. Flows may be reduced but would still continue and thus protect more archaeological sites than the No Action Alternative.

¹⁵ Precontact archaeological resources are those that predate Native American contact with Europeans.

Under Action Alternative 1, the median exposed sediment acreage ranges from 1,730,261 m² at the 80th percentile to 1,575,186 m² at the 100th percentile. Flows would be more evenly distributed under Action Alternative 1; therefore, sediment would be available for longer amounts of time and at more regular intervals than under the No Action Alternative.

As with the No Action Alternative, lower river levels due to changes in release volumes could also increase access to precontact archaeological sites between Lake Powell and Lake Mead.

Under Action Alternative 1, flows, and therefore river levels, from Lake Mead would be the same as under the No Action Alternative during 2023. They would drop in 2024–2025, and they would raise in 2026. Flows would be maintained for a longer duration of time than under the No Action Alternative as the minimum power pool level for Lake Mead would be maintained, preventing the lake from reaching dead pool.

Action Alternative 2

For Action Alternative 2, impacts on cultural resources along the river reach from Lake Powell to Lake Mead, as well as downstream from Lake Mead, would be the same as they would be for Action Alternative 1.

Cumulative Effects

Reclamation has identified one reasonably foreseeable future project that may, in conjunction with the proposed near-term Colorado River operations, contribute to cumulative effects on cultural resources; this project is the Glen Canyon Dam/Smallmouth Bass flow options. Reclamation is proposing to regulate flows from the Glen Canyon Dam to control smallmouth bass populations. All proposed flow options in the EA adhere to operational and regulatory constraints as outlined in the LTEMP FEIS and are unlikely to cause any additional impacts on archaeological sites in the reach from Glen Canyon Dam to Lake Mead; they should not contribute to cumulative impacts in conjunction with the proposed near-term Colorado River operations.

Issue 3: How would changes in operations affect TCPs and resources of concern to Native Americans?

Summary

Both Action Alternative 1 and Action Alternative 2 would have fewer impacts on sacred sites and TCPs than the No Action Alternative. Under the two action alternatives, visitor access to previously inundated sacred sites could increase to a lesser degree than under the No Action Alternative. Vegetation that may be considered elements of the river and canyon's TCPs would increase in Marble Canyon and the eastern Grand Canyon but decrease in the western Grand Canyon under the action alternatives. Any decline in the health of life within the Grand Canyon beyond those due to poor hydrologic conditions could have adverse effects on contributing elements of the TCP. Adverse effects on TCPs would be resolved through the LTEMP PA, other land management agency NHPA agreement documents, or the NHPA Section 106 process.

No Action Alternative

Under the No Action Alternative, visitor access to sacred sites below 3,496 feet at Lake Powell could increase; however, resources would be exposed in canyons that are difficult to access. At Lake

Mead, sacred sites could be more accessible to visitors above 1,000 feet in 2024 and above 895 feet in 2025–2026. Resources along the river could also be more accessible during low-flow times or if there is a complete drop in flows when less or no water is released from Lake Powell and/or Lake Mead. Habitat for nonnative plant species along the river is projected to increase in Marble Canyon, but not in Grand Canyon. Habitat for native plant species would be lost in both Marble and Grand Canyons (Butterfield and Palmquist 2023a). No flows could have significant adverse effects on fish that are a contributing element to the Colorado River TCP and to the health of the ecosystem as a whole.

Action Alternative 1

Under Action Alternative 1, visitor access to sacred sites at Lake Powell is not expected to greatly increase; this is because the lake level is likely to be at or above 3,500 feet through 2026. Lake Mead could drop below the previously analyzed 1,080 feet to 960 feet, which could increase visitor access to sacred sites located between 1,080 feet and 960 feet. Lower release volumes could result in increased accessibility to sacred sites along the river.

In general, Action Alternative 1 would result in increases in native and nonnative riparian vegetation in eastern Grand Canyon and Marble Canyon, respectively, when compared with the No Action Alternative. Action Alternative 1 would result in a decline in primarily nonnative species in the western Grand Canyon in comparison with the No Action Alternative (Butterfield and Palmquist 2023a). Any decline in the health of life within the Grand Canyon beyond those due to poor hydrologic conditions could have adverse effects on contributing elements of the TCP.

Action Alternative 2

For Action Alternative 2, impacts on TCPs and resources of concern to Native Americans would be the same as they would be for Action Alternative 1.

Cumulative Effects

Reclamation has identified one reasonably foreseeable future project that may, in conjunction with the proposed near-term Colorado River operations, contribute to cumulative effects on cultural resources; this project is the Glen Canyon Dam/Smallmouth Bass flow options. Reclamation is proposing to regulate flows from the Glen Canyon Dam to control smallmouth bass populations. All proposed flow options in the EA adhere to operational and regulatory constraints as outlined in the LTEMP FEIS; however, they may negatively impact characteristics of TCPs important to Native Americans. Adverse effects on TCPs, as historic properties, that result from the actions analyzed in this SEIS will be resolved through the LTEMP PA, other land management agency NHPA agreement documents, or the NHPA Section 106 process; therefore, the project should not contribute to cumulative impacts in conjunction with the proposed near-term Colorado River operations.

3.12 Paleontological Resources

3.12.1 Affected Environment

Paleontological resources (with some exceptions) include any fossilized remains, traces, or imprints of organisms preserved in or on the earth's crust. The Paleontological Resources Preservation Act (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 Bureau of Land Management, Reclamation, the NPS, and the Service and ensure that 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, although 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

The fossil record near the Colorado River in this region 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 preserve 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 in 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 the majority of potential resources and localities were submerged during the filling of the reservoirs. There is 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 feet of sedimentary rocks that represent approximately 300 million years of earth 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. GCNRA, IMR, and WASO are working on a 2-year project to compile and update existing data into one authoritative source. Based on current best available GIS paleontological data, at approximately 3,522 feet (current elevation as of February 16, 2023), 152 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 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 paleontology sites to wet/dry cycling thus has the potential to result in greater numbers of paleontology sites being subject erosion and damage as a result of exposure.

Erosion is the primary agent that exposes paleontological resources on the surface. Reclamation manages a significant amount of land along the Colorado River corridor, resulting in higher-than-normal erosional rates and increased potential for the exposure of paleontological resources. From a scientific perspective, elevated erosion levels along waterways provide an opportunity in that 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).

The GCNRA has one of the most extensive exposures of Mesozoic era rocks 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 have 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 park. 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 and the Muddy Creek Formation, and the Pliocene and Pleistocene river gravels. Where these formations outcrop along the lake are now more spatially exposed, providing a high chance to find new fossil localities with them. Increased exposure of fossil bearing geological formations around the lake would be anticipated with lower lake levels and exposed shorelines.¹⁶

3.12.2 Environmental Consequences

Methodology

There was no formal analysis of effects on paleontological resources in developing 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, the 10th percentile as the “worst-case scenario” for Lake Powell was used 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 re addressed in this current analysis. For Lake Mead, an elevation of 1,080 feet was used as 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 windblow 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 where they cover and protect 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 in 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.

¹⁶ 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 over 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/balancing Lake Mead and Lake Powell affect previously submerged paleontological resources, as well as those at the lake margins?

Summary

All the alternatives would result in lake elevations which may further expose resources to damage from wave action, wet-dry cycling of fluctuating water levels, increase visitation and unauthorized collection or vandalism. However, Action Alternative 1 and Action Alternative 2 would maintain power pools that would reduce the potential for impacts on paleontological resources from the lowest lake levels. Implementation of the PRPA by both NPS and Reclamation provides protections and fines for disturbances to paleontological resources.

No Action Alternative

Under the No Action Alternative, Lake Powell pool elevations for the 10th percentile is 3,450 feet. In 2025 through 2026, pool elevations may dip below 3,496 feet to 3,425 feet with an estimated additional exposed shoreline of 28,000 acres. An additional 25–43 known paleontological sites would be exposed. Newly exposed resources below 3,496 feet may be exposed to increased visitation. Visitor impacts could result from unauthorized driving off approved roads, visitor-created

boat launch areas, visitor-created walking trails on newly exposed land, and unauthorized collecting and vandalism. Negative impacts from wave action and wet/dry cycles may be seen on newly exposed resources. Note that these site numbers do not capture the entirety of the paleontological resources, since many areas have not had assessments.

Lake Mead pool elevations are currently below 1,080 feet and are projected to dip to approximately 1,000 feet by the end of 2024, with an estimated additional exposed shoreline of 94,350 acres. The 10th-percentile scenario for Lake Mead between 2025 and 2026 is a pool level of almost dead pool at 895 feet, potentially exposing paleontological resources. These locations may be affected by wave action at lake margins, wet/dry cycles, and likely increased visitation.

Action Alternative 1

Under Action Alternative 1, Lake Powell pool elevations may dip below the minimum power pool of 3,490 feet in 2024; however, the minimum power pool elevation of 3,500 feet will be protected under extraordinary circumstances. Pool elevations are projected to be at or above 3,500 feet through 2025–2026. Therefore, potential impacts on exposed paleontological resources at Lake Powell for Reservoir Operations Modifications would be less than those anticipated under the No Action Alternative.

For Lake Mead, pool elevations are projected to be as low as 925 feet in 2025 but up above 950 feet in 2026; however, the 950 feet power pool will be protected except under extraordinary circumstances. Because the power pool level of 950 feet would be maintained, impacts on paleontological resources under Action Alternative 1 would be less than those under the No Action Alternative.

Action Alternative 2

Potential impacts on paleontological resources at Lake Powell and Lake Mead for Action Alternative 2 would be the same as for Action Alternative 1.

Cumulative Effects

Reclamation is proposing to regulate flows from the Glen Canyon Dam to control smallmouth bass populations. The proposed releases are within the previously approved flows under the No Action Alternative and are unlikely to cause any additional impacts on paleontological resources.

Cumulatively, negative impacts on paleontological resources are anticipated in the near and long term from each of the proposed alternatives associated with the drop in lake levels.

Issue 2: How would changes in river flow from water releases from Lake Mead and from equalizing/balancing Lake Mead and Lake Powell affect paleontological resources along the river?

Summary

All the alternatives would result in releases that may lower river levels and increase visitor access and potential impacts on paleontological resources. However, Action Alternative 1 and Action Alternative 2 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 from Lake Powell may fall below levels approved for LTEMP. Impacts on paleontological resources may occur from changes in erosion or depositional processes between Lake Powell and Lake Mead.

Median acreages of available sediment for windblown transport for the No Action Alternative ranges from 1,643,222 m² at the 80th percentile to 1,575,186 m² at the 100th percentile. Lower river flows will result in the most sediment available in late 2024, again in late 2025, and again in late 2027 at the 100th percentile. Increases in available sediment are a beneficial impact of low river flows by reducing the potential exposures of paleontological resources.

If reduced releases result in 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 resource because of increased visitation.

Action Alternative 1

Under Action Alternative 1, releases from Lake Powell would be consistent with those approved and analyzed under the LTEMP while conditions permit. If insufficient water is available, releases would be coordinated to protect the minimum power pool elevation of 3,500 feet elevation in Lake Powell. Under Action Alternative 1, median exposed sediment acreage ranges from 1,730,261 m² at the 80th percentile to 1,575,186 m² at the 100th percentile. As flows are more evenly distributed under Action Alternative 1, sediment is available for longer amounts of time and at more regular intervals than under the No Action Alternative, thus reducing the potential for exposure of previously inundated paleontological resources.

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.

Action Alternative 2

Impacts on paleontological resources along the river reach from Lake Powell to Lake Mead for Action Alternative 2 would be the same as for Action Alternative 1.

Cumulative Effects

The proposed releases are within the previously approved flows under the No Action Alternative and are unlikely to cause any additional impacts on paleontological resources. Cumulatively, negative impacts on paleontological resources are anticipated in the near and long term from each of the proposed alternatives from associated with fluctuating water levels, increase visitation and unauthorized collection or vandalism. Violations of the PRPA by visitors can result in punishments under law.

3.13 Biological Resources

3.13.1 Affected Environment

In order to supplement 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 2004), 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 2004); and a query of BLM sensitive species in the natural heritage databases for Utah (BLM 2018), Arizona (BLM 2017b), Nevada (BLM 2017a), 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; 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* sp.).

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, and increase the risk of severe wildfires. In addition to terrestrial impacts, tamarisk impacts aquatic

systems by eliminating side channel and backwater habitats that provide critical spawning and nursery habitat for native fish and by trapping sediment (NPS 2023l). Tamarisk changes the ecology and hydrology of riparian systems. It has one of the highest evapotranspiration rates of any riparian shrub, removing water from the soil and releasing it through the leaves. Water loss caused by tamarisk can range to 13 afy.

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 2023l).

GCNRA has many springs and seeps that are common in alcoves along Glen Canyon walls, and 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 does occur 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. Sediment deposits that can support vegetation occur along channel margins, on banks in the pools upstream from channel constrictions, on the boulder dominated debris fans, and as sandbars in eddies downstream from debris fans (Palmquist et al. 2018). Plant communities present along the river have developed through associations of species with similar responses to moisture gradients, tolerance to water stress, and modes of reproduction. Such species associations occur on geomorphic surfaces of debris fan-eddy complexes, such as reattachment bars and separation bars, as well as on channel margins between these complexes, and respond dynamically to changes in flow characteristics. Because of historical patterns of dam releases, communities below the 25,000-cfs elevation on these surfaces differ somewhat from those above that level. Seven plant community types have been identified as occurring on these geomorphic surfaces and are listed in Table 3.6-1 of the LTEMP EIS (Reclamation and NPS 2016).

The distribution of species within the riparian zone generally follows a hydrologic gradient, with obligate wetland species at the water's edge and facultative and upland species farther from the shoreline. Vegetation associated with the riparian zone is a mix of native and nonnative woody and herbaceous vegetation that reflects the pre- and post-dam habitats available for plant species. The current vegetation is still comprised of many of the native species historically documented as occurring along the river, including Emory's baccharis (*Baccharis emoryi*), mule fat (*Baccharis salicifolia*), spiny chloracantha (*Chloracantha spinosa*), alkali goldenbush (*Isocoma acradenia*), arrowweed (*Pluchea sericea*), coyote willow (*Salix exigua*), and sand dropseed (*Sporobolus cryptandrus*). Other common native species include Arizona threeawn (*Aristida arizonica*), white sagebrush (*Artemisia ludoviciana*), desert broom (*Baccharis sarothroides*), horsetail (*Equisetum x ferrissii*), western goldentop (*Euthamia occidentalis*), and mesa dropseed (*Sporobolus flexuosus*). Some nonnative species are dominant components of this system as well, including tamarisk (*Tamarix* spp.), creeping bentgrass (*Agrostis stolonifera*), camelthorn (*Alhagi maurorum*), annual *Bromus* spp., and bermudagrass (*Cynodon dactylon*) (Palmquist et al. 2018).

As described in the LTEMP EIS (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 EIS (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.

The dominant woody species of the Glen Canyon and Grand Canyon new high water zone scrub communities include tamarisk, coyote willow, arrowweed, and seepwillow (*Baccharis* spp.), along with desert broom downstream from RM 162. Wide, alluvial reaches have greater vegetation cover than narrow, confined reaches. The old high water zone, above 45,000 cfs to approximately 200,000 cfs, supports pre-dam drought-tolerant riparian species found in riparian and upland habitats, such as honey mesquite, catclaw acacia, netleaf hackberry, Apache plume, New Mexico olive, and mountain pepperweed (*Lepidium montanum*), along with desert species such as Mormon tea (*Ephedra* spp.), prickly pear (*Opuntia* spp.), creosote, ocotillo, and brittlebush. Mortality of old high water zone plants is occurring. Some species such as mesquite and hackberry are no longer recruiting in this zone because of the lack of sufficiently high flows and nutrient-rich sediment inputs; however, mesquite and catclaw acacia are now recruiting in the new high water zone. Because flows do not exceed 45,000 cfs with normal dam operations, the upper margins of this zone are moving downslope, resulting in a narrowing of the zone. Desert species occupy pre-dam flood terraces and windblown sand deposits above the old high water zone (Reclamation and NPS 2016).

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) coarsened substrates, affected nutrient concentrations, and reduced opportunities for subsequent recruitment of tamarisk and native shrubs such as coyote willow and Emory seepwillow (Reclamation and NPS 2016).

The population of Goodding's willow along the river below Glen Canyon Dam appears to have been affected by the reduction in flood flows on upper riparian terraces. It has been in decline and either no longer occurs at or does not reproduce at two-thirds of the sites where it previously existed (Reclamation and NPS 2016). Restoration of Goodding's willow and several other native species has been a focus of revegetation efforts. The lack of flood and flow attenuation parameters, which prevent seedling establishment, have reduced Goodding's willow and Fremont cottonwood (*Populus fremontii*) within the canyon and may influence the invasion of resultant open areas by tamarisk (Mortenson et al. 2008). In addition, recruitment of these species along the river is nearly eliminated each year by beavers (*Castor canadensis*) foraging on seedlings, and very few Fremont cottonwood occur along the river below the dam (Reclamation and NPS 2016).

A number of nonnative plant species, many of which are invasive species, occur throughout the riparian zone. Among the most common species are tamarisk, camelthorn, Russian thistle (*Salsola tragus*), ripgut brome (*Bromus diandrus*), red or foxtail brome (*Bromus rubens*), cheatgrass (*Bromus tectorum*), yellow sweetclover (*Melilotus officinalis*), spiny sow thistle (*Sonchus asper*), Ravenna grass (*Saccharum ravennae*), perennial peppergrass (*Lepidium latifolium*), and Bermuda grass (*Cynodon dactylon*) (Reclamation and NPS 2016). Tamarisk has long been the most prominent of these invasive species. Mortenson et al. (2012) showed how changes in the flow regime resulted in successive recruitment of tamarisk to lower river stages.

The tamarisk leaf beetle has had a marked impact on the ecology of riparian zones in Glen, Marble, and Grand Canyons in recent years. The beetle causes early and repeated defoliation of tamarisk during the summer months, which may eventually result in mortality after several successive years of defoliation. The long-term effects of the tamarisk leaf beetle and splendid tamarisk weevil on tamarisk abundance and distribution in Glen and Grand Canyons are currently not known; however, plant communities in which tamarisk is currently a dominant species would likely undergo compositional change (Reclamation and NPS 2016). Both native and nonnative plant species may become established on sites of tamarisk mortality, although native species establishment may be slow, and future community composition and habitat characteristics would depend on a variety of site-specific factors, including site hydrology and microclimate, changes in nutrient dynamics, available seed sources, and active restoration efforts (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 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. There are four specific vegetation issues influenced by dam operations that emerged in the LTEMP FEIS that the restoration projects specifically seek to address: 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 HFEs under the LTEMP have influenced riparian vegetation in this reach. Since 2012, five HFEs have been conducted; none have been conducted since 2018.

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 de-water 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 km) while exposing more than 61,776 acres (25,000 ha) 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 re-exposed 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 2004). 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 2004).

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 2021d).

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 ha) 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 restored and are managed by the LCR MSCP (LCR MSCP 2022).

Wildlife

Lake Powell

Lake Powell and its associated upland habitat supports 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 14 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*), and smallmouth bass (*Micropterus dolomieu*). Additionally, management actions in this reservoir have also introduced nonnative forage fish to support this sport fishery.

Deltaic deposits have formed in the inflows of the Colorado and San Juan Rivers and have 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 San Juan River inflow, riverine habitat has been expanded by about 30 miles (48 km) and a 20-foot (6-meter) waterfall has formed at the upper end that now blocks upstream movement by fish.

At the time of the FEIS (Reclamation 2007), it was unclear whether zebra mussels or quagga mussels were established in Lake Powell. However, quagga mussels were discovered in 2012 and sampling in subsequent years (2014–2019) indicated that this species has continued to spread throughout the reservoir (Utah Department of Natural Resources 2021).

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). 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 km) and the Lake Mead inflow for an additional 25 miles (40 km). A large rapid has formed near Pearce Ferry (RM 280) that serves as a partial barrier to upstream fish movement. The entire reach from the dam to Lake Mead includes approximately 18 species of nonnative fish and 5 native species (Valdez and Carothers 1998). A Blue Ribbon trout fishery exists in the 15 miles (24 km) of river below Glen Canyon Dam (Lees Ferry), consisting of rainbow trout, although in recent years brown trout populations have been increasing. Smallmouth bass, which are an invasive and predatory fish have been detected below Glen Canyon Dam, creating a need to prevent establishment before they impact native fish. Reclamation is pursuing an EA that would allow them to use dam operations to reduce the temperature of the water to prevent establishment 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. A large rapid has formed near Pearce Ferry (RM 280) that serves as a partial barrier to upstream fish movement.

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 (Cross et al. 2010), downstream of Glen Canyon Dam.

Lake Mead

Similar to Lake Powell, Lake Mead and its associated upland habitat supports 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 fluctuations, 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. 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.

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 with 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 Lakes Mead and 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 supports 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 2004). 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.

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 2017b), Nevada (BLM 2017a), 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 3-28** and **Table 3-29**.

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 3-28** and **Table 3-29**, 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 assessment. Updated information will be incorporated into the final SEIS when it is available.

Lake Powell

Table 3-28 lists all federally threatened, endangered, or proposed species and whether they occupy Lake Powell. **Table 3-29** lists all non-ESA-listed special status species and whether they occupy Lake Powell.

In the Colorado River inflow to Lake Powell, Colorado pikeminnow are found as larvae and age-0 fish that are transported from upstream, but a population has not become established in the inflow. 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 Colorado River inflow 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). 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).

Table 3-28
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
Fish						
Bonytail	<i>Gila elegans</i>	Endangered BLM NV	X (rare, stocked)			X (stocked)
Colorado pikeminnow	<i>Ptychocheilus lucius</i>	Endangered	X (rare in lake, common in inflows)			
Humpback chub	<i>Gila cypha</i>	Threatened		X	X (new population below full pool elevation in Colorado River Inflow)	

3. Affected Environment and Environmental Consequences (Biological Resources)

Common Name	Scientific Name	Listing Status	Location			
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB
Razorback sucker	<i>Xyrauchen texanus</i>	Endangered BLM NV	X	X (currently present downstream of Lava Falls Rapid)	X	X
Birds						
Southwestern willow flycatcher	<i>Empidonax traillii extimus</i>	Endangered BLM AZ BLM CA BLM NV	No habitat present for this species	Present	Habitat only in Lower Las Vegas Wash within full pool of Lake Mead	X
Western yellow-billed cuckoo	<i>Coccyzus americanus</i>	Threatened BLM AZ BLM CA BLM NV	No habitat present for this species	Habitat present in unaffected tributaries	Habitat only in Lower Las Vegas Wash within full pool of Lake Mead	Habitat in LCR MSCP conservation areas
Yuma Ridgway's rail	<i>Rallus obsoletus yumaniensis</i>	Endangered BLM AZ BLM CA BLM NV	No habitat present for this species	Habitat present above the waterline	Habitat in lower Grand Canyon within full pool of Lake Mead	Present
Mammals						
None						
Reptiles and Amphibians						
Desert tortoise	<i>Gopherus agassizii</i>	Threatened BLM NV	Not present	Not present	Present	Present
Northern Mexican garter snake	<i>Thamnophis eques megalops</i>	Threatened	Not present	Not present	Not present	Present
Invertebrates						
None						
Plants						
None						

Table 3-29
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
Fish						
Bluehead sucker	<i>Catostomus discobolus</i>	BLM AZ BLM UT		X	X (rare)	X (rare)
Desert sucker	<i>Catostomus clarkii</i>	BLM AZ				X (found in tributaries)
Flannelmouth sucker	<i>Catostomus latipinnis</i>	BLM AZ BLM UT	X	X	X	X
Gila longfin dace	<i>Agosia chrysogaster chrysogaster</i>	BLM AZ				X (found in tributaries)
Sonora sucker	<i>Catostomus insignis</i>					X (found in tributaries)
Speckled dace	<i>Rhinichthys osculus</i>	BLM AZ	X (rare)	X	X	X
Virgin spinedace	<i>Lepidomeda mollispinis</i>				X (found in Virgin River upstream of project area)	
Woundfin	<i>Plagopterus argentissimus</i>				X (found in Virgin River upstream of project area)	
Birds						
American peregrine falcon	<i>Falco peregrinus</i>	BLM AZ BLM NV		X	X	X
American white pelican	<i>Pelicanus erythrorhynchos</i>	BLM UT	X			X ¹
Arizona bell's vireo	<i>Vireo bellii arizonae</i>	BLM CA				X
Arizona grasshopper sparrow	<i>Ammodramus savannarum ammolegus</i>	BLM AZ		X	X	X
Bald eagle	<i>Haliaeetus leucocephalus</i>	BLM AZ BLM NV BLM UT	X	X	X	X
Bank swallow	<i>Riparia riparia</i>	BLM CA				X
Bendire's thrasher	<i>Toxostoma bendirei</i>	BLM CA				X

3. Affected Environment and Environmental Consequences (Biological Resources)

Common Name	Scientific Name	Status	Location			
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB
Black swift	<i>Cypseloides niger</i>	BLM UT	X			
Burrowing owl	<i>Athene cunicularia</i>	BLM AZ BLM UT BLM NV	X		X ¹	X
Cactus ferruginous pygmy owl	<i>Glaucidium brasilianum cactorum</i>	BLM AZ		X	X	X
California black rail	<i>Laterallus jamaicensis coturniculus</i>	BLM AZ BLM CA				X
California brown pelican	<i>Pelecanus occidentalis californicus</i>	BLM CA				X
California condor	<i>Gymnogyps californianus</i>	BLM AZ	X	X		
Crissal thrasher	<i>Toxostoma crissale</i>	BLM CA				X
Elf owl	<i>Micrathene whitneyi</i>	BLM CA				X
Ferruginous hawk	<i>Buteo regalis</i>	BLM UT	X			
Gila woodpecker	<i>Melanerpes uropygialis</i>	BLM CA				X
Gilded flicker	<i>Colaptes chrysoides</i>	BLM AZ BLM CA				X
Golden eagle	<i>Aquila chrysaetos</i>	BLM UT BLM AZ	X	X	X ¹	X
Least bittern	<i>Ixobrychus exilis</i>	BLM NV			X	X ¹
LeConte's thrasher	<i>Toxostoma lecontei</i>	BLM AZ		X	X	X
Lucy's warbler	<i>Vermivora luciae</i>	BLM CA				X
Mountain plover	<i>Charadrius montanus</i>	BLM CA				X
Northern goshawk	<i>Accipiter gentilis</i>	BLM AZ		X		
Phainopepla	<i>Phainopepla nitens</i>	BLM NV			X	X ¹
Swainson's hawk	<i>Buteo swainsoni</i>					X
Tricolored blackbird	<i>Agelaius tricolor</i>	BLM CA				X
Western snowy plover	<i>Charadrius nivosus nivosus</i>	BLM NV			X	
White-tailed kite	<i>Elanus leucurus</i>	BLM CA				X

3. Affected Environment and Environmental Consequences (Biological Resources)

Common Name	Scientific Name	Status	Location			
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB
Mammals						
Allen’s big-eared bat	<i>Idionycteris (=Plecotus) phyllotis</i>	BLM AZ BLM NV BLM UT	X		X	
Allen’s lappet-browed bat	<i>Idionycteris phyllotis</i>	BLM AZ		X		
Arizona myotis	<i>Myotis occultus</i>	BLM AZ		X	X	X
Big brown bat	<i>Eptesicus fuscus</i>	BLM NV	X	X	X	X ¹
Big free-tailed bat	<i>Nyctinomops macrotis</i>	BLM NV			X	X ¹
California leaf-nosed bat	<i>Macrotus californicus</i>	BLM AZ BLM NV			X	X
California myotis	<i>Myotis californicus</i>	BLM NV	X	X	X	X ¹
Canyon bat	<i>Parastrellus hesperus</i>	BLM NV	X	X	X	X ¹
Cave myotis	<i>Myotis velifer</i>	BLM AZ BLM NV	X	X	X	X
Desert bighorn sheep	<i>Ovis canadensis nelsoni</i>	BLM CA	X	X	X	X
Fringed myotis	<i>Myotis thysanodes</i>	BLM UT BLM NV	X		X	
Hoary bat	<i>Lasiurus cinereus</i>	BLM NV			X	X ¹
Houserock Valley chisel-toothed kangaroo rat	<i>Dipodomys microps leucotis</i>	BLM AZ		X		
Kit fox	<i>Vulpes macrotis</i>	BLM UT	X			
Long-eared myotis	<i>Myotis evotis</i>	BLM CA				X
Mexican free-tailed bat	<i>Tadarida brasiliensis</i>	BLM NV	X	X	X	X ¹
Pale Townsend’s big-eared bat	<i>Corynorhinus townsendii pallescens</i>	BLM AZ	X	X	X	X
Pallid bat	<i>Antrozous pallidus</i>	BLM NV	X	X	X	X
Palm springs pocket mouse	<i>Perognathus longimembris bangsi</i>	BLM CA				X
Palm springs round-tailed ground squirrel	<i>Xerospermophilus tereticaudus chlorus</i>	BLM CA				X

3. Affected Environment and Environmental Consequences (Biological Resources)

Common Name	Scientific Name	Status	Location			
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB
Silver-haired bat	<i>Lasionycteris noctivagans</i>	BLM NV	X	X	X	X ¹
Spotted bat	<i>Euderma maculatum</i>	BLM AZ BLM NV BLM UT		X		X
Townsend's big-eared bat	<i>Corynorhinus townsendii</i>	BLM AZ BLM CA BLM NV BLM UT	X		X	X
Western mastiff bat	<i>Eumops perotis</i>	BLM AZ BLM NV		X	X	X
Western red bat	<i>Lasiurus blossevillii</i>	BLM NV BLM UT			X	X ¹
Western small-footed myotis	<i>Myotis ciliolabrum</i>	BLM CA BLM NV			X	X
Yuma myotis	<i>Myotis yumanensis</i>	BLM CA BLM NV	X	X	X	X
Reptiles and Amphibians						
Arizona striped whiptail	<i>Aspidoscelis arizonae</i>	BLM AZ		X	X	X
Arizona toad	<i>Anaxyrus microscaphus</i>	BLM AZ BLM UT BLM NV	X			X
Banded gila monster	<i>Heloderma suspectum cinctum</i>	BLM NV			X	X
Coast horned lizard	<i>Phrynosoma blainvillii</i>	BLM CA				X
Coronado skink	<i>Plestiodon skiltonianus interparietalis</i>	BLM CA				X
Couch's spadefoot	<i>Scaphiopus couchii</i>	BLM CA				X
Desert box turtle	<i>Terrapene ornata luteola</i>	BLM AZ		X	X	X
Flat-tailed horned lizard	<i>Phrynosoma mcallii</i>	BLM AZ				X
Foothill yellow-legged frog (south coast DPS)	<i>Rana boylei</i>	BLM CA				X

3. Affected Environment and Environmental Consequences (Biological Resources)

Common Name	Scientific Name	Status	Location			
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB
Lowland burrowing treefrog	<i>Smilisca fodiens</i>	BLM AZ		X	X	X
Lowland leopard frog	<i>Rana yavapaiensis</i>	BLM AZ BLM CA			X	X
Mohave fringe-toed lizard	<i>Uma scoparia</i>	BLM AZ		X	X	X
Northern leopard frog	<i>Lithobates [=Rana] pipiens</i>	BLM AZ	X ²	X		
Relict leopard frog	<i>Rana onca</i>	BLM AZ BLM NV			X	X
Sinoloan narrow-mouthed toad	<i>Gastrophryne mazatlanensis</i>	BLM AZ		X	X	X
Sonoran green toad	<i>Bufo retiformis</i>	BLM AZ		X	X	X
Two-striped garter snake	<i>Thamnophis hammondi</i>	BLM CA				X
Western pond turtle	<i>Emys marmorata</i>	BLM CA				X
Western spadefoot	<i>Spea hammondi</i>	BLM CA				X
Yuman desert fringe-toed lizard	<i>Uma rufopunctata</i>	BLM AZ		X	X	X
Invertebrates						
Apache springsnail	<i>Pyrgulopsis arizonae</i>	BLM AZ		X	X	X
Gila tyronia	<i>Tryonia gilae</i>	BLM AZ		X	X	X
Grand wash springsnail	<i>Pyrgulopsis bacchus</i>	BLM NV		X	X	X
Kingman springsnail	<i>Pyrgulopsis conica</i>	BLM AZ		X	X	X
MacNeill's sooty-winged skipper	<i>Hesperopsis graciellae</i>	BLM NV			X	X ¹
Mojave gypsum bee	<i>Andrena balsamorhizae</i>	BLM NV			X	
Mojave poppy bee	<i>Perdita meconis</i>	BLM NV			X	

3. Affected Environment and Environmental Consequences (Biological Resources)

Common Name	Scientific Name	Status	Location			
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB
Monarch butterfly	<i>Danaus plexippus plexippus</i>	Candidate BLM NV		X	X	X
Sonoran talussnail	<i>Sonorella magdalenensis</i>	BLM AZ		X	X	X
Thorne's hairstreak	<i>Callophrys thornei</i>	BLM CA				X
Plants						
Alkali mariposa lily	<i>Calochortus striatus</i>	BLM NV			X	
Aravaipa sage	<i>Salvia amissa</i>	BLM AZ		X	X	X
Aravaipa woodfern	<i>Thelypteris puberula</i> var. <i>sonorensis</i>	BLM AZ		X		
Arizona eryngo	<i>Eryngium sparganophyllum</i>	BLM AZ		X	X	X
Arizona sonoran rosewood	<i>Vauquelinia californica</i> ssp. <i>sonorensis</i>	BLM AZ		X	X	X
Bartram stonecrop	<i>Graptopetalum bartramii</i>	BLM AZ		X	X	X
Beaver dam breadroot	<i>Pediomelum castoreum</i>	BLM NV			X	
Blue diamond cholla	<i>Cylindropuntia X multigeniculata</i>	BLM NV			X	
Blue sand lily	<i>Triteleopsis palmeri</i>	BLM AZ		X	X	X
California flannelbush	<i>Fremontodendron californicum</i>	BLM AZ		X	X	X
California screw moss	<i>Tortula californica</i>	BLM CA				X
Chaparral sand-verbena	<i>Abronia villosa</i> var. <i>aurita</i>	BLM CA				X
Cochise sage	<i>Carex ultra</i>	BLM AZ		X	X	X
Coulter's goldfields	<i>Lasthenia glabrata</i> ssp. <i>coulteri</i>	BLM CA				X
Deane's milkvetch	<i>Astragalus deanei</i>	BLM CA				X
Decumbent goldenbush	<i>Isocoma menziesii</i> var. <i>decumbens</i>	BLM CA				X
Delicate clarkia	<i>Clarkia delicata</i>	BLM CA				X

3. Affected Environment and Environmental Consequences (Biological Resources)

Common Name	Scientific Name	Status	Location			
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB
Dunn's mariposa lily	<i>Calochortus dunnii</i>					X
Fish creek fleabane	<i>Erigeron piscaticus</i>	BLM AZ		X	X	X
Felt-leaved monardella	<i>Monardella hypoleuca ssp. lanata</i>	BLM CA				X
Gander's pitcher sage	<i>Lepechinia ganderi</i>	BLM CA				X
Gander's ragwort	<i>Packera ganderi</i>	BLM CA				X
Gold butte moss	<i>Ceratodon purpureus</i>	BLM NV			X	
Grand Canyon rose	<i>Rosa stellata</i> var. <i>abyssa</i>	BLM AZ		X		
Harrison's barberry	<i>Berberis harrisoniana</i>	BLM AZ		X	X	X
Harwood's eriastrum	<i>Eriastrum harwoodii</i>	BLM CA				X
Hohokam agave	<i>Agave murpheyi</i>	BLM AZ		X	X	X
Horn's milkvetch	<i>Astragalus hornii</i> var. <i>hornii</i>	BLM CA				X
Huachuca golden aster	<i>Heterotheca rutteri</i>	BLM AZ		X	X	X
Lace-leaf rockdaisy	<i>Perityle ambrosiifolia</i>	BLM AZ		X	X	X
Lakeside ceanothus	<i>Ceanothus cyaneus</i>	BLM CA				X
Las Vegas bearpoppy	<i>Arctomecon californica</i>	BLM NV			X	
Las Vegas buckwheat	<i>Eriogonum corymbosum</i> var. <i>nilesii</i>	BLM NV			X	
Latimer's woodland-gilia	<i>Saltugilia latimeri</i>	BLM CA				X
Lincoln rockcress	<i>Boechera lincolnensis</i>	BLM CA				X
Little San Bernardino Mtns. linanthus	<i>Linanthus maculatus</i> ssp. <i>maculatus</i>	BLM CA				X

3. Affected Environment and Environmental Consequences (Biological Resources)

Common Name	Scientific Name	Status	Location			
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB
Long-spined spineflower	<i>Chorizanthe polygonoides</i> var. <i>longispina</i>	BLM CA				X
Marble canyon milkvetch	<i>Astragalus cremnophylax</i> var. <i>hevronii</i>	BLM AZ		X		
Mecca-aster	<i>Xylorhiza cognata</i>	BLM CA				X
Mojave indigo bush	<i>Psoralea arborescens</i> var. <i>pubescens</i>	BLM AZ		X		
Mojave tarplant	<i>Deinandra mohavensis</i>	BLM CA				X
Mokiak milkvetch	<i>Astragalus mokiensis</i>	BLM NV			X	
Mt Trumbull beardtongue	<i>Penstemon distans</i>	BLM AZ		X		
Nuttall's scrub oak	<i>Quercus dumosa</i>	BLM CA				X
Oil neststraw	<i>Stylocline citroleum</i>	BLM CA				X
Orcutt's brodiaea	<i>Brodiaea orcuttii</i>	BLM CA				X
Orocopia Mountains spurge	<i>Euphorbia jaegeri</i>	BLM CA				X
Otay manzanita	<i>Arctostaphylos otayensis</i>	BLM CA				X
Otay Mountain ceanothus	<i>Ceanothus otayensis</i>	BLM CA				X
Parish's meadowfern	<i>Limnanthes alba</i> ssp. <i>parishi</i>	BLM CA				X
Parish's phacelia	<i>Phacelia parryi</i>	BLM NV			X	
Parry's spineflower	<i>Chorizanthe parryi</i> var. <i>parryi</i>	BLM CA				X
Parry's tetradococcus	<i>Tetradococcus dioicus</i>	BLM CA				X
Pima Indian mallow	<i>Abutilon parishii</i>	BLM AZ		X	X	X
Pinto beardtongue	<i>Penstemon bicolor</i> ssp. <i>roseus</i>	BLM AZ				X
Polished blazing star	<i>Mentzelia laevicaulis</i>	BLM NV			X	

3. Affected Environment and Environmental Consequences (Biological Resources)

Common Name	Scientific Name	Status	Location			
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB
Rainbow manzanita	<i>Arctostaphylos rainbowensis</i>	BLM CA				X
Ramona horkelia	<i>Horkelia truncata</i>	BLM CA				X
Reveal's buckwheat	<i>Eriogonum contiguum</i>	BLM CA				X
Robinson's monardella	<i>Monardella robisonii</i>	BLM CA				X
Rosy twotone beardtongue	<i>Penstemon bicolor ssp. roseus</i>	BLM NV			X	
Salt marsh bird's beak	<i>Chloropyron maritimum ssp. maritimum</i>	BLM CA				X
San Bernadino milkvetch	<i>San Bernardino milkvetch</i>	BLM CA				X
San Diego goldenstar	<i>Bloomeria clevelandii</i>	BLM CA				X
San Diego gumplant	<i>Grindelia hallii</i>	BLM CA				X
San Diego milkvetch	<i>Astragalus oocarpus</i>	BLM CA				X
Sandfood	<i>Pholisma sonora</i>	BLM AZ		X	X	X
San Jacinto mariposa lily	<i>Calochortus palmeri var. munzii</i>	BLM CA				X
San Luis Obispo sedge	<i>Carex obispoensis</i>	BLM CA				X
San Miguel savory	<i>Clinopodium chandleri</i>	BLM CA				X
Sanford's arrowhead	<i>Sagittaria sanfordii</i>	BLM CA				X
Santa Lucia dwarf rush	<i>Juncus luciensis</i>	BLM CA				X
Scaly sandplant	<i>Pholisma arenarium</i>	BLM AZ		X	X	X
Shevock's copper moss	<i>Mielichhoferia shevockii</i>	BLM CA				X
Siler fishhook cactus	<i>Sclerocactus sileri</i>	BLM AZ		X		
Silverleaf sunray	<i>Enceliopsis argophylla</i>	BLM AZ BLM NV		X	X	X
Small wirelettuce	<i>Stephanomeria exigua ssp. exigua</i>	BLM AZ		X	X	X

3. Affected Environment and Environmental Consequences (Biological Resources)

Common Name	Scientific Name	Status	Location			
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB
Snake cholla	<i>Cylindropuntia californica</i> var. <i>californica</i>	BLM CA				X
Spring mountains milkvetch	<i>Astragalus remotus</i>	BLM NV			X	
Sticky buckwheat	<i>Eriogonum viscidulum</i>	BLM AZ BLM NV			X	
Sticky dudleya	<i>Cylindropuntia californica</i> var. <i>californica</i>	BLM CA				X
Sticky ringstem	<i>Anulocaulis leiosolenus</i>	BLM NV			X	
Summer holly	<i>Comarostaphylis diversifolia</i> ssp. <i>diversifolia</i>	BLM CA				X
Tecate cypress	<i>Hesperocyparis forbesii</i>	BLM CA				X
Tecate tarplant	<i>Deinandra floribunda</i>	BLM CA				X
Threecorner milkvetch	<i>Astragalus geyeri</i> var. <i>triquetrus</i>	BLM NV			X	
Tumamoc globeberry	<i>Tumamoca macdougalii</i>	BLM AZ		X	X	X
Variegated dudleya	<i>Dudleya variegata</i>	BLM CA				X
White bearpoppy	<i>Arctomecon merriamii</i>	BLM NV			X	
White margined beardtongue	<i>Penstemon albomarginatus</i>	BLM NV			X	
White-bracted spineflower	<i>Chorizanthe xanti</i> var. <i>leucotheca</i>	BLM CA				X
Wiggins' croton	<i>Croton wigginsii</i>	BLM CA				X
Yellow twotone beardtongue	<i>Penstemon bicolor</i> ssp. <i>bicolor</i>	BLM NV			X	
Yucaipa onion	<i>Allium marvinii</i>	BLM CA				X

¹Additional location information received from personal communication with Carolyn Ronning, Wildlife Group Manager, Reclamation, on March 3, 2023.

²Additional location information received from the NPS (2023I)

Colorado pikeminnow are stocked in the San Juan River annually as juveniles (Service 2022), and razorback sucker as large subadults. These fish are successfully reproducing in the San Juan River,

but survival of young and recruitment of razorback sucker are low. 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. These species presently occupy about 30 miles of newly carved river each in the San Juan River and Colorado River inflows. Native fish in these inflows encounter large numbers of nonnative fish species that are potential predators and competitors, although the species and numbers of nonnative fish in the river channel are generally lower than in the body of the lake.

Glen Canyon Dam to Lake Mead

Table 3-28 lists all federally threatened, endangered, or proposed species and whether they occupy the Glen Canyon Dam to Lake Mead section. **Table 3-29** lists all non-ESA-listed special status species and whether they occupy the Glen Canyon Dam to Lake Mead section.

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, such as 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 locally common to abundant 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 over the last few years. This is likely due to the warmer water in the lower Grand Canyon and due to the lack of predators (Vanhaverbeke 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.¹⁷

Since 1944, only 10 razorback suckers have been reported from the Grand Canyon, including one from Bright Angel Creek, four from the mouth of the Paria River, one near Shinumo Creek, and four from the mouth of the Little Colorado River (Valdez et al. 2012). Since the year 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). The razorback sucker in the Grand Canyon is found only downstream of Lava Falls Rapid.

Lake Mead

Table 3-28 lists all federally threatened, endangered, or proposed species and whether they occupy Lake Mead. **Table 3-29** lists all non-ESA-listed special status species and whether they occupy Lake Mead.

Two native sucker species occupy this area and include flannelmouth sucker and razorback sucker (Reclamation 2007). The largest self-sustaining population of razorback sucker in the lower Basin is

¹⁷ Personal communication with Randy Van Haverbeke, Service, Flagstaff, Arizona, March 2023.

found in Lake Mead. Humpback chub, bonytail, and Colorado pikeminnow do not occur in this reach.

Humpback chub have become established in the Colorado River extended channel as far downstream as Pearce Ferry (Rogowski et al., 2018), but they are not moving into Lake Mead and it is unlikely the species would move into the lake since it is primarily a riverine species. However, there is a large population of razorback sucker 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 use emergent vegetation that is inundated with spring runoff as shelter, although predation by nonnative fish is high and survival and recruitment are low (Service 2018a). In the Colorado River inflow, the razorback sucker is found in large numbers 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 3-28 lists all federally threatened, endangered, or proposed species and whether they occupy the Hoover Dam to the SIB section. **Table 3-29** lists all non-ESA-listed special status species and whether they occupy the Hoover Dam to the SIB section.

The endangered razorback sucker and bonytail are introduced from hatchery stocks into Lake Mohave, Lake Havasu, and in 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 NWR. There is some evidence of reproduction by these species, but self-sustaining populations have not become established.

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. The bluehead sucker is found locally in tributary inflows.

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 (2023l) and the 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 WAPA, and the smallmouth bass model developed by the USGS. As with vegetation analyses, fisheries impacts could not be quantitatively determined from relationships of

flow to habitat or habitat to fish abundance, but rather as an evaluation of the hydrology associated with each alternative and as a professional scientific assessment.

Similar to the 2007 FEIS, this analysis evaluates the relative difference between the action alternatives and the No Action Alternative (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 four sections: 1) Lake Powell, 2) Glen Canyon Dam to Lake Mead, 3) Lake Mead, and 4) Hoover Dam to the SIB. 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 impacted by the project. See **Appendix E** for information narrowing the species in the impact analysis area to those potentially impacted by the alternatives.

The analysis area for fish and aquatic species includes the Colorado River and associated aquatic habitat that is contiguous with the mainstem 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. DO 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 hydrological 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 hydrological 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. If HFEs were to be decreased or discounted under the No Action Alternative, there would be at least an order of magnitude greater adverse impact on vegetation resources than simply comparing Action Alternative 1 or 2 to the No Action Alternative with both scenarios having HFEs.

The types of impacts on riparian vegetation associated with each action alternative are similar, as the action alternatives only vary by magnitude and timing of effects. At Lake Powell and Lake Mead, fewer acres have the potential to be invaded by nonnative species under the action alternatives 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 greater under the action alternatives compared with the No Action Alternative, as water flows are reduced to these sections to maintain higher water elevations in Lake Powell and Lake Mead. These impacts include a short-term increase in suitable habitat for nonnative species and a decrease in native species of interest that have established in recent decades.

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 releases 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 in the summer of 2023 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.

The NPS is estimating that an additional 20,000 acres of shoreline would be exposed around Lake Powell under this No Action Alternative. It is anticipated that this additional acreage of exposed shoreline 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 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; by dropping reservoir levels even more, these wetlands may disappear completely (NPS 2023l).

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. Releases from Lake Powell under poor hydrologic conditions would deplete Lake Powell, exposing a large acreage of increased shoreline at Lake Powell. Releases from Lake Powell would remain the same as existing conditions, depleting Lake Powell but maintaining similar release levels from Glen Canyon Dam to Lake Mead. Therefore, it is expected that the current vegetation conditions, as described above and in the LTEMP EIS, 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 CR—Marble Canyon (RM0–RM61), eastern Grand Canyon (RM61–RM161), and western Grand Canyon (RM161–RM226)—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, 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 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 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). 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 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 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).

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 and HFEs would be decreased or discontinued. At this point, riparian habitat may be further impacted. To demonstrate this, an additional set of comparisons was conducted (Butterfield and Palmquist 2023b), in which Action Alternative 1 with HFEs was compared with the No Action Alternative without HFEs, focusing on the 80 percent ESP and subdividing by traces from worst- to best-case scenarios with respect to lake levels. The results of this comparative modeling are described below under Action Alternative 1.

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 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 3-30**), at which point riparian habitat may be impacted.

Action Alternative 1

Lake Powell

Implementation of Alternative 1 would result in an increasing trend in Lake Powell's elevation (**Figure 3-5**). By 2026, the median elevation is projected to be 3,550 feet (1,082 meters), which is within the Mid-Elevation Release tier. Overall, more water would be preserved in Lake Powell and variability in water surface elevation would be reduced. Initial impacts on vegetation from implementation of this alternative would include inundation of vegetation that has established along the shoreline in response to lower water levels and an overall decrease in riparian plant habitat. However, as the elevation of the lake stabilizes, an upward shift in the riparian zone would occur. The NPS projected that a maximum of 8,000 acres have the potential to be invaded by nonnative plant species, which is substantially less than the number of possible infested acres under the No Action Alternative (NPS 2023l).

Glen Canyon Dam to Lake Mead

Hydrological niche modeling for the Action Alternative 1 scenario as it relates to the No Action Alternative show projected net changes in suitable habitat for combined native and nonnative species across years (2023–2027) and ESPs (80 percent, 90 percent, 100 percent), along with projected losses and gains in suitable habitat for each species within each region. In general, the riparian vegetation model did not project substantial changes in habitat suitability under Action Alternative 1 compared with the No Action Alternative, with one exception. Action Alternative 1 would result in statistically significantly less projected habitat for native species under the 80 percent ESP scenario (**Table 3-30**). Variation in projected net habitat change accumulated across all riparian plant species was greater among traces than between ESPs. However, there were some notable differences between ESPs, which are described below by region. Furthermore, these net habitat changes obscure substantial variation among species in projected habitat gains and losses (Butterfield and Palmquist 2023a).

Table 3-30
Overall Summary of Riparian Plant Community Modeling Comparing the Projected Suitable Habitat under Action Alternative 1 as Compared with the No Action Alternative

River Segment	ESP	Action Alternative 1 Relative to No Action Alternative					
		Native Species	Native Species with Gains	Native Species with Losses	Nonnative Species	Nonnative Species with Gains	Nonnative Species with Losses
Marble Canyon	100%	Similar	twin bugs, common reed	Jointed rush, alkali muhly, Emory's baccharis	Similar	annual grasses, salt cedar	horseweed, some perennial grasses
	90%	Similar			Greater		
	80%	Similar			Greater		
Eastern Grand Canyon	100%	Similar	twin bugs, common reed	Emory's baccharis, mule fat, cane bluestem	Similar	annual grasses, salt cedar	horseweed, some perennial grasses
	90%	Greater			Similar		
	80%	Greater			Similar		

River Segment	ESP	Action Alternative 1 Relative to No Action Alternative					
		Native Species	Native Species with Gains	Native Species with Losses	Nonnative Species	Nonnative Species with Gains	Nonnative Species with Losses
Western Grand Canyon	100%	Similar	twin bugs, catclaw	Emory's baccharis,	Similar	annual	beard grass
	90%	Similar			Similar	grasses,	
	80%	Declining over time	acacia, dropseed grasses, arrowweed	mule fat, cane bluestem, alkali goldenbush	Similar	salt cedar	

Source: Butterfield and Palmquist 2023a.

Note: Similar – projected suitable habitat is similar to No Action Alternative; Greater – projected suitable habitat is greater than for No Action Alternative; Declining over time – projected suitable habitat declines to less than the No Action Alternative over the 5-year span.

In Marble Canyon, nonnative species show sustained increases in suitable habitat for the majority of traces under the 80 percent and 90 percent ESPs compared with the 100 percent ESP, while native species did not. The **nonnative species** with greatest projected gains in suitable habitat included annual grasses (*Bromus* species and *Schismus arabicus*) and salt cedar (*Tamarix*), while horseweed (*Conyza canadensis*) and several perennial grass species (*Polypogon viridis*, *Eragrostis curvula* and *Schedonorus arundinaceus*) had the greatest projected losses. **Native species** with greatest projected habitat gains were the annual forb twin bugs (*Dicoria canescens*) and common reed (*Phragmites australis*), while those with the greatest projected losses included jointed rush (*Juncus articulatus*), bunchgrass alkali muhly (*Muhlenbergia asperifolia*), and the large shrub Emory's baccharis (*Baccharis emoryi*) (Butterfield and Palmquist 2023a).

In eastern Grand Canyon, native and nonnative species exhibited the opposite pattern from Marble Canyon with respect to net projected habitat change, with native species showing sustained increases in suitable habitat under the 80 percent and 90 percent ESPs, and nonnative species showing no difference from the 100 percent ESP. The **nonnative species** with greatest projected gains and losses were the same as in Marble Canyon. The **native species** with greatest projected gains were the same as in Marble Canyon, specifically twin bugs and common reed. Once again, Emory's baccharis had high projected losses, as did mule fat (*Baccharis salicifolia*) and the perennial grass cane bluestem (*Bothriochloa barbinodis*) (Butterfield and Palmquist 2023a).

In western Grand Canyon, projected net habitat change became increasingly negative over time for native species under the 80 percent ESP, but did not differ from the 100 percent ESP scenario in all other cases. The **nonnative species** with greatest projected gains were the same as in the other regions, while beard grass (*Polypogon viridis*) was the only species with significant losses relative to gains. The **native species** with greatest projected gains were twin bugs, catclaw acacia (*Acacia greggii*), several species of dropseed grasses (*Sporobolus* species), and arrowweed (*Pluchea sericea*). Those with the greatest projected losses were the same as in eastern Grand Canyon, with the addition of alkali goldenbush (*Isocoma acradenia*) (Butterfield and Palmquist 2023a).

In summary, total vegetation can be expected to increase in Marble Canyon and eastern Grand Canyon, driven by nonnative and native species, respectively, and to decline in western Grand Canyon, driven by native species. However, these general trends are weak relative to the variation

among traces, and obscure substantial shifts in suitable and unsuitable habitat among species as water levels decline. This variability also reflects the individualistic responses of different species to various aspects of hydrology and climate, revealed by the species-specific changes in habitat suitability shown here. In general, suitable habitat is expected to increase across all three regions for nonnative, fire-prone annual grasses and salt cedar. Likewise, the native common reed is expected to increase in suitable habitat in Marble Canyon and eastern Grand Canyon, though possibly decline in western Grand, while native dropseed, catclaw acacia, and arrowweed are expected to increase in western Grand Canyon. Water-loving baccharis species are expected to decrease in suitable habitat across all three regions.

When Action Alternative 1 with HFEs is contrasted with the No Action Alternative without HFEs, focusing on the 80 percent ESP (Butterfield and Palmquist 2023b), projections averaged across the 2024–2027 period, among the lowest water 10th percentile of traces, are as follows:

- Overall, projected effects of losing HFEs under the No Action Alternative have at least an order of magnitude greater impact on vegetation resources than simply comparing Action Alternative 1 with the No Action Alternative, with both scenarios having HFEs (as described above).
- Total vegetation is expected to be reduced by 33.7 percent under Action Alternative 1 with HFEs; however, it affects groups differentially. Native vegetation is expected to be reduced by 41 percent and nonnative vegetation is expected to increase by 20.1 percent.
- Native species of interest that have expanded in recent decades are expected to be reduced under Action Alternative 1 with HFEs (i.e., desert broom, coyote willow, arrowweed, and common reed) with the most dramatic decrease in water-loving species that have expanded near the river channel.
- Nonnative species of interest are projected to exhibit more variable responses:
 - Fire-prone annual grasses in the genera *Bromus* and *Schismus* are expected to increase substantially.
 - *Tamarix* is expected to increase slightly, while *Schedonorus arundinaceus* is expected to decrease substantially (Butterfield and Palmquist 2023b).

Lake Mead

Implementation of Action Alternative 1 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 1,015 feet (309 meters), 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 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 Action Alternative 1 would be similar to the impacts described for the Glen Canyon Dam to Lake Mead section of river.

In addition, Reclamation 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. Reduced flows under this alternative may also result in less water available for implementation of conservation actions associated with the LCR MSCP HCP, described above in **Section 3.13.1**.

Action Alternative 2

Action Alternative 2 modifies water delivery priorities compared with Action Alternative 1, which would not have a measurable impact on vegetation. Therefore, impacts on vegetation would be similar to those described under Action Alternative 1 for all analysis areas.

Cumulative Effects

If one of the Glen Canyon Dam Smallmouth Bass 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 are found within the analysis area that do not rely on riparian vegetation. 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.

Flow is an important factor in managing native and nonnative fish, and responses to reduced flows and declining lake elevations may impact fish species on a species-specific basis as well as based on developmental phase or life history. Furthermore, levels of discharge and lake elevations may also affect water temperatures, which can affect habitat availability and utilization on a species-specific and developmental-phase level. For example, reduction in flows can potentially reduce available lacustrine habitat while increasing riverine habitat as lake levels drop and more river channel is exposed at the inflow. Impacts on reduced flows and habitat availability were evaluated on a reach-specific basis.

Summary

The type of impacts associated with each alternative are similar, as alternatives vary only by magnitude and timing of effects. The No Action Alternative would result in increased impacts on terrestrial wildlife at Lake Powell and Lake Mead compared with Action Alternative 1 and Action Alternative 2. With no modifications to water management to address worsening drought conditions, water elevations are projected to decrease over time as water resources become depleted in Lake Powell and Lake Mead to sustain flows in the Colorado River below Glen Canyon Dam to Lake Mead and the Hoover Dam to the SIB sections. The retention of water in Lake Powell under Action Alternatives 1 and 2 provides for the opportunity for high-flow experimental releases that may mitigate some impacts in the Glen Canyon Dam to Lake Mead section related to beach building and sediment transport. This would make Action Alternatives 1 and 2 preferable to the No Action Alternative for terrestrial wildlife.

In most potential hydrologic futures (**Section 3.6.2**), impacts on terrestrial wildlife in the Colorado River below the Hoover Dam to the SIB section would be greater under Action Alternative 1 and Action Alternative 2 compared with the No Action Alternative, as water flows are reduced to these sections to maintain higher water elevations in Lake Powell and Lake Mead.

However, in some potential hydrologic futures (**Section 3.6.2, Figure 3-8**), Lake Mead would hit dead pool in early 2026. Under the No Action Alternative, no contingencies are in place to prevent Lake Mead from reaching dead pool. This would result in catastrophic impacts on the Hoover Dam to SIB section, as no water could be released beyond the inflows (run of the river operations). Action Alternative 1 and Action Alternative 2 have contingencies in place to reduce flows should Lake Mead be at risk of reaching dead pool to ensure flowing water in all sections (**Chapter 2**).

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) 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 water elevations decrease.

If conditions continue to degrade in the form of reduced water availability, declining lake levels, and reduced available flows for release, there are likely multiple results from this scenario for aquatic species. The low lake levels have resulted in exposed deltaic deposits, through which both the Colorado River and San Juan River have carved new channels. Further declining lake levels would likely expand or increase riverine habitat benefiting riverine species in the inflows to Lake Powell as riverine habitat is increased in the San Juan River and other Colorado River inflows. There are

various nonnative fish species in Lake Powell, and some were introduced as sport fish or forage fish. The No Action Alternative may lead to changing habitats conditions for nonnative fish such as smallmouth bass, channel catfish, and other centrarchids through lower lake levels and warmer water temperatures. Depending on lake levels, decreasing talus shoreline spawning habitat of largemouth bass, smallmouth bass, bluegill, and other centrarchids. can be negatively affected, resulting in long-term population changes in these species. Additionally, reduced lake levels may reduce the amount of available habitat for midwater forage fish such as threadfin shad that are used to support the nonnative sport fishery in the lake. Low reservoir elevations may also negatively affect reservoir productivity and available food supplies for these nonnative fish.

Glen Canyon Dam to Lake Mead

If water elevations continue to decline in Lake Powell, less water will be available for release below Glen Canyon Dam to Lake Mead by 2026. Riparian vegetation along this stretch would be impacted as water levels dropped. Some vegetation in the current riparian zone would be expected to die off while new vegetation colonized the lower riparian zone. The timing of this transition is unknown but may begin within the analysis window of 2026 and continue afterward. During this transitional period, there could be impacts on species that utilize riparian habitat (Butterfield and Palmquist 2023; Holm et al. 2023).

Lower water levels could impact invertebrate biodiversity and have subsequent effects on species that rely on invertebrates for food. Specifically, bat species could be impacted by changing prey availability causing reduced fitness and increased susceptibility to white-nose syndrome (Holm et al. 2023).

There are about 18 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, and the fish community is predominantly composed of native species. The lowered lake elevation and reduction in releases from Glen Canyon Dam under the No Action Alternative could result in increased water temperatures that could benefit nonnative fish species such as smallmouth bass, common carp, channel catfish, bullheads, green sunfish, fathead minnows, and red shiners. This may result in increased interactions between nonnative and native fish and result in potential 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. With increased temperatures (above 18°C), parasites such as Asian tapeworm (*Bothriocephalus acheilognathi*) and anchorworms (*Lernaea cyprinacea*) could be expected to 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. A reduction in releases from Glen Canyon Dam may also increase the river's water clarity and the possibility of predation by sight predators, such as rainbow trout and brown trout, on native fish (Ward et al. 2016). This effect of reduced turbidity could be offset by warmer temperatures that will reduce the swimming efficiency of trout and improve the efficiency of warmwater species, such as humpback chub, razorback sucker, and flannelmouth sucker (Valdez and Carothers 1998).

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 impacted by different releases from Glen Canyon Dam, as low releases may desiccate these habitats and high releases may inundate them.

According to the USGS Smallmouth Bass Model (Yackulic 2023), smallmouth bass entrainment through Glen Canyon Dam may increase under the No Action Alternative compared with Action Alternative 1 and Action Alternative 2. However, entrainment depends on specific hydrologic traces, and hydrologic traces where low inflows occur may increase entrainment even under the action alternatives. In dry hydrologic traces, both alternatives would have increased entrainment compared with the No Action Alternative. Population growth is expected to be the same between the No Action Alternative and Action Alternative 1 in wet years.

Overall, both action alternatives are likely to result in less population growth than the No Action Alternative. However, in the driest hydrologic traces, both action alternatives result in substantial population growth. In the 25 percent of driest traces, Action Alternative 1 may result in increases in population growth of approximately 500 percent over the 4-year period of analysis. 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. This model indicated that population growth depended on the degree of available water during the modeled period.

Under the No Action Alternative, the GTMax Model shows that releases through the penstocks at Glen Canyon Dam would drop to zero from January through April 2024, meaning that water would be released through the river outlets where power is not generated. At low levels of Lake Powell, release temperatures are projected to be as high as 20°C, 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 elevation (Valdez et al. 2015). There could be an effect, however, on fish populations downstream of Glen Canyon Dam when the temperature of the water released shifts from warm water to cold water. This colder release could shock juvenile and adult rainbow trout in the Lees Ferry reach as well as eggs and fry that would be in the gravel beds at that time.

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 likely improve and increase habitat for nonnative fish that prey upon native species. 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.

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 with 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 Lakes Mead and Mohave.

Hoover Dam to the SIB

Given the decrease in water elevations projected in Lake Mead, less water would be available for release into this section.

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 potential for predation on native species.

In some of the driest potential hydrologic futures (**Section 3.6.2, Figure 3-8**), Lake Mead hits dead pool in early 2026. At this point, no water would be released from Lake Mead into the Hoover Dam to SIB section, severely limiting water resources in this section. Water in this section would be limited to inflows that enter the Colorado River below Hoover Dam. It is likely that these inflows would be insufficient to support aquatic species populations, leading to extirpation or extreme reductions in population numbers. Wildlife capable of moving to alternative habitat areas may be able to locate resources outside of the Colorado River corridor. Species that are not able to move to alternative habitat areas may become extirpated from the area.

Action Alternative 1

Lake Powell

No additional impacts beyond those described in the 2007 FEIS (Reclamation 2007) are expected on terrestrial wildlife species under this alternative.

Overall, Action Alternative 1 maintains higher water levels in Lake Powell throughout the entire period compared with the No Action Alternative. This would likely result in no negative impacts on the nonnative sport fish in the lake. Maintaining higher lake elevations also would not negatively affect native riverine species; however, it may reduce the length of riverine habitat associated with the inflow into Lake Powell compared with scenarios where lake elevation is reduced.

Glen Canyon Dam to Lake Mead

After implementing Action Alternative 1, releases from Lake Powell would be reduced, which would result in lower river flows in this section compared with the No Action Alternative.

The riparian vegetation model projects similar or greater native plant species availability under Action Alternative 1 compared with the No Action Alternative in all modeled areas except for in the western Grand Canyon area. In this area, native plant species availability would be lower under Action Alternative 1 compared with the No Action Alternative under the 80 percent ESP, which evaluates a worse-case scenario. Nonnative plant species availability is projected to be similar or greater under Action Alternative 1 compared with the No Action Alternative. Nonnative plant species provide lower-quality habitat than native species and can lead to monotypic habitat types that support fewer wildlife species (NatureServe 2023).

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 begin to decrease and nonnative plant cover increases. However, the greater likelihood for high-flow experimental releases under this alternative, relative to the No Action Alternative, reduces some of the impacts described under that alternative. Specifically, the likelihood of impacts on invertebrate diversity and subsequent prey availability effects would be reduced (Holm et al. 2023).

Action Alternative 1 would maintain flows of 5,000 cfs during the night and 8,000 cfs during the day within the LTEMP operations. This flow scenario would maintain shoreline habitat conditions for juvenile humpback chub and large recirculating eddies for adults. Compared with the No Action Alternative, Action Alternative 1 would maintain more suitable habitat conditions for humpback chub through the Grand Canyon. Action Alternative 1 would also provide suitable habitat conditions for razorback sucker that are present downstream of Lava Falls Rapid.

According to the USGS Smallmouth Bass Model (Yackulic 2023), Action Alternative 1 is likely to decrease the risk of entrainment (fish passage) of smallmouth bass compared with the No Action Alternative. However, entrainment depends on specific hydrologic traces, and hydrologic traces where low inflows occur may increase entrainment even under the action alternatives. In dry hydrologic traces, Action Alternative 1 would have increased entrainment compared with the No Action Alternative. Population growth is expected to be the same between the No Action Alternative and Action Alternative 1 in wet years.

Overall, Action Alternative 1 is likely to result in less population growth than the No Action Alternative. However, in the driest hydrologic traces, Action Alternative 1 is likely to result in substantial population growth. In the 25 percent of driest traces, Action Alternative 1 may result in increases in population growth of approximately 500 percent over the 4-year period of analysis. 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.

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. Impacts associated with wildlife becoming trapped in soft sediments would be more likely under this alternative, as more sediments would be exposed.

Reduction of lake elevation is expected to occur at a greater 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 sportfish in the lake. Following August 2025, this reduction would lessen and result in increased lake elevations compared with the No Action Alternative.

Action Alternative 1 would help to stabilize the elevation of Lake Mead and therefore continue to provide extended riverine habitat for the humpback chub. This area would also provide suitable habitat for the razorback sucker.

Hoover Dam to the SIB

After implementing Action Alternative 1, releases from Lake Mead would be reduced, which would result in lower water elevations in this section compared with the No Action Alternative. Impacts on riparian vegetation and terrestrial wildlife species would, therefore, be greater under Action Alternative 1 than the No Action Alternative in all but the driest potential hydrologic futures (**Section 3.6.2, Figure 3-8**).

However, in the driest potential hydrologic futures (**Section 3.6.2, Figure 3-8**), where Lake Mead is projected to reach dead pool, water deliveries from Lake Mead would be reduced in advance to avoid reaching these levels. Should these adjustments prove successful, the scenario of no water passing through Hoover Dam would not occur. Water levels in the section between Hoover Dam and the SIB could be critically low, but there would still be flow in the river to support aquatic species at levels substantially greater than those described under the No Action Alternative.

The fish community is dominated by nonnative fish, and the continued drop in water would likely result in improved habitat for nonnative species, continued pressure on native species, and potentially more interactions between nonnative and native species. Backwater habitats that presently occur in this reach and support stocked populations of razorback sucker and bonytail will be better sustained under Action Alternative 1 than under the No Action Alternative.

Action Alternative 2

Action Alternative 2 modifies water delivery priorities compared with Action Alternative 1 and marginally increases the water supply to Lake Powell through releases of water from the Upper Basin reservoirs. This would result in marginally more water available throughout the system

compared with Action Alternative 1. These marginal increases in water could be meaningful in the driest potential hydrologic futures (**Section 3.6.2**), especially immediately downstream of Hoover Dam. Also, the changes in water allocations under this alternative, relative to Action Alternative 1, would result in more water in the Colorado River between Hoover Dam and the locations where water is diverted for uses in California. However, these differences are minimal when considering impacts on wildlife. Therefore, overall impacts on wildlife species are similar to those described under Action Alternative 1 for all analysis sections other than part of the Hoover Dam to SIB section, where impacts of Action Alternative 2 are reduced compared with Action Alternative 1.

Cumulative Effects

The Glen Canyon Dam Smallmouth Bass flow options described in the environmental assessment that Reclamation is pursuing is the only cumulative action identified in **Section 3.5.1**. If one of the flow options were 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 action is to prevent the establishment of invasive smallmouth bass. Prevention of smallmouth bass establishment is important because smallmouth bass are adept predators with wide diet variability and may impact native fish (Bestgen and Hill 2016). Under all alternatives analyzed in this SEIS, the effects of this cumulative action would be beneficial for aquatic wildlife species unless water levels in Lake Powell reached minimum power pool levels. At minimum power pool, water would be released through the river outlet works out of necessity, nullifying this cumulative action.

Under the driest hydrologic futures, both alternatives are expected to increase smallmouth bass population growth substantially. For example, in the driest 25 percent of hydrologic traces, Action Alternative 1 increases smallmouth bass population growth by an average of approximately 500 percent over the 4-year period as compared with the No Action Alternative. Under moderate hydrologic scenarios, both alternatives would decrease smallmouth bass population growth. Under the wettest hydrologic traces, all alternatives would perform similarly (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 do not 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 3-31** and **Table 3-32** not analyzed in detail, and their habitat needs, is included in **Appendix E**, Table of Sensitive Species.

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, and Hoover Dam to the SIB). 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 magnitude and timing of effects. The No Action Alternative would result in increased

impacts on special status species at Lake Powell and Lake Mead compared with Action Alternatives 1 and 2. With no modifications to water management to address worsening drought conditions, water elevations would likely decrease over time as water resources become depleted in Lake Powell and Lake Mead to sustain flows in the Colorado River below Glen Canyon Dam to Lake Mead and the Hoover Dam to the SIB sections. The retention of water in Lake Powell under Action Alternatives 1 and 2 provides for high-flow events that may mitigate some impacts in the Glen Canyon Dam to Lake Mead section, making Action Alternatives 1 and 2 preferable to the No Action Alternative for terrestrial wildlife.

In most potential hydrologic futures (**Section 3.6.2**), impacts on special status species in the Colorado River below the Hoover Dam to the SIB section would be greater under Action Alternatives 1 and 2 compared with the No Action Alternative, as water flows are reduced to these sections to maintain higher water elevations in Lake Powell and Lake Mead.

In some of the driest potential hydrologic futures (**Section 3.6.2, Figure 3-8**), Lake Mead hits dead pool in early 2026. Under the No Action Alternative, no contingencies are in place to prevent Lake Mead from reaching dead pool. This would result in catastrophic impacts on the Hoover Dam to SIB section, as no water could be released beyond the inflows (run of the river operations). Action Alternatives 1 and 2 have contingencies in place to reduce flows should Lake Mead or Lake Powell be at risk of reaching dead pool, to ensure water delivery in all sections (**Chapter 2**).

The No Action Alternative would generally result in greater impacts on fish compared with Action Alternatives 1 and 2 in moderate to wet years. Under the No Action Alternative, the elevations of Lake Powell and Lake Mead would continue to decline, likely providing more suitable conditions for nonnative fish in both reservoirs. Although this could benefit game fish populations, it could also result in more predation and competition for native and listed fish species. Under the No Action Alternative, releases from Glen Canyon Dam and Hoover Dam would also decrease and reduce habitat for native and listed fish species downstream. Although these lower warmer releases may benefit subadults and adults of native fish species, these lower releases would likely benefit nonnative fish that are predators and competitors of native and listed fish species.

Under Action Alternatives 1 and 2, the elevations of Lake Powell and Lake Mead are expected to remain relatively stable (relative to the steady declines of the No Action Alternative), maintaining the newly established riverine habitat in the Colorado River and San Juan River inflows that are being used by endangered Colorado pikeminnow and razorback sucker. Releases from Glen Canyon Dam under Action Alternatives 1 and 2 would also 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, razorback sucker, flannelmouth sucker, and bluehead sucker in the Colorado River. However, depending on annual water supply, releases from Glen Canyon and Hoover Dams would potentially decrease under Action Alternatives 1 and 2 by up to 4,000 maf or more, compared with the No Action Alternative. Such reductions under Action Alternatives 1 and 2 would thus be less stable and result in more reductions in habitat for native and listed fish species than the No Action Alternative.

Both Action Alternatives 1 and 2 would have greater impacts than the No Action Alternative in the driest of potential hydrological futures. Both action 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.

Overall, the No Action Alternative would result in greater impacts on fish compared with Action Alternative 1 and Action Alternative 2. 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. These have allowed for downstream expansions of the endangered Colorado pikeminnow and razorback sucker below the full pool elevation of Lake Powell. In Lake Mead, a new river channel of about 40 miles in length has been carved from Separation Canyon to Pearce Ferry, enabling the establishment of a new population of humpback chub. Under the No Action Alternative, lake elevations would continue to decline; these riverine channels would continue to expand and create more habitat for the benefit of the species. Under Action Alternatives 1 and 2, 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 in the 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 impacted (**Table 3-31**, also see **Appendix E**, Table of Sensitive Species). 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.

Foraging habits vary widely by species, but many bats forage for insects over open water and riparian vegetation. Many insects use wet areas and riparian vegetation for breeding. Loss of habitat for insects could reduce their populations, thereby reducing foraging opportunities for bats. Therefore, the No Action Alternative may impact individuals, as described in the 2007 FEIS (Reclamation 2007), but it would not likely lead to population declines for bats.

Arizona toads at Lake Powell rely on riparian habitats that are disconnected from the main body of the lake at lower lake levels and maintained by springs or inflows rather than water from the lake. As water levels drop, the distance from the water's edge to existing riparian habitat would increase, further disconnecting these habitats from the lake (Pedersen 2023). This would result in positive impacts on amphibians in these habitats due to a further disconnect from nonnative predatory fish. Therefore, the No Action Alternative may beneficially impact individuals of these species.

Table 3-31
Special Status Species with Records at Lake Powell and Potential Habitat Impacts

Common Name	Scientific Name	Status	Potential Impacts
Colorado pikeminnow	<i>Ptychocheilus lucius</i>	Endangered	Habitat expansion due to declining lake levels as result of increased riverine habitat
Razorback sucker	<i>Xyrauchen texanus</i>	Endangered	Habitat expansion due to declining lake levels as result of increased riverine habitat
Flannelmouth sucker	<i>Catostomus latipinnis</i>	BLM AZ BLM UT	Habitat expansion due to declining lake levels as result of increased riverine habitat
Bluehead sucker	<i>Catostomus discobolus</i>	BLM AZ BLM UT	Habitat expansion due to declining lake levels as result of increased riverine habitat
American white pelican	<i>Pelicanus erythrorhynchos</i>	BLM UT	Changes to open-water habitat availability, impacting foraging habitat
Bald eagle	<i>Haliaeetus leucocephalus</i>	BLM AZ BLM NV BLM UT	Changes to water levels, impacting foraging habitat
California condor	<i>Gymnogyps californianus</i>	BLM AZ	Changes to water levels potentially increasing scavenging opportunities
Golden eagle	<i>Aquila chrysaetos</i>	BLM UT BLM AZ	Changes to water levels potentially increasing scavenging opportunities
Allen's big-eared bat	<i>Idionycteris</i> (= <i>Plecotus</i>) <i>phyllotis</i>	BLM AZ BLM NV BLM UT	Changes to riparian habitat availability, impacting foraging habitat
Big brown bat	<i>Eptesicus fuscus</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
California myotis	<i>Myotis californicus</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Canyon bat	<i>Parastrellus hesperus</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Cave myotis	<i>Myotis velifer</i>	BLM AZ BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Fringed myotis	<i>Myotis thysanodes</i>	BLM UT BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Mexican free-tailed bat	<i>Tadarida brasiliensis</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat

Common Name	Scientific Name	Status	Potential Impacts
Pale Townsend's big-eared bat	<i>Corynorhinus townsendii pallescens</i>	BLM AZ	Changes to riparian habitat availability, impacting foraging habitat
Silver-haired bat	<i>Lasionycteris noctivagans</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Townsend's big-eared bat	<i>Corynorhinus townsendii</i>	BLM AZ BLM CA BLM NV BLM UT	Changes to riparian habitat availability, impacting foraging habitat
Yuma myotis	<i>Myotis yumanensis</i>	BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Arizona toad	<i>Anaxyrus microscaphus</i>	BLM AZ BLM UT BLM NV	Changes in water levels, beneficially impacting breeding and foraging habitat by reducing predation

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 would limit the impacts of increased distances to the water's edge for species utilizing these habitats.

Declining lake levels would likely expand or increase habitat for Colorado pikeminnow, razorback sucker, flannelmouth sucker, and bluehead sucker in the inflows to Lake Powell as riverine habitat would increase in the San Juan River and Colorado River inflows.

Glen Canyon Dam to Lake Mead

From 2023 to early 2026, 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 are projected to decrease and habitat declines would be expected to occur if water elevations continue to decrease.

Bald eagles are the only special status species that utilizes open-water habitat for foraging that has the potential to be impacted by project operations (**Table 3-32**; see also **Appendix E**, Table of Sensitive Species). Open-water habitat is expected to decline in the Glen Canyon Dam to Lake Mead section 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 3-32
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	<i>Xyrauchen texanus</i>	Endangered	<ul style="list-style-type: none"> • Shoreline habitat reduction due to reduced flows • Warmer water temperatures and lower lake Powell elevation may benefit fish as a site • Cold water temperature shock from rapid bypass water releases below elevation 3,490 feet • Potential expansion of nonnative smallmouth bass through entrainment and warmer water temperatures which may increase potential interactions with nonnative species
Humpback chub	<i>Gila cypha</i>	Threatened	<ul style="list-style-type: none"> • Shoreline habitat reduction due to reduced flows • Warmer water temperatures and lower lake Powell elevation may benefit fish as a site • Cold water temperature shock from rapid bypass water releases below elevation 3,490 feet • Potential expansion of nonnative smallmouth bass through entrainment and warmer water temperatures which may increase potential interactions with nonnative species
Flannelmouth sucker	<i>Catostomus latipinnis</i>	BLM AZ BLM UT	<ul style="list-style-type: none"> • Shoreline habitat reduction due to reduced flows • Potential expansion of nonnative smallmouth bass through entrainment and warmer water temperatures which may increase potential interactions with nonnative species

3. Affected Environment and Environmental Consequences (Biological Resources)

Common Name	Scientific Name	Status	Potential Impacts
Bluehead sucker	<i>Catostomus discobolus</i>	BLM AZ BLM UT	<ul style="list-style-type: none"> Shoreline habitat reduction due to reduced flows Potential expansion of nonnative smallmouth bass through entrainment and warmer water temperatures which may increase potential interactions with nonnative species
Bald eagle	<i>Haliaeetus leucocephalus</i>	BLM AZ BLM NV BLM UT	Changes to water levels, impacting foraging habitat
California black rail	<i>Laterallus jamaicensis coturniculus</i>	BLM AZ BLM CA	Changes to riparian habitat availability, impacting foraging and nesting habitat
Yuma Ridgeway's rail	<i>Rallus obsoletus yumaniensis</i>	Endangered BLM AZ BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging and nesting habitat
Allen's lappet-browed bat	<i>Idionycteris phyllotis</i>	BLM AZ	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Arizona myotis	<i>Myotis occultus</i>	BLM AZ	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Big brown bat	<i>Eptesicus fuscus</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
California leaf-nosed bat	<i>Macrotus californicus</i>	BLM AZ BLM NV	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
California myotis	<i>Myotis californicus</i>	BLM NV	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Canyon bat	<i>Parastrellus hesperus</i>	BLM NV	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Cave myotis	<i>Myotis velifer</i>	BLM AZ BLM NV	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Greater western bonneted bat	<i>Eumops perotis</i>	BLM AZ	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Mexican free-tailed bat	<i>Tadarida brasiliensis</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Pale Townsend's big-eared bat	<i>Corynorhinus townsendii pallescens</i>	BLM AZ	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Spotted bat	<i>Euderma maculatum</i>	BLM AZ BLM NV BLM UT	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Silver-haired bat	<i>Lasionycteris noctivagans</i>	BLM NV	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Western mastiff bat	<i>Eumops perotis</i>	BLM AZ BLM NV	Changes to riparian habitat availability and prey diversity, impacting foraging habitat

Common Name	Scientific Name	Status	Potential Impacts
Yuma myotis	<i>Myotis yumanensis</i>	BLM CA BLM NV	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Monarch butterfly	<i>Danaus plexippus plexippus</i>	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 and Yuma Ridgway's rail, could be impacted 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 limit the impacts of increased distances to the water's edge for species utilizing these habitats.

Bats often forage for insects over open water and riparian vegetation. Many insects use wet areas and riparian vegetation for breeding. Loss of habitat for insects could reduce their populations, thereby reducing foraging opportunities for bats. Lower water levels could also impact invertebrate biodiversity and have subsequent effects on bat species. Bat species could be impacted by changing prey availability causing reduced fitness and increased susceptibility to white-nose syndrome (Holm et al. 2023). Potential reduced fitness and greater susceptibility to disease could impact bat populations. Therefore, the No Action Alternative may impact individuals, as described in the 2007 FEIS (Reclamation 2007), and may lead to population declines for bats.

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 impacted 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 and could exacerbate downward trends for this species.

Adult humpback chub use deepwater recirculating eddies that are not affected by flow changes; however, age-0 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 been detected. 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.

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 species. Many of these species (e.g., channel catfish, bullheads, green sunfish, smallmouth bass, and largemouth bass) prey on different life stages of the native fish and could impose additional stressors on the population of humpback chub. Warmer temperatures, however, may also reduce foraging efforts by rainbow trout and brown trout that are the cold-water predators of humpback chub.

Spawning and rearing habitat in the lower end of Grand Canyon above the Lake Mead inflow may be reduced for humpback chub due to decreasing flows. Cobble bars at tributary inflows like Spencer Creek may be used for spawning and would be desiccated by reduced flows. Also, backwater habitats in lower Grand Canyon that are used by the young would be desiccated by reduced flows. Additionally, warmer water temperatures may increase the razorback sucker's and humpback chub's exposure to parasites that are detrimental to the species, such as the Asian tapeworm and anchorworm. Warmer water temperatures may also provide more suitable conditions for spawning and survival of young nonnative fish that are predators of native fish species.

Reduction in flows through Grand Canyon could also negatively affect the razorback sucker. Lower flows would make it nearly impossible for adults to move from Lake Mead upstream past the Pearce Ferry Rapid and into the lower Grand Canyon. This barrier would also potentially reduce upstream movement by other native and nonnative fish. The Colorado River in Grand Canyon could serve as a potential spawning area to the razorback sucker population from Lake Mead. This impediment would reduce the number of razorback suckers in the Colorado River through the Grand Canyon and impede the establishment of a population in this reach. This would negatively affect recovery of the species.

Under the No Action Alternative, the GTMax Model shows that releases through the penstocks at Glen Canyon Dam would drop to zero from January through April 2024, and water would need to be released through the river outlet works. At low levels of Lake Powell, release temperatures are projected to be as high as 20°C) and switching to releasing water through the river outlet works 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 (1,097-meter) (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 that would be in the gravel beds at this time. 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 of these species.

Lake Mead

Bald eagles are the only special status species that utilize open-water habitat for foraging that have the potential to be impacted by project operations (**Table 3-33**, see also **Appendix E**, Table of Sensitive Species). 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 3-33
Special Status Species with Records at Lake Mead and Potential Habitat Impacts

Common Name	Scientific Name	Status	Potential Impacts
Razorback sucker	<i>Xyrauchen texanus</i>	Endangered	Changes to water levels, impacting spawning and rearing habitat and increased predation on young
Humpback chub	<i>Gila cypha</i>	Threatened	Changes to water levels, impacting spawning and rearing habitat and increased predation on young
Flannelmouth sucker	<i>Catostomus latipinnis</i>	BLM AZ BLM UT	Changes to water levels, impacting spawning and rearing habitat and increased predation on young
Bluehead sucker	<i>Catostomus discobolus</i>	BLM AZ BLM UT	Changes to water levels, impacting spawning and rearing habitat and increased predation on young
Bald eagle	<i>Haliaeetus leucocephalus</i>	BLM AZ BLM NV BLM UT	Changes to water levels, impacting foraging habitat
Southwestern willow flycatcher	<i>Empidonax traillii extimus</i>	Endangered BLM AZ BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging and nesting habitat
Yuma Ridgway's rail	<i>Rallus obsoletus yumaniensis</i>	Endangered BLM AZ BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging and nesting habitat
Allen's big-eared bat	<i>Idionycteris (=Plecotus) phyllotis</i>	BLM AZ BLM NV BLM UT	Changes to riparian habitat availability, impacting foraging habitat
Arizona myotis	<i>Myotis occultus</i>	BLM AZ	Changes to riparian habitat availability, impacting foraging habitat
Big brown bat	<i>Eptesicus fuscus</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Big free-tailed bat	<i>Nyctinomops macrotis</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
California leaf-nosed bat	<i>Macrotus californicus</i>	BLM AZ BLM NV	Changes to riparian habitat availability, impacting foraging habitat
California myotis	<i>Myotis californicus</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Canyon bat	<i>Parastrellus hesperus</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Cave myotis	<i>Myotis velifer</i>	BLM AZ BLM NV	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Desert bighorn sheep	<i>Ovis canadensis nelsoni</i>	BLM CA	Exposed soft sediments trapping individuals and causing mortality
Fringed myotis	<i>Myotis thysanodes</i>	BLM UT BLM NV	Changes to riparian habitat availability, impacting foraging habitat

3. Affected Environment and Environmental Consequences (Biological Resources)

Common Name	Scientific Name	Status	Potential Impacts
Hoary bat	<i>Lasiurus cinereus</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Mexican free-tailed bat	<i>Tadarida brasiliensis</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Pale Townsend's big-eared bat	<i>Corynorhinus townsendii pallescens</i>	BLM AZ	Changes to riparian habitat availability, impacting foraging habitat
Pallid bat	<i>Antrozous pallidus</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Silver-haired bat	<i>Lasionycteris noctivagans</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Townsend's big-eared bat	<i>Corynorhinus townsendii</i>	BLM AZ BLM CA BLM NV BLM UT	Changes to riparian habitat availability, impacting foraging habitat
Western mastiff bat	<i>Eumops perotis</i>	BLM AZ BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Western red bat	<i>Lasiurus blossevillii</i>	BLM NV BLM UT	Changes to riparian habitat availability, impacting foraging habitat
Western small-footed myotis	<i>Myotis ciliolabrum</i>	BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Yuma myotis	<i>Myotis yumanensis</i>	BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Lowland leopard frog	<i>Rana yavapaiensis</i>	BLM AZ BLM CA	Changes to riparian habitat availability and water levels, impacting breeding and foraging habitat
Gold butte moss	<i>Ceratodon purpureus</i>	BLM NV	Changes to hydrology, impacting suitable habitat
Mojave poppy bee	<i>Perdita meconis</i>	BLM NV	Changes to hydrology, impacting suitable habitat
Monarch butterfly	<i>Danaus plexippus plexippus</i>	BLM NV ESA Candidate	Changes to riparian habitat availability, impacting breeding and foraging habitat
Mokiak milkvetch	<i>Astragalus mokiacensis</i>	BLM NV	Changes to hydrology, impacting suitable habitat
Sticky buckwheat	<i>Eriogonum viscidulum</i>	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 impacted through changes in habitat availability. 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 impacted 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, flannemouth 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 for shelter and feeding. This would reduce survival and recruitment for the species.

Hoover Dam to the SIB

Given the decrease in water elevations projected in Lake Mead, less water would be available for release into this section and ultimately no water would be released from Hoover Dam as Lake Mead reached dead pool. As shortages increase over time, riparian vegetation along the lower Colorado River would likely decrease.

In some of the driest potential hydrologic futures (**Section 3.6.2, Figure 3-8**), Lake Mead hits dead pool in early 2026. At this point, no water would be released from Lake Mead into the Hoover Dam to SIB section, severely limiting water resources in this section. Water in this section would be limited to inflows below Hoover Dam. It is likely that these inflows would be insufficient to support aquatic special status species populations, leading to extirpation or extreme reductions in population numbers. In this scenario, scavenger species such as bald eagles, golden eagles, and California condors may experience short-term benefits, as substantial amounts of carrion would be available.

Bald eagles are the only special status species that utilize open-water habitat for foraging that have the potential to be impacted by project operations (**Table 3-34**, see also **Appendix E**, Table of Sensitive Species). 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 3-34
Special Status Species with Records between Hoover Dam and the SIB and Potential Habitat Impacts

Common Name	Scientific Name	Status	Potential Impacts
Razorback sucker	<i>Xyrauchen texanus</i>	Endangered	Changes to water levels, impacting spawning and nursery habitat
Bonytail chub	<i>Gila elegans</i>	Threatened	Changes to water levels, impacting spawning and nursery habitat
Flannelmouth sucker	<i>Catostomus latipinnis</i>	BLM AZ BLM UT	Changes to water levels, impacting spawning and nursery habitat
Desert pupfish	<i>Cyprinodon macularius</i>	Endangered	Changes to water levels, impacting spawning and nursery habitat
Arizona bell's vireo	<i>Vireo bellii arizonae</i>	BLM CA	Changes to water levels, impacting foraging and nesting habitat
Bald eagle	<i>Haliaeetus leucocephalus</i>	BLM AZ BLM NV BLM UT	Changes to water levels, impacting foraging habitat
California black rail	<i>Laterallus jamaicensis coturniculus</i>	BLM AZ BLM CA	Changes to riparian habitat availability, impacting foraging and nesting habitat
Crissal thrasher	<i>Toxostoma crissale</i>	BLM CA	Changes to water levels, impacting foraging and nesting habitat
Gila woodpecker	<i>Melanerpes uropygialis</i>	BLM CA	Changes to water levels, impacting foraging and nesting habitat
Gilded flicker	<i>Colaptes chrysoides</i>	BLM AZ BLM CA	Changes to water levels, impacting foraging and nesting habitat
Golden eagle	<i>Aquila chrysaetos</i>	BLM UT BLM AZ	Changes to water levels potentially increasing scavenging opportunities
Lucy's warbler	<i>Vermivora luciae</i>	BLM CA	Changes to water levels, impacting foraging and nesting habitat
Mountain plover	<i>Charadrius montanus</i>	BLM CA	Changes to water levels, impacting foraging habitat
Southwestern willow flycatcher	<i>Empidonax traillii extimus</i>	Endangered BLM AZ BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging and nesting habitat
Tricolored blackbird	<i>Agelaius tricolor</i>	BLM CA	Changes to riparian habitat availability, impacting foraging and nesting habitat
Western yellow-billed cuckoo	<i>Coccyzus americanus</i>	Threatened BLM AZ BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging and nesting habitat
White-tailed kite	<i>Elanus leucurus</i>	BLM CA	Changes to riparian habitat availability, impacting foraging habitat

3. Affected Environment and Environmental Consequences (Biological Resources)

Common Name	Scientific Name	Status	Potential Impacts
Yuma Ridgway's rail	<i>Rallus obsoletus yumaniensis</i>	Endangered BLM AZ BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Arizona myotis	<i>Myotis occultus</i>		Changes to riparian habitat availability, impacting foraging habitat
Big brown bat	<i>Eptesicus fuscus</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
California leaf-nosed bat	<i>Macrotus californicus</i>	BLM AZ BLM NV	Changes to riparian habitat availability, impacting foraging habitat
California myotis	<i>Myotis californicus</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Cave myotis	<i>Myotis velifer</i>	BLM AZ BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Long-eared myotis	<i>Myotis evotis</i>	BLM CA	Changes to riparian habitat availability, impacting foraging habitat
Mexican free-tailed bat	<i>Tadarida brasiliensis</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Pale Townsend's big-eared bat	<i>Corynorhinus townsendii pallescens</i>	BLM AZ	Changes to riparian habitat availability, impacting foraging habitat
Pallid bat	<i>Antrozous pallidus</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Spotted bat	<i>Euderma maculatum</i>	BLM AZ BLM NV BLM UT	Changes to riparian habitat availability, impacting foraging habitat
Silver-haired bat	<i>Lasionycteris noctivagans</i>	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Townsend's big-eared bat	<i>Corynorhinus townsendii</i>	BLM AZ BLM CA BLM NV BLM UT	Changes to riparian habitat availability, impacting foraging habitat
Western mastiff bat	<i>Eumops perotis</i>	BLM AZ BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Western small-footed myotis	<i>Myotis ciliolabrum</i>	BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging habitat

Common Name	Scientific Name	Status	Potential Impacts
Yuma myotis	<i>Myotis yumanensis</i>	BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Arizona toad	<i>Anaxyrus microscaphus</i>	BLM UT BLM NV	Changes to riparian habitat availability and water levels, impacting breeding and foraging habitat
Couch's spadefoot	<i>Scaphiopus couchii</i>	BLM CA	Changes to riparian habitat availability, impacting foraging and breeding habitat
Lowland leopard frog	<i>Rana yavapaiensis</i>	BLM AZ BLM CA	Changes to riparian habitat availability and water levels, impacting breeding and foraging habitat
Northern Mexican garter snake	<i>Thamnophis eques megalops</i>	Threatened	Changes to riparian habitat availability and water levels, impacting breeding and foraging habitat
Relict leopard frog	<i>Rana onca</i>	BLM AZ BLM NV	Changes to riparian habitat availability and water levels, impacting breeding and foraging habitat
Monarch butterfly	<i>Danaus plexippus plexippus</i>	BLM NV ESA Candidate	Changes to riparian habitat availability and water levels, impacting breeding and foraging habitat
Mojave tarplant	<i>Deinandra mohavensis</i>	BLM CA	Changes to hydrology, impacting suitable habitat
Parish's meadowfern	<i>Limnanthes alba ssp. parishii</i>	BLM CA	Changes to hydrology, impacting suitable habitat
Variegated dudleya	<i>Dudleya variegata</i>	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 3-34**, 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. Given the newly discovered populations, it is assumed that this species could be present anywhere along the Hoover Dam to the SIB section. 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.

Action Alternative 1

Lake Powell

Once Action Alternative 1 was implemented, water elevations would gradually increase through 2026, and are projected to be higher than the No Action Alternative. This increase in water elevation could result in the loss of some riparian habitat that has recently established along the lake during lower water periods. Terrestrial special status species in this section are not particularly riparian dependent and increased water levels would increase foraging acreage for open-water species. Therefore, impacts on terrestrial special status species in this section would be similar to those described in the 2007 FEIS (Reclamation 2007) and the No Action Alternative, with a decreasing magnitude of effects as lake levels increase.

Under Action Alternative 1, the elevation of Lake Powell would not be allowed to drop below the minimum power pool elevation of 3,490 feet (1,063 meters). This alternative would fundamentally stabilize lake levels and would maintain extended fish habitat in the Colorado River and San Juan River inflows that are occupied by Colorado pikeminnow, razorback sucker, and flannelmouth sucker. The extended habitat would be a benefit to these species, and this alternative would help maintain that habitat. There may be some reduction of shoreline riverine habitat used by young fish as the reservoir elevation is increased toward 2026. This is due to the rise in elevation of the lake and encroachment upon riverine habitat that was created from low levels in the lake in the inflow areas; however, the reduction in shoreline habitat is not quantified. About 30 miles of inflow riverine habitat has been created by lowered lake elevations, but the amount that would be inundated by an increasing lake elevation is unknown.

Glen Canyon Dam to Lake Mead

Once Action Alternative 1 was implemented, releases from Lake Powell would be reduced, which would result in lower water elevations in this section compared with the No Action Alternative (**Table 3-30**).

See the vegetation section above for impacts related to native and nonnative species that provide habitat for special status species. While still providing some habitat, nonnative plant species provide lower-quality habitat than native species and can lead to monotypic habitat types that support fewer wildlife species (NatureServe 2023).

Impacts on terrestrial wildlife would be similar to those described for the No Action Alternative with an increasing magnitude of effects as water elevations begin to decrease and nonnative plant

cover increases. However, the greater likelihood for high-flow experiments under this alternative, relative to the No Action Alternative, reduces some of the impacts described under that alternative. Specifically, the likelihood of impacts on invertebrate diversity and subsequent prey availability effects could be reduced.

Under Action Alternative 1, releases from Lake Powell and through Glen Canyon Dam would not be allowed to drop below the minimum power pool elevation of 3490 feet. This would allow water to continue to be released in the Colorado River below Glen Canyon Dam, although at a reduced level in some years. In years when reduced flow occurred, reduced amount of shoreline habitat and backwaters would be available for use by age-0, juvenile, and subadult humpback chub. In the lower Grand Canyon, reduced flows could reduce availability of potential spawning areas for humpback chub, razorback sucker, and flannelmouth sucker, as well as backwaters used by the young of these species. Reduced river flows and lake elevation would also make it more difficult for adult razorback sucker to ascend Pearce Ferry Rapid and enter the Colorado River through Grand Canyon. This is already a rare occurrence, and increased difficulty would further limit the expansion of the species and negatively affect species recovery. Reductions in flow releases also may result in increased water temperatures, thereby creating better conditions for nonnative fish, such as smallmouth bass, and subsequently increasing the potential for predation on native species.

Lake Mead

Once Action Alternative 1 was implemented, water elevations would continue to gradually decrease to levels slightly below the No Action Alternative, but then would increase in 2025 to higher than the No Action Alternative. However, water elevations would remain lower in 2026 than 2022.

Therefore, impacts on special status species in this section would be similar to those described in the 2007 FEIS (Reclamation 2007) and the No Action Alternative, with a decreasing magnitude of effects as lake levels increase in 2025.

Hoover Dam to the SIB

After implementing Action Alternative 1, releases from Lake Mead would be reduced, which would result in lower water elevations in this section compared with the No Action Alternative. Impacts on riparian vegetation and terrestrial wildlife species would, therefore, be greater under Action Alternative 1 than the No Action Alternative in all but the driest potential hydrologic futures (**Section 3.6.2, Figure 3-8**). Furthermore, this alternative would lead to water shortages at existing irrigated riparian habitat mitigation areas, leading to reductions in available habitat for riparian species.

However, in the driest potential hydrologic futures (**Section 3.6.2, Figure 3-8**), where Lake Mead is projected to reach dead pool, water deliveries from Lake Mead would be reduced in advance to avoid reaching these levels. Should these adjustments prove successful, the scenario of no water passing through Hoover Dam would not occur. Water levels in the section between Hoover Dam and the SIB could be critically low, but there would still be flow in the river to support special status species at levels substantially greater than those described under the No Action Alternative.

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.

Action Alternative 2

Action Alternative 2 includes modified water delivery priorities through Glen Canyon Dam compared with Action Alternative 1 and marginally increases the water supply to Lake Powell through releases of water from the Upper Basin reservoirs. This would result in marginally more water throughout the system compared with Action Alternative 1. These marginal increases could be meaningful in the driest potential hydrologic futures (**Section 3.6.2**), especially immediately downstream of Hoover Dam. Also, the changes in water allocations under this alternative, relative to Action Alternative 1, would result in more water in the Colorado River between Hoover Dam and the locations where water is diverted for uses in California. However, these differences are minimal when considering impacts on special status species. Therefore, overall impacts on special status species are similar to those described under Action Alternative 1 for all analysis sections, other than part of the Hoover Dam to SIB section, where impacts of Action Alternative 2 are reduced compared with Action Alternative 1.

Cumulative Effects

The Glen Canyon Dam/Smallmouth Bass flow options is the only cumulative action identified in **Section 3.5.1**. If one of the flow options were implemented, this action would cumulatively impact aquatic species within the Colorado River below Glen Canyon Dam to Lake Mead due to changes in the temperature of water released through Glen Canyon Dam. The intent of this cumulative action is to prevent the establishment of invasive smallmouth bass. Under all alternatives, the effects of this cumulative action would be beneficial for aquatic special status species 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.

There are two important points in the analysis of smallmouth bass effects by Yackulic (2023). First, under poor/drier hydrology, the action alternatives can increase the predator population by 500 percent, unless coupled with the smallmouth bass release strategies. Second, under the No Action Alternative and very poor hydrology, the smallmouth bass flow release strategies cannot be used; this is because the reservoir is below power pool. In the first year or two, the drop below power pool elevation (3,490 feet) would require releases from the river outlet works, thereby cooling the water and reducing the entrainment of smallmouth bass. However, after a year or two the reservoir level would decrease enough that the river outlet works would no longer release cool water. The thermocline (mesolimnion or middle warm oxygenated zone of the reservoir) moves down with the reservoir level; when it is in a range as low as 3,425 to 3,450 feet, the water is once again warm, and entrainment is possible again. Both of these dynamics are critical to understanding the interaction of reservoir elevation, dam releases, and water temperatures.

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. In addition, based on proposed changes to the flow rate of the Colorado River between Glen Canyon Dam and Lake Mead, the following recreation resource issue may also be affected:

- Ecotourism of previously buried ecosystems in Glen Canyon, which has become increasingly popular as Lake Powell recedes

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 they 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 2023a). **Table 3-35** summarizes visitation to GCNRA for the most recent 6 years.

Table 3-35
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

Year	Recreational Visitors
2022	2,842,776

Source: NPS 2023a

Table 3-36 summarizes the total number of visits to GCNRA by visitor segment for 2022, the most recent year for which data are available.

Table 3-36
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 2023b

*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)

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 2023c). 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 2023d).

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 2023d).

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 2023d).

Table 3-37
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
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: Personal communications with Heidie Grigg, GCNRA Acting Chief of External Affairs, NPS, on 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.

Ecotourism in Glen Canyon

Declining water levels have exposed approximately 100,000 acres of Glen Canyon that were previously inundated by Lake Powell, creating new ecotourism 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 staff; 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 2006).

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 2006). 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 take-out at Pearce Ferry. The Navajo Indian Reservation borders Grand Canyon National Park 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. A Tribal enterprise operates a river rafting company that offers rafting trips on the

section of the Colorado River from Diamond Creek to Quartermaster Canyon. 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 2023e). **Table 3-38** summarizes visitation to GCNP for the most recent 6 years.

Table 3-38
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 2023e

*Park closure April–May due to the COVID-19 pandemic

Table 3-39 summarizes the total number of visits to GCNP by visitor segment for 2022, the most recent year for which data are available.

Table 3-39
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 2023f

*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. Take-outs are at Diamond Creek and Pearce Ferry. The reach downstream of Diamond Creek offers different recreation opportunities than 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.

Several helicopter operations transport people into the Grand Canyon and connect them with motorized pontoon boats that give 20-minute tours of the immediate area. These same helicopters provide a dual service in flying out boaters who have traveled from Diamond Creek on commercial motor day trips.

Camping also occurs in GCNP on undeveloped beaches along the river. The important variable is the number and quality of high-water versus low-water campsites.

Boating Facilities

No boating facilities are within GCNP. Development along the Colorado River within the park is limited to the utilitarian 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. At a given time, 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 2006)

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; however, that sand has not been redistributed to camping beaches because high flows have not occurred since 2018. From 2012 to 2018, there were more frequent HFEs, which build more sandbars and beaches, on average, in Marble and Grand Canyons. Since 2018, the lack of HFEs has resulted in greater erosion than deposition on the high-elevation sandbars, due to erosive flows in the main channel and gulying from side channels with no rebuilding. Also, the lack of HFEs has contributed to more vegetation encroachment since 2018 (USGS 2023d).

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 “non-camps” 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, 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.¹⁸

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. The number of visitors to LMNRA amounted to approximately 5.6 million visitors in 2022 (NPS 2023g).

Table 3-40 summarizes recreational visits to LMNRA for the last 6 years.

Table 3-40
Lake Mead National Recreation Area Recreational Visitors

Year	Recreational Visitors
2017	7,882,339
2018	7,578,958
2019	7,499,049
2020	8,016,510
2021	7,603,474
2022	5,578,226

Source: NPS 2023g

Table 3-41 summarizes the total number of visits to LMNRA by visitor segment for 2022, the most recent year for which data are available.

Table 3-41
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 2023h

*The NPS defines reportable non-recreation visits to include:

- Persons going to and from inholdings across significant parts of park land

¹⁸ Personal communication with the Nevada Department of Wildlife 2023

- 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 2023i). 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 2022b). 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 3-42** shows critical elevations identified by the NPS for Lake Mead, below which marinas, boat docks, or boat launch ramps become inoperable.

Table 3-42
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

Lake Elevation (feet)	Impact and Facility
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 National Wildlife Refuge (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 3-43** lists the visitation at Arizona's Lake Havasu and Cattail Cove State Parks.

Table 3-43
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

Year	Lake Havasu State Park Visitation	Cattail Cove State Park Visitation
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. Located on the edge of the historical floodplain to the east of the Colorado River, typical water activities within this reach include boating, swimming, and sport fishing.

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 to take out houseboats and motorboats for multiple day excursions to explore the reservoir. As the pool elevation decreases, the surface area suitable for boats 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.

As of 2016, 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 2023i).

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 impacted 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 take-outs. 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 limited access by vehicle and helicopter (commercial use only) to join trips in the western portion of the Grand Canyon.

GCNP staff regulates recreational boating in accordance with the CRMP (NPS 2006). 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 this 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 comprised 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 fish by wading, or they 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 comprised 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 below where 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 by adding a needed resource for tournament anglers. 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 alternatives, including the No Action Alternative, on recreation within the analysis area. Reclamation's CRMMS modeling results helped develop potential releases, reservoir elevations, and flow rates from the action 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 use of selected marinas, boat docks, and launch ramps, as well as whether impacts could occur in 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 recreation 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 action alternatives, 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 action alternatives 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

Issue 1: How would reduced reservoir levels impact recreation at Lake Powell?

Section 3.14.1, Table 3-37 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 all alternatives, projected Lake Powell elevations for much of the analysis period are below the critical thresholds for most boat launch facilities and safely navigating Castle Rock and Gregory Butte. This would result in a reduction in the quality of or loss of reservoir boating opportunities on Lake Powell. Under all alternatives, dock access would continue to be unavailable from the Rainbow Bridge National Monument shoreline, which would continue until the NPS could secure funding to develop a long-term access solution.

Under all alternatives, impacts on public health resulting from harmful algal blooms would likely increase as lake elevations decline. Under all alternatives, declining pool 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 given access to new areas, as described in the affected environment. There may also be new recreation and ecotourism positive benefits in some locations. All alternatives are not expected to significantly impact sport fish populations. Recreation impacts at Lake Powell would be slightly reduced under the action alternatives because the action alternatives 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 2024 projected Lake Powell elevation (3,510 feet) is below the critical threshold for all Lake Powell boat launch facilities, which would necessitate they be closed or relocated. As described in **Section 3.14.1**, launch ramp closures resulting from declining water levels would continue to result in longer lines, limited parking, and congestion at boat ramps and docks. If the median 2024 projected Lake Powell elevation were to be reached before the NPS

develops the Stanton Creek area launch ramp, 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 the NPS would be able to secure funding/permitting for and construct new boat launch facilities in a riverine environment.

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 such hazards. 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 the NPS prohibiting boating 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 the NPS implementing boating restrictions around Castle Rock and Gregory Butte. These restrictions would likely be in place throughout the analysis period, unless the upper projected pool elevation for 2026 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 the NPS could secure funding to develop a long-term access solution.

Harmful Algal Blooms

Under the No Action Alternative, reduced pool elevations would result in increasingly warm water temperatures, which 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**.)

Ecotourism in Glen Canyon

Under the No Action Alternative, declining pool elevations would expose additional areas of Glen Canyon that were previously inundated by Lake Powell. This would continue to create new ecotourism opportunities to view landscapes and archaeological sites, as described in the affected environment.

Lake Powell Sport Fish Populations

Under the No Action Alternative, the maximum lethal limits of 37 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, and lower depths provide cooler water. Reclamation assumes that 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.

Action Alternative 1

In general, impacts on recreation under Action Alternative 1 would be similar to those described under the No Action Alternative. Impacts on recreation under Action Alternative 1 that differ from the No Action Alternative are presented below.

Boat Launch Facilities

Under Action Alternative 1, the median 2024 projected Lake Powell elevation (3,510 feet) is 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. The highest projected 2024 pool elevations under Action Alternative 1 (3,560 feet) are higher than under the No Action Alternative, which increases 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 Action Alternative 1, as compared with the No Action Alternative.

Action Alternative 2

Overall, Action Alternative 2 would improve the median pool elevation conditions over time by preserving more water in Lake Powell and reducing the overall variability in water surface elevations, compared with the No Action Alternative; this would be similar to Action Alternative 1. In general, under Action Alternative 2, impacts on recreation at Lake Powell would be similar to those described under Action Alternative 1.

Cumulative Effects

The Glen Canyon Dam/Smallmouth Bass flow options would not cumulatively affect recreation on Lake Powell.

Issue 2: How would reduced flows downstream of Lake Powell affect recreation from Glen Canyon Dam to Lake Mead?

Summary

Under all 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 all alternatives, lethal limits for rainbow trout are not projected to be exceeded in any month throughout the analysis period. As seen in **Figure 3-31**, the warmest release temperatures were observed in trace 1999 80 percent under the action alternatives. As seen in **Figure 3-32**, release temperatures were also more likely to exceed 20°C under the action alternatives, which could result in a greater likelihood that temperatures would reach or exceed the 23°C threshold at which rainbow trout stop growing from 2023 to 2026. This would negatively impact the rainbow trout fishery in the Glen Canyon reach. However, under the No Action Alternative, Lake Powell would be much more likely to reach dead pool (3,370 feet). If Lake Powell were to reach dead pool, it would lead to a large increase in water temperature, which would lead to potentially lethal conditions for rainbow trout.

No Action Alternative

Boating

Current operation of Glen Canyon Dam under the 2007 Interim Guidelines 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. Therefore, 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 much more likely to reach power pool (3,490 feet). If Lake Powell were to reach power pool, it would likely result in lower, unknown 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 EIS 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 (DOI 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; DOI 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, under trace 1999 90 percent ESP, water temperatures are projected to be the warmest (23°C) just before outflows at Glen Canyon Dam switch to the river outlet works in fall 2024 (**Figure 3-31**). Release temperatures are also projected to be high (23°C) in trace 1999 80 percent ESP when Lake Powell's pool elevation is projected to be just above the power pool in July 2023 and after elevations drop closer to the bypass elevation in July 2025 and in subsequent years (**Figure 3-31**). Growth of rainbow trout may be limited when temperatures reach 23°C. Under the No Action Alternative, lethal limits for rainbow trout are not projected to be exceeded in any month. However, under the No Action Alternative, Lake Powell would be much more likely to reach dead pool (3,370 feet). If Lake Powell were to reach dead pool, it would lead to a large increase in water temperature, which would lead to potentially lethal conditions for rainbow trout. See **Section 3.13.2** for further details on the impacts on fish species.

Action Alternative 1

Boating

Under Action Alternative 1, daytime flows would not drop lower than the safe whitewater boating threshold of 5,000 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 Action Alternative 1, both 1999 80 percent ESP and 1999 90 percent ESP traces are projected to have the warmest temperatures with releases exceeding 20°C in all years within the analysis period (**Figure 3-31**). Projected release temperatures under Action Alternative 1 would have higher temperatures than under the No Action Alternative (assuming dead pool is not reached under the No Action Alternative), resulting from Lake Powell elevations being held just above the power pool. Compared with the No Action Alternative, this could result in a greater likelihood that temperatures would reach or exceed the 23°C threshold at which rainbow trout stop growing. Under Action Alternative 1, lethal limits for rainbow trout are not projected to be exceeded in any month.

Action Alternative 2

Boating

The impacts on whitewater boating would be similar to those described under Action Alternative 1.

Sport Fish Populations

The impacts on the rainbow trout sport fishery would be similar to those described under Action Alternative 1.

Cumulative Effects

The Glen Canyon Dam Smallmouth Bass flow options would cumulatively impact 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 all 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 Glen Canyon Dam Smallmouth Bass flow options were not implemented, the action alternatives 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**.

Issue 3: How would reduced reservoir levels impact recreation at Lake Mead?

Section 3.14.1, Table 3-42 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 for all Lake Mead boat launch facilities except the Pearce Ferry Road launch ramp. This would necessitate closing the boat launch facilities or relocating them throughout the entire analysis period. The slight rebound in Lake Mead pool elevations under the action alternatives could marginally help limit the closure or relocation of boat launch facilities at Lake Mead in year 2026, compared with the No Action Alternative. Additionally, under all alternatives, the projected median pool elevation for Lake Mead would be at a level at which boaters are likely to encounter boating navigational hazards. Under all 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 (1,025 feet) is below the critical threshold for all Lake Mead boat launch facilities except the Pearce Ferry Road launch ramp. 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 2006). 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 such hazards. 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 situation for striped bass and threadfin shad in Lake Powell is 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.

Action Alternative 1

Access or Use of Lake Mead Boating Facilities

Under Action Alternative 1, 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; 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 (1,015 feet) remains below the critical threshold for most Lake Mead boating facilities, the upper range of projections for 2026 could be up to 1,060 feet. This could enable the Echo Bay public launch ramp to reopen, unlike under the No Action Alternative. Overall, the slight rebound in Lake Mead pool elevations under Action Alternative 1 could marginally help limit the closure or relocation of boat launch facilities and public safety risks due to shoreline access at Lake Mead in year 2026 compared with the No Action Alternative.

Safe Boating and Navigation Hazards

Under Action Alternative 1, 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 Action Alternative 1, 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.

Action Alternative 2

Under Action Alternative 2, impacts on Lake Mead boating facilities, safe boating and navigation hazards, shoreline access, and sport fish populations would be similar to those described under Action Alternative 1.

Cumulative Effects

The Glen Canyon Dam/Smallmouth Bass flow options would not cumulatively affect recreation at Lake Mead.

Issue 4: How would reduced flows downstream of Lake Powell affect recreation from Hoover Dam to SIB?

Summary

Under all 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.

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 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.

Action Alternative 1

Under Action Alternative 1, impacts on recreation from Hoover Dam to SIB would be the same as those described under the No Action Alternative.

Action Alternative 2

Under Action Alternative 2, impacts on recreation from Hoover Dam to SIB would be the same as those described under the No Action Alternative.

Cumulative Effects

The Glen Canyon Dam/Smallmouth Bass flow options would not cumulatively affect recreation from Hoover Dam to SIB.

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). Electrical power resources analyzed include:

- 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,¹⁹ 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 impacted 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 impacted 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; the information is incorporated by reference (Reclamation 2007).

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 2021b). 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) non-firm, which only includes charges for energy delivered. Firm and non-firm contracts can be short or long term. The majority of CRSP power is sold under long-term, firm contracts. Customers can purchase firm and non-firm 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 2021b).

¹⁹ The pressure caused by a difference in water depth. In this case, it is the difference between the lake reservoir elevation and the hydroelectric generators.

Table 3-44 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 3-44
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

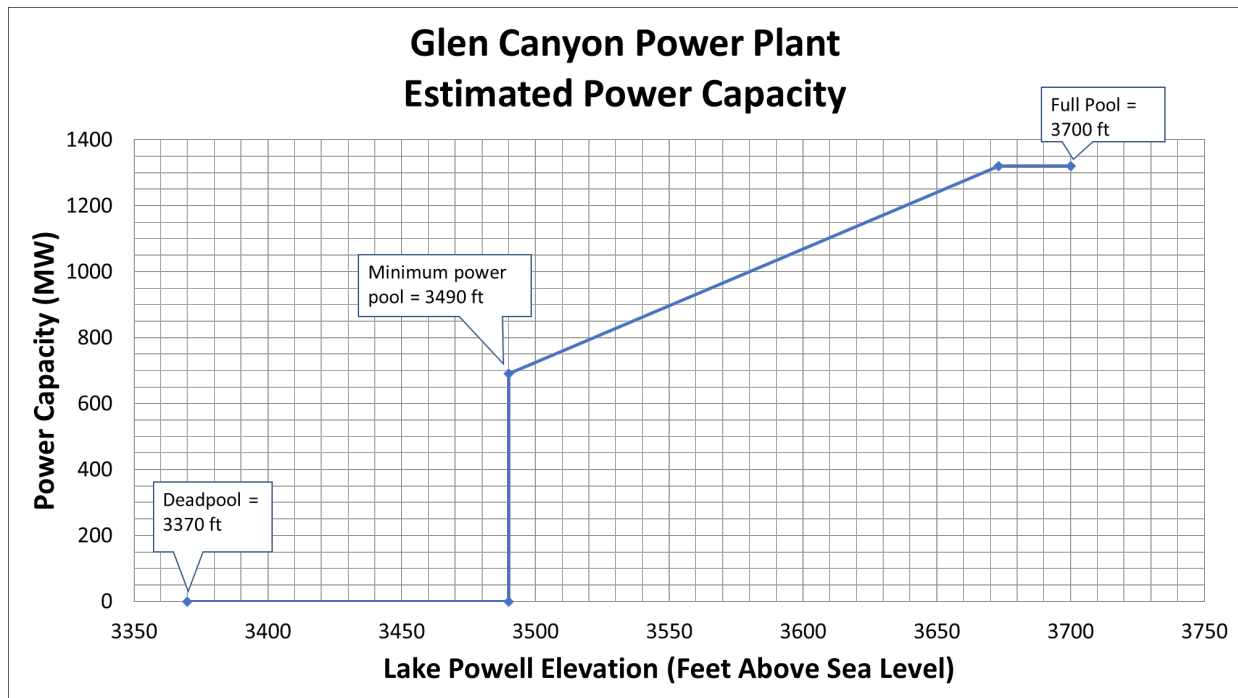
Lake Powell and Glen Canyon Dam

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 (AZCentral 2015). Reclamation also optimized software within the facility, resulting in higher efficiency. Standard operations and maintenance work also have continued throughout this time (Reclamation 2021b).

Despite the improved efficiency, Glen Canyon Powerplant has been heavily impacted by drought conditions in the Basin. The powerplant's capacity decreases as the lake elevation drops. **Figure 3-40** shows the estimated capacity at a range of lower lake elevations. 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 the minimum power pool (elevation 3,490 feet), the powerplant has an estimated capacity of 630 MW (Reclamation 2021b).

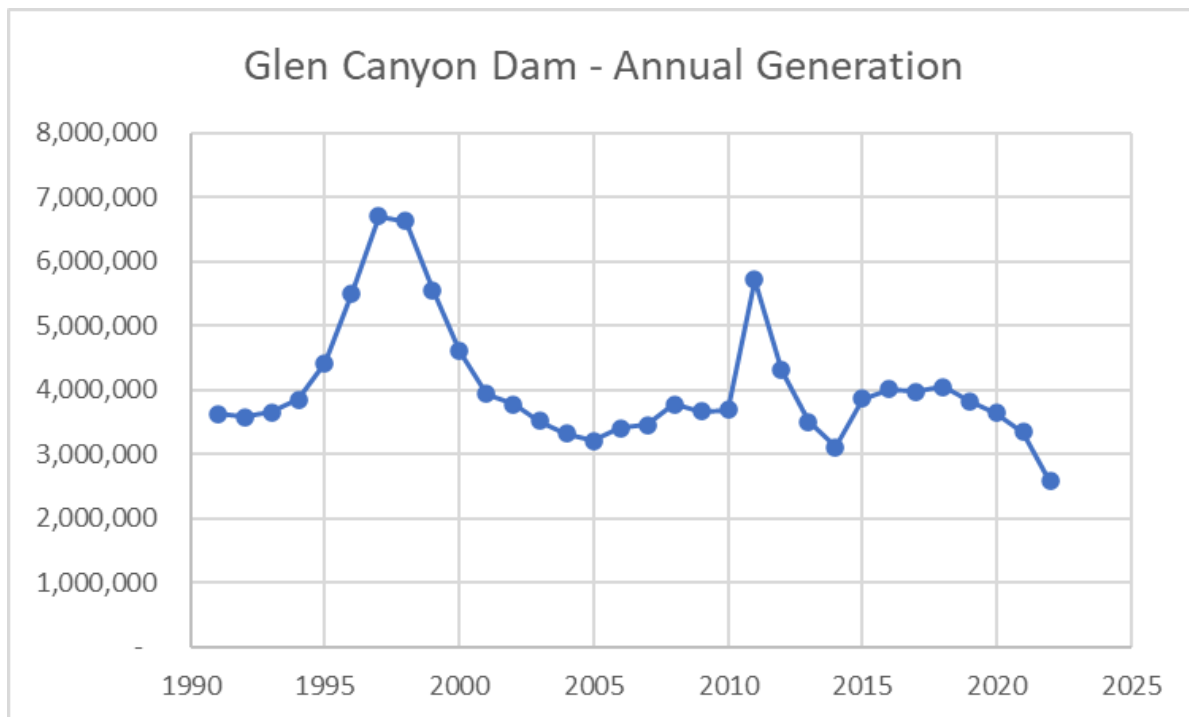
Despite a decrease in head since 2007, sustained annual flows have allowed power generation to continue with an average annual energy production of 3,833 gigawatt hours (GWh) from 2000 through 2020. However, a decrease in flows from 2020 through 2021 resulted in a decline in energy generation (Reclamation 2021b). **Figure 3-41** shows the historical annual generation at Glen Canyon Powerplant from 1991 to 2022.

Figure 3-40
Glen Canyon Powerplant Estimated Power Capacity



Source: Reclamation 2021b

Figure 3-41
Glen Canyon Dam – Annual Generation



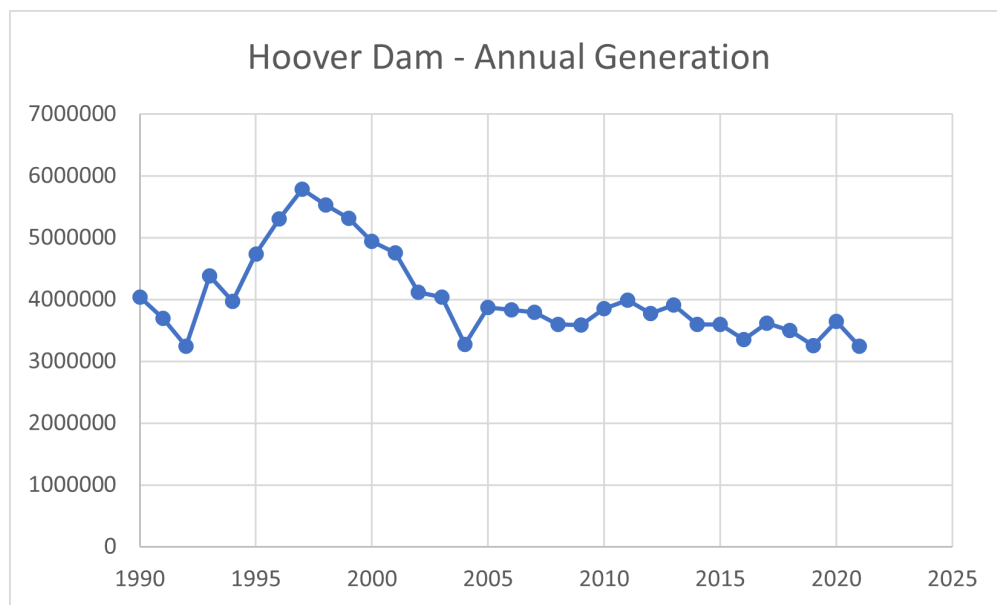
Source: Reclamation 2023b

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 gates²⁰ at most units, which allows 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 2021b).

Similar to conditions at Glen Canyon, the Hoover Powerplant has experienced significant impacts since 2007 due to drought conditions. **Figure 3-42** 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 capacity. **Figure 3-43** shows the relationship between lake elevation and capacity at the Hoover Powerplant. This reduction in head has led to a steady decline in energy production starting in 2015 (Reclamation 2021b).

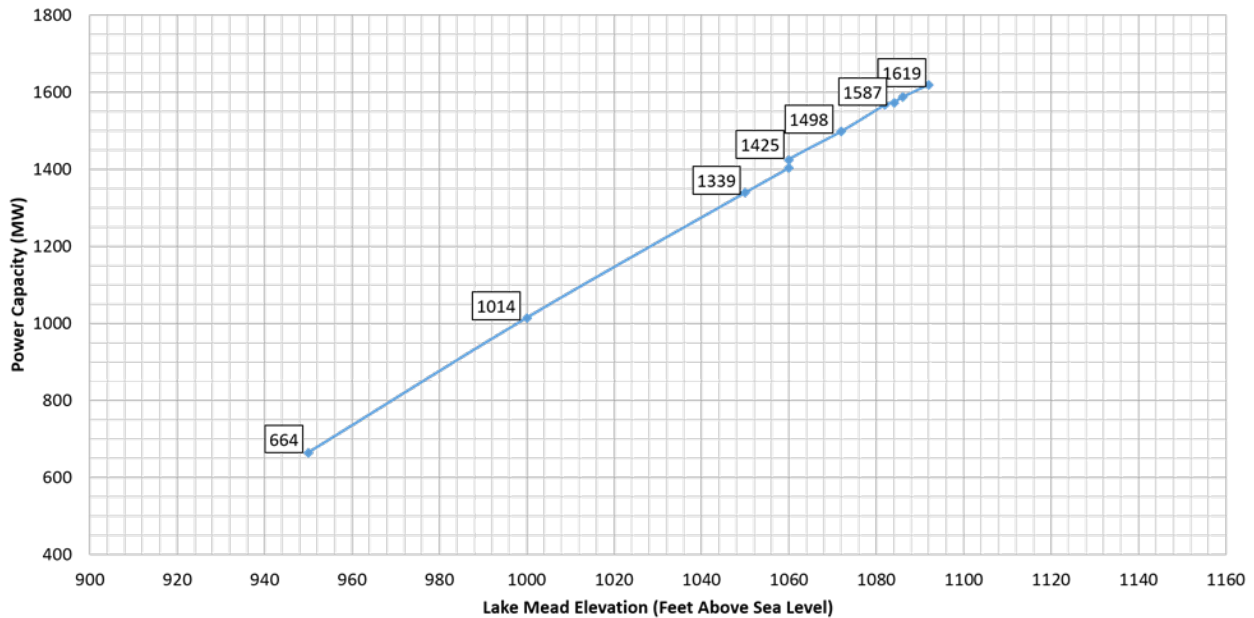
Figure 3-42
Hoover Dam – Annual Generation



Source: Reclamation 2021b

²⁰Wicket gates can open and close to allow or stop water from entering the turbines.

Figure 3-43
Low Lake Power Capacity Expectations for Hoover Powerhouse



Source: Reclamation 2021b

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 non-firm, which could impact contractors if droughts result in a further reduction in electric power generation (Reclamation 2007, 2021b).

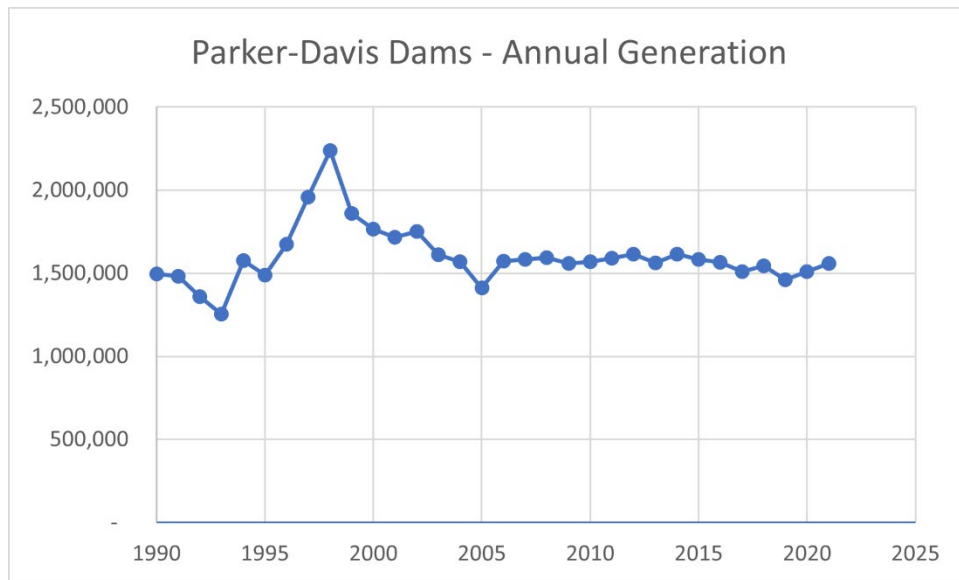
Parker-Davis Project

The Parker-Davis Project consists of the Davis Powerplant with five generators and the Parker Powerplant with four generators (Reclamation 2023b). 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 2021b).

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 lake reservoirs' (Lake Havasu above Parker Dam and Lake Mohave above Davis Dam) elevations remain relatively constant. Both dams are run of the river, with some flexibility to control releases (Reclamation 2021b). **Figure 3-44** 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 impacted the 40 power customers who have contracts with the Parker-Davis Project.

Figure 3-44
Parker-Davis Dam – Annual Generation



Source: Reclamation 2023b

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 impacted only slightly by drought since 2007. Due to the elevation protection and run-of-the-river operations, the three alternatives would not have a substantial impact on Headgate Rock Powerplant. The other small facilities would not be impacted by any of the alternatives and are, therefore, not analyzed further.

Power Funds

Upper Colorado River Basin Fund

The Colorado River Storage Project (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 as well as operation and maintenance of CRSP units and the CRSP transmission system. 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; this information is incorporated by reference (Reclamation 2007).

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 impacted

by drought conditions. The reduction of power generation has reduced available resources in the Basin Fund (Reclamation 2021b).

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 Central Arizona Project, Lower Colorado River Multi-Species Conservation Program, and the Salinity Control Project (Reclamation 2021b, 2022b). Additional information on how the funds operate can be found in Section 3.11.6.2 of the 2007 FEIS and is incorporated by reference (Reclamation 2007).

All three funds have been impacted by drought conditions since 2007, but it has been a manageable decrease in financial resources. These reductions in financial resources have impacted money delivered to the CAP, Lower Colorado River Multi-Species Conservation Program, and the Salinity Control Project (Reclamation 2021b).

Table 3-45 and **Table 3-46** show the amount of money spent on governmental programs from 2015 to 2020 for Hoover Powerplant and the Parker and Davis Powerplants, respectively.

Table 3-45
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 2021b

Table 3-46
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 2021b

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 was recently connected to the river outlet works, 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 Lake Mead Intake 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. Regulation depends on ramp rates and acts to provide sufficient generating capacity to serve customer loads. Reserves are used to quickly replace lost generation from an outage. 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 actions 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 action alternatives 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, and economic impacts from the action 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 impacted by the action 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 C**, 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 total hydropower value 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 total hydropower value 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 total hydropower value 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, 10th percentile), typical conditions (median), and wet hydrologic conditions (90th percentile, maximum).

Summary

Compared with the No Action Alternative, Action Alternatives 1 and 2 result in substantially more power generation at Glen Canyon Powerplant under low hydrology scenarios. This is particularly true in operating years 2025–2026 when lake elevations under the No Action Alternative could drop

below the minimum power pool. The difference is more varied at higher hydrologic scenarios due to the possibility of the dams releasing under different operational tiers. The difference was calculated by subtracting the estimated annual generation of the action alternative by the estimated annual generation of the No Action Alternative. This was repeated for every year and every statistical scenario. **Table 3-47** shows the difference in Glen Canyon Powerplant generation under each action alternative compared with the No Action Alternative.

Table 3-47
Difference in Glen Canyon Powerplant Annual Energy Generation (MWh) Compared with the No Action Alternative

	Minimum	10th Percentile	Median	90th Percentile	Maximum
Action Alternative 1					
2024	0	718,138	-204,811	131,850	0
2025	724,394	1,912,703	-16,434	-22,222	485,188
2026	1,523,534	1,995,451	86,293	-115,842	-49,259
Total	2,247,928	4,626,292	-134,952	-6,214	435,929
Action Alternative 2					
2024	0	791,345	-204,811	131,682	0
2025	836,973	1,919,434	32,154	-22,156	-55,496
2026	1,901,462	2,056,928	97,958	-48,279	207,484
Total	2,738,435	4,767,707	-74,699	61,247	151,988

Source: WAPA 2023

Annual releases at Lake Mead are higher under the No Action Alternative, leading to less power generation at Hoover Powerplant under Action Alternatives 1 and 2 across all hydrologic scenarios. Action Alternative 2 shows slightly less reduction in generation compared with the No Action Alternative due to the potential additional DROA releases. **Table 3-48** 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 action alternative by the estimated annual generation of the No Action Alternative.

Table 3-48
Difference in Hoover Powerplant Annual Energy Generation (MWh) Compared with the No Action Alternative

	Minimum	10th Percentile	Median	90th Percentile	Maximum
Action Alternative 1					
2024	-761,040	-308,076	-275,205	-163,961	-81,740
2025	-715,290	-599,204	-514,645	-100,004	-51,360
2026	0	651,160	-251,455	34,653	20,300
Total	-1,476,330	-256,120	-1,041,305	-229,312	-112,800

	Minimum	10th Percentile	Median	90th Percentile	Maximum
Action Alternative 2					
2024	-593,510	-321,236	-299,275	-145,224	-57,550
2025	-715,290	-520,181	-513,955	-68,374	-200,530
2026	0	705,924	-249,175	65,826	-80,200
Total	-1,308,800	-135,493	-1,062,405	-147,772	-338,280

Source: Reclamation 2023g

Reduced annual releases at both Parker and Davis Powerplants under both action alternatives 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 negatively impact generation. Impacts would be greater under low hydrologic scenarios. **Table 3-49** 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 action alternative by the estimated annual generation of the No Action Alternative.

Table 3-49
Difference in Parker-Davis Powerplants Annual Energy Generation (MWh) Compared with the No Action Alternative

	Minimum	10th Percentile	Median	90th Percentile	Maximum
Action Alternative 1					
2024	-91,885	-94,588	-90,457	-64,999	-43,536
2025	-314,347	-265,159	-222,481	-93,745	-51,811
2026	-61,425	-292,451	-171,416	-61,353	-21,766
Total	-467,657	-652,198	-484,354	-220,097	-117,113
Action Alternative 2					
2024	-123,734	-127,794	-123,356	-74,846	-59,678
2025	-314,369	-291,242	-262,824	-113,477	-88,461
2026	3,497	-320,149	-211,266	-72,342	-62,761
Total	-434,606	-739,185	-597,446	-260,665	-210,900

Source: Reclamation 2023g

Overall, the action alternatives result in substantially more generation under low hydrologic conditions. This is mainly the result of elevation protections at Lake Powell. The action alternatives result in a decrease in generation during wetter hydrologic conditions due to the increased releases under the No Action Alternative. **Table 3-50** shows the total difference in energy generation across all four powerplants analyzed.

Table 3-50
Total Difference in Annual Energy Generation (MWh) Compared with the No Action Alternative

	Minimum	10th Percentile	Median	90th Percentile	Maximum
Action Alternative 1					
2024	-852,925	315,474	-570,473	-97,110	-125,276
2025	-305,243	1,048,340	-753,560	-215,971	382,017
2026	1,462,109	2,354,160	-336,578	-142,542	-50,725
Total	303,941	3,717,974	-1,660,611	-455,623	206,016
Action Alternative 2					
2024	-717,244	342,315	-627,442	-88,388	-117,228
2025	-192,686	1,108,011	-744,625	-204,007	-344,487
2026	1,904,959	2,442,703	-362,483	-54,795	64,523
Total	995,029	3,893,029	-1,734,550	-347,190	-397,192

Source: Reclamation 2023g; 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 dry hydrologic conditions, the likelihood of water elevations dropping below the minimum power pool at Lake Powell and Lake Mead rises drastically. Elevation protections at Parker and Davis Dams would allow generation to continue; however, it would drop significantly as flows decrease over time.

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, 10th percentile), typical conditions (median), and wet hydrologic scenarios (90th percentile, maximum). These tables help show the trend of generation over the 3 years analyzed.

Table 3-51 shows the annual generation at Glen Canyon Powerplant under the No Action Alternative. Under dry hydrologic conditions, lake elevations quickly drop below minimum power pool, resulting in a complete halt in generation. Under more typical hydrologic conditions, generation would continue at a relatively stable rate, but still well below historical rates, as shown in **Figure 3-41**. Under wetter hydrologic conditions, generation at Glen Canyon Dam would begin to increase with the ability for higher releases.

Table 3-51
No Action Alternative – Glen Canyon Annual Energy Generation

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	0	607,984	2,631,335	2,952,797	3,609,284
2025	0	0	2,733,138	3,551,216	4,990,953
2026	0	0	2,714,932	3,772,168	5,329,671

Source: WAPA 2023

Table 3-52 shows annual generation at Hoover Powerplant under the No Action Alternative. Similar to Glen Canyon, under dry hydrologic conditions, the lake elevation would rapidly decline, resulting in severely diminished generation in 2026, with the potential for elevations to drop below minimum power pool. Under typical or wet hydrologic conditions, generation would maintain at a relatively similar rate across the 3 operating years.

Table 3-52
No Action Alternative – Hoover Dam Annual Energy Generation

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	2,261,650	2,551,860	2,816,735	3,148,790	3,478,980
2025	715,290	2,158,103	2,667,670	3,059,795	3,542,470
2026	0	907,162	2,662,905	3,111,136	3,811,310

Source: Reclamation 2023g

Table 3-53 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 a negligible change throughout the 3 operating years. However, under the absolute driest hydrologic conditions, generation would start to decrease rapidly from operating year 2025–2026. This is likely due to a significant decrease in releases.

Table 3-53
No Action Alternative – Parker-Davis Annual Energy Generation

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	1,298,674	1,390,061	1,466,151	1,548,398	1,666,832
2025	1,254,596	1,349,356	1,425,099	1,510,693	1,632,800
2026	862,966	1,361,427	1,445,894	1,531,410	1,672,721

Source: Reclamation 2023g

Table 3-54 shows the combined total annual generation across all four powerplants under the No Action Alternative. The trend typically mirrors those from Glen Canyon and Hoover Powerplants as they exhibit the dominant changes across hydrologic scenarios and operating years.

Table 3-54
No Action Alternative – Total Annual Energy Generation

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	3,560,324	4,549,905	6,914,221	7,649,985	8,755,096
2025	1,969,886	3,507,459	6,825,907	8,121,704	10,166,223
2026	862,966	2,268,589	6,823,731	8,414,714	10,813,702

Source: Reclamation 2023g; WAPA 2023

Action Alternative 1

Under Action Alternative 1, elevations at Lake Powell would be protected at 3,500 feet, allowing hydroelectric generation to continue at Glen Canyon Powerplant even under the driest hydrologic

conditions. This would result in a considerably smaller chance of dropping below the minimum power pool at Glen Canyon Dam. However, protecting elevations at Lake Powell could result in a decrease in elevation at Lake Mead. This would lead to significantly less generation at the Hoover Powerplant. Releases at Hoover Dam would also be decreased under Action Alternative 1, further impacting generation.

The Parker and Davis Powerplants would be impacted by reduced releases; however, because lake reservoir elevations are protected, generation would continue. Releases from the dams would be the major factor for impacts on generation.

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, 10th percentile), typical conditions (median), and wet hydrologic scenarios (90th percentile, maximum). These tables help show the trend of generation over the 3 years analyzed.

Table 3-55 shows the values for annual energy generation at the Glen Canyon Powerplant for operating years 2024–2026 under Action Alternative 1. Under most hydrologic scenarios, generation would continue over the 3 operating years at a relatively constant rate. There would be a slight uptick in generation between 2024 and 2025 as elevation levels are raised to protect 3,500 feet. Under the driest hydrologic conditions, generation would not be possible in operating year 2024 because lake reservoir elevations would begin below minimum power pool. Over time, the elevations would be raised to allow for generation to begin again.

Table 3-55
Action Alternative 1 – Glen Canyon Annual Energy Generation

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	0	1,326,122	2,426,524	2,829,203	3,084,647
2025	724,394	1,912,703	2,716,705	3,233,171	3,528,994
2026	1,523,534	1,995,451	2,801,225	3,466,217	3,656,326

Source: WAPA 2023

Table 3-56 shows the annual generation at Hoover Powerplant under Action Alternative 1. Under typical and wet hydrologic conditions, generation would continue at a similar rate. However, under drier hydrologic conditions, the elevation protection at Lake Powell would result in a decrease in elevations and releases at Hoover Powerplant, resulting in a substantial decrease in generation in operating years 2025–2026. Under the driest hydrologic conditions, elevations would drop below minimum power pool prior to operating year 2025, resulting in a complete halt in generation.

Table 3-56
Action Alternative 1 – Hoover Powerplant Annual Energy Generation

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	1,500,610	2,243,784	2,541,530	2,984,829	3,397,240
2025	0	1,558,899	2,153,025	2,959,791	3,491,110
2026	0	1,558,322	2,411,450	3,145,789	3,831,610

Source: Reclamation 2023g

Table 3-57 shows the annual combined generation at Parker and Davis Powerplants under Action Alternative 1. Generation rates would remain similar under most hydrologic scenarios as the elevation protection allows for continued generation at both powerplants. Under the driest hydrologic conditions, a larger decline in generation would occur as drought conditions continue to worsen and releases continue to decrease.

Table 3-57
Action Alternative 1 – Parker-Davis Annual Energy Generation

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	1,206,789	1,295,473	1,375,694	1,483,399	1,623,296
2025	940,249	1,084,197	1,202,618	1,416,948	1,580,989
2026	801,541	1,068,976	1,274,478	1,470,057	1,650,955

Source: Reclamation 2023g

Table 3-58 shows the total combined annual generation across all four powerplants under Action Alternative 1. There are substantial decreases in total generation between the hydrologic scenarios. However, with the exception of the driest scenarios, the generation rates remain relatively constant over the 3 operating years. The wetter hydrologic conditions result in a continued increase in generation each year. The driest hydrologic scenarios result in variable generation as Lake Powell and Lake Mead experience a drop below minimum power pool at some point during the 3 years.

Table 3-58
Action Alternative 1 – Total Annual Energy Generation

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	2,707,399	4,865,379	6,343,748	7,297,431	8,105,183
2025	1,664,643	4,555,799	6,072,348	7,609,910	8,601,093
2026	2,325,075	4,622,749	6,487,153	8,082,063	9,138,891

Source: Reclamation 2023g; WAPA 2023

Action Alternative 2

Under Action Alternative 2, different allocations would redirect water below the Hoover Powerplant. This would have no impact on hydroelectric generation at the Glen Canyon and Hoover Powerplants compared with Action Alternative 1. There would be slight changes in impacts on generation at the Parker and Davis Powerplants compared with Action Alternative 1.

The potential DROA contributions would result in higher lake elevations and releases at Lake Powell and Lake Mead. These conditions would lead to greater generation potential at the Glen Canyon and Hoover Powerplants. The potential DROA contributions would have slight impacts on the Parker and Davis Powerplants.

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, 10th percentile), typical conditions (median), and wet hydrologic scenarios (90th percentile, maximum). These tables help show the trend of generation over the 3 years analyzed.

Table 3-59 shows the values for annual energy generation at the Glen Canyon Powerplant for operating years 2024–2026 under Action Alternative 2. The trends are nearly identical as those under Action Alternative 1 with slightly higher generations across all hydrologic scenarios; this is because the potential DROA contributions allow for higher elevation and greater releases. Even with the potential DROA contributions, the driest hydrologic scenarios would result in lake elevations below minimum power pool in operating year 2024, resulting in a complete halt in generation.

Table 3-59
Action Alternative 2 – Glen Canyon Annual Energy Generation

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	0	1,399,329	1,989,596	2,426,524	2,829,178
2025	836,973	1,919,434	2,218,021	2,765,292	3,231,255
2026	1,901,462	2,056,928	2,408,524	2,812,890	3,462,758

Source: WAPA 2023g

Table 3-60 shows the annual energy generation at the Hoover Powerplant under Action Alternative 2. The trends are nearly identical as under Action Alternative 1 with slightly higher generations across all hydrologic scenarios; this is because the potential DROA contributions allow for higher elevation and greater releases. Even with the potential DROA contributions, the driest hydrologic scenarios would result in lake elevations below minimum power pool in operating years 2025 and 2026, resulting in a complete halt in generation.

Table 3-60
Action Alternative 2 – Hoover Annual Energy Generation

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	1,668,140	2,230,624	2,517,460	3,003,566	3,421,430
2025	0	1,637,922	2,153,715	2,991,421	3,341,940
2026	0	1,613,086	2,413,730	3,176,962	3,731,110

Source: Reclamation 2023g

Table 3-61 shows the combined annual energy generation at the Parker and Davis Powerplants under Action Alternative 2. The trends are nearly identical as under Action Alternative 1 with slightly higher generations across all hydrologic scenarios; this is because the potential DROA contributions allow for higher elevation and greater releases.

Table 3-61
Action Alternative 2 – Parker-Davis Annual Energy Generation

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	1,174,940	1,262,267	1,342,795	1,473,552	1,607,154
2025	940,227	1,058,114	1,162,275	1,397,216	1,544,339
2026	866,463	1,041,278	1,234,628	1,459,068	1,609,960

Source: Reclamation 2023g

Table 3-62 shows the values for total combined annual energy generation at all four powerplants under Action Alternative 2. The trends are nearly identical as under Action Alternative 1 with slightly higher generations across all hydrologic scenarios; this is because the potential DROA contributions allow for higher elevation and greater releases.

Table 3-62
Action Alternative 2 – Total Annual Energy Generation

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	2,843,080	4,892,220	5,849,851	6,903,642	7,857,762
2025	1,777,200	4,615,470	5,534,011	7,153,929	8,117,534
2026	2,767,925	4,711,292	6,056,882	7,448,920	8,803,828

Source: Reclamation 2023g; WAPA 2023

Cumulative Effects

The potential operational changes included in the Glen Canyon Dam/Smallmouth Bass flow options would result in a substantial decrease in power generation at the Glen Canyon Powerplant. The flow options would alter how water is released through Glen Canyon Dam by rerouting releases through the river outlet works as opposed to the power-generating penstocks. This would result in a cumulative negative impact on generation across all alternatives outlined in the SEIS. The flow options would have minor impacts on dry hydrologic scenarios under the No Action Alternative, because lake elevations would drop below minimum power pool and all releases would be through the river outlet works. Overall, monthly and annual volume releases from Lake Powell would not change; therefore, no additional impacts would occur at any downstream powerplants.

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 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, 10th percentile), typical conditions (median), and wet hydrologic conditions (90th percentile, 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, Action Alternatives 1 and 2 result in a substantially greater capacity at Glen Canyon Powerplant under low hydrologic scenarios. This is particularly true in operating years 2025–2026 when lake elevations under the No Action Alternative could drop below the minimum power pool. The difference is more varied at higher hydrologic scenarios due to the possibility of the dams releasing under different operational tiers resulting in varied lake elevations. The difference was calculated by subtracting the estimated August capacity of the action alternative by the estimated August capacity of the No Action Alternative. This was repeated for every year and every statistical scenario. **Table 3-63** shows the difference in Glen Canyon Powerplant capacity under each action alternative compared with the No Action Alternative.

Table 3-63
Difference in Glen Canyon Powerplant August Capacity (MW) Compared with the No Action Alternative

	Minimum	10th Percentile	Median	90th Percentile	Maximum
Action Alternative 1					
August 2024	0	193	24	74	82
August 2025	58	322	68	47	60
August 2026	80	338	68	26	-1
Action Alternative 2					
August 2024	0	233	24	74	82
August 2025	79	328	71	54	1
August 2026	295	343	68	31	71

Source: WAPA 2023

Lake reservoir elevations at Lake Mead are variable across the alternatives at different hydrologic conditions, resulting in variable capacity. Under the driest hydrologic conditions, capacity is greatest in operating year 2024 under the No Action Alternative; however, all alternatives result in a drop below minimum power pool and a drop to zero capacity in operating years 2025 and 2026. For all remaining hydrologic scenarios, capacity under the No Action Alternative outperforms both action alternatives in operating year 2024. However, capacity under both action alternatives outperforms the No Action Alternative under the remaining operating years. **Table 3-64** shows the difference in Hoover Powerplant capacity under each action alternative compared with the No Action Alternative. The difference was calculated by subtracting the estimated August capacity of the action alternative by the estimated August capacity of the No Action Alternative.

Table 3-64
Difference in Hoover Powerplant August Capacity (MW) Compared with the No Action Alternative

	Minimum	10th Percentile	Median	90th Percentile	Maximum
Action Alternative 1					
August 2024	-719	-48	-34	-1	6
August 2025	0	49	76	58	21
August 2026	0	754	163	141	34
Action Alternative 2					
August 2024	-719	-33	-31	-6	0
August 2025	0	54	77	55	20
August 2026	0	756	181	127	54

Source: Reclamation 2023g

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 rates, under dry hydrologic conditions, the likelihood of water elevations dropping below the minimum power pool at Lake Powell and Lake Mead rises drastically.

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, 10th percentile), typical conditions (median), and wet hydrologic scenarios (90th percentile, maximum). These tables help show the trend of potential capacity over the 3 years analyzed.

Table 3-65 shows the August capacity at Glen Canyon Powerplant under the No Action Alternative. Under dry hydrologic conditions, lake elevations drop below minimum power pool, resulting in a complete halt in capacity. Under more typical hydrologic conditions, capacity would continue at a relatively stable rate, but still well below historical levels. Under wetter hydrologic conditions, capacity at Glen Canyon Dam would begin to increase with the potential for higher lake reservoir elevations.

Table 3-65
No Action Alternative – Glen Canyon August Capacity

	Minimum	10th Percentile	Median	90th Percentile	Maximum
August 2024	0	0	460	572	620
August 2025	0	0	478	605	926
August 2026	0	0	483	636	928

Source: WAPA 2023

Table 3-66 shows August capacity at Hoover Powerplant under the No Action Alternative. Similar to Glen Canyon, under dry hydrologic conditions, the lake elevation would rapidly decline, resulting in severely diminished capacity, with the potential for elevations to drop below minimum power pool in operating years 2025 and 2026. Under typical or wet hydrologic conditions, capacity would maintain at a relatively similar rate across the 3 operating years.

Table 3-66
No Action Alternative – Hoover Dam August Capacity

	Minimum	10th Percentile	Median	90th Percentile	Maximum
August 2024	719	876	1,030	1,182	1,319
August 2025	0	700	991	1,187	1,415
August 2026	0	0	971	1,174	1,464

Source: Reclamation 2023g

Action Alternative 1

Under Action Alternative 1, elevations at Lake Powell would be protected at 3,500 feet, allowing for continued capacity at Glen Canyon Powerplant even under the driest hydrologic conditions. This alternative would result in a considerably smaller chance of dropping below the minimum power pool at Glen Canyon Dam. However, protecting elevations at Lake Powell could result in an immediate decrease in elevation at Lake Mead in operating year 2024. This would result in lower capacity at Hoover Powerplant, but a recovery of capacity in operating years 2025 and 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, 10th percentile), typical conditions (median), and wet hydrologic scenarios (90th percentile, maximum). These tables help show the trend of capacity over the 3 years analyzed.

Table 3-67 shows the values for August capacity at the Glen Canyon Powerplant for operating years 2024–2026 under Action Alternative 1. Under most hydrologic scenarios, capacity would continue over the 3 operating years. There would be a slight uptick in capacity over the 3 years as elevation levels are raised to protect 3,500 feet. Under the driest hydrologic conditions, capacity would not be possible in operating year 2024 because lake reservoir elevations would begin below minimum power pool. Over time, the elevations would be raised to allow for capacity to begin again.

Table 3-67
Action Alternative 1 – Glen Canyon August Capacity

	Minimum	10th Percentile	Median	90th Percentile	Maximum
August 2024	0	193	484	646	702
August 2025	58	322	545	652	985
August 2026	80	338	551	662	927

Source: WAPA 2023

Table 3-68 shows the August capacity at Hoover Powerplant under Action Alternative 1. Under typical and wet hydrologic conditions, generation would continue at a similar rate. However, under the driest hydrologic conditions, the elevation protection at Lake Powell would result in elevations at Hoover Dam dropping below minimum power pool, resulting in a halt of capacity.

Table 3-68
Action Alternative 1 – Hoover Powerplant August Capacity

	Minimum	10th Percentile	Median	90th Percentile	Maximum
August 2024	0	828	996	1,181	1,325
August 2025	0	749	1,067	1,245	1,436
August 2026	0	754	1,134	1,315	1,498

Source: Reclamation 2023g

Action Alternative 2

Under Action Alternative 2, different allocations would redirect water below the Hoover Powerplant. This would have no impact on capacity at the Glen Canyon and Hoover Powerplants compared with Action Alternative 1.

The potential DROA contributions would result in higher lake elevations at Lake Powell and Lake Mead. These conditions would lead to slightly greater potential capacity at the Glen Canyon and Hoover Powerplants across most hydrologic conditions compared with Action Alternative 1.

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. These values represent dry hydrologic scenarios (minimum, 10th percentile), typical conditions (median), and wet hydrologic scenarios (90th percentile, maximum). These tables help show the trend of capacity over the 3 years analyzed.

Table 3-69 shows the values for August capacity at the Glen Canyon Powerplant for operating years 2024–2026 under Action Alternative 2. The trends are nearly identical as Action Alternative 1 with higher capacity across all hydrologic scenarios because the potential DROA contributions allow for higher elevation and greater releases. Even with the potential DROA contributions, the driest hydrologic scenarios would result in lake elevations below minimum power pool in operating year 2024, resulting in a complete halt in capacity.

Table 3-69
Action Alternative 2 – Glen Canyon August Capacity

	Minimum	10th Percentile	Median	90th Percentile	Maximum
August 2024	0	233	484	646	702
August 2025	79	328	548	659	927
August 2026	295	343	551	666	999

Source: WAPA 2023g

Table 3-70 shows the August capacity at the Hoover Powerplant under Action Alternative 2. The trends are nearly identical as under Action Alternative 1 with slightly higher generations across all hydrologic scenarios; this is because the potential DROA contributions allow for higher elevation. Even with the potential DROA contributions, the driest hydrologic scenarios would result in lake elevations below minimum power pool in all operating years, resulting in a complete halt in capacity.

Table 3-70
Action Alternative 2 – Hoover Annual Energy Generation

	Minimum	10th Percentile	Median	90th Percentile	Maximum
August 2024	0	843	999	1,176	1,319
August 2025	0	754	1,068	1,242	1,435
August 2026	0	756	1,152	1,301	1,518

Source: Reclamation 2023g

Issue 3: How would changes in power generation and capacity impact the total hydropower value?

The total hydropower value 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 total hydropower value 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 total hydropower value 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, 10th percentile), typical conditions (median), and wet hydrologic conditions (90th percentile, maximum).

Summary

Action Alternatives 1 and 2 result in more financial resources at Glen Canyon Powerplant when compared with the No Action Alternative. The difference is substantially larger under low hydrologic scenarios. This increase is particularly apparent in operating years 2025–2026 when lake elevations under the No Action Alternative could drop significantly and revenue would decrease proportionally. **Table 3-71** shows the difference in the Glen Canyon Powerplant under each action alternative when compared with the No Action Alternative.

Table 3-71
Difference in the Glen Canyon Powerplant's Total Hydropower Value Compared with the No Action Alternative (Thousands of Dollars)

	Minimum	10th Percentile	Median	90th Percentile	Maximum
Action Alternative 1					
2024	\$0	\$40,872	-\$12,461	\$19,071	\$0
2025	\$64,414	\$149,301	\$4,557	-\$712	\$45,815

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2026	\$109,581	\$161,050	\$11,338	-\$6,457	\$841
Total	\$173,995	\$351,223	\$3,434	\$11,902	\$46,656
Action Alternative 2					
2024	\$0	\$46,496	-\$12,461	\$19,056	\$0
2025	\$72,260	\$153,173	\$7,207	-\$719	-\$5,119
2026	\$142,740	\$165,527	\$12,829	-\$2,101	\$24,958
Total	\$215,000	\$365,196	\$7,575	\$16,236	\$19,839

Source: WAPA 2023

Reduced generation under the action alternatives would result in a decrease in hydropower value across most hydrologic scenarios at the Hoover Powerplant when compared with the No Action Alternative. The difference is substantially larger under the driest and typical hydrologic conditions. **Table 3-72** shows the difference in the Hoover Powerplant under each action alternative when compared with the No Action Alternative.

Table 3-72
Difference in the Hoover Powerplant's Total Hydropower Value Compared with the No Action Alternative (Thousands of Dollars)

	Minimum	10th Percentile	Median	90th Percentile	Maximum
Action Alternative 1					
2024	-\$136,717	-\$36,591	-\$31,303	-\$17,365	-\$9,202
2025	-\$92,615	-\$64,913	-\$51,341	-\$5,002	-\$4,235
2026	\$0	\$109,828	-\$15,470	\$12,972	\$4,776
Total	-\$229,332	\$8,324	-\$98,114	-\$9,395	-\$8,661
Action Alternative 2					
2024	-\$101,021	-\$38,741	-\$35,647	-\$16,329	-\$6,829
2025	-\$92,615	-\$55,141	-\$52,773	-\$3,588	-\$22,587
2026	\$0	\$115,557	-\$16,487	\$14,060	-\$5,888
Total	-\$193,636	\$21,675	-\$104,907	-\$5,857	-\$35,304

Source: Reclamation 2023g

The combined reduced generation under the action alternatives would result in a decrease in hydropower value across all hydrologic scenarios at the Parker and Davis Powerplants when compared with the No Action Alternative. The difference is substantially larger under the drier and typical hydrologic conditions. **Table 3-73** shows the difference in the combined Parker and Davis Powerplants under each action alternative when compared with the No Action Alternative.

Table 3-73
Change in the Parker-Davis Powerplants' Total Hydropower Value Compared with the No Action Alternative (Thousands of Dollars)

	Minimum	10th Percentile	Median	90th Percentile	Maximum
Action Alternative 1					
2024	-\$8,909	-\$9,443	-\$8,984	-\$6,545	-\$4,548
2025	-\$32,397	-\$27,509	-\$22,320	-\$9,077	-\$4,918
2026	-\$13,082	-\$28,462	-\$16,442	-\$5,625	-\$1,741
Total	-\$54,388	-\$65,414	-\$47,746	-\$21,247	-\$11,207
Action Alternative 2					
2024	-\$13,079	-\$13,592	-\$13,030	-\$7,888	-\$6,675
2025	-\$33,387	-\$30,543	-\$27,003	-\$11,595	-\$9,365
2026	-\$6,862	-\$31,456	-\$20,883	-\$7,059	-\$5,997
Total	-\$53,328	-\$75,591	-\$60,916	-\$26,542	-\$22,037

Source: Reclamation 2023g

Table 3-74 combines the total hydropower value for all four powerplants to analyze overall economic impacts under the action alternatives when compared with the No Action Alternative. Under the action alternatives, a combined increase in generation under the drier hydrologic conditions leads to an increase in total hydropower value when compared with the No Action Alternative. However, under the driest, typical, and wet hydrologic conditions, a decrease in combined generation leads to a decrease in total hydropower value. These results are highly variable and show the complexity of total hydropower value.

Table 3-74
Total Change in Hydropower Value Compared with the No Action Alternative (Thousands of Dollars)

	Minimum	10th Percentile	Median	90th Percentile	Maximum
Action Alternative 1					
2024	-\$145,626	-\$5,162	-\$52,748	-\$4,839	-\$13,750
2025	-\$60,598	\$56,879	-\$69,104	-\$14,791	\$36,662
2026	\$96,499	\$242,416	-\$20,574	\$890	\$3,876
Total	-\$109,725	\$294,133	-\$142,426	-\$18,740	\$26,788
Action Alternative 2					
2024	-\$114,100	-\$5,837	-\$61,138	-\$5,161	-\$13,504
2025	-\$53,742	\$67,489	-\$72,569	-\$15,902	-\$37,071
2026	\$135,878	\$249,628	-\$24,541	\$4,900	\$13,073
Total	-\$31,964	\$311,280	-\$158,248	-\$16,163	-\$37,502

Source: Reclamation 2023g; 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 and Lake Mead rises drastically. As lake

elevations decline, generation and capacity would decrease and halt as soon as elevations drop below the minimum power pool. Total hydropower value trends typically mirror generation and capacity trends; therefore, when generation and capacity are reduced or stop, the total hydropower value is also reduced or halted. Therefore, the total hydropower value is much lower under low hydrological scenarios.

The following tables show the annual total hydropower value 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, 10th percentile), typical conditions (median), and wet hydrologic scenarios (90th percentile, maximum). These tables help show the trend of hydropower value over the 3 years analyzed.

Table 3-75 shows the annual total hydropower value at the Glen Canyon for operating years 2024–2026 under the No Action Alternative. Generation and capacity are near or below minimum power pool throughout the drier hydrologic conditions, resulting in a near or complete halt in total hydropower value. At typical and wet hydrologic conditions, the total hydropower value remains relatively consistent across the 3 operating years with slight differences between the hydrologic conditions.

Table 3-75
No Action Alternative – Glen Canyon Dam Annual Hydropower Value (Thousands of Dollars)

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	\$0	\$69,593	\$224,362	\$239,992	\$256,214
2025	\$0	\$0	\$230,664	\$252,992	\$298,622
2026	\$0	\$0	\$218,813	\$254,945	\$301,780
Total	\$0	\$69,593	\$673,839	\$747,929	\$856,616

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 halt, the impacts on hydropower value are still substantial. Typical and wet hydrologic scenarios result in consistent total hydropower value through the 3 operating years. In the drier hydrologic scenarios, total hydropower is substantially impacted by the reduction in generation and capacity. The driest scenarios result in elevations below minimum power pool and an associated halt in total hydropower value in operating year 2026. **Table 3-76** shows the annual total hydropower value for Hoover Powerplant under the No Action Alternative.

Table 3-76
No Action Alternative – Hoover Dam Annual Hydropower Value (Thousands of Dollars)

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	\$298,158	\$337,938	\$374,521	\$420,232	\$464,841
2025	\$92,615	\$287,641	\$360,349	\$413,867	\$482,993
2026	\$0	\$106,915	\$342,954	\$403,017	\$497,688
Total	\$390,773	\$732,494	\$1,077,824	\$1,237,116	\$1,445,522

Source: Reclamation 2023g

Revenue from the combined Parker and Davis Powerplants' customer contracts are 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 maintain generation and capacity through all hydrologic scenarios, and only minor impacts are felt on the total hydropower value. Only in the driest hydrologic scenarios is there a substantial impact on total hydropower value. **Table 3-77** shows the combined annual total hydropower value for Parker and Davis Powerplants under the No Action Alternative.

Table 3-77
No Action Alternative – Parker-Davis Dams Annual Hydropower Value (Thousands of Dollars)

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	\$131,824	\$141,168	\$148,840	\$157,040	\$169,917
2025	\$128,786	\$138,204	\$145,743	\$154,659	\$168,019
2026	\$94,016	\$134,015	\$142,136	\$150,712	\$164,688
Total	\$354,626	\$413,387	\$436,719	\$462,411	\$502,624

Source: Reclamation 2023g

Table 3-78 shows the combined total hydropower value across all four powerplants under the No Action Alternative. The trend typically mirrors those from Glen Canyon and Hoover Powerplants, 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 Hoover Dam approaches minimum power pool.

Table 3-78
No Action Alternative – Total Annual Economic Value of Electrical Power (Thousands of Dollars)

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	\$429,982	\$548,699	\$747,723	\$817,264	\$890,972
2025	\$221,401	\$425,845	\$736,756	\$821,518	\$949,634
2026	\$94,016	\$240,930	\$703,903	\$808,674	\$964,156
Total	\$745,399	\$1,215,474	\$2,188,382	\$2,447,456	\$2,804,762

Source: Reclamation 2023g; WAPA 2023

Action Alternative 1

Under Action Alternative 1, power generation and capacity at the Glen Canyon Powerplant would be greater than they would be under the No Action Alternative. This would result in higher hydropower value at the Glen Canyon Powerplant under all hydrologic scenarios.

The total hydropower value would decrease as lake elevations decline at Lake Mead. There would still be the potential for lake elevations at Lake Mead to drop below the minimum power pool, which would result in a halt of generation. 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.

Revenue from generation at Parker and Davis Powerplants would continue because minimum power pool elevations would be protected. However, changes in releases would impact revenue.

The following tables show the annual total hydropower value 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, 10th percentile), typical conditions (median), and wet hydrologic scenarios (90th percentile, maximum). These tables help show the trend of hydropower value over the 3 years analyzed.

Table 3-79 shows the values for the annual total hydropower value at the Glen Canyon Powerplant for operating years 2024–2026 under Action Alternative 1. Overall, Action Alternative 1 results in positive hydropower across all hydrologic scenarios. The wetter the conditions, the greater the hydropower value. However, due to a halt in generation and capacity in operating year 2024 under the driest conditions, hydropower value would still fall to zero before climbing up as the reservoir fills back up.

Table 3-79
Action Alternative 1 – Glen Canyon Dam Annual Hydropower Value (Thousands of Dollars)

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	\$0	\$110,465	\$168,835	\$211,901	\$247,455
2025	\$64,414	\$149,301	\$179,706	\$235,221	\$274,959
2026	\$109,581	\$161,050	\$186,528	\$230,152	\$279,326
Total	\$173,995	\$420,816	\$535,069	\$677,274	\$801,740

Source: WAPA 2023

Table 3-80 shows the values for the annual total hydropower value at the Hoover Powerplant under Action Alternative 1. Like hydropower value at Glen Canyon, the wetter the hydrologic conditions, the greater the total hydropower value. However, Hoover Powerplant is much more susceptible to dropping below minimum power pool under the driest conditions in Action Alternative 1. This would result in a substantial decrease in hydropower value, particularly in operating years 2025 and 2026.

Table 3-80**Action Alternative 1 – Hoover Dam Annual Hydropower Value (Thousands of Dollars)**

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	\$161,441	\$301,347	\$343,218	\$402,867	\$455,639
2025	\$0	\$222,728	\$309,008	\$408,865	\$478,758
2026	\$0	\$216,743	\$327,484	\$415,989	\$502,464
Total	\$161,441	\$740,818	\$979,710	\$1,227,721	\$1,436,861

Source: Reclamation 2023g

Table 3-81 shows the values for the combined annual total hydropower value at the Parker and Davis Powerplants. The Parker and Davis Powerplants are able to continue generation and capacity rates, resulting in continued hydropower value across all hydrologic scenarios. Under the driest conditions, there is a substantial decrease in hydropower value in operating years 2025 and 2026 as releases decline due to continued drought conditions.

Table 3-81**Action Alternative 1 – Parker-Davis Dams Annual Hydropower Value (Thousands of Dollars)**

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	\$122,915	\$131,725	\$139,856	\$150,495	\$165,369
2025	\$96,389	\$110,695	\$123,423	\$145,582	\$163,101
2026	\$80,934	\$105,553	\$125,694	\$145,087	\$162,947
Total	\$300,238	\$347,973	\$388,973	\$441,164	\$491,417

Source: Reclamation 2023g

Table 3-82 shows the total combined annual hydropower value across all four powerplants under Action Alternative 1. There are substantial decreases in total hydropower value between the hydrologic scenarios. However, with the exception of the driest scenarios, the hydropower value remains relatively constant over the 3 operating years. The wetter hydrologic conditions result in a continued increase in hydropower value each year. The driest hydrologic scenarios result in variable hydropower value as Lake Powell and Lake Mead experience a drop below minimum power pool at different points during the 3 operating years.

Table 3-82**Action Alternative 1 – Total Annual Hydropower Value (Thousands of Dollars)**

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	\$284,356	\$543,537	\$651,909	\$765,263	\$868,463
2025	\$160,803	\$482,724	\$612,137	\$789,668	\$916,818
2026	\$190,515	\$483,346	\$639,706	\$791,228	\$944,737
Total	\$635,674	\$1,509,607	\$1,903,752	\$2,346,159	\$2,730,018

Source: Reclamation 2023g; WAPA 2023

Action Alternative 2

Under Action Alternative 2, hydropower value at Glen Canyon Powerplant would be slightly higher compared with Action Alternative 1 due to the potential DROA contributions. The lake reservoir elevation at Lake Powell would maintain continued capacity and generation. This would allow for a continued positive total hydropower value. However, as reservoir elevations at Lake Mead decline, the total hydropower value would also decline. There would be a potential for lake reservoir elevations at Lake Mead to drop below the minimum power pool, which would result in substantial impacts on the total hydropower value. Alternative sources of revenue, such as visitor fees to Hoover Dam, would continue.

Revenue from generation at Parker and Davis Powerplants would continue, as minimum power pool elevations would be protected. However, changes in releases would impact revenue.

The following tables show the annual total hydropower value 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, 10th percentile), typical conditions (median), and wet hydrologic scenarios (90th percentile, maximum). These tables help show the trend of hydropower value over the 3 years analyzed.

Table 3-83 shows the values for the annual total hydropower value at the Glen Canyon Powerplant for operating years 2024–2026 under Action Alternative 2. The trends are nearly identical to the trends under Action Alternative 1, with slightly higher total hydropower value across all hydrologic scenarios. This is because the potential DROA contributions allow for higher generation and capacity. Even with the potential DROA contributions, the driest hydrologic scenarios would result in lake elevations below minimum power pool in operating year 2024, resulting in a complete halt in total hydropower value.

Table 3-83
Action Alternative 2 – Glen Canyon Dam Annual Hydropower Value (Thousands of Dollars)

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	\$0	\$116,089	\$169,325	\$211,901	\$247,463
2025	\$72,260	\$153,173	\$185,838	\$237,871	\$276,188
2026	\$142,740	\$165,527	\$199,500	\$231,642	\$279,346
Total	\$215,000	\$434,789	\$554,663	\$681,414	\$802,997

Source: WAPA 2023

Table 3-84 shows the annual totally hydropower value at the Hoover Powerplant under Action Alternative 2. The trends are nearly identical to the trends under Action Alternative 1, with higher total hydropower value across all hydrologic scenarios. This is because the potential DROA contributions allow for higher generation and capacity. Even with the potential DROA contributions, the driest hydrologic scenarios would result in lake elevations below minimum power pool in operating years 2025 and 2026, resulting in a substantial decline in total hydropower value.

Table 3-84**Action Alternative 2 – Hoover Dams Annual Hydropower Value (Thousands of Dollars)**

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	\$197,137	\$299,197	\$338,874	\$403,903	\$458,012
2025	\$0	\$232,500	\$307,576	\$410,279	\$460,406
2026	\$0	\$222,472	\$326,467	\$417,077	\$491,800
Total	\$197,137	\$754,169	\$972,917	\$1,231,259	\$1,410,218

Source: Reclamation 2023g

Table 3-85 shows the combined annual total hydropower value at the Parker and Davis Powerplants under Action Alternative 2. The trends are nearly identical to the trends under Action Alternative 1, with slightly higher total hydropower value across all hydrologic scenarios; this is because the potential DROA contributions allow for higher generation.

Table 3-85**Action Alternative 2 – Parker-Davis Dams Annual Hydropower Value (Thousands of Dollars)**

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	\$118,745	\$127,576	\$135,810	\$149,152	\$163,242
2025	\$95,399	\$107,661	\$118,740	\$143,064	\$158,654
2026	\$87,154	\$102,559	\$121,253	\$143,653	\$158,691
Total	\$301,298	\$337,796	\$375,803	\$435,869	\$480,587

Source: Reclamation 2023g

Table 3-86 shows the values for total combined annual hydropower value at all four powerplants under Action Alternative 2. The trends are nearly identical to the trends under Action Alternative 1, with slightly higher total hydropower value across all hydrologic scenarios; this is because the potential DROA contributions allow for greater generation and capacity.

Table 3-86**Action Alternative 2 – Total Annual Hydropower Value (Thousands of Dollars)**

	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	\$315,882	\$542,862	\$644,009	\$764,956	\$868,717
2025	\$167,659	\$493,334	\$612,154	\$791,214	\$895,248
2026	\$229,894	\$490,558	\$647,220	\$792,372	\$929,837
Total	\$713,435	\$1,526,754	\$1,903,383	\$2,348,542	\$2,693,802

Source: Reclamation 2023g; WAPA 2023

Cumulative Effects

The potential operational changes included in the Glen Canyon Dam/Smallmouth Bass flow options would result in a substantial decrease in power generation, capacity, and, therefore, total hydropower value at the Glen Canyon Powerplant. The reduction in generation would be offset by the purchase of replacement power. This purchase of replacement power could further impact the total hydropower value.

The additional revenue from the action alternatives, particularly under dry hydrologic scenarios, could help offset this reduction in total hydropower value. The EA would have minor cumulative impacts under the No Action Alternative and dry hydrologic conditions because lake elevations would drop below minimum power pool, resulting in a halt of revenue at Glen Canyon Dam. The EA would not impact operations at the Lower Basin powerplants. Therefore, there would be no additional impacts on the total hydropower value at other powerplants.

Issue 4: How would changes in total hydropower value impact the various power funds?

The various power funds are operated in different manners and, therefore, are impacted 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 will 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 total hydropower value modeling associated with each analyzed powerplant under each action alternative. Quantitative impacts are difficult to accurately model.

Summary

Lake Powell has the highest chance 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. Compared with the No Action Alternative, both action alternatives would result in increased revenue and total hydropower value at the Glen Canyon Powerplant and, therefore, increased financial resources for the Basin Fund. The Basin Fund would have the greatest amount of financial resources under the wet hydrologic scenarios.

Compared with the No Action Alternative, Action Alternatives 1 and 2 would decrease total hydropower value at Hoover Dam, resulting in a decrease in financial resources for the Development Fund. Under Action Alternatives 1 and 2, the Parker and Davis Powerplants would continue to have positive total hydropower value and would continue to contribute to 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 amount of impacts on the Development Fund.

The Dam Fund and Parker-Davis Account would receive the same amount of revenue from customers under all three alternatives and would only be impacted by operations and maintenance costs. It can be assumed that the impacts under the action alternatives would be greater than the impacts under the No Action Alternative due to the decreased releases and total hydropower value.

No Action Alternative

Under the No Action Alternative, the total hydropower value would decrease at the Glen Canyon Powerplant. Lake reservoir elevations at Lake Powell have the potential to drop below the minimum power pool and halt generation and total hydropower value completely. This is particularly true under dry hydrologic scenarios. Any large reduction or halt in total hydropower value would have severe impacts on the Basin Fund. Under the wet hydrologic conditions, total hydropower value would remain above zero, but it would still be lower compared with under the action alternatives.

The Development Fund would remain relatively unimpacted under wet hydrologic scenarios under the No Action Alternative. However, during dry hydrologic scenarios, total hydropower value would be severely impacted, particularly later in the project timeline, and could result in severe 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 total hydropower value; this would result in minor impacts on the Parker-Davis Account.

Action Alternative 1

Under Action Alternative 1, the total hydropower value would increase at the Glen Canyon Powerplant compared with under the No Action Alternative. Lake reservoir elevation protection at Lake Powell would result in continued operations above minimum power pool under all but the driest hydrologic scenarios. This would result in additional financial resources for the Basin Fund. The driest hydrologic scenario would result in impacts on the Basin Fund, particularly in operating year 2024 when elevations could start below minimum power pool, but the fund would recover in operating years 2025 and 2026.

Under Action Alternative 1, Lake Mead could drop below minimum power pool in the drier hydrologic scenarios, resulting in substantial impacts on the Development Fund. Even under typical hydrologic scenarios, Lake Mead's elevation would be reduced, resulting in impacts on total hydropower value and the associated contributions to the Development Fund. These impacts would be slightly offset by continued total hydropower value at the Parker and Davis Powerplants. However, the Parker and Davis Powerplants would also see slight impacts on the total hydropower value and the associated contributions to the Development Fund. Overall, Action Alternative 1 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 Action Alternative 1. Reduced total hydropower value 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 total hydropower value; this would result in minor impacts on the Parker-Davis Account.

Action Alternative 2

Under Action Alternative 2, impacts on the Basin Fund would be very similar compared with Action Alternative 1, but with slightly less impacts on the Basin Fund. This is because the potential DROA contributions would help total hydropower value at Glen Canyon Dam.

Impacts on the Development Fund would be very similar to impacts under Action Alternative 1; however, there would be slightly less impacts on the Development Fund because the potential DROA contributions would help total hydropower value at Hoover Dam.

Impacts on the Dam Fund and Parker-Davis Account would remain minor, which would be similar to both the No Action Alternative and Action Alternative 1. There would be a very slight change in impacts compared with Action Alternative 1, as the potential DROA contributions would only slightly help total hydropower value.

Cumulative Effects

The potential operational changes included in Glen Canyon Dam would result in a substantial decrease in total hydropower value at the Glen Canyon Powerplant and a decrease in the associated contributions to the Basin Fund. The additional total hydropower value at Glen Canyon Powerplant from the action alternatives could help offset this decrease in revenue. Overall, the Basin Fund would see a decrease in revenue compared with recent annual values. The EA would not impact total hydropower value at the Lower Basin powerplants. Therefore, there would be no additional impacts on other Lower Basin power funds.

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 Upper Colorado River Endangered Fish Recovery Program, the Colorado River Basin Salinity Control Program, the Glen Canyon Adaptive Management Program, the Central Arizona Project, 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 impacted by any changes in financial reserves within the power funds. Some programs are able to receive flexible funding from both upper and lower power funds, which could help reduce impacts.

These impacts are difficult to model accurately; therefore, a qualitative analysis has been included based on total hydropower value modeling and impacts on the power funds, as outlined in Issue 4.

Summary

Compared with under the No Action Alternative, available funding in the Basin Fund would be greater under the action alternatives. These additional financial reserves would help provide funding for the government programs that rely on funding from the Basin Fund. Impacts on the Development Fund and Dam Fund are harder to analyze but would most likely be negatively impacted by the action alternatives under higher hydrologic scenarios.

No Action Alternative

Under the No Action Alternative, the Basin Fund and Development Fund would see significant impacts due to reduced total hydropower value from power generation and capacity, particularly in low hydrology scenarios. The Basin Fund provides funding for the Upper Colorado River Endangered Fish Recovery Program, the Colorado River Basin Salinity Control Program, and the Glen Canyon Adaptive Management Program. All three programs 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 impacted under the No Action Alternative compared with the Basin and Development Funds. However, there would be slight impacts on total hydropower value 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.

Action Alternative 1

Under Action Alternative 1, the Basin Fund would see minor impacts due to the decrease in reservoir elevations but continuation of generation, capacity, and total hydropower value at Glen Canyon Powerplant. Funding for the Upper Colorado River Endangered Fish Recovery Program, the Colorado River Basin Salinity Control Program, and the Glen Canyon Adaptive Management Program would experience only slight impacts. These impacts would be substantially less 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; if Lake Mead dropped below the minimum power pool, impacts could be severe. This would result in a decrease in total hydropower value 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 Action Alternative 1, the Dam Fund and Parker-Davis Account would be less impacted compared with the Basin and Development Funds. However, there would be slight impacts on total hydropower value 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 slight reductions in funding and repayment from the Dam Fund and Parker-Davis Account.

Action Alternative 2

Under Action Alternative 2, impacts on the various power funds would be very similar to those described under Action Alternative 1 and would, therefore, have similar impacts on any governmental programs listed above. With the potential DROA contributions, there would be slightly greater total hydropower value and slightly less impacts on the power funds. This would result in slightly more funds being available for governmental programs. These impacts would be minor compared with Action Alternative 1.

Cumulative Effects

The potential operational changes included in the Glen Canyon Dam/Smallmouth Bass flow options would result in a substantial decrease in funds available in the Basin Fund and, therefore, a substantial decrease in available funds for the governmental programs aided by the Basin Fund. The additional total hydropower value from the action alternatives could help offset this decrease in funds. There would be no additional impacts on the Lower Basin funds and the governmental programs that receive funding from them.

Issue 5: 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 impacted.

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. The Glen Canyon Powerplant typically holds approximately 40 MW in regulation.

Hoover Dam ancillary services would be proportionately impacted 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 all four analyzed dams would be impacted under the No Action Alternative as reservoir elevations approached minimum power pool. In low hydrologic scenarios, under the No Action Alternative, reservoir elevations at Lake Powell and Lake Mead would 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 significantly more impacted under the No Action Alternative compared with either of the action alternatives. Ancillary services at the Hoover Powerplant would be negatively impacted under the action alternatives compared with the No Action Alternative. 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 would result in reservoir elevations dropping below the minimum power pool at Lake Powell and Lake Mead. 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.

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 can drop to the point where ancillary services may be impacted.

Under the wet hydrologic scenarios, ancillary services at all four analyzed powerplants would be able to continue.

Action Alternative 1

Overall, the Glen Canyon Powerplant ancillary services would be much less impacted under Action Alternative 1 compared with the No Action Alternative. Under Action Alternative 1, lake reservoir elevations at Lake Powell would be protected, resulting in continued power generation and capacity. Ancillary services at the Glen Canyon Powerplant would continue unimpacted 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 impacted. 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.

Under the driest hydrologic conditions, Lake Mead reservoir elevations would drop below minimum power pool. This would result in a halt of ancillary services at the Hoover Powerplant. As flows decrease toward the minimum power pool, regulation and reserves at Hoover Dam would be negatively impacted. If reservoir elevations were to drop below power pool, ancillary services would cease entirely. If this were to occur, it may or may not be feasible for WAPA to find other facilities to make up for the decrease in regulation and reserve.

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 can drop to the point where ancillary services may be impacted.

Under the wet hydrologic scenarios, ancillary services at all four analyzed powerplants would be able to continue.

Action Alternative 2

Under Action Alternative 2, impacts on ancillary services would be very similar to those described under Action Alternative 1. However, if potential DROA contributions are planned during any year, the additional water would result in higher reservoir elevations, higher releases, and less impacts on ancillary services.

Cumulative Effects

The potential operational changes included in the Glen Canyon Dam/Smallmouth Bass flow options could have substantial negative impacts on ancillary services if reservoir elevations drop toward minimum power pool and releases drop below LTEMP minimums flows. Additional water would be released through the river outlet works, resulting in less generation and potentially negative impacts on regulation and reserve. The EA would not impact operations at the Lower Basin powerplants. Therefore, the EA would not result in any additional impacts on ancillary services at Hoover, Parker, or Davis Dams.

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 impacted 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 Colorado River Basin states.

The Arizona study area consists of Coconino, 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. Although Ventura County is also in MWD's 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 impacted 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), Arizona study area counties follow this trend, with the biggest increase in Pinal County (27.7 percent). **Table 3-87**, below, provides an overview.

Employment

Table 3-88, below, provides an overview for employment by sector for the counties in the study area within Arizona. Comparisons are made where applicable 2004 data are 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 seven 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).

Table 3-87
Arizona Population 2010–2021

	Coconino County	La Paz County	Maricopa County	Mohave County	Pima County	Pinal County	Yuma County	Arizona
Population 2010	131,824	20,549	3,751,410	199,177	964,462	329,297	190,526	6,246,816
Population 2021	144,942	16,845	4,367,186	211,274	1,035,063	420,625	202,944	7,079,203
Percent Change 2010–2021	10.0	-18.0	16.4	6.1	7.3	27.7	6.5	13.3

Source: Headwaters Economics Economic Profile System 2023

Table 3-88
Arizona Employment by Industry (2021)

	Coconino County	La Paz County	Maricopa County	Mohave County	Pima County	Pinal County	Yuma County	Arizona
Total employment	84,555	7,801	2,860,955	78,406	537,770	109,679	91,280	4,055,932
Wage and salary employment	64,693	6,259	2,202,144	56,716	404,217	68,886	73,885	3,076,770
Proprietors' employment	19,862	1,551	658,811	21,690	130,553	40,793	17,395	979,162
Farm employment (number and percentage of total employment)	2,117 2.5%	458 5.9%	6,453 0.2%	520 0.7%	1,161 0.2%	2,287 2.1%	3,353 19.1%	29,309 0.7%
Non-farm employment (number and percentage of total employment)	82,438 97.5%	7,352 94.1%	2,854,520 99.8%	77,886 99.3%	533,609 99.8%	107,392 97.9%	87,927 80.9%	4,026,623 99.3%

3. Affected Environment and Environmental Consequences (Socioeconomics)

	Coconino 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 0.3%	D D	2,553 0.1%	D D	490 0.1%	572 0.5%	7,157 7.8%	13,832 0.3%
Mining, quarrying, and oil and gas extraction	142 0.2%	59 0.8%	6,453 0.2%	445 0.6%	3,300 0.6%	1,256 1.1%	88 0.1%	17,894 0.4%
Utilities	196 0.2%	21 0.8%	8,309 0.3%	405 0.5%	2,095 0.4%	332 0.3%	165 0.2%	12,720 0.3%
Construction	4,034 4.8%	184 2.4%	184,242 6.4%	6,557 8.4%	28,062 5.2%	6,283 5.7%	4,920 5.4%	253,184 6.2%
Manufacturing	3,661 4.3%	257 3.3%	141,468 4.9%	3,401 4.3%	29,734 5.6%	5,446 5.0%	3,044 2.1%	195,722 4.8%
Wholesale trade	1,204 1.4%	130 1.7%	92,909 3.2%	1,691 2.2%	8,857 1.7%	1,944 1.8%	1,925 2.1%	115,142 2.8%
Retail trade	8,669 10.3%	1,673 21.4%	282,511 9.9%	12,180 15.5%	52,464 9.8%	14,072 12.8%	9,909 10.9%	413,565 10.2%
Transportation and warehousing	2,384 2.8%	193 2.5%	169,998 5.9%	2,960 3.8%	28,933 5.4%	6,359 5.8%	3,220 3.5%	224,294 5.5%
Information	645 0.8%	87 1.1%	48,230 1.7%	656 0.8%	6,653 1.2%	872 0.8%	482 0.5%	59,769 1.5%
Finance and insurance	1,962 2.3%	D D	243,962 8.5%	2,808 3.6%	24,871 4.7%	4,315 3.9%	3,692 4.0%	290,236 7.2%
Real estate rental and leasing	4,147 4.9%	D D	172,770 7.3%	4,821 6.1%	28,896 5.4%	5,946 5.4%	3,143 3.4%	234,832 5.8%
Professional, scientific, and technical services	3,735 4.4%	D D	39,192 1.4%	2,909 3.7%	33,399 6.2%	5,017 4.6%	3,709 4.1%	269,961 6.7%
Management of companies and enterprises	468 0.6%	D D	244,023 8.5%	222 0.3%	2,726 0.5%	434 0.4%	353 0.4%	44,165 1.1%
Administrative, support, and waste management	2,626 3.1%	150 1.9%	65,739 2.3%	4,211 5.4%	37,001 6.9%	7,968 7.3%	6,191 6.8%	313,831 7.7%

3. Affected Environment and Environmental Consequences (Socioeconomics)

	Coconino County	La Paz County	Maricopa County	Mohave County	Pima County	Pinal County	Yuma County	Arizona
Educational services	1,075	D	325,464	805	9,300	2,205	697	85,070
	1.3%	D	11.4%	1.0%	1.7%	2.0%	0.8%	2.1%
Health care and social assistance	9,627	D	56,772	9,491	70,081	7,241	9,221	459,980
	11.4%	D	2.0%	12.1%	13.1%	6.6%	10.1%	11.3%
Arts, entertainment, and recreation	3,083	D	56,772	D	11,588	2,676	683	81,541
	3.6%	D	2.0%	D	2.2%	2.4%	0.7%	2.0%
Accommodation and food services	13,716	D	193,676	9,572	38,277	7,385	7,055	293,749
	16.2%	D	6.8%	12.2%	7.2%	6.7%	7.7%	7.2%
Other services	3,695	D	135,811	5,109	29,315	6,872	4,148	200,894
	4.4%	D	4.7%	6.5%	5.5%	6.3%	4.5%	5.0%
Government and government enterprises	17,103	2,022	234,204	8,352	87,567	20,197	18,125	446,242
	20.2%	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.

Personal Income

Total personal income in Arizona totaled just over \$403.4 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 3-89**; Bureau of Economic Analysis 2023b).

Among the seven 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 seven counties represents around 92 percent of the state total (Bureau of Economic Analysis 2023b).

Table 3-89
Arizona Personal Income and Earnings (2021)

	Coconino County	La Paz County	Maricopa County	Mohave County	Pima County	Pinal County	Yuma County	Arizona
Personal income (\$1,000s)	\$8,255,426	\$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	\$49,933	\$59,759	\$41,331	\$52,942	\$43,793	\$44,299	\$55,487
Earnings by place of work	\$4,633,046	\$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	\$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	\$72,577	\$27,989,246	\$591,791	\$5,328,512	\$870,907	\$1,013,969	\$39,417,203
Proprietors' income	\$668,177	\$10,974	\$18,014,773	\$588,891	\$3,750,419	\$799,123	\$726,236	\$26,326,533

Source: 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 2017²¹ (Duval et al. 2020), 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 and 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).

²¹ 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.

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 \$1,200 million in Yuma County (Duval et al. 2020). **Table 3-90** 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 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 percentage 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).

Table 3-90
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 Area²	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 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 3-91** provides a summary of county-wide irrigated agricultural lands within the Arizona study area.

Table 3-91
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 Arizona²	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 3-92 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 percent change in irrigated cropland and 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.

Table 3-92
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 Arizona²	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 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.

The proportion of irrigation water that comes from all surface water resources in each county is shown in **Table 3-93**. 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 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, the total water usage of Mohave County, 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 3-93
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	-10
Pima County	33	39	9
Pinal County	76	62	-28
Total within CAP Counties	51	39	-23

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)
La Paz County	92	87	-13
Mohave County	75	56	-14
Yuma County	85	90	2
Total within Arizona Study Area²	70	61	-11
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.) is 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

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 and public water use as well as the greatest percentage decreases in projected water yield (Warziniack and Brown 2019).

As described in the 2007 FEIS, municipalities potentially affected by the proposed alternatives include the cities of Phoenix, Tucson, Scottsdale, and other Arizona towns and cities served by the CAP, as well as Arizona municipalities along the Colorado River, such as Lake Havasu City, that have post-1968 Colorado River water delivery contracts. Industrial land uses in Arizona 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 3-94**).

Table 3-94
California Population 2010–2021

	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 2004, 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 than the California state average (1.0 percent) in Imperial County (5.2 percent) and lower in all other counties (see **Table 3-95**).

Table 3-95
California Employment by Industry (2021)

	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 5.2%	4,110 0.1%	1,363 0.1%	7,293 0.6%	2,467 0.2%	10,820 0.5%	229,419 1.0%
Non-farm employment (number and percentage of total employment)	77,886 94.8%	6,424,049 99.9%	2,251,707 99.9%	1,119,868 99.4%	1,119,550 99.8%	2,120,297 99.5%	23,676,934 99.0%
Forestry, fishing, and related	6,934 8.4%	2,747 <0.0%	1,327 0.1%	6,950 0.6%	1,153 0.1%	3,030 0.1%	250,669 1.0%
Mining, quarrying, and oil and gas extraction	395 0.5%	5,738 0.1%	2,436 0.1%	1,689 0.1%	1,351 0.1%	1,810 0.1%	33,528 0.1%
Utilities	525 0.6%	13,326 0.2%	3,403 0.2%	1,903 0.2%	3,898 0.3%	5,465 0.3%	65,390 0.3%
Construction	2,501 3.0%	252,952 3.9%	132,853 5.9%	98,788 8.8%	60,656 5.4%	113,440 5.3%	1,253,884 20.8%
Manufacturing	2,532 3.1%	341,233 5.3%	158,005 7.0%	49,600 4.4%	56,632 5.0%	123,412 5.8%	1,375,410 5.8%

3. Affected Environment and Environmental Consequences (Socioeconomics)

	Imperial County	Los Angeles County	Orange County	Riverside County	San Bernardino County	San Diego County	California
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	2,093,532
	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 2024, 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 3-96**).

In 2004, total personal income ranged from a low of approximately \$8.5 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 3-96
California Personal Income and Earnings (2021)

	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 3-97** shows acres of irrigated and total cropland within the California study area.

Table 3-97
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
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 in the last 10 years. Clark County's population change (17.7 percent) was higher than that of the state overall (see **Table 3-98**).

Table 3-98
Nevada Population 2010–2021

	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 represents almost 70 percent of total employment in Nevada. Full- and part-time employment in the Clark County government sector was lower than the Nevada average (United States Department of Commerce, Bureau of Economic Analysis 2006e). 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 3-99**.

Table 3-99
Nevada Employment by Industry (2021)

	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 <0.0%	5,028 0.3%
Non-farm employment (number and percentage of total employment)	1,368,083 >99.9%	1,870,681 99.7%

3. Affected Environment and Environmental Consequences (Socioeconomics)

	Clark County	Nevada
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%
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

(D) = Not shown to avoid disclosure of confidential information; estimates are included in higher-level totals.

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 3-100**.

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 3-100**.

Table 3-100
Nevada Personal Income and Earnings (2021)

	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; 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 3-101** shows acres of irrigated and total cropland within the Nevada study area.

Table 3-101
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

The counties in the Utah study area are not anticipated to be impacted 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 impacted 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.

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 3-102, below, displays the total economic contributions from recreation occurring in the GCNRA, LMNRA, and GCNP. Economic contributions result when visitors spend dollars on recreation. Those contributions include increased sales, income, and jobs. Direct economic contributions 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.

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.

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**.

Table 3-102
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 2022c

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 the incomes of proprietors 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).

As shown in **Table 3-131**, below, recreational visits to 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), and GCNP recreation supported 9,390 jobs (including 2,243 indirect and induced jobs) (NPS 2022c). Specific job data are unavailable for LMNRA. However, LMNRA recreation supported 4,054 total jobs in 2021.

Table 3-103
Jobs by Sector Supported by Economic Contributions from NPS-Based Recreation (2021)

	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 2022c

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 2022d). This spending represent an important contribution to local communities in Coconino County in Arizona

and Garfield, San Juan, Wayne, and Kane County 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.²²

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). These 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 2006).

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 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.

The current analysis applied the 2007 agricultural modeling framework, using crops' profitability in each county to determine which crops farmers are most likely to fallow. 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 of the Lower Division States 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

²² Personal communication provided from Laurie Dyer, the NPS Supervisory Concessions Management Specialist in the Commercial Services Division at GCNP, on March 15, 2023.

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 planning 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. To account for the higher shortage volumes under the action alternatives, additional crops, including vegetables and other field crops such as forage and grain crops produced for silage and green chop, were included in the analysis. 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 variable costs per acre of land required to grow a given crop. In the Arizona and Nevada planning areas, calculations were updated with the most recent available data from the US Department of Agriculture²³ (USDA 2019a); county-level revenue for each crop was based on 5-year (2014 to 2018) averages of yield²⁴ and prices. The US Department of Agriculture does not provide recent county-level data for California; yield, acreage, and price data for the California analysis 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, 2018; 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 (University of Arizona 2001) for 1999; 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

²³ 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.

²⁴ 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.

each crop), the estimated return plus irrigation cost was divided by the amount of water per acre²⁵ 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 planning area. In Arizona and Nevada, cotton is most likely to be fallowed first. In California, wheat and alfalfa would be fallowed before cotton; vegetables are expected to be fallowed last in the entire planning 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 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.

Impact Analysis Area

Potential changes in agricultural production within the analysis 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 acres of land and per acre-foot of water.
- Changes in the amount of irrigated water would be the result of changes in water allocations from the Colorado River sources (such as from CAP); they do not involve changes to irrigation water from groundwater.
- Estimated shortages in the agricultural sector are based on the Shortage Allocation Model (**Appendix D**). This model accounts for shortages currently allocated to non-consumptive use (such as for conservation programs) under both action alternatives. Therefore, total water shortage estimates represent higher levels of shortage than would be seen in actual consumptive uses of water (that is, agriculture, municipal, and industrial).
- For Action Alternative 1 and the No Action Alternative, available water is distributed in proportion to entitlements unless specifically provided otherwise. A shortage results when water available to an entity is less than its expected use.²⁶
- For Action Alternative 2, 2021 adjusted consumptive use is the baseline by which shortages are calculated (with the exception of parties within CAP; see below).

²⁵ Water (per acre) required by a particular crop is assumed to be relatively constant over time.

²⁶ Different states and/or priorities have different assumptions; see **Appendix D**.

- 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 do not hold long-term contracts for project water, but they are shown as absorbing significant shortage based on their access to and historical use of the CAP excess water pool.
- In most cases, the contractor or recipient of an allocation is shown as the entity bearing shortage, by sector. In some cases, water allocated for one sector of use (for example, Indian agriculture) may be leased for other uses (that is, municipal use). No attempt is made in this analysis to track actual end use of the water allocation due to uncertainties of this end use.

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 EIS (Gaston et al. 2015). Models were informed from past survey research and used to project the change in net economic value for angling in Glen Canyon and whitewater rafting in Grand Canyon; these were compared with Action Alternative 1 and the 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 action alternatives and No Action Alternative.

Impact Analysis Area

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 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, the ability of each state to manage shortages to the M&I sector were analyzed. The M&I shortages allocated to each state were compared with the drought plans or actions that state or local agencies could institute during a shortage. The analysis then qualitatively discussed whether such drought planning mechanisms are adequate to address shortages to the M&I sector.

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.

Impact Indicators

The potential for economic impacts as a result of anticipated shortages

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 all alternatives. Under the action alternatives, the shortage scenarios would result in a greater level of short-term impacts on agricultural production, associated jobs, income, and tax revenue, compared with the No Action Alternative. However, in the long term, preservation of reservoir levels above a critical value (dead pool) due to the proposed shortage scenarios are anticipated to lessen the need for more severe restrictions and long-term (potentially permanent) economic impacts.

The No Action Alternative has the potential to result in \$100 million to \$116 million in agricultural revenue loss, \$60 million to \$100 million in income loss from jobs lost, and \$9 to \$21 million in tax revenue loss. Impacts would be limited to Arizona under the No Action Alternative.

Action Alternative 1 would result in \$82 million to \$207 million in agricultural revenue loss, \$87 million to \$115 million in income loss, and \$14 to \$31 million in tax revenue loss in 2024; during this period, impacts would be limited to Arizona. The maximum shortage scenario (4,000 maf) in 2025 and 2026 would result in a \$743 million loss of revenue, \$452 million loss of income, and \$192 million loss of tax revenue in Arizona. In 2025 and 2026, in addition to Arizona, Riverside and Imperial Counties in California would also experience economic impacts including \$185 million in lost income and \$66 million in lost tax revenue.

Under Action Alternative 2, agricultural revenue would decrease \$125 million to \$457 million in 2024. Under the maximum shortage scenario (4,000 maf) in 2025 and 2026, the agricultural revenue loss would increase to \$918 million. Under this alternative, the planning areas in Arizona, California, and Nevada would experience impacts during 2024 through 2026. Total impacts on income from jobs lost in Arizona would range between \$81 million and \$164 million in Arizona and \$9 and \$64 million in California; the tax revenue loss would range between \$14 million and \$25 million in Arizona and \$3 and \$23 million in California in 2024. Under the maximum shortage scenario in 2025 and 2026, the income loss would increase to \$290 million in Arizona and \$165 in California, and tax revenue loss would increase to \$60 million in Arizona and \$50 million in California. In this analysis, impacts on jobs, income, and tax revenue from agricultural impacts were not evaluated for Nevada.

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 50,000 to 94,000 acres of fallowed cropland, and \$100 to \$116 million in loss of agricultural production. The impacts would be restricted to the Arizona planning 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 3-104** shows the total estimated acres of fallowed cropland and the reduction in dollar value of agricultural production, for different shortage volumes under the No Action Alternative.

Table 3-104
Acres of Fallowed Cropland and the Loss of Market Value of Agricultural Production in Arizona – No Action Alternative

Shortage Amount (1,000 af)	Non-Indian Agriculture		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
200	49,797	\$100,292,274	0	\$0	49,797	\$100,292,274
533	73,023	\$101,169,138	0	\$0	73,023	\$101,169,138
617	82,079	\$100,292,274	2,456	\$3,052,073	84,535	\$103,344,347
867	82,734	\$101,169,138	5,387	\$6,693,991	88,121	\$107,863,129
917	82,734	\$101,169,138	5,387	\$6,693,991	88,121	\$107,863,129
967	82,734	\$101,169,138	5,387	\$6,693,991	88,121	\$107,863,129
1,017	82,734	\$101,169,138	5,387	\$6,693,991	88,121	\$107,863,129
1,100	83,480	\$102,932,699	10,821	\$12,967,706	93,783	\$115,900,405

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 entitled water 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.

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 acre-feet, \$3 to \$13 million in agricultural production loss would be due to fallowed Indian agricultural lands, which account for 3 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 planning areas in Arizona, California, and Nevada would experience long-term (potentially permanent) production loss from fallowed crops.

Table 3-105 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 3-106** provides an overview of the change to tax revenue from agricultural production losses over the same period. Shortages under the No Action Alternative, and related economic impacts, are limited to Arizona agriculture.

Table 3-105
Estimated Jobs and Income under the No Action Alternative

Shortage Amount (1,000 af)	Non-Indian Agriculture		Indian Agriculture		Total	
	Total Jobs	Total Income	Total Jobs	Total Income	Total Jobs	Total Income
200	657	\$60,442,632	0	0	657	\$60,442,632
533	1,082	\$86,379,768	0	0	1,082	\$86,379,768
617	1,506	\$97,314,296	31	\$2,780,000	1,537	\$89,379,768
867	1,539	\$98,108,605	68	\$6,097,798	1,607	\$100,094,296
917	1,539	\$98,108,605	68	\$6,097,798	1,607	\$104,206,403
967	1,539	\$98,108,605	68	\$6,097,798	1,607	\$104,206,403
1,017	1,539	\$98,108,605	68	\$6,097,798	1,607	\$104,206,403
1,100	1,526	\$99,877,874	88	\$8,368,185	1,613	\$108,274,059

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 3-106
Estimated Tax Revenue Change under the No Action Alternative

Shortage Amount (1,000 af)	Non-Indian Agriculture	Indian Agriculture
200	\$10,625,983	0
533	\$14,457,659	0
617	\$16,330,902	\$2,087,855
867	\$16,468,180	\$4,579,323
917	\$16,468,180	\$4,579,323
967	\$16,468,180	\$4,579,323
1,017	\$16,468,180	\$4,579,323
1,100	\$16,970,661	\$6,404,036

Source: Agricultural model output and IMPLAN 2021 software and data

Note: Total includes local, state, and federal tax revenue. Tax amounts are impacted by agricultural subsidies. The agriculture Sectors in IMPLAN see 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 received more subsidies from the government than it paid 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.

Action Alternative 1

During 2024, under Action Alternative 1, 72,423 to 158,050 acres of cropland in Arizona would temporarily be fallowed; this would result in a loss of \$82 to \$207 million in agricultural production. Similar to the No Action Alternative, this would be limited to loss primarily from fallowed field crops. Indian agriculture would experience impacts at allocated shortages above 1.066 maf and would account for approximately 27 to 33 percent of total impacts in agricultural production. **Table 3-107** shows the total estimated acres of fallowed cropland and the reduction in market value of agricultural production in Arizona for different shortage amount in 2024, under Action Alternative 1. There would be no impacts in the California and Nevada study areas in 2024.

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. Under Action Alternative 1, temporary agricultural impacts due to shortage allocations up to 2.083 maf would be the same during the 2024 to 2026 operating years. An increase in the allocated shortages above 2.083 maf, proposed for the 2025 and 2026 operating years, would result in additional short-term impacts on agriculture in Arizona, such as an increase in acres of fallowed field crops and acres of fallowed vegetables and other irrigated crops. Impacts would also affect a wider range of users and would extend to non-Indian croplands in Imperial and Riverside Counties in California. Economic impacts from production loss in Arizona would range from \$82 million to \$207 million in 2024 and will reach \$257 million for the highest shortage volume. Economic impacts in California during 2025 and 2026 would range from \$0 to \$486 million.

Table 3-107
Acres of Fallowed Cropland and the Loss of Market Value of Agricultural Production
in Arizona in 2024 – Action Alternative 1

Shortage Amount (1,000 af)	Non-Indian Agriculture		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
400	72,423	\$82,222,615	0	\$0	72,423	\$82,222,615
1,066	86,993	\$103,050,566	23,467	\$37,286,299	110,460	\$140,336,865
1,234	88,882	\$105,978,210	30,162	\$53,049,322	119,044	\$159,027,532
1,734	106,671	\$127,062,640	32,635	\$59,962,276	139,306	\$187,024,916
2,083	125,415	\$146,618,873	32,635	\$59,962,276	158,050	\$206,581,149

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 entitled water 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.

No agricultural impacts would occur to in the Nevada planning area during the 2025 and 2026 operating years.

Table 3-108 and Table 3-109 show the potential impacts on agriculture in terms of acres of fallowed field crops and loss of agricultural production during the 2025 and 2026 operating years, in Arizona and California, respectively, under Action Alternative 1.

Table 3-108
Acres of Fallowed Cropland and the Loss of Market Value of Agricultural Production
in Arizona in 2025–2026 – Action Alternative 1

Shortage Amount (1,000 af)	Non-Indian Agriculture		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
400	72,423	\$82,222,615	0	\$0	72,423	\$82,222,615
1,066	86,993	\$103,050,566	23,467	\$37,286,299	110,460	\$140,336,865
1,234	88,882	\$105,978,210	30,162	\$53,049,322	119,044	\$159,027,532
1,734	106,671	\$127,062,640	32,635	\$59,962,276	139,306	\$187,024,916
2,083	125,415	\$146,618,873	32,635	\$59,962,276	158,050	\$206,581,149
2,250	133,772	\$155,351,557	32,635	\$59,962,276	166,407	\$215,313,833
2,500	145,883	\$168,220,990	32,635	\$59,962,276	178,518	\$228,183,266
3,000	158,786	\$192,018,523	32,635	\$59,962,276	191,421	\$251,980,799

Shortage Amount (1,000 af)	Non-Indian Agriculture		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
3,333	159,926	\$193,766,405	32,635	\$59,962,276	192,561	\$253,728,681
3,667	160,935	\$195,262,454	32,635	\$59,962,276	193,570	\$255,224,730
4,000	161,925	\$196,731,353	32,635	\$59,962,276	194,560	\$256,693,629

Source: Values were calculated using input from the Shortage Allocation Model and crop profitability estimates, 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 entitled water 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 3-109
Acres of Fallowed Cropland and the Loss of Market Value of Agricultural Production in California in 2025–2026 – Action Alternative 1

Shortage Amount (1,000 af)	Non-Indian Agriculture		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
400	0	\$0	0	\$0	0	\$0
1,066	0	\$0	0	\$0	0	\$0
1,234	0	\$0	0	\$0	0	\$0
1,734	0	\$0	0	\$0	0	\$0
2,083	0	\$0	0	\$0	0	\$0
2,250	0	\$0	0	\$0	0	\$0
2,500	16,911	\$19,340,588	0	\$0	16,911	\$19,340,588
3,000	51,879	\$73,913,147	0	\$0	51,879	\$73,913,147
3,333	74,832	\$113,389,673	0	\$0	74,832	\$113,389,673
3,667	109,642	\$166,323,981	0	\$0	109,642	\$166,323,981
4,000	175,586	\$486,285,463	0	\$0	175,586	\$486,285,463

Source: Values were calculated using input from the Shortage Allocation Model and crop profitability estimates, 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 entitled water 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.

In the long term, operating guidelines consistent with Action Alternative 1 would be expected to reduce the potential for water levels to decline below a critical level in Lake Mead. This would reduce the potential long-term impacts on agriculture in fallowed crops and production loss, compared with the No Action Alternative.

Table 3-110 provides an overview of the jobs, income, and total economic output associated with the estimated changes in agricultural production value in 2024 under Action Alternative 1 for Arizona. **Table 3-111** provides an analysis for the changes in associated tax revenue for the same period. No shortages would occur in California or Nevada under this time period; therefore, no changes to contributions are modeled. Compared with the No Action Alternative, estimated jobs losses would increase from 1,613 to 3,122 at the highest shortage levels modeled, with the majority of the additional losses related to the additional fallowed crops in Indian Agriculture. Labor income and tax revenue changes would follow similar trends.

Table 3-110
Estimated Jobs and Income under Action Alternative 1 (2024) - Arizona

Shortage Amount (1,000 af)	Non-Indian Agriculture		Indian Agriculture		Total	
	Total Jobs	Total Income	Total Jobs	Total Income	Total Jobs	Total Income
400	1,060	\$87,053,271	0	0	1,060	\$87,053,271
1,066	1,411	\$102,849,513	680	\$25,188,393	2,091	\$132,100,677
1,234	1,709	\$111,317,293	1,104	\$46,509,628	2,594	\$144,699,734
1,734	1,863	\$115,102,728	1,249	\$47,932,919	2,957	\$156,474,153
2,083	1,933	\$116,802,486	1,249	\$47,932,919	3,112	\$160,259,588

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 3-111
Estimated Tax Revenue Change under Action Alternative 1 (2024)

Shortage Amount (1,000 af)	Non-Indian Agriculture	Indian Agriculture
400	\$14,628,722	\$0
1,066	\$17,924,854	\$5,337,194
1,234	\$18,452,931	\$7,182,153
1,734	\$222,541,934	\$8,394,585
2,083	\$22,702,247	\$8,394,585

Source: Agricultural model output and IMPLAN 2021 software and data

Note: Total includes local, state, and federal tax revenue. Tax amounts are

impacted by agricultural subsidies. The agriculture Sectors in IMPLAN see 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 received more subsidies from the government than it paid 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.

Table 3-112 and **Table 3-113** provide an overview of the jobs, income, and total economic output associated with the estimated changes in the agricultural production value in 2025–2026 estimated shortage levels under Action Alternative 1 for Arizona and California respectively. **Table 3-114** provides an analysis for the changes in associated tax revenue for the same period. Although changes to agricultural revenue are projected for Nevada in Action Alternative 1 for 2025–2026, changes to economic contributions are not modeled here or under any alternative. This is because shortages would impact only one Tribal entity and are therefore not anticipated to result in substantial regional economic impacts. Because the No Action Alternative modeled shortages did not exceed 1.100 maf/year, and shortages examined for 2025/2026 under Action Alternative 1 include levels up to 4.000 maf/year, acres of fallowed crops and related losses in jobs, income, and tax revenue are substantially higher under Action Alternative 1 as compared to the No Action Alternative. At the highest shortage level, as many as 7,078 jobs and as much as \$452 million in labor income in Arizona may be reduced due to reduced agricultural production. In addition, at the higher shortage levels under Action Alternative 1 in 2025–2026, shortages are also anticipated to occur in California. A total of up to 2,924 jobs and \$185 million in labor income could be impacted in this state under the 4.000-maf shortage level. Tax revenue reduction would follow similar trends.

Table 3-112
Estimated Jobs and Income under Action Alternative 1 (2025–2026) - Arizona

Shortage Amount (1,000 af)	Non-Indian Agriculture		Indian Agriculture		Total	
	Total Jobs	Total Income	Total Jobs	Total Income	Total Jobs	Total Income
400	1,060	\$87,053,271	0	\$0	1,060	\$87,053,271
1,066	1,411	\$102,849,513	680	\$29,251,164	2,091	\$132,100,677
1,234	1,490	\$104,977,434	1,104	\$39,722,300	2,594	\$144,699,734
1,734	1,709	\$111,317,293	1,249	\$45,156,860	2,957	\$156,474,153
2,083	1,863	\$115,102,728	1,249	\$45,156,860	3,112	\$160,259,588
2,250	1,933	\$116,802,486	1,249	\$45,156,860	3,182	\$161,959,346
2,500	2,032	\$119,199,304	1,249	\$45,156,860	3,280	\$164,356,164
3,000	2,180	\$122,819,752	1,249	\$45,156,860	3,429	\$167,976,612
3,333	3,929	\$260,639,745	1,249	\$45,156,860	5,178	\$305,796,606
3,667	4,863	\$333,964,166	1,249	\$45,156,860	6,111	\$379,121,026
4,000	5,829	\$407,048,234	1,249	\$45,156,860	7,078	\$452,205,094

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 3-113
Estimated Jobs and Income under Action Alternative 1 (2025–2026) - California

Shortage Amount (1,000 af)	Non-Indian Agriculture		Indian Agriculture		Total	
	Total Jobs	Total Income	Total Jobs	Total Income	Total Jobs	Total Income
400	0	0	0	0	0	0
1,066	0	0	0	0	0	0
1,234	0	0	0	0	0	0
1,734	0	0	0	0	0	0
2,083	0	0	0	0	0	0
2,250	0	0	0	0	0	0
2,500	89	\$7,825,785	0	0	89	\$7,825,785
3,000	493	\$34,244,689	0	0	493	\$34,244,689
3,333	780	\$53,682,957	0	0	780	\$53,682,957
3,667	1,072	\$70,821,791	0	0	1,072	\$70,821,791
4,000	2,924	\$185,271,092	0	0	2,924	\$185,271,092

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 3-114
Estimated Tax Revenue Change under Action Alternative 1 (2025–2026)

Shortage Amount (1,000 af)	Non-Indian Agriculture		Indian Agriculture ¹
	TotalAZ	TotalCA	TotalAZ
400	\$14,628,722	0	0
1,066	\$17,924,853	0	\$5,337,194
1,234	\$18,452,931	0	\$7,182,153
1,734	\$22,541,934	0	\$8,394,585
2,083	\$22,702,247	0	\$8,394,585
2,250	\$22,769,737	0	\$8,394,585
2,500	\$22,948,577	\$3,711,572	\$8,394,585
3,000	\$27,136,249	\$11,265,481	\$8,394,585
3,333	\$45,844,786	\$17,850,058	\$8,394,585
3,667	\$64,891,936	\$22,975,677	\$8,394,585
4,000	\$83,878,460	\$66,229,271	\$8,394,585

Source: Agricultural model output and IMPLAN 2021 software and data

¹ No Indian Agriculture contribution changes in California under Action Alternative 1

Note: Total includes local, state, and federal tax revenue. Tax amounts are impacted by agricultural subsidies. The agriculture Sectors in IMPLAN see 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 received more subsidies from the government than it paid 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.

Action Alternative 2

The total volume of allocated shortages is the same under both action alternatives; however, under Action Alternative 2, shortages are distributed among users and across the study area, rather than according to the priority system as under Action Alternative 1. The total area of fallowed lands would likely be similar under both action alternatives; however, the distribution of impacts across the study area would include a wider range of users for all shortage volumes.

Indian and Non-Indian agriculture in Imperial, Riverside, and San Bernardino Counties, California, as well as Indian agriculture in Clark County, Nevada would experience impacts for operating years 2024 to 2026 under Action Alternative 2. In 2024, economic impacts from production loss would range from \$78 million to \$179 million in Arizona, from \$23 million to \$132 million in California, and from \$23,000 to \$146,000 in Nevada. In 2025 and 2026, economic loss would reach \$264 million in Arizona, \$338 million in California, and \$316,000 in Nevada. **Table 3-115**, **Table 3-116**, and **Table 3-117** show the total estimated acres of fallowed cropland and the reduction in market value of agricultural production in Arizona, California, and Nevada, respectively, for different shortage amounts in 2024, under Action Alternative 2.

Table 3-115
Acres of Fallowed Cropland and the Loss of Market Value of Agricultural Production
in Arizona in 2024 – Action Alternative 2

Shortage Amount (1,000 af)	Non-Indian		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
400	66,615	\$75,833,745	1,835	\$2,695,839	68,450	\$78,529,584
1,066	97,254	\$112,326,161	9,907	\$13,441,250	107,161	\$125,767,411
1,234	99,729	\$114,733,093	16,153	\$23,020,765	115,882	\$137,753,858
1,734	108,257	\$123,620,834	29,363	\$45,485,161	137,620	\$169,105,995
2,083 ¹	111,195	\$126,248,174	28,400	\$44,020,448	139,595	\$170,268,622
2,083 ²	116,758	\$131,767,250	30,142	\$47,003,029	146,900	\$178,770,279

Source: Values were calculated using input from the Shortage Allocation Model and crop profitability estimates, according to the methodology described above.

¹Indicates 13.11-percent reduction to each water user's 2021 adjusted consumptive use.

²Indicates 15.55-percent reduction to each water user's 2021 adjusted consumptive use.

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 entitled water 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 3-116
Acres of Fallowed Cropland and the Loss of Market Value of Agricultural Production
in California in 2024 – Action Alternative 2

Shortage Amount (1,000 af)	Non-Indian		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
400	18,946	\$22,548,853	39	\$35,089	18,985	\$22,583,942
1,066	43,604	\$59,692,441	105	\$93,512	43,709	\$59,785,953
1,234	49,499	\$69,251,638	121	\$108,249	49,620	\$69,359,887
1,734	67,044	\$97,701,630	198	\$186,024	67,242	\$97,887,654
2,083 ¹	75,185	\$110,902,426	245	\$229,062	75,430	\$111,131,488
2,083 ²	88,027	\$131,727,792	277	\$256,755	88,304	\$131,984,547

Source: Values were calculated using input from the Shortage Allocation Model and crop profitability estimates, according to the methodology described above.

¹Indicates 13.11-percent reduction to each water user's 2021 adjusted consumptive use.

²Indicates 15.55-percent reduction to each water user's 2021 adjusted consumptive use.

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 entitled water 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 3-117
Acres of Fallowing Cropland and the Loss of Market Value of Agricultural Production
in Nevada in 2024 – Action Alternative 2

Shortage Amount (1,000 af)	Non-Indian		Indian Agriculture		Total Agriculture in the Study Area	
	Fallowing Cropland (Acres)	Change in Production Value	Fallowing Cropland (Acres)	Change in Production Value	Fallowing Cropland (Acres)	Change in Production Value
400	0	\$0	19	\$22,882	19	\$22,882
1,066	0	\$0	51	\$60,980	51	\$60,980
1,234	0	\$0	59	\$70,591	59	\$70,591
1,734	0	\$0	96	\$112,286	96	\$112,286
2,083 ¹	0	\$0	119	\$132,821	119	\$132,821
2,083 ²	0	\$0	133	\$145,949	133	\$145,949

Source: Values were calculated using input from the Shortage Allocation Model and crop profitability estimates, according to the methodology described above.

¹Indicates 13.11-percent reduction to each water user's 2021 adjusted consumptive use.

²Indicates 15.55-percent reduction to each water user's 2021 adjusted consumptive use.

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 entitled water 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 3-118, Table 3-119, and Table 3-120 show potential impacts on agriculture in terms of fallowed field crops and agricultural production loss for the 2025–2026 period, for the Arizona, California, and Nevada planning area, respectively, under Action Alternative 2.

Table 3-118
Acres of Fallowing Cropland and the Loss of Market Value of Agricultural Production
in Arizona in 2025–2026 – Action Alternative 2

Shortage Amount (1,000 af)	Non-Indian Agriculture			Indian Agriculture		Total Agriculture in the Study Area
	Fallowing Cropland (Acres)	Change in Production Value	Fallowing Cropland (Acres)	Change in Production Value	Fallowing Cropland (Acres)	Change in Production Value
400	66,615	\$75,833,745	1,835	\$2,695,839	68,450	\$78,529,584
1,066	97,254	\$112,326,161	9,907	\$13,441,250	107,161	\$125,767,411
1,234	99,729	\$114,733,093	16,153	\$23,020,765	115,882	\$137,753,858

Shortage Amount (1,000 af)	Non-Indian Agriculture			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	
1,734	108,257	\$123,620,834	29,363	\$45,485,161	137,620	\$169,105,995	
2,083 ¹	111,195	\$126,248,174	28,400	\$44,020,448	139,595	\$170,268,622	
2,083 ²	116,758	\$131,767,250	30,142	\$47,003,029	146,900	\$178,770,279	
2,250	121,515	\$137,075,698	30,142	\$47,003,029	151,657	\$184,078,727	
2,500	126,587	\$141,613,184	33,649	\$53,489,195	160,236	\$195,102,379	
3,000	136,280	\$154,887,139	43,694	\$75,492,535	179,974	\$230,379,674	
3,333	140,046	\$162,601,480	46,627	\$82,969,504	186,673	\$245,570,984	
3,667	144,167	\$170,101,915	49,109	\$87,625,317	193,276	\$257,727,232	
4,000	145,368	\$171,964,873	51,585	\$92,270,321	196,953	\$264,235,194	

Source: Values were calculated using input from the Shortage Allocation Model and crop profitability estimates, according to the methodology described above.

¹Indicates 13.11-percent reduction to each water user's 2021 adjusted consumptive use.

²Indicates 15.55-percent reduction to each water user's 2021 adjusted consumptive use.

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 entitled water 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 3-119
Acres of Fallowed Cropland and the Loss of Market Value of Agricultural Production in California in 2025–2026 – Action Alternative 2

Shortage Amount (1,000 af)	Non-Indian Agriculture		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
400	18,946	\$22,548,853	39	\$35,089	18,985	\$22,583,942
1,066	43,604	\$59,692,441	105	\$93,512	43,709	\$59,785,953
1,234	49,499	\$69,251,638	121	\$108,249	49,620	\$69,359,887
1,734	67,044	\$97,701,630	198	\$186,024	67,242	\$97,887,654
2,083 ¹	75,185	\$110,902,426	245	\$229,062	75,430	\$111,131,488
2,083 ²	88,027	\$131,727,792	277	\$256,755	88,304	\$131,984,547
2,250	96,238	\$145,042,417	277	\$256,755	96,515	\$145,299,172
2,500	110,274	\$167,802,411	332	\$304,094	110,606	\$168,106,505

Shortage Amount (1,000 af)	Non-Indian Agriculture		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
3,000	139,539	\$215,256,997	446	\$402,795	139,985	\$215,659,792
3,333	163,250	\$255,060,133	537	\$481,614	163,787	\$255,541,747
3,667	187,422	\$297,160,257	628	\$560,670	188,050	\$297,720,927
4,000	213,571	\$337,812,785	718	\$639,511	214,289	\$338,452,296

Source: Values were calculated using input from the Shortage Allocation Model and crop profitability estimates, according to the methodology described above.

¹Indicates 13.11-percent reduction to each water user's 2021 adjusted consumptive use.

²Indicates 15.55-percent reduction to each water user's 2021 adjusted consumptive use.

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 entitled water 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 3-120
Acres of Fallowed Cropland and the Loss of Market Value of Agricultural Production in Nevada in 2025–2026 – Action Alternative 2

Shortage Amount (1,000 af)	Non-Indian Agriculture		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
400	0	\$0	19	\$22,882	19	\$22,882
1,066	0	\$0	51	\$60,980	51	\$60,980
1,234	0	\$0	59	\$70,591	59	\$70,591
1,734	0	\$0	96	\$112,286	96	\$112,286
2,083 ¹	0	\$0	119	\$132,821	119	\$132,821
2,083 ²	0	\$0	133	\$145,949	133	\$145,949
2,250	0	\$0	133	\$145,949	133	\$145,949
2,500	0	\$0	158	\$168,391	158	\$168,391
3,000	0	\$0	197	\$213,381	197	\$213,381
3,333	0	\$0	216	\$247,686	216	\$247,686
3,667	0	\$0	235	\$282,094	235	\$282,094
4,000	0	\$0	254	\$316,398	254	\$316,398

Source: Values were calculated using input from the Shortage Allocation Model and crop profitability estimates, according to the methodology described above.

¹Indicates 13.11-percent reduction to each water user's 2021 adjusted consumptive use.

²Indicates 15.55-percent reduction to each water user's 2021 adjusted consumptive use.

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 entitled water 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 3-121 provides an overview of the jobs, income, and total economic output associated with the estimated changes in agricultural production value in 2024 under Action Alternative 2 in Arizona. California data are provided in **Table 3-122**. **Table 3-123** provides an analysis for changes in the associated tax revenue for the same period. For the 2.083-maf shortage level, a high and low estimate are provided, based on a range of different water releases possible under this modeling scenario, dependent on the reservoir elevation in Lake Mead. Compared with the No Action Alternative, impacts on water users in Arizona would be increased. An estimated total of 2,163 jobs and \$164 million in labor income would be impacted by reduced agricultural production in Arizona at shortages up to 2.083 maf, compared with a total of 1,613 jobs and \$108 million in losses under the No Action Alternative in Arizona. Action Alternative 2 would also result in increased impacts on jobs and income in California at shortage levels modeled for 2024. Under the No Action Alternative, no impacts would be anticipated to agricultural users in California. Under Action Alternative 2, an estimated 912 jobs and \$662 million in labor income would be impacted under the 2.083-maf shortage level. Similar trends would be seen in tax revenue.

Table 3-124 provides an overview of the jobs, income, and total economic output associated with the estimated changes in agricultural production value in 2025–2026 estimated shortage levels under Action Alternative 2. California data are provided in **Table 3-125**. **Table 3-126** provides an analysis for the changes in associated tax revenue for the same period. As noted, under Action Alternative 1, shortage levels modeled under action alternatives exceed those examined in the No Action Alternative; therefore, the anticipated impacts on agricultural production losses and related economic contributions are higher under the action alternatives. For the 4.000-maf shortage level, an estimated total of 4,410 jobs and \$290 million in labor income would be impacted by reduced agricultural production in Arizona, compared with a total of 1,613 and \$108 million in losses under the No Action Alternative in Arizona. Action Alternative 2 would result in increased impacts on jobs and income in California. Under the No Action Alternative, no impacts would be anticipated to agricultural users in California. Under Action Alternative 2, an estimated 2,439 jobs and \$165 million in labor income would be impacted under the 4.000 maf shortage level. Similar trends would be seen in tax revenue.

Table 3-121
Estimated Jobs and Income under Action Alternative 2 (2024) - Arizona

Shortage Amount (1,000 af)	Non-Indian Agriculture		Indian Agriculture		Total	
	Total Jobs	Total Income	Total Jobs	Total Income	Total Jobs	Total Income
400	871	\$79,524,394	18	\$1,983,822	889	\$81,508,217
1,066	1,392	\$112,751,059	113	\$11,049,422	1,505	123,800,489
1,234	1,415	\$115,045,717	245	\$18,005,232	1,660	133,050,948
1,734	1,549	\$123,457,795	423	\$27,116,487	1,972	150,574,283
2,083 (low)	1,555	\$125,976,723	609	\$34,672,186	2,163	160,648,909
2,083 (high)	1,616	\$131,212,498	546	\$33,268,885	2,163	164,481,382

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 3-122
Estimated Jobs and Income under Action Alternative 2 (2024) - California

Shortage Amount (1,000 af)	Non-Indian Agriculture		Indian Agriculture		Total	
	Total Jobs	Total Income	Total Jobs	Total Income	Total Jobs	Total Income
400	110	\$8,573,019	0	\$12,342	110	\$8,585,362
1,066	370	\$27,324,493	0	\$32,893	370	\$27,357,386
1,234	442	\$32,038,008	0	\$38,076	442	\$32,076,084
1,734	656	\$46,065,776	0	\$61,554	656	\$46,127,330
2,083 (low)	755	\$52,575,464	1	\$76,057	756	\$52,651,521
2,083 (high)	912	\$62,841,129	1	\$89,008	912	\$62,930,137

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 3-123
Estimated Tax Revenue Change under Action Alternative 2 (2024)

Shortage Amount (1,000 af)	Non-Indian Agriculture		Indian Agriculture	
	Total AZ	Total CA	Total AZ	Total CA
400	\$14,441,786	\$3,320,768	\$451,002	\$4,695
1,066	\$18,920,153	\$9,954,879	\$2,094,427	\$12,511
1,234	\$18,849,730	\$11,659,670	\$3,217,611	\$14,483
1,734	\$18,913,577	\$16,733,262	\$5,103,649	\$22,378
2,083 (low)	\$18,702,085	\$19,087,692	\$6,356,835	\$26,950
2,083 (high)	\$18,586,552	\$22,800,519	\$6,193,748	\$31,349

Source: Agricultural model output and IMPLAN 2021 software and data

Note: Total includes local, state, and federal tax revenue. Tax amounts are impacted by agricultural subsidies. The agriculture Sectors in IMPLAN see 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 received more subsidies from the government than it paid 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.

Table 3-124
Estimated Jobs and Income under Action Alternative 2 (2025–2026) - Arizona

Shortage Amount (1,000 af)	Non-Indian Agriculture		Indian Agriculture		Total	
	Total Jobs	Total Income	Total Jobs	Total Income	Total Jobs	Total Income
400	871	\$79,524,394	18	\$1,983,822	889	\$81,508,217
1,066	1,392	\$112,751,059	113	\$11,049,422	1,505	\$123,800,481
1,234	1,415	\$115,045,717	245	\$18,005,232	1,660	\$133,050,948
1,734	1,415	\$115,045,717	423	\$27,116,487	1,838	\$142,162,204
2,083 (low)	1,555	\$125,976,723	609	\$34,672,186	2,164	\$160,648,909
2,083 (high)	1,616	\$131,212,498	546	\$33,268,885	2,163	\$164,481,382
2,250	1,723	\$136,194,407	583	\$35,152,248	2,306	\$171,346,654
2,500	1,555	\$125,976,723	730	\$39,466,014	2,285	\$165,442,737
3,000	1,947	\$152,247,351	1,239	\$53,613,367	3,186	\$205,860,719
3,333	2,037	\$158,432,980	1,314	\$57,881,909	3,351	\$216,314,889
3,667	2,387	\$180,686,106	1,364	\$60,859,943	3,751	\$241,546,049
4,000	2,995	\$226,174,042	1,415	\$63,832,236	4,410	\$290,006,278

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 3-125
Estimated Jobs and Income under Action Alternative 2 (2025–2026) - California

Shortage Amount (1,000 af)	Non-Indian Agriculture		Indian Agriculture		Total	
	Total Jobs	Total Income	Total Jobs	Total Income	Total Jobs	Total Income
400	110	\$8,573,019	0	\$12,342	110	\$8,585,362
1,066	370	\$27,324,493	0	\$32,893	370	\$27,357,386
1,234	442	\$32,038,008	0	\$38,076	442	\$32,076,084
1,734	656	\$46,065,776	0	\$61,554	656	\$46,127,330
2,083 (low)	755	\$52,575,464	1	\$76,057	756	\$52,651,521
2,083 (high)	912	\$62,841,129	1	\$89,008	912	\$62,930,137
2,250	1,012	\$69,409,445	1	\$94,861	1,012	\$69,504,305
2,500	1,183	\$80,632,098	1	\$104,864	1,183	\$80,736,963
3,000	1,539	\$104,031,331	1	\$125,722	1,540	\$104,157,054
3,333	1,827	\$123,667,535	1	\$142,379	1,828	\$123,809,913
3,667	2,120	\$144,447,567	1	\$159,085	2,121	\$144,606,652
4,000	2,438	\$164,501,613	1	\$175,650	2,439	\$164,677,263

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 3-126
Estimated Tax Revenue Change under Action Alternative 2 (2025–2026)

Shortage Amount (1,000 af)	Non-Indian Agriculture		Indian Agriculture	
	Total AZ	Total CA	Total AZ	Total CA
400	\$14,441,786	\$3,320,768	\$451,002	\$4,695
1,066	\$18,920,153	\$9,954,879	\$2,094,427	\$12,511
1,234	\$18,849,730	\$11,659,670	\$3,217,611	\$14,483
1,734	\$18,913,577	\$16,733,262	\$5,103,649	\$22,378
2,083 (low)	\$18,702,085	\$19,087,692	\$6,356,835	\$26,950
2,083 (high)	\$18,586,552	\$22,800,519	\$6,193,748	\$31,349
2,250	\$18,795,183	\$25,176,234	\$6,516,527	\$33,474
2,500	\$18,431,747	\$29,235,262	\$7,260,834	\$37,105
3,000	\$19,721,923	\$37,698,335	\$9,807,362	\$44,677
3,333	\$21,141,410	\$52,329,140	\$10,748,976	\$50,723
3,667	\$26,630,213	\$52,329,140	\$11,372,762	\$56,787
4,000	\$38,388,829	\$59,573,111	\$11,995,366	\$62,799

Source: Agricultural model output and IMPLAN 2021 software and data

Note: Total includes local, state, and federal tax revenue. Tax amounts are impacted by agricultural subsidies. The agriculture Sectors in IMPLAN see 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 received more subsidies from the government than it paid 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.

Cumulative Effects

The potential operational changes included in the Glen Canyon Dam/Smallmouth Bass flow options would not result in changes to water diversion amounts, water available for agriculture, or associated economic contributions.

Issue 2: How would changes to reservoir levels as a result of water shortages impact economic activity associated with recreation?

Summary

Under all alternatives, economic contributions from recreation in Lake Powell, Mead, and river-based recreation as well as adjacent land-based recreation would continue. Due to anticipated reservoir levels, there is 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 in all alternatives. For river-based recreation, activities and associated economic contributions and non-market values would be supported for all alternatives due to minimum flow requirements. Net economic value for whitewater rafting and anglers as a function of river flow would be similar across alternatives, with a slight decrease under Action Alternative 1.

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 activities and 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, represents 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 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 in circumstances with decreased water levels.

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 the park, 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 the park and local businesses.

The loss of visitation and associated visitor spending associated with 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 impacted from a loss of direct visitor spending and the associated indirect and induced spending.

For river-based recreation, commercial recreation upstream of Lake Powell may continue at present levels for the No Action Alternative and both action alternatives. High variability of flow 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, 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 3-127**. It should be noted that the modeling estimates for all alternatives 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).

Table 3-127
Mean High - Low Annual Net Economic Value for River-Based Recreation in Glen and Grand Canyon by Alternative (Millions of \$2022)

Activity	Alternative		
	No Action	Action Alternative 1	Action Alternative 2
Whitewater rafting	24.57–38.37	21.52–38.46	23.56–38.49
Anglers	1.30–1.71	1.06–1.57	1.25–1.69

Note: Use values are based methods in Gaston et al. (2015). Mean annual high and low values based on high and low values by month from 90 ESP traces, with values provided for 60-month simulation period. Estimated individual whitewater trips per month (NPS 2006) are multiplied by the net economic value per trip to obtain the aggregate net economic value for whitewater rafting. 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 pricing index (US Bureau of Labor Statistics 2023). This information represents estimates based on best available data and should be utilized for the purposed of alternative comparison only

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.

Action Alternative 1

Impacts on economic contributions associated with water-based recreation on Lake Powell would be as described under the No Action Alternative, as boat launches would remain inaccessible.

For Lake Mead, a slight improvement to boat launch facilities may be seen for upper estimates of reservoir levels in 2026. However, overall impacts would be similar to those described under the No Action Alternative, with limits on accessibility and navigation and resulting impacts on economic contributions from water-based recreation.

For river-based recreation, impacts on the net economic value from flow changes would be similar to those described under the No Action Alternative. Modeling scenarios indicate a slight decrease in the lower range in net economic values as result of lower flow under some traces for whitewater rafting. For anglers, the net economic value based on river flow would be slightly reduced as compared with the No Action Alternative. Further impacts could occur on the angler experience and associated value based on temperature change impacts on sport fish.

Action Alternative 2

Impacts on economic contributions associated with water-based recreation on Lake Powell and Lake Mead would be as described under Action Alternative 1.

For river-based recreation, impacts on the net economic value from flow changes would be similar to those described under the No Action Alternative.

Cumulative Effects

As discussed above, the SEIS alternatives would result in relatively minor changes in use value and economic activity associated with reservoir and river recreation. The Glen Canyon Dam/Smallmouth Bass flow options would have 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 water temperature released from Glen Canyon Dam as detailed in **Section 3.14.2**.

Issue 3: How would water shortages impact municipal and industrial uses of water?

Summary

Under all alternatives, allocated water shortages for different elevations in Lake Mead would result in domestic (e.g., municipal and industrial) water shortages compared with 2021 use levels, the last non-shortage year in the Lower Basin. Allocated water shortages are higher under Action Alternatives 1 and 2 than under the No Action Alternative, and the shortages vary by Lake Mead elevation and by state depending on the action alternative. The economic impacts from domestic and industrial water shortages is unknown due to the variety of approaches municipalities and other entitlement holders utilize in shortage scenarios, including supply-side actions (e.g. groundwater recharge, water purchase agreements, and alternative water supplies) and demand-side strategies (e.g. water conservation measures). One study estimated that if all Colorado water was lost for one year, this would result in impacts to 16 million job years and \$871 billion in labor income in 2014 for the Upper and Lower Basin Region (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 178,590 af in Arizona, 30,000 af in Nevada, and 350,000 af in California (based on California's DCP contribution).).

Under Action Alternative 1, impacts would be realized at the lowest shortage level (400,000-af scenario) for Arizona and Nevada entitlement holders, while California would experience impacts starting at the 1.734-maf scenario (based on California's DCP contribution). The lowest levels of shortage (at which the respective state would begin to experience impacts) would result in domestic water shortages of 58,316-af in Arizona, 16,000 af in Nevada, and 200,000 af in California. The maximum levels of shortage in 2024 (2.083-maf shortage scenario) would result in domestic water shortages of 722,586 af in Arizona, 83,230 af in Nevada, and 350,000 af in California (based on California's DCP contribution).

Under Action Alternative 2, impacts would be realized at all shortage scenarios in all three states. The lowest levels of shortage would result in domestic water shortages of 1,402-af in Arizona, 15,919 af in Nevada, and 25,827 af in California. The maximum levels of shortage in 2024 (2.083-maf shortage scenario) would result in domestic water shortages of 306,980 af in Arizona, 73,168 af in Nevada, and 400,571 af in California.

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 a drought progresses. Some CAP entities would face a priority-specific reduction of project water to zero levels in the absence of alternative water sources, starting at 533,000-af shortage scenario levels. Due to shortages triggered pursuant to the 2007 Interim Guidelines in 2022 and 2023 and contributions that were made under the DCP and other programs in the Lower Division States, some municipalities are already enacting drought response programs that 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 3-128**, below, shows estimated shortages for domestic use.

Table 3-128
No Action Alternative—Impacts on Arizona Domestic Water Shortages from Range of Analyzed Volume of Total Shortages (af)

Arizona	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	133,558
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	178,590

In 2024, Arizona M&I shortages would range from approximately 89,525 af during a 533,000-af shortage to 178,590 af during a 1.100-maf shortage. Implementing statewide and local demand-side and supply-side strategies are expected to minimize adverse socioeconomic effects occurring during the maximum M&I shortage under 2024 levels of shortage (see **Table 3-128**).

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 DCP, 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 we acknowledge that flexibility exists for how the DCP contributions may be made. Estimated shortages for domestic use are shown below in

Table 3-129. 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).

Table 3-129
No Action Alternative—Impacts on California Domestic Water Shortages from Range of Analyzed Volume of Total Shortages (af)

	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	200,000	250,000	300,000	350,000	350,000

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. Management includes voluntary and involuntary conservation programs as well as water banking. Estimated shortages for domestic use are shown below in **Table 3-130**.

Table 3-130
No Action Alternative—Impacts on Nevada Domestic Water Shortages from Range of Analyzed Volume of Total Shortages (af)

	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 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, more severe domestic shortages would be triggered with the potential for additional social and economic impacts.

Action Alternative 1

Under Action Alternative 1, in 2024–2026, Arizona M&I shortages would range from approximately 58,316 af during a 400,000-af shortage to 741,409 af during a 4,000-maf shortage (see **Table 3-131**). Implementing statewide and local demand-side and supply-side strategies would reduce the impacts of 2024 shortage levels on some users; however, for certain priorities at the deepest level of shortage contemplated for 2024, and for shortage levels anticipated in 2025–2026, not all social and economic impacts may be mitigated. Should shortages result in a reduction or elimination of legal access to municipal water, widespread impacts on social and economic conditions may be possible. In some scenarios, municipalities may find the need to utilize alternative water sources, or trucked water, as

an alternative to support continued services. The exact costs of these actions are unknown and would depend on numerous factors, including but not limited to, market conditions for alternative water sources and distance from alternative sources (such as for trucked water costs).

In addition to direct costs associated with water replacement, other indirect social costs may occur as a result of a reduction in ecosystem services, or benefits to people provided by the environment. For example, trees in urban areas have been shown to provide high levels of benefits to people in the form of shade (mitigating impacts of increasing temperatures from climate change), local air quality improvements, and enhancement of the visual setting. Should a reduction in domestic water supply result in die-offs of urban and suburban area trees, this could represent a loss of value that would take decades to recapture, due to the growth time required for trees (see, for example, Broome et al. 2016).

Under Action Alternative 1, in California, deliveries to MWD are not modeled as being adversely affected by Lower Basin shortages until 2.083 maf as a result of modeling assumptions about the priority system in the Lower Basin. However, California is assumed to continue making contributions required under the DCP, which begin sooner and are independent of the priority system. See **Appendix D**, Shortage Allocation Model, for additional details. **Table 3-132**, below, shows the estimated shortages for domestic use.

In Nevada, the maximum shortage would equal 160,000 af, more than half the state's apportionment. With Nevada's drought plan in place, shortages to the M&I sector may be managed. Socioeconomic effects on southern Nevada's M&I sector would vary depending on the size of the shortage and the ability of adaptive management policies to mitigate impacts.

Action Alternative 2

Under Action Alternative 2, in 2024–2026, Arizona M&I shortages would range from 238,007 af during a 400,000-af shortage to 1,387,109 af during a 4.000-maf shortage (see **Table 3-134**, below). Impacts, as described under Action Alternative 1, could occur; however, the impacts would occur at a reduced intensity due to the distribution of shortages in the same percentage across all Lower Basin water users rather than based on priority level.

In California, under Action Alternative 2, deliveries for domestic use would impact a wider range of users than under the other alternatives during the 2024–2026 analysis period. This is due to the distribution of shortages in the same percentage across all Lower Basin water users under this alternative. Impacts would occur at all shortage levels, with up to 724,491 af of shortage overall under the 4.000-maf shortage scenario. Estimated shortages for domestic use are shown below in **Table 3-135**.

In Nevada, estimated shortages would result in impacts as discussed under Action Alternative 1; however, impacts would occur at a slightly reduced level due to the distribution of shortages in the same percentage across all Lower Basin water users. See **Table 3-136**.

Table 3-131

Action Alternative 1 Impacts on Arizona Domestic Water Shortages from Range of Analyzed Volume of Total Shortages

Arizona	400,000	1,066,000	1,234,000	1,734,000	2,083,000	2,250,000	2,500,000	3,000,000	3,333,000	3,667,000	4,000,000
Coconino County	0	0	0	9	9	9	9	9	9	9	9
Gila County	0	1,280	1,740	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906
La Paz County	0	11	67	1,217	1,239	1,239	1,793	3,904	5,310	6,721	8,127
Maricopa County	46,965	243,406	300,231	447,506	449,732	450,724	452,210	455,181	457,160	459,145	461,124
Mohave County	0	8,208	10,865	19,138	19,277	19,290	19,309	19,348	19,373	19,399	19,425
Pima County	7,317	94,976	126,499	206,357	206,357	206,357	206,357	206,357	206,357	206,357	206,357
Pinal County	4,034	14,739	18,589	28,341	28,341	28,341	28,341	28,341	28,341	28,341	28,341
Yuma County	0	4	8	14,991	14,995	14,995	14,995	14,995	14,995	15,019	15,120
Arizona Domestic Shortages	58,316	362,624	457,998	720,464	722,856	723,861	725,920	731,041	734,452	737,896	741,409

Table 3-132

Action Alternative 1—Impacts on California Domestic Water Shortages from Range of Analyzed Volume of Total Shortages (af)

	400,000	1,066,000	1,234,000	1,734,000	2,083,000	2,250,000	2,500,000	3,000,000	3,333,000	3,667,000	4,000,000
California Domestic Shortages	0	0	0	0	261,593	389,176	502,287	665,231	773,752	834,052	843,052

¹ Includes the combined area of Los Angeles, Orange, San Diego, Riverside, and San Bernardino Counties supplied by the MWD

Table 3-133
Action Alternative 1—Impacts on Nevada Domestic Water Shortages from Range of Analyzed Volume of Total Shortages (af)

	400,000	1,066,000	1,234,000	1,734,000	2,083,000	2,250,000	2,500,000	3,000,000	3,333,000	3,667,000	4,000,000
Nevada Domestic Shortages	16,000	42,640	49,360	69,360	83,320	90,000	100,000	120,000	133,320	146,680	160,000

Table 3-134
Action Alternative 2—Impacts on Arizona Domestic Water Shortages from Range of Analyzed Volume of Total Shortages (af)

	400,000	1,066,000	1,234,000	1,734,000	2,083,000 ¹	2,250,000	2,500,000	3,000,000	3,333,000	3,667,000	4,000,000
Arizona	0	1	1	1	1	2	2	2	3	3	3
Coconino County	0	1	1	1	1	2	2	2	3	3	3
Gila County	0	156	482	789	942–1,126	1,065	1,218	1,740	1,986	2,200	2,415
La Paz County	385	1,025	1,187	1,668	1,891–2,243	2,468	2,853	3,655	4,296	4,939	5,579
Maricopa County	0	104,683	144,911	182,794	201,735–224,465	216,888	235,830	300,231	330,537	357,055	383,573
Mohave County	603	1,606	1,859	2,613	2,962–3,514	3,866	4,469	5,726	6,729	7,736	8,739
Pima County	0	17,986	40,336	61,351	71,859–84,468	80,265	90,772	126,499	143,311	158,022	172,732
Pinal County	0	5,337	8,066	10,633	11,196–13,456	12,942	14,226	18,589	20,642	22,438	24,235
Yuma County	414	1,104	1,278	1,796	2,036–2,415	2,658	3,072	3,936	4,626	5,318	6,008
Arizona Domestic Shortages	1,402	131,899	198,120	261,644	293,925–306,980	320,155	352,442	460,377	512,710	557,710	603,284

¹ Includes a range of shortages based on Lake Mead's elevation

Table 3-135
Action Alternative 2—Impacts on California Domestic Water Shortages from Range of Analyzed Volume of Total Shortages (af)

	400,000	1,066,000	1,234,000	1,734,000	2,083,000 ¹	2,250,000	2,500,000	3,000,000	3,333,000	3,667,000	4,000,000
MWD Service Area²	25,787	68,722	79,552	311,786	400,337–487,443	465,422	541,209	594,974	637,909	680,973	723,908
San Bernardino County	36	97	112	158	179–212	2,338	269	345	406	466	527
Riverside County	1	3	4	6	6–7	8	9	12	14	16	18
Imperial County	3	7	8	11	13–15	17	19	24	29	33	37
California Domestic Shortages	25,827	68,829	79,676	311,960	400,571–487,658	465,680	541,507	595,356	638,358	681,489	724,491

¹ Includes a range of shortages based on Lake Mead's elevation

² Includes the combined area of Los Angeles, Orange, San Diego, Riverside, and San Bernardino Counties supplied by the MWD

Table 3-136
Action Alternative 2—Impacts on Nevada Domestic Water Shortages from Range of Analyzed Volume of Total Shortages (af)

	400,000	1,066,000	1,234,000	1,734,000	2,083,000	2,250,000	2,500,000	3,000,000	3,333,000	3,667,000	4,000,000
Nevada Domestic Shortages¹	15,919	42,104	49,430	61,329	68,922–73,168	77,800	85,719	105,230	118,415	131,640	144,825

¹ Includes a range of shortages based on Lake Mead's elevation

Cumulative Effects

The potential operational changes included in the Glen Canyon Dam/Smallmouth Bass flow options would not impact water shortage amounts for municipal and industrial uses or associated economic contributions.

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 on determine 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 impacted by management direction, resulting 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. 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, water rights settlements involving Colorado River water delivered through the CAP water have been executed 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. CAP water is also set aside for the Navajo Nation. Additional details are included in **Section 3.18**, Indian Trust Assets (ITAs).

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 water surface level fluctuations. 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.



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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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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 3-137 provides an overview of the environmental justice screening results for the study area.

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, there are a total of 19 environmental justice populations in the study area. 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 3-137** for more information; details for each indicator are provided below.

Table 3-137
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

US Census Bureau [2021a](#), [2021b](#), [2021c](#)

Further, 11 of the 12 Arizona study area counties, which each contain communities that receive CAP water deliveries or rely on Colorado River mainstream water, 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 are located 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. **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) and are considered environmental justice communities. 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.

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.

3.17.2 Environmental Consequences

Methodology

This section relies on analysis in other resource sections to identify whether any of the alternatives are likely to have adverse human health or environmental impacts. These impacts are discussed in the context of potential for disproportionate adverse impacts on identified environmental justice communities.

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 are no replacement water sources. Should these areas experience water shortages that result in available water being reduced to zero, impacts would be more severe compared with areas where replacement water sources exist.

Assumptions

The Shortage Allocation Model does not account for replacement water sources. Refer to **Appendix D** for more information on the Shortage Allocation Model assumptions.

Impact Indicators

- Disproportionate and adverse human health or environmental impacts
- Shortage levels at which available water would be reduced to zero for priorities/users located within environmental justice study area counties

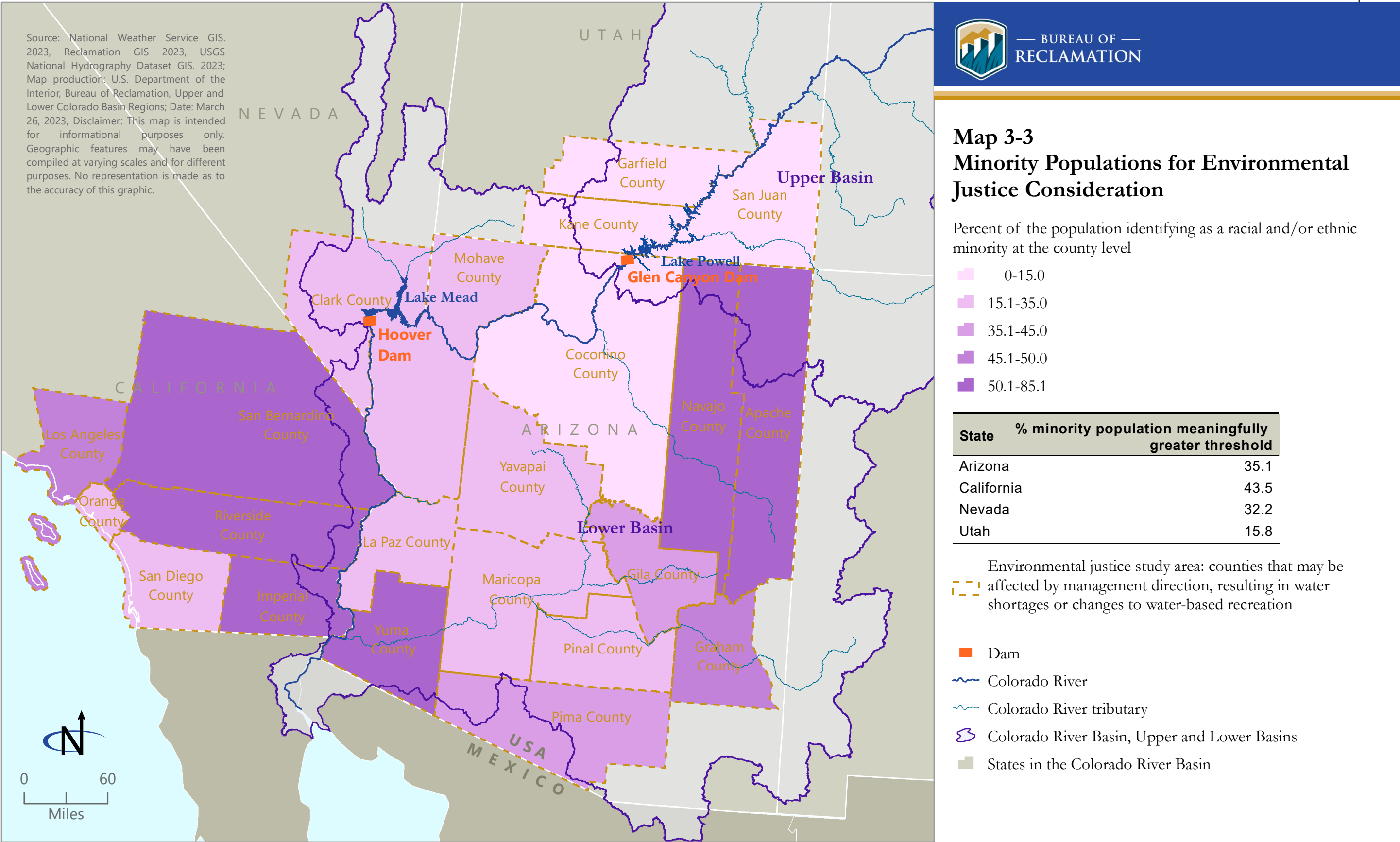
Issue 1: How would management decisions affect environmental justice communities?

Summary

Under the No Action Alternative, there were no modeled shortage levels that resulted in available water being reduced to zero under any priorities for California and Nevada. However, if shortages reached 533,000 to 617,000 af, available water would be reduced to zero for fourth priorities in Arizona. Arizona fifth and sixth priorities are not available in any level of shortage. Some users in Maricopa, Pinal, and Pima Counties would have their water supply reduced to zero and would need to locate alternative water sources to continue historical levels of consumptive use.

It should be noted that shortage levels modeled in the No Action Alternative would be less than those for the action alternatives in the short term. However, projections based on low-flow hydrology 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 Action Alternative 1, additional modeled shortage levels in the near term (2024–2026) indicate that available water would be reduced for additional counties in Arizona (La Paz, Mohave, and Yuma Counties), compared with the No Action Alternative. As such, impacts on irrigation and domestic use from water shortages would be more widely distributed under Action Alternative 1 compared with the No Action Alternative for this time period. While the shortage levels at which available water would be reduced to zero would vary by state and priority, a higher total number of environmental justice study area counties would experience available water reaching zero under Action Alternative 1 for this time period. In the longer term, hydrology models indicate that reservoir levels would be maintained above critical levels for a longer length of time with the implementation of these shortages. Therefore, impacts on environmental justice communities could be reduced compared with the No Action Alternative in the long term.





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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

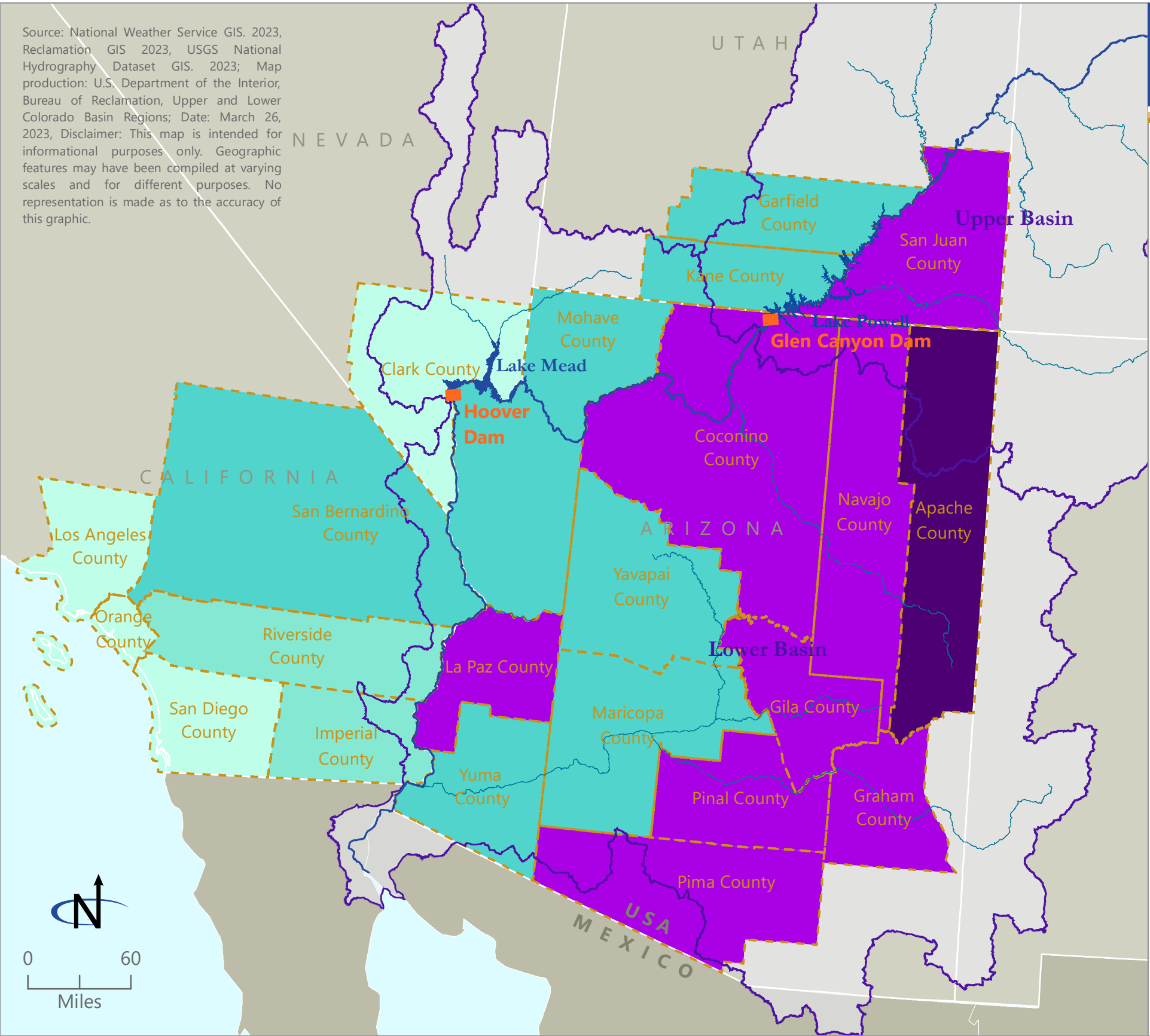
- 1.5- 2.2
- 2.3- 2.5
- 2.5- 5.7
- 5.8-50.0
- 50.1-75.0

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
- Colorado River tributary
- 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 26, 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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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

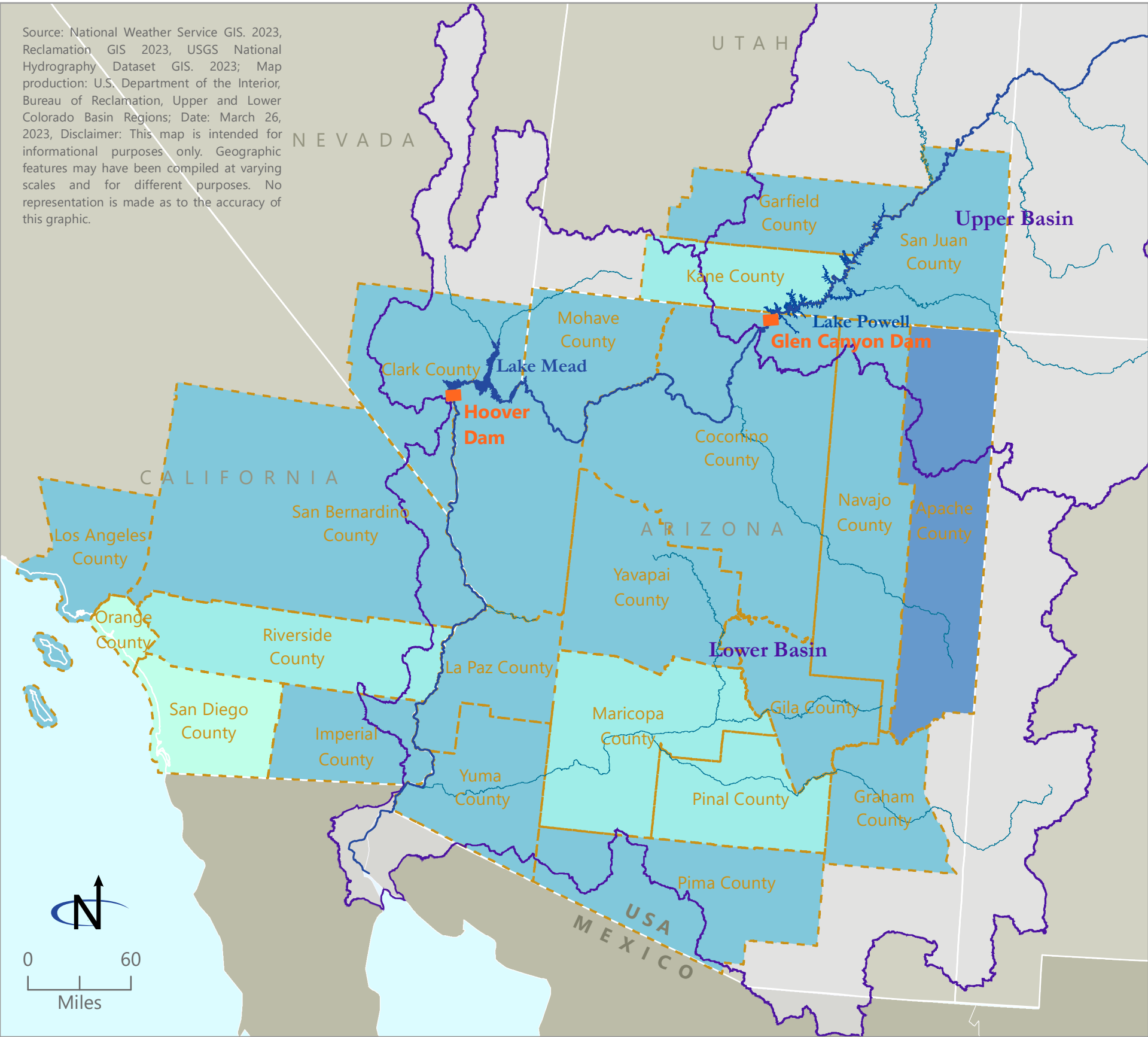
- 23.0-28.4
- 28.5-31.5
- 31.6-50.0
- 50.1-59.3

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

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 26, 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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Compared with the No Action Alternative and Action Alternative 1, Action Alternative 2 would result in less concentration of impacts on individual users, including those located within environmental justice counties. As such, the impacts would be more widely distributed. Under Action Alternative 2, an increased number of users would experience water shortages, whereas under the No Action Alternative, the same users may not experience shortages. While some users, including those within environmental justice communities, would still experience water shortages, the distribution of shortage would be such that impacts would be less concentrated and lower in magnitude for some communities.

No Action Alternative

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 served by the CAP are environmental justice communities (Pinal and Pima). A Lower Basin shortage would cause the reduction of water deliveries first to the CAP and other post-1968 Colorado River contractors in Arizona.

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 5th (unused entitlement/apportionment) and 6th (surplus) priority entitlements along the mainstream Colorado River, and users of the CAP excess pool in Maricopa, Pinal, and Pima Counties, Arizona, would be reduced to zero.

Domestic Use

At levels of shortage of 533,000 af and greater, domestic water supply from the CAP NIA-B²⁷ 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

Under the No Action Alternative, available water for all users under CAP NIA-A priority in Maricopa, Pima, and Pinal Counties would be reduced to zero if water shortages reached 617,000 af. At this shortage level, available water would be reduced to zero for some Tribal allocations (Tohono

²⁷ NIA refers to Non-Indian agricultural. NIA-A refers to NIA priority contracts and subcontracts executed prior to 2021. NIA-B refers to NIA priority contracts and subcontracts executed in 2021 or later.

O’odham Nation and Gila Indian River Community). However, even when water deliveries are reduced to Tribes, the underlying water rights would not be affected.

Action Alternative 1

The Shortage Allocation Model utilizes different volume inputs of state shortage for the No Action Alternative and Action Alternative 1. As such, under Action Alternative 1, the shortage level at which available water for some users under some priorities in Arizona would be reduced to zero would be lower (400,000 af) compared with under the No Action Alternative (533,000 af). However, the Shortage Allocation Model for Action Alternative 1 and the No Action Alternative would produce an identical distribution between Arizona users if the volumes of shortage to Arizona were the same.

Under Action Alternative 1, water shortages ranging from 400,000 af to 4,000 maf would result in some water users within the Arizona environmental justice study area counties who receive water deliveries from the CAP and/or the Colorado River mainstream to be reduced to zero. Detailed information is provided below.

Action Alternative 1 would result in more impacts on water deliveries to users in the states of Arizona, California, and Nevada, compared with the No Action Alternative.

Hydrologic Resources and Water Deliveries

Irrigation

If shortages reached 1.734 maf, water supply for one (priority 3) entitlement holder in Yuma County would be reduced to zero. If shortages reached 2.083 maf, water supply from the Colorado River mainstream for irrigation use would be reduced to zero for some users (all 4(i) priority entitlement holders and one 3 priority entitlement holder) in La Paz, Yuma, and Mohave Counties. This would result in impacts on irrigation.

La Paz, Mohave, and Yuma 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 historically relied on water allocations from the CAP and Colorado River to irrigate crops would need to use alternative water supplies, such as groundwater, if available, to continue agricultural production.

Through the 2024 operating year, available water supply for irrigation use would not be reduced to zero for any priorities in California or Nevada (see **Appendix D**).

Domestic Use

Consumptive-use impacts on domestic uses would vary by 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 increases as the volume of total shortage to Lower Division States increased (see **Appendix D**, Shortage Allocation Model).

If water shortages reached 400,000 af, water supply from the CAP for domestic use would be reduced to zero for some users in Maricopa, Pinal, and Pima Counties (all users with CAP NIA-B

priority). The shortage level at which available water for users under CAP NIA-B priority is reduced to zero is smaller than that of the No Action Alternative. However, this is a result of the Shortage Allocation Model using different state shortage volumes for the No Action Alternative and Action Alternatives 1 and 2. As Lake Mead's elevation decreases, 2024 additional shortage increases for the Lower Division States as a whole and individually. The same is true for the 2025–2026 total shortage.

If water shortages reached 1.066 maf, water supply from the CAP for domestic use would be reduced to zero for some users in Maricopa, Pinal, and Pima Counties (all users with CAP NIA-B and CAP NIA-A priority). Water supply for these users would be reduced to zero for all subsequent shortage volume scenarios as well.

If water shortages reached 1.734 maf or 2.083 maf, water supply from the CAP and from the Colorado River mainstream would be reduced to zero for some users within Coconino, Gila, La Paz, Maricopa, Mohave, Pima, Pinal, and Yuma Counties. Through the 2024 operating year, the available water supply for domestic use would not be reduced to zero for any priorities in California or Nevada (see **Appendix D**). Coconino, Gila, La Paz, Mohave, Pima, Pinal, and Yuma Counties, Arizona, are identified as environmental justice communities. As such, the water users within these counties who would experience zero water supply would face disproportionate consumptive-use impacts on domestic uses.

Tribal Allocations

Under Action Alternative 2, the available water supply would not be reduced to zero for any Tribes in California or Nevada (see **Appendix D**).

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 D**). If water shortages reached 1.066 maf, NIA-A priority water supply from the CAP would be reduced to zero for two Tribal communities in Maricopa, Pima, and Pinal Counties (the same communities impacted under the No Action Alternative). The same is true for these communities under the 1.234-maf, 1.734-maf, and 2.083-maf total shortage scenarios. If water shortages reached 1.734 maf, fourth-priority water supply from the CAP are modeled to be reduced to zero for most contractors and subcontractors, including seven Tribes (in Gila, Maricopa, Pima, and Pinal Counties). If water shortages reached 2.083 maf, water supply from the Colorado River mainstream is modeled to be reduced to zero for a Tribe's agricultural lands in La Paz County that is served pursuant to the Tribe's priority-four water delivery contract.

Gila, La Paz, Pima, Pinal, and Yuma Counties are identified as environmental justice communities. As such, the water users within these counties could face temporary, disproportionate consumptive-use impacts on Tribal allocations for 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. The Ak-Chin Indian Community, Tohono O'odham Nation, and GRIC engage in on-reservation farming. The aforementioned shortages could impact on-reservation farming and could result in disproportionate impacts from losses in revenue.

However, it is important to note that losses in revenue are impacted by other factors, including, but not limited to, the implementation of water rights settlements and availability of other resources.

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 allocations based on priority may result in the loss of production for Tribal agricultural lands for a given year. Water delivery reductions may result in fallowing of some Indian lands, with the potential for economic impacts, as described above. However, annual variability in water deliveries and associated use and economic contributions would not affect the underlying settled water rights.

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

Potential changes to fugitive dust emissions due to exposed shoreline are minor at Lake Powell and there would be no disproportionate effect on the health of residents of San Juan County compared with the other counties. Likewise, there would be no significant difference among alternatives at Lake Mead or downstream. Under Action Alternative 1, there would be no increase in GHG emissions due to alternative power sources (see **Section 3.9**, Air Quality). Therefore, Action Alternative 1 would not result in any disproportionate effects on environmental justice communities.

Visual Resources

Potential impacts on visual resources were considered for attraction features, calcium carbonate rings, and sediment deltas (for both Lake Mead and Lake Powell), which would be viewed from adjacent highways, from the lake surface, and from trails in the area. 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.

Additionally, 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 were considered (see **Section 3.10**, Visual Resources). Changes to the natural landscape character along the Colorado River between Glen Canyon Dam and Lake Mead (associated with potentially lower flows through Grand Canyon) would impact any environmental

justice communities located within these areas. Additionally, 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 large-scale 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.

Biological Resources

Potential impacts on biological resources would not disproportionately impact any environmental justice community identified within the study area. Potential impacts on vegetation, wildlife, and fish due to the action alternatives would be similar.

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 will 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. Action Alternative 1 would have fewer impacts on sacred sites and TCPs than the No Action Alternative. Under this alternative, visitor access to previously inundated sacred sites could increase to a lesser degree than under the No Action Alternative. 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.

Indian Trust Assets

Reclamation has concluded that Action Alternative 1 would have no significant impacts on 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 among the alternatives have the potential to affect environmental justice communities disproportionately through possible increases in electricity rates resulting from decreased electrical power generation under both action alternatives. 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 the first year of the drought (2011–2012) by 1.8 million tons of carbon, the equivalent of emissions from roughly

one 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. Individuals and businesses within San Juan County, Utah, 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 Action Alternative 1, there is potential for economic impacts from shortages to agricultural value changes, municipal water shortages, and change to recreation-based economic contributions. The locations of impacts would vary by shortage level, but would be concentrated in Arizona, with impacts, as discussed in the Water Delivery section above.

Action Alternative 2

Under Action Alternative 2, there would be a potential for impacts on a wider range of users compared with the No Action Alternative and Action Alternative 1. Impacts for other resources that could impact environmental justice communities under Action Alternative 2 would generally be similar to those described under Action Alternative 1. However, the distribution of impacts across the study area would include a wider range of users for all shortage volumes. For instance, impacts on visual resources would generally be the same under both action alternatives; however, because Action Alternative 2 would distribute water shortages across all three Lower Division States, impacts on the landscape character would be more widely distributed, but less intense (**Section 3.10.2**, Visual Resources). More information can be found in the respective resource sections.

Hydrologic Resources and Water Deliveries

Although shortages would occur at earlier levels across the environmental justice study area, the Shortage Allocation Model results indicate there would be no shortage volumes at which available water for a user would be reduced to zero. This is because, unlike Action Alternative 1, which distributes additional shortage based on priority, Action Alternative 2 distributes additional shortages based on the same percentage for all water users. As a result, it is anticipated that the potential for disproportionate impacts on environmental justice communities would be reduced compared with Action Alternative 1.

Irrigation

Under Action Alternative 2, the Shortage Allocation Model results indicate more consumptive-use impacts on irrigation across California water users, compared with the No Action Alternative and Action Alternative 1. This is because under Action Alternative 2, all six water users located within San Bernadino, Riverside, and Imperial Counties, California, would experience water shortages. For these water users, shortage contributions would increase as the total shortage volume increases. As a

result, these water users would experience water shortages and consumptive-use impacts on irrigation. However, under Action Alternative 2, available water supply would not be reduced to zero at any shortage volume for California water users. Under all alternatives, shortages would not occur for irrigation water users in Nevada.

Overall, under Action Alternative 2, the Shortage Allocation Model results indicate fewer irrigation users across various Arizona priorities would experience available water supply being reduced to zero, compared with Action Alternative 1, and the same amount of users compared with the No Action Alternative. As is the case with Action Alternative 1, under Action Alternative 2, if shortages reached 400,000 af, water supply for all 5th- and 6th-priority contracts, contracts for unused CAP water, and CAP agricultural and other excess contracts (in Arizona) would not be available. The same Arizona environmental justice study areas—Pinal and Pima Counties—would be impacted.

However, unlike Action Alternative 1, available water supply for irrigation use would not be reduced to zero for any other Arizona priorities. While water shortages for irrigation use would increase for some Arizona priorities as the volume of total shortage increases, the impacts on irrigation would be less concentrated and severe, compared with Action Alternative 1.

With fewer priorities experiencing water supply reduced to zero under Action Alternative 2, compared with the other alternatives, consumptive-use impacts on irrigation would occur across fewer environmental justice study area counties. However, water users within Pima and Pinal Counties who would have water delivery reduced to zero would face disproportionate consumptive-use impacts on irrigation. Farmers who have historically relied on water allocations from the CAP and Colorado River to irrigate crops would need to use alternative water supplies, such as groundwater, if available, to continue agricultural production.

Domestic Use

Consumptive-use impacts on domestic uses would vary by the volume of the total shortage to the Lower Division States. The number of counties and different domestic water users whose water supply would be reduced would increase as the volume of total shortage to Lower Division States increased (see **Appendix D**, Shortage Allocation Model).

In California and Nevada, the environmental justice study area counties where water shortages would be experienced are the same as the No Action Alternative and Action Alternative 1 (Clark County, Nevada, and Los Angeles, Orange, San Diego, Riverside, and San Bernardino Counties, California). Under Action Alternative 2, consumptive-use impacts on domestic uses would be distributed across a wider range of water users in California and Nevada. Like under the No Action Alternative, available water supply from the CAP NIA priority for domestic use is the only supply potentially reduced to zero under Action Alternative 2 in Arizona. As is the case across alternatives, for priorities experiencing shortage, the shortage allocation generally increases as the volume of shortage increases.

If water shortages reached 400,000 af and above, water supply from the Colorado River for domestic use would be reduced for more users in Clark County, Nevada, compared with under the No Action Alternative and Action Alternative 1.

As Lake Mead's elevation decreases, the 2024 additional shortage would increase for the Lower Division States as a whole and individually.

As is the case with Action Alternative 1, if water shortages reached 1.066 maf, water supply from the CAP for domestic use would be reduced to zero for some users in Maricopa, Pinal, and Pima Counties, Arizona (all users with CAP NIA-B and CAP NIA-A priority). Water supply for these users would be reduced to zero for all subsequent shortage volume scenarios as well. Pima and Pinal Counties, Arizona, are identified as environmental justice communities. As such, the water users within these counties who would experience zero water supply would face disproportionate consumptive-use impacts on domestic uses.

Unlike Action Alternative 1, water supply from the CAP and from the Colorado River mainstream would not be reduced to zero for some users within Coconino, Gila, La Paz, Maricopa, Mohave, Pima, Pinal, and Yuma Counties. As such, consumptive use impacts on domestic uses would occur in fewer Arizona environmental justice study area counties under Action Alternative 2, compared with Action Alternative 1.

Tribal Allocations

For priorities within California and Nevada, available water supply would not be reduced to zero under any volume of total shortage. However, impacts on mainstream Tribal entitlements would increase under Action Alternative 2 compared with under Action Alternative 1 (where no shortages occur for mainstream Tribal entitlement holders under PPR). Action Alternative 2 distributes additional shortages based on the same percentage for all water users, including shortage to the mainstream Tribal entitlement holders. This is because the four entitlement-holding Tribes in California (Fort Mojave, Chemehuevi, Colorado River Indian Tribes, and Quechan) and the one Tribal entitlement holder in Nevada (Fort Mojave) would experience water shortages.

The Shortage Allocation Model results indicate some users within these communities would face increased shortage allocation under all volumes of total shortage. These entitlement holders are located within San Bernadino, Riverside, and Imperial Counties, California, and Clark County, Nevada. All of these are identified as environmental justice communities. However, because water supply would not be reduced to zero, these counties would face fewer potential disproportionate impacts due to water shortages, compared with under Action Alternative 1.

Overall, under Action Alternative 2, the Shortage Allocation Model results indicate fewer Tribes across various Arizona priorities would experience available water supply being reduced to zero. While water shortages would increase for some priorities as the volume of the total shortage increases, the impacts on Tribal allocations would be less concentrated and severe, compared with Action Alternative 1. These impacts on the Arizona environmental justice study area counties are discussed in further detail below.

As is the case for Action Alternative 1, under Action Alternative 2, if water shortages reached 1.066 maf, NIA-A priority water supply from the CAP would be reduced to zero for two Tribal communities in Maricopa, Pima, and Pinal Counties, Arizona. The same is true for these communities under all subsequent total shortage scenarios.

However, unlike under Action Alternative 1, if water shortages reached 1.734 maf and above, fourth-priority water supply from the CAP would not be reduced to zero for most contractors and subcontractors, including 7 Tribes (in Gila, Maricopa, Pima, and Pinal Counties, Arizona). If water shortages reached 1.734 maf and above, for CAP Indian priority, CAP NIA-A priority, and priority 3 CAP water supply, there would be no shortages for five Tribes. For Arizona priorities across 13 Tribes, the allocation of shortage (af) would increase as the total volume of shortage increases; however, the available water supply would not be reduced to zero.

As described in the Action Alternative 1 Tribal allocations discussion above, Pima and Pinal Counties are identified as environmental justice communities. As such, under Action Alternative 2, the water users within these counties could face temporary, disproportionate consumptive-use impacts on Tribal allocations for irrigation and domestic use. However, the available water supply being reduced to zero would be experienced by some users in fewer environmental justice counties (two), compared with the No Action Alternative and Action Alternative 1. As described in Action Alternative 1, production on Tribal lands provides an important economic base; a lack of water supply could result in reduced agricultural production and a loss of Tribal revenue. Under Action Alternative 2, the aforementioned shortages could impact on-reservation farming and could result in disproportionate impacts from losses in revenue for Tribes engaging in on-reservation farming. In this case, fewer Tribes could experience these impacts compared with Action Alternative 1.

As discussed under the Action Alternative 1 section above, shortage allocations may result in the loss of production for Tribal agricultural lands for a given year. Under Action Alternative 2, shortage allocations would be distributed in the same percentage across water users; therefore, impacts may occur on a wider range of users of all priority levels. Impacts on those Tribes holding lower-priority levels would be reduced as compared with Action Alternative 1. Those holding higher-priority rights may see a greater impact than under Action Alternative 1. Water delivery reductions may result in fallowing of some Indian lands, with the potential for economic impacts, as described above. However, annual variability in water deliveries and associated use and economic contributions would not affect the underlying settled water rights.

Cumulative Effects

The Glen Canyon Dam/Smallmouth Bass 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 impacted—and will continue to impact—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](#)).

3.18 Indian Trust Assets

3.18.1 Affected Environment

This section is summarized from Section 3.10, Indian Trust Assets, from the 2007 FEIS (Reclamation 2007) and is updated with changes since 2007. ITAs are those 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 regarding the proposed changes to the 2007 Interim Guidelines, including those Tribes with water rights and water delivery contracts.

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 rights in Arizona were amended with the Colorado River Indian Tribes Water Resiliency Act of 2022 to allow for the lease or exchange of water with non-reservation users within Arizona.

Central Arizona Project

Tribal Colorado River water delivered through the CAP in central Arizona is 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. An allocation of CAP water is also set aside for the Navajo Nation.

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 the Shortage Allocation Models 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 allocations will not affect settled water rights.
- Previously gathered data on TCPs and Tribal concerns are sufficient.
- Tribes will supply any additional needed information.

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 a matter of settled law; however, annual water deliveries may change as a result of shortages. The projected timing and magnitude of shortages vary between the No Action Alternative and the action alternatives, but long-term water deliveries are projected to be more reliable under the action alternatives than under the No Action Alternative. The number of Tribes affected (and how they are affected) varies between Action Alternative 1 and Action Alternative 2. This is because under Action Alternative 1, water deliveries are based on priority while under Action Alternative 2, additional shortages are distributed based on the same percentage for all water users.

Water rights for individual Tribes are settled law. The determination of water allocations to individual entities is beyond the scope of this SEIS. As with the 2007 Interim Guidelines, “[n]o 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 D**, Shortage Allocation Model Documentation.

No Action Alternative

Under the No Action Alternative, water deliveries for Tribes would follow the 2007 Interim Guidelines as analyzed in Section 4.10.1 of the 2007 FEIS (Reclamation 2007) and the DCPs. Water deliveries to Tribes would 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 would occur as lake levels decline. Any water available would be allocated by priority among and within each state. As discussed in **Section 3.17.2**, Environmental Justice, this means that CAP NIA-A priority Tribes in Arizona may have their available water reduced to zero if shortages reach a critical level. In addition, shortage allocations based on priority may result in the loss of production for Tribal agricultural lands. Any annual variability in water deliveries would not affect the underlying settled water rights.

Action Alternative 1

Under Action Alternative 1, additional shortages, including those to Tribes, would be based on priority (see **Section 3.6**, Hydrologic Resources).

Action Alternative 2

Under Action Alternative 2, additional shortages would be distributed based on the same percentage for all water users. Therefore, compared with the No Action Alternative or Action Alternative 1, water deliveries to more Tribes would be impacted when shortages occur; however, impacts on certain Tribes may be lessened.

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 Glen Canyon Dam/Smallmouth Bass flow options project. Reclamation is proposing to regulate flows from the Glen Canyon Dam to control smallmouth bass populations; this will not contribute to cumulative impacts on water deliveries. No cumulative impacts on water deliveries to Tribes are anticipated.

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 would be more accessible to visitation under the No Action Alternative than under either of the action alternatives; however, the resources themselves would be more protected under the action alternatives than under the No Action Alternative. Both action alternatives would protect habitat important to riparian vegetation more than the No Action Alternative.

No Action Alternative

Under the No Action Alternative, decreases in the pool elevations at Lake Powell and Lake Mead and lower river levels during times of low releases may increase visitor access to sacred sites that were previously inaccessible, under water, or buried under river sediment (see **Section 3.11.2**, above). Native plant species' habitat would decrease while nonnative species' habitat would increase (see **Section 3.13.2**, above). Vegetation is an important element of TCPs important to Native Americans.

Action Alternative 1

Under Action Alternative 1, decreases in the pool elevation at Lake Powell and Lake Mead and lower river levels during times of low releases could increase visitor access to sacred sites, but to a lesser degree than under the No Action Alternative (see **Section 3.11.2**, above).

Action Alternative 1 would result in increases in riparian vegetation in Marble Canyon and eastern Grand Canyon. Riparian vegetation would decline in the western Grand Canyon (see **Section 3.13.2**, above).

Action Alternative 2

Impacts under Action Alternative 2 would be the same as described under Action Alternative 1.

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 Glen Canyon Dam/Smallmouth Bass flow options project. Reclamation is proposing to regulate flows from the Glen Canyon Dam to control smallmouth bass populations. The proposed releases are within the previously approved flows under the LTEMP, 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.

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 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 a [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 a NOI and 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 hydrology and operations 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 comments and the scoping summary report available for public viewing in an accessible format on the project website.

¹ <https://www.usbr.gov/ColoradoRiverBasin/SEIS.html>

The draft SEIS is available for public review on the project website. Reclamation will hold several 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 US Environmental Protection Agency'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, the Service, the NPS, WAPA, and the 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 they worked closely with Reclamation in development of two biological assessments to support consultation under Section 7 of the ESA.
- Given their 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 to resources under their 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 to power generation and revenue across the major generation facilities in the Upper and Lower Basin.
- 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 in **Map 4-1**.

Table 4-1
Basin Tribes

<ul style="list-style-type: none"> • Ak-Chin Indian Community • Chemehuevi Indian Tribe • Cocopah Indian Tribe • Colorado River Indian Tribes • Fort McDowell Yavapai Nation • Fort Mojave Indian Tribe • Gila River Indian Community • Havasupai Tribe • Hopi Tribe • Hualapai Indian Tribe • Jicarilla Apache Nation • Kaibab Band of Paiute Indians • Las Vegas Tribe of Paiute Indians • Moapa Band of Paiute Indians • Navajo Nation • Paiute Indian Tribe of Utah 	<ul style="list-style-type: none"> • Pascua Yaqui Tribe • Quechan Indian Tribe • Salt River Pima-Maricopa Indian Community • San Carlos Apache Tribe • San Juan Southern Paiute • Southern Ute Indian Tribe • Tohono O'odham Nation • Tonto Apache Tribe • Ute Indian Tribe of the Uintah and Ouray Reservation • Ute Mountain Ute Tribe • White Mountain Apache Tribe • Yavapai-Apache Nation • Yavapai-Prescott Indian Tribe • Zuni Tribe
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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 it 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

<ul style="list-style-type: none"> • Ute Mountain Ute Tribe • Southern Ute Indian Tribe • Ute Indian Tribe of the Uintah and Ouray Reservation • Jicarilla Apache Nation • Navajo Nation 	<ul style="list-style-type: none"> • Fort Mojave Indian Tribe • Colorado River Indian Tribes • Chemehuevi Indian Tribe • Quechan Indian Tribe • Cocopah Indian Tribe
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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.

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	



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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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 April 1, 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 <i>Federal Register</i> 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 <i>Federal Register</i> 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 <i>Federal Register</i> 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 of Arizona to all Tribal leaders and representatives for Tribes throughout the Basin.

Date	Meeting Title/Subject of Correspondence	Purpose	Tribes Invited
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	Ten Member Tribes of the Ten Tribes Partnership
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 Apache 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

Date	Meeting Title/Subject of Correspondence	Purpose	Tribes Invited
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
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	Ten 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

4.5 Endangered Species Act Section 7 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 River² in relation to the Multi-Species Conservation Program, and one for the Upper Colorado River³ in relation to the LTEMP. Additional coordination is being conducted between Reclamation and the Lower Basin States to ensure compliance with the existing Habitat Conservation Plan and future actions. Consultation is ongoing with an anticipated finalization of two biological opinions in July 2023.

² From Lake Mead to the SIB

³ Lake Powell, Glen Canyon Dam, and the Colorado River downstream to Lake Mead

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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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—Vertebrate animal that has a life stage in water and a life stage on land (for example, 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)—The AOP describes 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)—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 that identifies the likely effects of the proposed federal action on threatened and endangered species. *See also* Endangered Species Act.

biological opinion (BO)—Document stating the United States Fish and Wildlife Service (Service) and/or the National Marine Fisheries Service opinion 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—Plant or animal species not yet officially listed as threatened or endangered under the ESA, but which 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; the 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)—This act authorized construction of a number of water development projects, including the Central Arizona Project (CAP), and required 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, executed by commissioners for Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming. It was approved by Herbert Hoover, representative of the United States, and proclaimed effective by the president of the United States 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—Entered by the United States Supreme Court on March 27, 2006, in the case of *Arizona v. California*, 547 US 150 (2006). In 1963, the Supreme Court reached a decision in the case of *Arizona v. California*. The 1964 Supreme Court decree in the case of *Arizona v. California*

implemented the 1963 Decision. This 1964 Supreme Court decree was supplemented over time after its adoption, and the Supreme Court entered a Consolidated Decree in 2006 that incorporates all applicable provisions of the earlier-issued decisions and decrees.

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—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 electric-generating, transmission, and distribution facilities 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 powerplants; 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 statutes, 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.

PM₁₀ (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.

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 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.

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

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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 which are generally considered as 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

<ul style="list-style-type: none">▪ 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	<ul style="list-style-type: none">▪ The Colorado River Storage Project Act of April 11, 1956▪ Water Supply Act of July 3, 1958▪ Boulder City Act of September 2, 1958▪ Report of the Special Master, Simon H. Rifkind, <i>Arizona v. California</i>, et al., December 5, 1960▪ The Consolidated Decree entered by the United States Supreme Court in the case of <i>Arizona v. California</i>, 547 US 150 (2006) (Consolidated Decree)▪ International Flood Control Measures, Lower Colorado River Act of August 10, 1964
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Table A-1
Selected Documents Included in the Law of the River

<ul style="list-style-type: none"> ▪ 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 ▪ 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 ▪ Gila Project Act of July 30, 1947 ▪ The Upper Colorado River Basin Compact of October 11, 1948 ▪ Consolidated Parker Dam Power Project and Davis Dam Project Act of May 28, 1954 ▪ Palo Verde Diversion Dam Act of August 31, 1954 ▪ Change Boundaries, Yuma Auxiliary Project Act of February 15, 1956 	<ul style="list-style-type: none"> ▪ 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 ▪ Hoover Power Plant Act of August 17, 1984 ▪ The 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 ▪ Reclamation States Emergency Drought Relief Act of 1991 ▪ 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 Fed. Reg. 7772). ▪ Interim 602(a) Storage Guideline, May 19, 2004 (69 Fed. Reg. 28945) ▪ Colorado River Water Delivery Agreement of October 10, 2003 (69 Fed. Reg. 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)
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Among other provisions of applicable federal law, NEPA and the Endangered Species Act of 1973 (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 sub-basins, the Upper Basin and the Lower Basin, and divided the seven Basin States into the Upper Division and the Lower Division (**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 (maf). 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. 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 ten 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. Upper Division state apportionments were established by the Upper Colorado River Basin Compact of 1948. These apportionments allocate the Upper Division States' consumptive use after deduction of up to 50,000 acre-feet per year (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 Boulder Canyon Project Act (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 that 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 for use in California; and 4 percent 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 acre-feet (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, but 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 present perfected rights (PPRs), which the Consolidated Decree defines as those perfected rights existing on June 25, 1929, the effective date of the BCPA. 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 intra-state priority systems in accordance with that body of 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 proposed federal action 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 federal action and implementation of the 1944 Water Treaty with Mexico through the USIBWC in consultation with the Department of State.



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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.



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 is because the SEIS is not considering alternative actions that would change water deliveries to Mexico. The provisions of the 1944 Water Treaty and implementing Minutes are not affected by this SEIS.

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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 and 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 Colorado River Lower Division States (Arizona, California, and Nevada) below 7.5 million acre-feet (maf) (a “Shortage”) pursuant to Article II(B)(3) of the United States Supreme Court Decree in the case of *Arizona v. California*, 547 US 150 (2006) (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 non-system 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 Colorado River Storage Project (CRSP). The LTEMP provides a framework for adaptively managing Glen Canyon Dam operations through 2036 consistent with the Grand Canyon Protection Act of 1992 (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 it 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 to resources and infrastructure in the Upper Basin.

Pursuant to the DROA, Reclamation worked with the Upper Division States on a Drought Response Operations Plan (Plan) in 2022 with the goal of implementing operational measures to augment water deliveries from the three upstream CRSP Initial Units (i.e., Wayne N. 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 water level above the target elevation.

Appendix B

Hydrologic Modeling of Submitted Proposals

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- B-1 Sensitivity Analysis of Potential DROA Contributions from 6-States Proposal
- B-2 Submitted Proposals

Appendix B. Hydrologic Modeling of Submitted Proposals

B.1 Introduction

During the scoping period and during preparation of the draft Supplemental Environmental Impact Statement (SEIS), Reclamation received many suggestions for operations or operational concepts. The submissions that were eliminated from detailed analysis are described in **Chapter 2**, Section 7 of this draft SEIS. The focus of this appendix is on proposals that were within the scope and which had sufficient detail or relevance for additional discussion and analysis. The proposals addressed in this appendix are:

- The **6-States Proposal**: reflects the “Consensus-Based Modeling Alternative” submitted by the States of Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming
- The **CA Proposal**: reflects the “California SEIS Modeling Framework Alternative” submitted by the Colorado River Board of California
- The **Utton Center Proposal**: reflects the suggested actions submitted by the University of New Mexico School of Law’s Utton Center
- The **4-Lower Basin (LB) Tribes Proposal**: reflects the principles and modeling assumptions submitted by the Chemehuevi Indian Tribe, the Colorado River Indian Tribes, the Quechan Tribe, and the Cocopah Tribe

Formal submission letters from these entities are included as **Attachment B-2** to this appendix.

This appendix compares the proposals to the three SEIS alternatives described in **Chapter 2** of this study report: the No Action Alternative, Action Alternative 1, and Action Alternative 2. This analysis does not cover the breadth of resources or geographic locations included in **Chapter 3** of this report but 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. For the sake of this analysis, some refinements were made to technical assumptions. These refinements are described in **Section B.3** of this appendix.

B.2 Review of Proposals Included in this Appendix

The proposals selected for this comparative analysis contained sufficient detail regarding modeling assumptions needed to perform additional modeling and analysis. This section provides a comparative review of the modeling assumptions provided in each of those proposals. For ease of comparison and analysis, the modeling assumptions reflected in the four proposals are described

according to four components: Upper Basin Demand Management, Colorado River Storage Project Act of 1956 (CRSPA) Initial Unit Contribution/Drought Response Operations Agreement (DROA; that is potential DROA contributions), Glen Canyon Dam Operations, and Lower Division States Shortages. In the table below, these components are described and compared across the four proposals. Following the table is additional discussion of concepts included in the proposals but not represented in the table.

As reflected in **Table B-1**, there are both similarities and differences across the modeling assumptions included in the submitted proposals. With respect to protection elevations in Lake Powell and Lake Mead, the importance of such a concept is noted in all (with a focus on Lake Mead in the 4-LB Tribes Proposal) with elevations suggested that range between 3,500 feet – 3,515 feet in Lake Powell and 975 feet – 1,000 feet at Lake Mead in the 6-States, CA, and Utton Center Proposals.

In terms of Glen Canyon Dam operations, the 6-States, CA, and Utton Center Proposals provide modeling assumptions to achieve the protection of Lake Powell elevations that consist of adjusting existing operating tiers (size of tier and specified releases) and minimum releases as necessary to protect the Lake Powell protection elevation. A key difference is that both the 6-States and CA Proposals move away from balancing releases while the Utton Center Proposal suggests solely balancing releases. While enough specific details are not provided to develop modeling assumptions, the 4-LB Tribes Proposal suggests that Glen Canyon Dam releases consider a minimum flow needed to ensure a “living river” below Lake Powell.

In the Lower Basin, the 6-States, CA, and Utton Center Proposals provide modeling assumptions for additional shortages to the Lower Division States but differ in their total volumes (see **Figure B-1**) and distribution across Lower Division States water users. While the 6-States and Utton Center Proposals include modeling assumptions that deviate from the strict application of the priority system in their distributions of Lower Division States Shortages, the CA and 4-Tribes Proposals reflect the priority system unless voluntary and compensated arrangements are otherwise made.

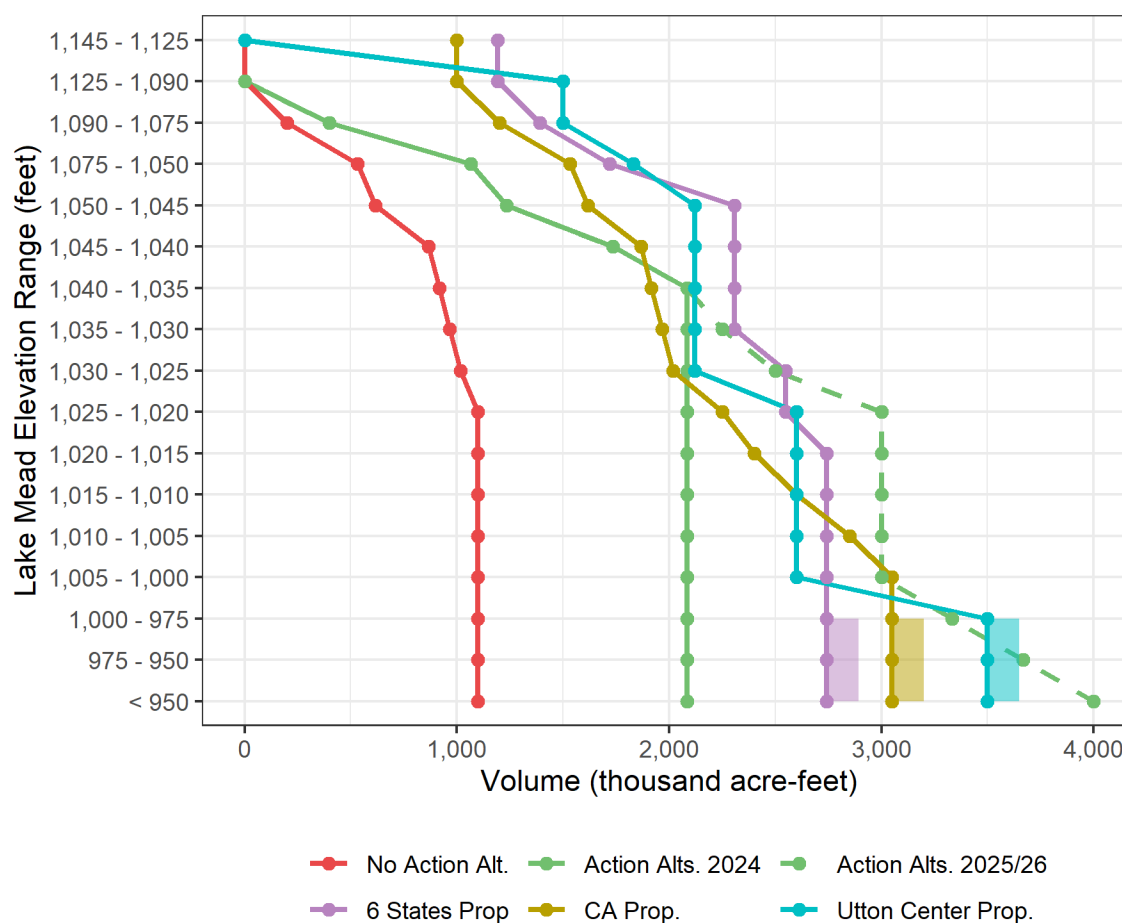
Figure B-1 compares Lower Division States’ Shortages across the proposals and with the SEIS action alternatives. The 4-LB Tribes Proposal is not reflected in this figure as it did not contain enough detailed information on volumes of Lower Division States’ Shortages.

The 6-States, CA, and Utton Center Proposals all propose additional shortages of over 1 million acre feet (maf) when Lake Mead is above 1,090 feet. For 2024, the Utton Center proposes the highest maximum specified shortages of 3.5 maf, but in 2025 and 2026 the SEIS action alternatives include modeled shortages of 4.0 maf. All three of the proposals include the “absolute protection” of Lake Mead elevations, meaning additional reductions would need to be implemented during the calendar year as necessary to protect Lake Mead elevations.

Table B-1
Summary of Modeling Assumptions Provided in Submitted Proposals

Component	6-States Proposal	CA Proposal	CA Proposal	4-LB Tribes Proposal
Upper Basin Demand Management	None provided	Up to 500,000 af annually when Lake Powell is below 3,575 ft	Between 100,000 af – 500,000 af annually	None provided
Initial Unit Contribution/ DROA Modeling Assumption	DROA releases up to 500,000 af annually to help protect Lake Powell elevation 3,500 feet	DROA releases up to 500,000 af annually to help protect Lake Powell elevation 3,500 feet	None provided	Determine if DROA releases could provide Lake Powell protection volumes or minimum flows below Lake Powell to ensure a living river
Glen Canyon Dam Operations	<ul style="list-style-type: none"> Reduce releases as necessary to protect 3,500 feet Below 3,575 feet set release to 7.48 maf or 7.0 maf; eliminate balancing releases 	<ul style="list-style-type: none"> Reduce releases as necessary to protect 3,500 feet Below 3,575 feet releases range from 7.0 maf to 8.23 maf 	<ul style="list-style-type: none"> Reduce releases as necessary to protect 3,515 feet Below 3,575 feet balancing releases while protecting 3,515 feet and 975 feet 	None provided
Lower Division States' Shortages	<ul style="list-style-type: none"> Start additional reductions at Lake Mead elevation 1,145 feet with a maximum specified reduction of 2.734 maf when Lake Mead reaches 1,020 feet Implement additional reductions necessary to protect 1,000 feet (unspecified reductions) Three types of specified reductions proposed: <ul style="list-style-type: none"> Additional reductions and DCP contributions between 1,050-1,000 feet to maintain current IG and DCP distribution "Infrastructure Protection Volume" reductions distributed to all Lower Basin water users proportional to historical use and dependent on distance downstream from Lake Mead Additional reductions proportional to state apportionment < 1,030 feet 	<ul style="list-style-type: none"> Start additional reductions at Lake Mead elevation 1,145 feet with a maximum specified reduction of 3.050 maf when Lake Mead reaches 1,005 feet Implement additional reductions necessary to protect 1,000 feet with releases available to protect human health and safety as determined by each Lower Basin state from stored ICS (unspecified reductions) Two types of specified reductions proposed: <ul style="list-style-type: none"> Additional voluntary or mandatory reductions with proposed distribution of 56 percent to AZ, 40 percent to CA and 4 percent to NV Additional reductions according to the priority system or voluntary arrangements < 1,025 feet 	<ul style="list-style-type: none"> Start additional reductions at Lake Mead elevation 1,125 feet with a maximum specified reduction of 3.5 maf when Lake Mead reaches 1,000 feet Implement additional reductions necessary to protect 975 feet (unspecified reductions) Specified reductions proportional to state apportionment 	<ul style="list-style-type: none"> Reductions to Tribal water allocations must be voluntary and compensated Convert system conservation to Reclamation-managed ICS account and maintain in Lake Mead as protection volume to protect critical infrastructure and/or volume to provide minimum flows to ensure a living river Maintain sufficient flow in Colorado River below Lee Ferry and Hoover Dam to ensure a living river through all reaches Analyze impacts to 5 mainstream Lower Basin Tribes as a unitary amount without regard to state line

Figure B-1
Modeled Lower Division States' Shortage Volume by Lake Mead Elevation –
Comparison of Action Alternatives and Submitted Proposals*



*Shaded regions indicate the 6-States, CA, and Utton Center Proposals include the concept of additional reductions during the calendar year as necessary to protect Lake Mead elevations.

The following sections provide a quantitative comparison of the proposals in terms of system performance. The LB 4-Tribes Proposal is not carried forward to this quantitative comparison as there is insufficient quantitative information to model the proposal. However, the LB 4-Tribes Proposal offers differing approaches and views for the main components reflected in the other three proposals and was, therefore, included to this point.

As described in detail in **Section B.3**, modifications were made to some of the specific modeling assumptions provided in the three modeled proposals. This was done to facilitate a more direct comparison of the system performance under each of the proposals.

Other proposals were received that included modeling assumptions but were determined to be not sufficiently different from the three proposals modeled in this appendix. The City of Peoria, Colorado School of Mines, Irrigation & Electrical Districts' Association of Arizona, John Rickenbach, Blue Ribbon Coalition, Colorado River Authority of Utah, and Pacific Institute all

provided scoping comments that included additional modeling assumption details. Reclamation reviewed and considered these assumptions as the submitted proposals were refined for comparison with the SEIS alternatives. The modeling assumptions included in these comments, which were within the scope of the SEIS, were found to be represented through the three explicitly modified proposals included in this appendix or the action alternatives. For example, the identified comments included additional shortages levels for the Lower Basin that are of similar volumes to those included in the proposals presented in this appendix, and their impact on the system performance can be inferred from those proposal comparisons.

B.3 Modeling Approach

This section summarizes the assumptions that were used in the hydrologic modeling and metrics used to analyze the submitted proposals. Future Colorado River system conditions during the analysis period for all alternatives and submitted proposals were simulated using the September 2022 Colorado River Mid-term Modeling System (CRMMS). For the purpose of this assessment, certain assumptions were modified from the submitted proposals. This was done to make certain assumptions consistent for all proposals analyzed, offering a more direct comparison of key components of each policy. Modeling assumptions included in the submissions are contained in **Table B-1**; details on the modeling assumptions used for the comparative analysis are found in **Sections B.3.1** and **B.3.2**. **Section B.3.3** summarizes the metrics used to compare the submitted proposals to the No Action Alternative and action alternatives.

B.3.1 Modeling Assumptions

The following section summarizes the assumptions for the submitted proposals analyzed in this appendix. The No Action and action alternatives are described in **Chapter 2** with detailed modeling assumptions in **Section 3.3.4** and **Appendix C**.

Initial conditions, hydrology inputs, and other modeling assumptions not described in the following sections are consistent with assumptions included in the No Action Alternative and action alternatives (see **Appendix C**).

Assumptions Common to All Submitted Proposals

The following modeling assumptions are used to model the 6-States, CA, and Utton Center Proposals:

- All simulations were performed with a start date of September 2022 and an end date of December 2026.
- 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 the No Action Alternative.

- Physical elevations are used for tier determinations and balancing releases for Water Years (WY) 2024 through 2026 with no assumptions for the repayment of the 480,000 acre feet (af) reduced delivery from Lake Powell in WY 2022¹.
- The DROA releases from Flaming Gorge—projected as 500,000 af for May 2022 through April 2023²—are included in tier determination and balancing releases as are the 2021 DROA releases (which totaled 161,000 af from Flaming Gorge and Aspinall), consistent with the official September 2022 CRMMS simulation.
- If the pool elevation at 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 any associated maintenance activities. Reclamation believes this is a conservative and prudent estimation given the historical and future operations and maintenance requirements for the river outlet works.
- Releases from Lake Powell will be reduced as needed to maintain elevation 3,500 feet starting in WY 2024³.
- Hourly, daily, and monthly releases from Lake Powell will be consistent with the LTEMP so long as sufficient water is available for annual releases. Minimum flows analyzed in the LTEMP were 5,000 cubic feet per second (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 the LTEMP.
- Several submitted proposals included some suggestions for Upper Basin demand management. No Upper Basin demand management is modeled in CRMMS as a program has not been established pursuant to the Demand Management Storage Agreement and is outside the scope of the SEIS.
- Intentionally Created Surplus (ICS) and Drought Contingency Plan (DCP) contribution assumptions are consistent with the official September 2022 CRMMS simulation.
- For Lower Division States and Mexico use in the first year of the model run, water depletion schedules use water orders that reflect 2007 Interim Guidelines shortage conditions, DCP contributions, reductions under low elevation reservoir conditions and Binational Water Scarcity Contingency Plan (BWSCP) contributions per Minute 323, and executed 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. All additional reductions (2007 Interim Guidelines shortages, DCP contributions, reductions under low elevation reservoir conditions and BWSCP contributions per Minute 323, and/or additional shortages in the action alternatives) reduce these “baseline/normal” consumptive use schedules.

¹ The reduction of releases from Lake Powell from 7.48 maf to 7.00 maf in WY 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 the 7.48 maf annual release volume, consistent with routine operations under the 2007 Interim Guidelines. The reduction of releases from Glen Canyon Dam in WY 2022 (resulting in increased storage in Lake Powell) did not affect the operating determinations for 2023, and it was accounted for “as if” this volume of water had been delivered to Lake Mead.

² The projected 500 kaf DROA release was reduced in March 2023 but is not reflected in the modeling assumptions. It may be updated for the final SEIS.

³ The Utton Center Proposal included an assumption to protect elevation 3,515 feet at Lake Powell; this was modified to 3,500 feet when modeling the proposal to facilitate a more direct comparison with the other submitted proposals.

- For modeling purposes, all additional shortages in the submitted proposals are treated as mandatory, regardless of proposed concepts for generating the reduction in use.
- For the purpose 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 at dead pool, or “system shortages”⁴. Combined, shortages and system shortages may be referred to as “total shortages.”
- Releases from Lake Mead will be reduced as needed to maintain elevation 1,000 feet starting in Calendar Year 2024⁵. These shortages are not attributed to any one state or entity and are referred to as “unassigned shortage”⁶.
- The analysis for each submitted proposal includes modeled water delivery reductions to Mexico under low elevation reservoir conditions and Mexico’s BWSCP savings in accordance with Minute 323. No additional reductions for Mexico are modeled even if specified in the submitted proposals.

Modeling Assumptions for the 6-States Proposal

- The minimum elevation of the Mid-Elevation Release Tier and maximum elevation of the Lower Elevation Balancing Tier in Lake Powell are changed to elevation 3,550 feet. If the elevation was greater than or equal to 3,550 feet, Lake Powell operates in the Mid-Elevation Release tier; if the elevation was less than 3,550 feet, Lake Powell operates in the Lower Elevation Balancing Tier.
- Balancing releases are eliminated in the Lower Elevation Balancing Tier. The Mid-Elevation Release and Lower Elevation Balancing Tiers have set annual releases of 7.48 maf and 7.00 maf, respectively.
- The 6 State Proposal includes a modeling assumption regarding contributions from the Upper Initial Units of up to 500,000 af per DROA year (May 1 – April 30), which will conform to the DROA and its implementing documents and will be made only to help protect Lake Powell elevation 3,500 feet. The analysis refers to these as “potential DROA contributions.” These potential DROA contributions of zero to 500,000 af are modeled to occur if the projected Lake Powell end-of-water year (EOWY) pool elevation is less than 3,525 feet for 2024 through 2026 and are modeled consistent with the assumptions included in Action Alternative 2 (see **Appendix C**).
- An additional modeling run includes potential DROA contributions from zero to 100,000 af per DROA year to assess the sensitivity of results to the magnitude of the potential DROA contributions (see **Attachment B-1**).

⁴ System shortages are reported as a total for the entire Lower Basin because there are no explicit assumptions made in the CRMMS associated with how these shortages would be distributed in the Lower Basin. This results in users being shorted “hydrologically,” that is, upstream users access water before downstream users, but it does not reflect potential implementation of such system shortages.

⁵ The Utton Center Proposal included an assumption to protect elevation 975 feet at Lake Mead; this was modified to 1,000 feet when modeling the proposal to facilitate a more direct comparison with the other submitted proposals.

⁶ In the CRMMS, unassigned shortages are modeled the same as system shortages; that is, there are no explicit assumptions in the CRMMS associated with how these shortages would be distributed in the Lower Basin.

- Shortages from the 2007 ROD and 2019 DCP contributions that occur below elevation 1,025 feet at Lake Mead will occur if Lake Mead is below elevation 1,050 feet. (See **Section B.3.2.**)
- Shortage reductions in excess of the 2007 ROD and 2019 DCP are distributed to each Lower Division State using the specified state volumes in the proposal. For CRMMS modeling, the additional state shortages are distributed within each state using the same percentage across all modeled water users within each state based on a water user's historical calendar year 2021 consumptive use. Additional details on Lower Division State total shortages and DCP contributions, including the distribution among the Lower Division States, are provided in **Section B.3.2.**

Modeling Assumptions for the CA Proposal

- The minimum elevation of the Mid-Elevation Release Tier and maximum elevation of the Lower Elevation Balancing Tier are changed to elevation 3,550 feet. If the elevation was greater than or equal to 3,550 feet, Lake Powell operates in the Mid-Elevation Release tier (otherwise consistent with the Mid-Elevation Release tier constraints in the No Action Alternative); if the elevation was less than 3,550 feet, Lake Powell operates in the Lower Elevation Balancing Tier.
- Balancing releases in the Lower Elevation Balancing Tier are constrained to balance between 7.00 maf and 7.48 maf.
- The CA Proposal includes a modeling assumption regarding potential DROA contributions of up to 500,000 af per DROA year (May 1 – April 30), which will conform to the DROA and its implementing documents and will be made only to help protect Lake Powell elevation 3,500 feet. These potential DROA contributions of zero to 500,000 af are modeled to occur if the projected Lake Powell EOWY pool elevation is less than 3,525 feet for 2024 through 2026, and are modeled consistent with the assumptions included in Action Alternative 2 (see **Appendix C**).
- For modeling purposes, all shortage reductions in excess of the 2007 ROD and 2019 DCP are assumed to be distributed to Lower Division States using the following percentages – 56% to Arizona, 4% to Nevada, and 40% to California. For CRMMS modeling, the state-specific shortages are distributed at the same percentage across all modeled water users within each state based on a water user's historical calendar year 2021 consumptive use. Additional details on Lower Division State total shortages and DCP contributions, including the distribution among the Lower Division States, are provided in **Section B.3.2.**
- Metropolitan Water District (MWD) is assumed to be ICS neutral with no ICS creation or delivery for calendar years 2024 through 2026. ICS assumptions for other entities are consistent with the official September 2022 CRMMS simulation.

Modeling Assumptions for the Utton Center Proposal

- The Mid-Elevation Release Tier and Lower Elevation Balancing Tier are replaced with a new tier that balances storage above elevation 3,500 feet at Lake Powell with storage above elevation 1,000 feet at Lake Mead. There is no specified minimum release from Lake Powell.

- The Utton Center Proposal did not suggest any potential DROA contributions; however, it did include a range of Upper Basin demand management with a similar magnitude as the modeled potential DROA contributions in the other proposals. To make the comparison among submitted proposals easier, potential DROA contributions from zero to 500,000 af per DROA year (May 1 – April 30), which will conform to the DROA and its implementing documents and will be made only to help protect Lake Powell elevation 3,500 feet, were modeled. These potential DROA contributions of zero to 500,000 af are modeled to occur if the projected Lake Powell EOWY pool elevation is less than 3,525 feet for 2024 through 2026 and are modeled consistent with the assumptions included in Action Alternative 2 (see **Appendix C**).
- Shortage reductions in excess of the 2007 ROD and 2019 DCP are distributed to each Lower Division State using the specified state volumes in the proposal. For CRMMS modeling, the state-specific shortages are distributed at the same percentage across all modeled water users within each state based on a water user's historical calendar year 2021 consumptive use. Additional details on Lower Division State total shortages and DCP contributions, including the distribution among the Lower Division States, are provided in **Section B.3.2**.

B.3.2 Shortage Sharing and Water Delivery Reduction Assumptions

A summary of modeling assumptions for the No Action Alternative, Action Alternatives 1, and Action Alternative 2, with respect to the reduction of deliveries to the Lower Division States, including the distribution of shortages by state for 2024–2026, is provided in **Tables 2-4, 2-7, 3-1, and 3-2**. The distribution of shortages to individual users based on CRMMS modeling assumptions can be found in **Appendix C**.

All three proposals provided shortage volumes in excess of the 2007 ROD and 2019 DCP. **Table B-2** summarizes the total Lower Division States' shortage volumes for the No Action Alternative, Action Alternatives 1 and 2, and the submitted proposals. **Table B-3** shows the shortage and DCP contributions for all Lower Division States for each Lake Mead elevation level for the No Action Alternative and the submitted proposals. This table does not include the state breakout for the action alternatives, which can be found in **Tables 2-4, 2-7, 3-1, and 3-2**. **Table B-2** and **Table B-3** represent the total shortage and DCP contributions, inclusive of the 2007 ROD and 2019 DCP and proposed additional shortages. For modeling purposes, state-level shortages in **Table B-3** were further disaggregated within each state as described in **Section B.3.1**.

Table B-2
Modeled Lower Division States' Shortages and DCP Contributions, Action Alternatives
and Modeled Proposals*
(All volumes in 1,000 af)

Lake Mead Elevation (ft)	No Action Alternative	SEIS Action Alternatives 2024	SEIS Action Alternatives 2025-2026	6-States Proposal**	CA Proposal	Utton Center Proposal
>1,145	0	0	0	0	0	0
1,145-1,125	0	0	0	1,191	1,000	0
1,125-1,090	0	0	0	1,191	1,000	1,500
1,090-1,075	200	400	400	1,391	1,200	1,500
1,075-1,050	533	1,066	1,066	1,720	1,533	1,830
1,050-1,045	617	1,234	1,234	2,309	1,617	2,120
1,045-1,040	867	1,934	1,934	2,309	1,867	2,120
1040-1035	917	2,083	2,083	2,309	1,917	2,120
1035-1030	967	2,083	2,098	2,309	1,967	2,120
1030-1025	1,017	2,083	2,197	2,551	2,017	2,600
1025-1020	1,100	2,083	3,000	2,551	2,250	2,600
1020-1015	1,100	2,083	3,000	2,743	2,400	2,600
1015-1010	1,100	2,083	3,000	2,743	2,600	2,600
1010-1005	1,100	2,083	3,000	2,743	2,850	2,600
1005-1000	1,100	2,083	3,000	2,743	3,050	2,600
1000-975	1,100	2,083	3,333	2,743	3,050	3,500
975-950	1,100	2,083	3,667	2,743	3,050	3,500
<950	1,100	2,083	4,000	2,743	3,050	3,500

* 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 and submitted proposal 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.

**Includes the Infrastructure Protection Volume (IPV) and additional reductions specified for the Lower Division States in the submitted proposal.

Table B-3
Modeled Shortages and Contributions by State, Modeled Proposals*
 (All volumes in 1,000 af)

Lake Mead Elevation	2007 ROD + 2019 DCP			6-States Proposal**			CA Proposal***			Utton Center Proposal		
	AZ	NV	CA	AZ	NV	CA	AZ	NV	CA	AZ	NV	CA
>1,145	0	0	0	0	0	0	0	0	0	0	0	0
1,145-1,125	0	0	0	408	17	766	560	40	400	0	0	0
1,125-1,090	0	0	0	408	17	766	560	40	400	560	60	880
1,090-1,075	192	8	0	600	25	766	752	48	400	560	60	880
1,075-1,050	512	21	0	899	39	782	1,072	61	400	880	70	880
1,050-1,045	592	25	200	1,094	49	1,166	1,152	65	400	960	80	1,080
1,045-1,040	640	27	250	1,094	49	1,166	1,200	67	600	960	80	1,080
1,040-1,035	640	27	300	1,094	49	1,166	1,200	67	650	960	80	1,080
1,035-1,030	640	27	350	1,094	49	1,166	1,200	67	700	960	80	1,080
1,030-1,025	640	27	350	1,182	59	1,309	1,200	67	750	960	80	1,080
1,025-1,020	720	30	350	1,182	59	1,309	1,364	76	810	1,280	90	1,230
1,020-1,015	720	30	350	1,252	67	1,424	1,448	82	870	1,280	90	1,230
1,015-1,010	720	30	350	1,252	67	1,424	1,560	90	950	1,280	90	1,230
1,010-1,005	720	30	350	1,252	67	1,424	1,700	100	1,050	1,280	90	1,230
1,005-1,000	720	30	350	1,252	67	1,424	1,812	108	1,130	1,280	90	1,230
<1,000	720	30	350	1,252	67	1,424	1,812	108	1,130	1,310	140	2,050

* This table only shows Lower Division State shortage volumes and DCP contributions. In addition to the volumes shown in this table, the analysis for each submitted proposal 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.

**Includes the Infrastructure Protection Volume (IPV) and additional reductions specified for the Lower Division States in the submitted proposal.

***For modeling purposes, all shortage reductions in excess of the 2007 ROD and 2019 DCP are assumed to be distributed to Lower Division States using the following percentages – 56% to Arizona, 4% to Nevada, and 40% to California.

B.3.3 Comparison Metrics

The modeled submitted proposals are compared with the No Action and Action Alternatives 1 and 2 in **Section B.4** using the following metrics:

Lake Powell

- Monthly pool elevation
- Percentages of traces that fall below elevation 3,490 feet in any month in a water year
- EOWY pool elevation
- Annual water year release
- Ten-year Lees Ferry gage flows

Lake Mead

- Monthly pool elevation
- Percentages of traces that fall below elevation 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
- System and unassigned shortages
- Total shortages

B.4 Modeling Results

This section presents comparison across the SEIS No Action Alternative, Action Alternative 1, Action Alternative 2, 6-States Proposal, CA Proposal, and Utton Center Proposal. 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. See **Appendix C** for more information about hydrology scenarios used and modeling assumptions.

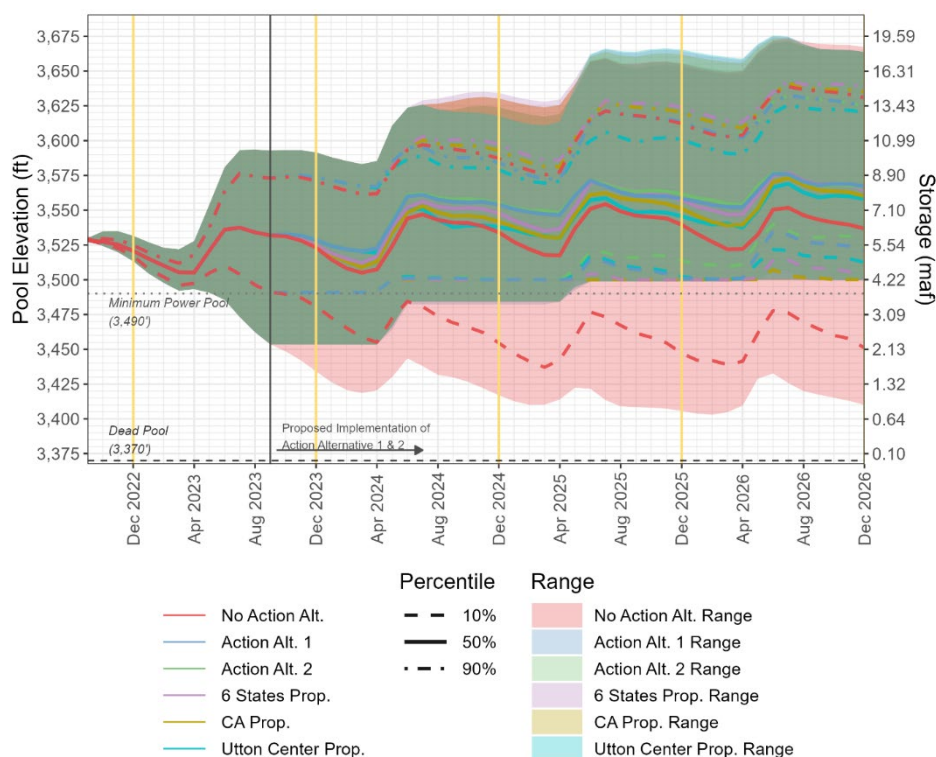
B.4.1 Lake Powell

Monthly Pool Elevations

Figure B-2 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 three SEIS alternatives and the three proposals through 2026.

The cloud extents, or full ranges of modeled Lake Powell elevations in **Figure B-2**, are very similar for all alternatives and proposals at the high end and nearly identical for the two SEIS action alternatives and the three proposals at the lower bound. The lower bound of the No Action Alternative cloud drops to 3,417 feet in 2024 and decreases to a minimum of 3,403 feet in 2026. The lower bounds of the clouds for the other five alternatives/proposals fall to 3,462 feet in August 2023, before the revised operations take effect, but because they all include a provision to protect Lake Powell elevation 3,500 feet, the bottoms of the ranges increases until they reach 3,500 feet in June 2025.

Figure B-2
Lake Powell End-of-Month Pool Elevations



In **Figure B-2** the 10th percentile of the No Action Alternative falls below Lake Powell elevation 3,490 feet (below which the ability of Glen Canyon Dam to operate as intended is not guaranteed) in September 2024 and does not recover during the period of analysis. The 10th percentiles of modeled elevations for all the action alternatives/proposals are nearly identical until April 2025, when they increasingly diverge through 2026. The two SEIS action alternatives are highest at this percentile, and the CA Proposal is lowest. With respect to the medians of modeled elevations, the action alternatives/proposals are consistently higher than the No Action Alternative, and the two SEIS action alternatives are always highest of the five. There is some spread among the five action alternatives/proposals, but they converge to approximately 3,565 feet by December 2026. At the 90th percentile, all alternatives/proposals result in similar Lake Powell elevations except from June 2025 to June 2026 when the Utton Center Proposal is lower.

Percentages of Traces Below Critical Elevations

Figure B-3 shows the percent of modeled traces that fell below Lake Powell elevation 3,490 feet at any time during a year for the period of analysis. Remaining above 3,490 feet is critical to ensuring that Glen Canyon Dam can continue to operate as designed.

Figure B-3
Lake Powell Minimum Water Year Elevation, Percent of Traces Less than Elevation 3,490 feet msl

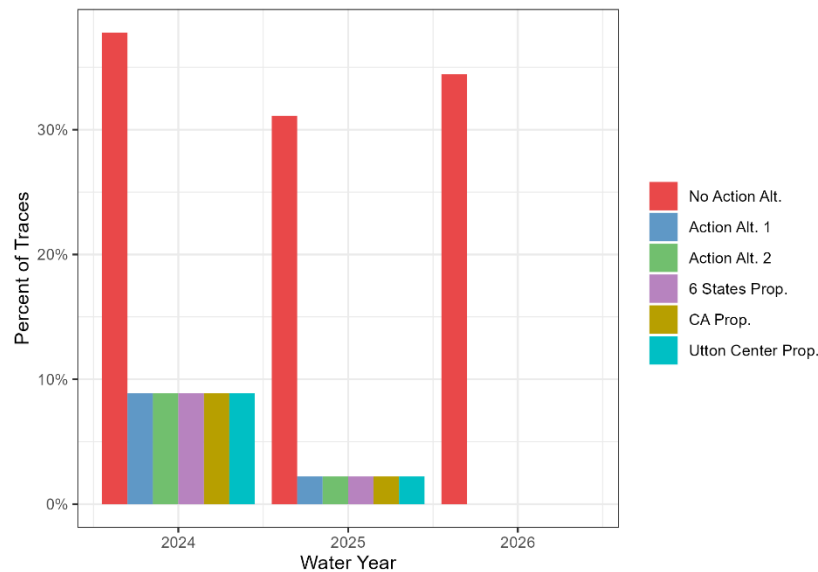


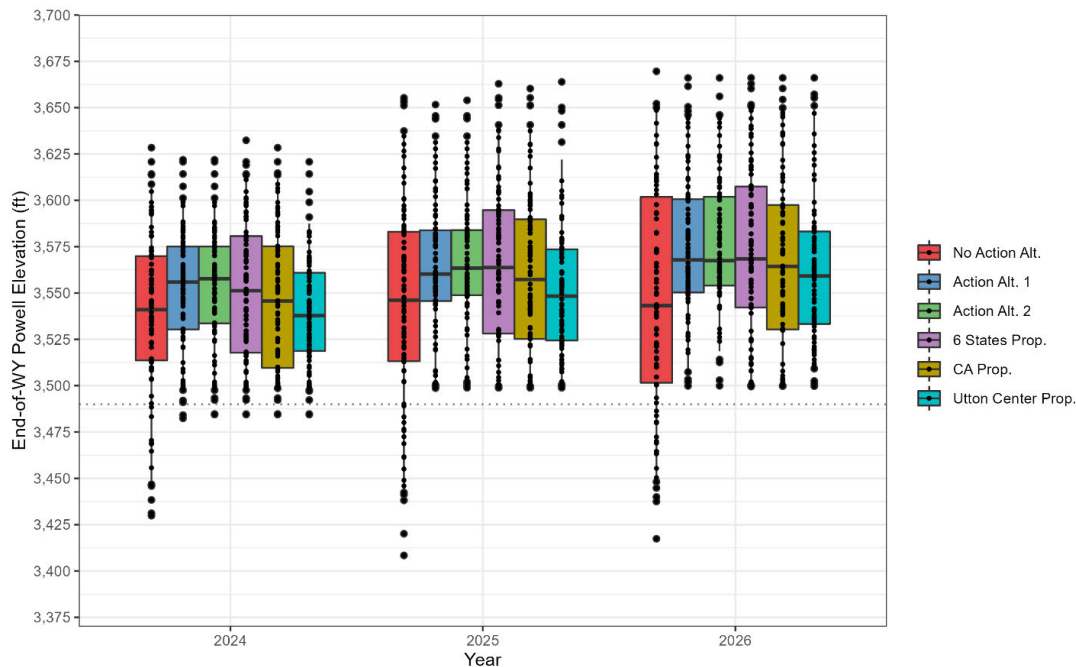
Figure B-3 shows that under the No Action Alternative more than 30 percent of modeled traces result in Lake Powell pool elevation dropping below 3,490 feet. Under the five action alternatives/proposals, identical numbers of traces fall below 3,490 feet in each year: 9 percent in 2024, 2 percent in 2025, and 0 in 2026 because each action alternative/proposal includes modeling to protect elevation 3,500 feet at Powell.

Annual Pool Elevations

Figure B-4 shows the distributions of modeled Lake Powell elevations on September 30 in 2024, 2025, and 2026. Each dot is the EOWY elevation produced by a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines.

Figure B-4 comparisons are consistent with those described above for **Figure B-2**. The No Action Alternative shows a wider range of modeled EOWY Lake Powell pool elevations than the five action alternatives/proposals throughout the period of analysis, especially at the lower ends of the ranges. The median pool elevations for the two SEIS action alternatives and the 6-States Proposal are the most similar to each other and are consistently 10 to 25 feet above the medians under the No Action Alternative. The CA Proposal and the Utton Center Proposal are approximately 3 and 20 feet below the two action alternatives, respectively, in all years.

Figure B-4
Powell EOWY Pool Elevations

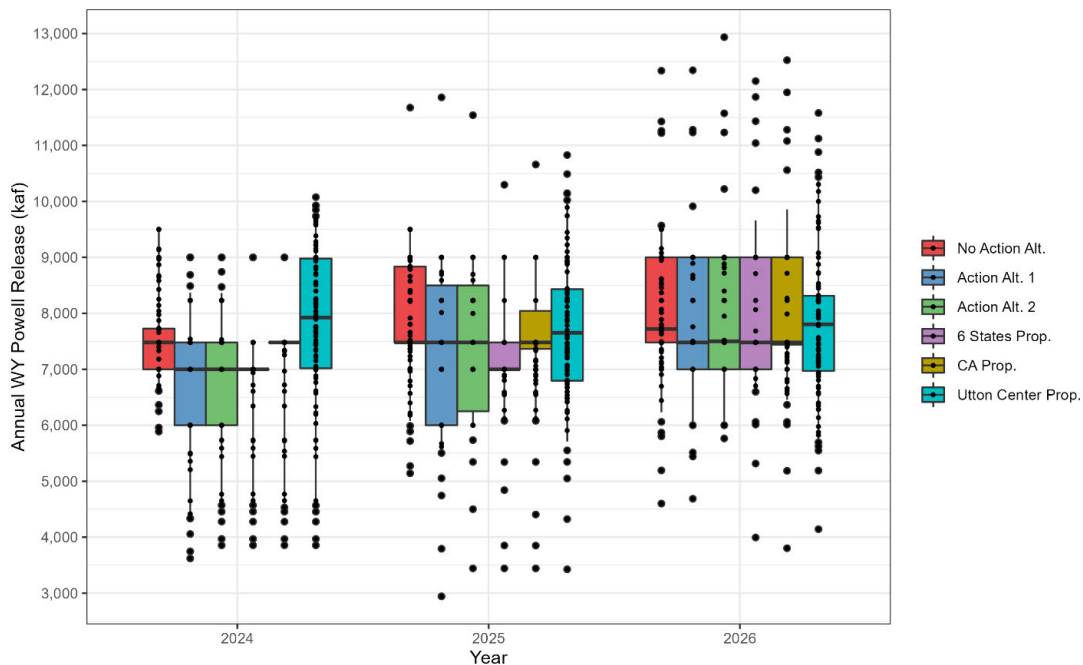


Annual Releases

Figure B-5 shows the distributions of modeled Glen Canyon Dam water year releases in 2024, 2025, and 2026. Each dot is annual release resulting from a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile of the modeled elevations, 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 B-5** reflect the different approaches to Lake Powell operations assumed in the five action alternatives/proposals. All five limit releases to protect Lake Powell elevation 3,500 feet, so they have similar ranges and distributions at the low ends. When Lake Powell is between elevations 3,500 and 3,575 feet, the two SEIS action alternatives and the 6-States Proposal only have set release volumes (not balancing). The set releases under the two SEIS action alternatives range between 6 and 8.23 maf, which can be seen in the width of the boxes, while the 6-States Proposal only specifies 7.48 or 7.0 maf releases, which is apparent in the lack of or small boxes in 2024 and 2025. The CA Proposal assumes balancing in the release range of 7.0 to 7.48 maf, when Lake Powell is below 3,550 feet, and releases up to 8.23 maf when between 3,550 and 3,575 feet, which is apparent in the higher median modeled water year releases and higher ranges of boxes. The Utton Center Proposal is distinct from the other four action alternatives/proposals in the generally higher range and larger variety of modeled releases because it assumes unlimited (that is, there is no range specified for the volume that can be released) balancing of the volumes above 3,500 feet at Lake Powell and above 1,000 feet at Lake Mead.

Figure B-5
Glen Canyon Dam Water Year Release



In **Figure B-5** the medians of annual releases under the No Action Alternative are generally stable at or slightly above 7.48 maf in all years, and the distributions overall tend to be higher than in the five action alternatives/proposals. This occurs because releases under the No Action Alternative will only fall below 7 maf when modeling assumptions about Glen Canyon Dam infrastructure limit release capacity. The exception is the Utton Center Proposal, which has higher or similar modeled median annual releases because it is balancing storage between Lake Powell and Lake Mead more aggressively than the other alternatives/proposals.

Ten-Year Lees Ferry Gage Flows

Figure B-6 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, but it is common to all alternatives so it does not impact relative performance among alternatives. The modeled 2025 volume drops the 2015 observed volume, and the modeled 2026 volume drops 2015 and 2016.

Each dot is the 10-year volume resulting from a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines.

Figure B-6
Lees Ferry Gage 10-Year Running Total

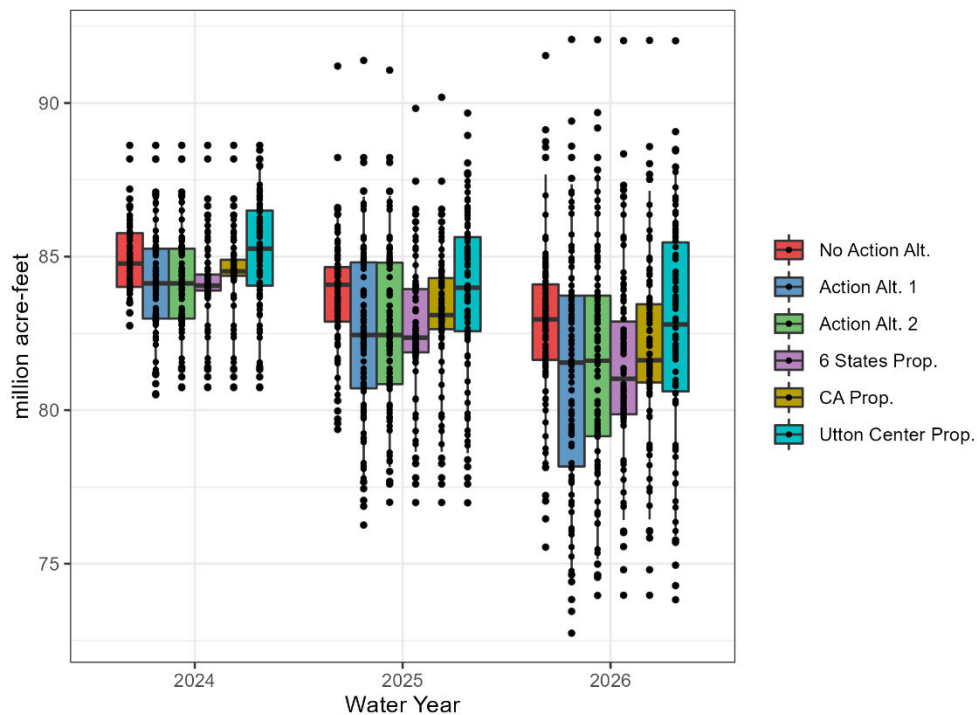


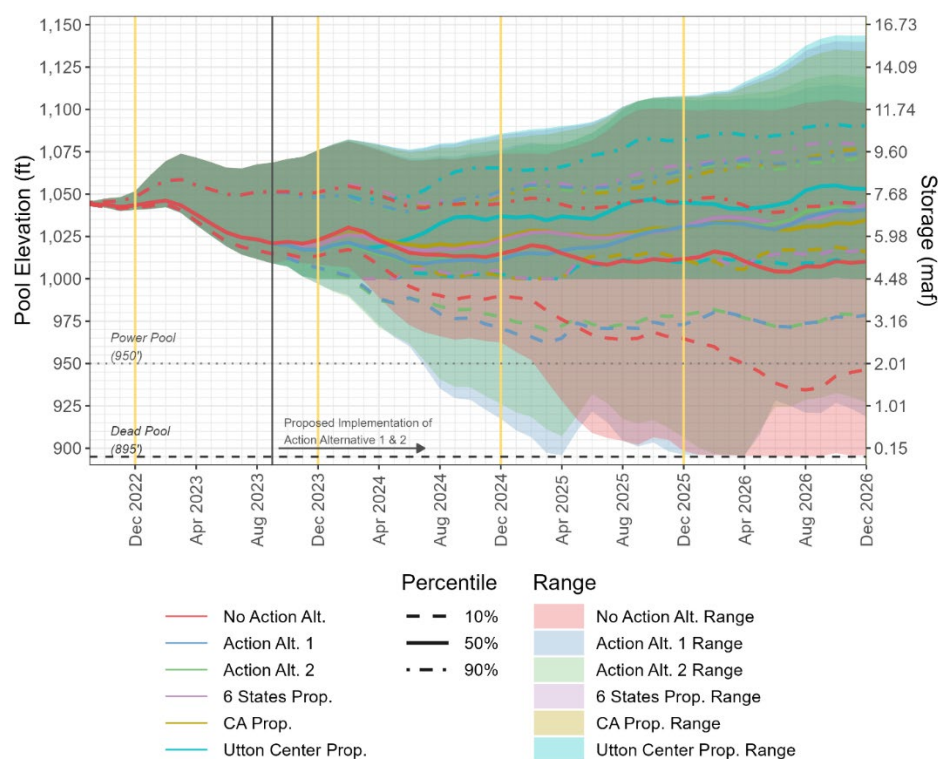
Figure B-6 shows that under all six alternatives/proposals, the median modeled 10-year total flows decline over time. Under the No Action Alternative, this is partially because relatively high Glen Canyon Dam releases from seven or more years ago dropping out of the running total and partially due to declining storage in Lake Powell. All five action alternatives/proposals have lower 10-year flows in the driest modeled traces than the No Action Alternative because they model limited releases to protect Lake Powell’s elevation 3,500 feet, and this occurs immediately in 2024. The median releases under the two SEIS action alternatives, the 6-States Proposal and the CA Proposal all have similar median 10-year flows because they constrain or eliminate balancing releases between Lake Powell and Lake Mead below Lake Powell elevation 3,575 feet. The Utton Center Proposal allows balancing in this range, resulting in higher median flows. By 2025, all alternatives/proposals result in 10-year totals below 82.3 maf in some modeled traces (ranging from approximately 20 percent under the No Action Alternative to almost 50 percent under the SEIS action alternatives). In 2026, approximately three to five percent of modeled traces fall below 75 maf in 10 years under the five action alternatives/proposals and zero percent do so under the No Action Alternative.

B.4.2 Lake Mead

Monthly Pool Elevations

Figure B-7 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 three SEIS alternatives and the three proposals through 2026.

Figure B-7
Lake Mead End-of-Month Pool Elevations



The upper bounds of the clouds in **Figure B-7** vary slightly between all alternatives/proposals in 2024 and 2025, and vary more in 2026. In 2026, the No Action Alternative has the lowest upper bound of modeled Lake Mead elevations and the Utton Center Proposal has the highest range of elevations. The six alternatives/proposals vary more significantly at the lower bounds of the clouds. In 2024, modeled Lake Mead elevations under the two SEIS action alternatives decline below elevation 926 feet by December, and each fluctuates between 895 feet (dead pool, or the elevation at which Lake Mead can no longer regularly release water) and 933 feet through the rest of the period of analysis. The lower bound of the No Action Alternative cloud declines more slowly, reaching dead pool in January 2026, and does not recover. The three proposals all have a provision to protect elevation 1,000 feet at Lake Mead, and therefore the lower bounds of their modeled elevations are all consistently at 1,000 feet.

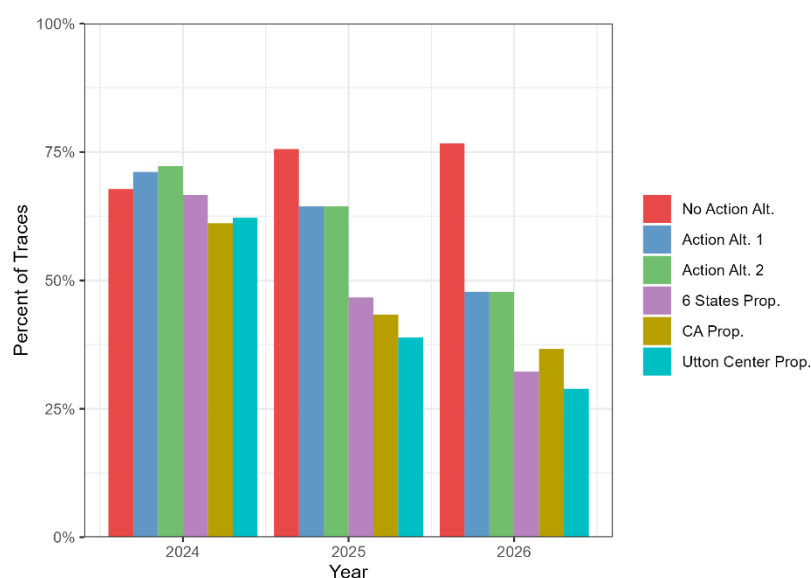
In **Figure B-7** the 10th percentiles of modeled Lake Mead elevations under the six alternatives/proposals exhibit the same relative dynamics as those described for the lower bounds of the clouds. At the median, the No Action Alternative declines slowly through the period of analysis and the other alternatives/proposals diverge at different times: in March 2024, the Utton Center Proposal median elevation climbs 17 to 25 feet higher than the other medians due to increased balancing releases from Lake Powell, reaching approximately 1,035 feet in September 2024 and continuing to increase over time; the CA Proposal climbs more slowly and does not reach approximately 1,035 feet until late in 2026; the two SEIS action alternatives do not diverge from the No Action Alternative until April 2025 and then reach an approximate Lake Mead elevation of 1,040

feet by the end of the period of analysis. At the 90th percentiles of modeled elevations, the No Action Alternative is significantly lower than all action alternatives/proposals, the two action alternatives and the 6-States Proposal and the CA Proposal follow similar trajectories, and the Utton Center Proposal is the highest at the 90th percentile.

Percentages of Traces Below Critical Elevations

Figure B-8 shows the percent of modeled traces that fell below Lake Mead elevation 1,020 feet at any time during a year for the period of analysis. Elevation 1,020 feet was identified as a critical elevation in the 2019 DCP.

Figure B-8
Lake Mead Minimum Calendar Year Elevation, Percent of Traces Less than Elevation 1,020 feet msl

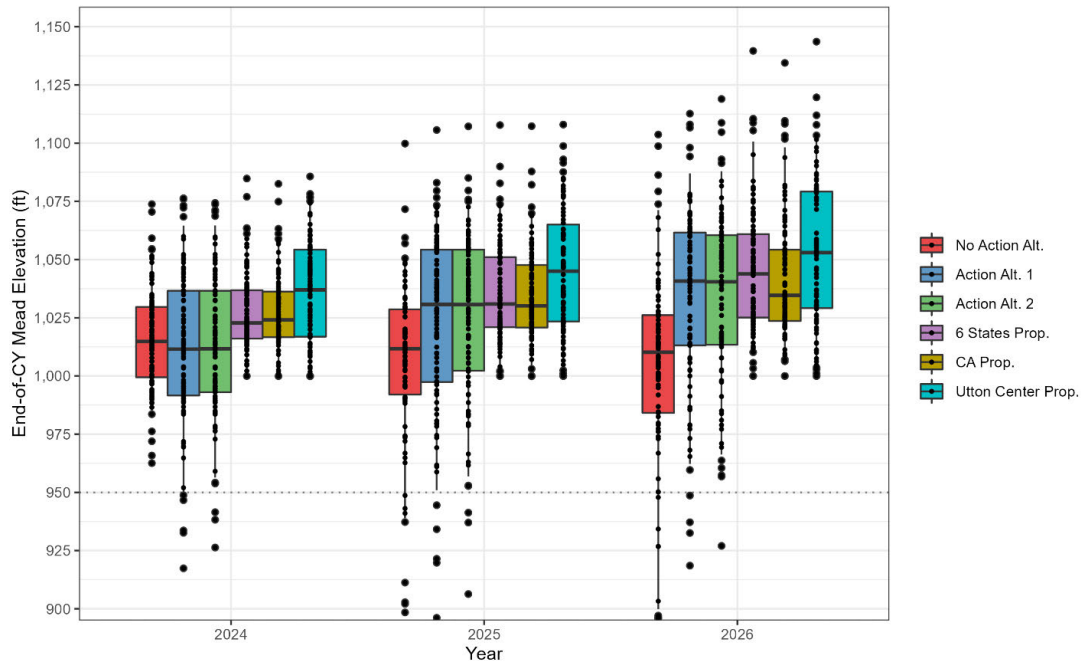


In **Figure B-8**, all six alternatives/proposals have similar percentages of modeled traces falling below Lake Mead elevation 1,020 feet in 2024; the No Action Alternative has approximately 68 percent, Action Alternative 2 has the highest percentage at 72 percent, and the CA Proposal has the fewest traces falling below at approximately 61 percent. Over the period of analysis, the percentages of traces falling below elevation 1,020 feet declines under all action alternatives/proposals, and in 2026 the Utton Center Proposal results in the fewest traces at 29 percent and the two action alternatives result in the most traces at 48 percent. The No Action Alternative exhibits increasing percentages of traces falling below Lake Mead elevation 1,020 feet; in 2026, 77 percent of the traces under this alternative fall below the critical threshold.

Annual Pool Elevations

Figure B-9 shows the distributions of modeled Lake Mead elevations on December 31 in 2024, 2025, and 2026. Each dot is the EOY elevation produced by a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines.

Figure B-9
Mead EOY Pool Elevations



The distributions of modeled EOY Lake Mead elevations for the six alternatives/proposals shown in **Figure B-9** exhibit the same dynamics as those described under **Figure B-7**. The medians of the No Action Alternatives decline from 2024 to 2026 and the variability increases, specifically as the lower ends of the distributions extend. Approximately 10 percent of modeled traces end the year below minimum power pool (950 feet) in 2025 and 2026 under the No Action Alternative. The two SEIS action alternatives display wide ranges in all years, but the medians and ranges consistently shift upward over the period of analysis. The three submitted proposals all include a provision to protect Lake Mead elevation 1,000 feet, so the bottoms of their ranges are truncated. The Utton Center Proposal has the highest median and range of elevations in all years due to the assumption of more balancing releases at lower elevations from Lake Powell.

Annual Releases

Figure B-10 shows the distributions of modeled annual releases from Hoover Dam in 2024, 2025, and 2026. Each dot is the volume release during that year under a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines.

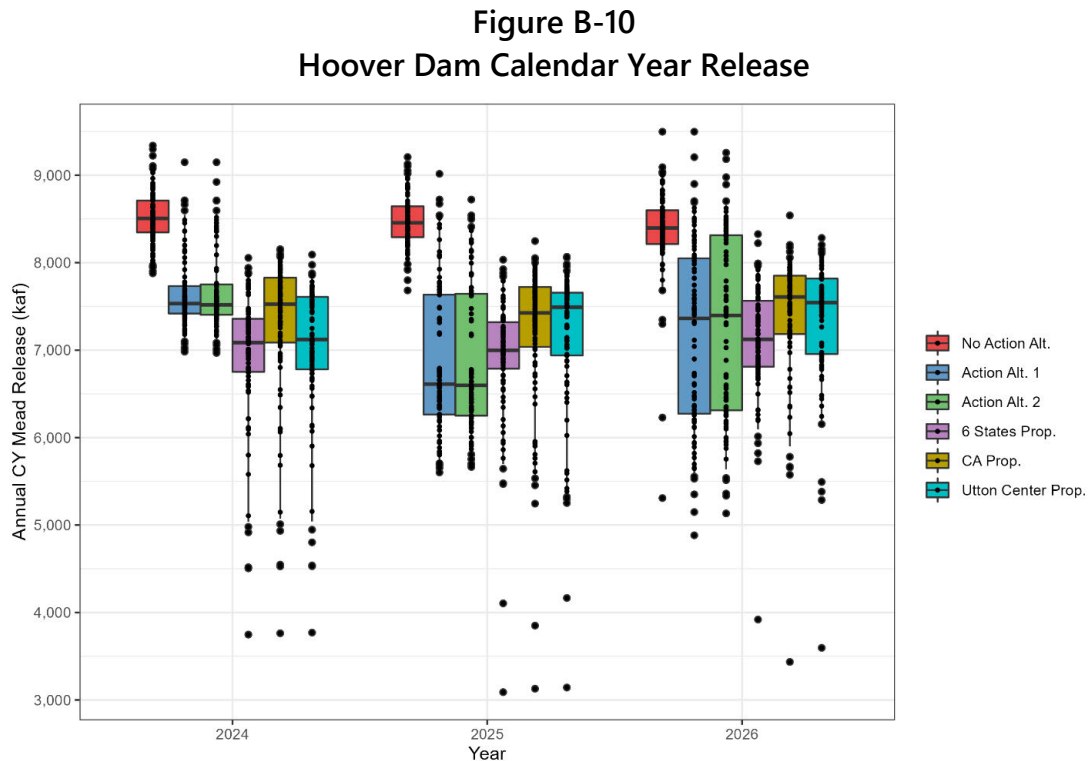
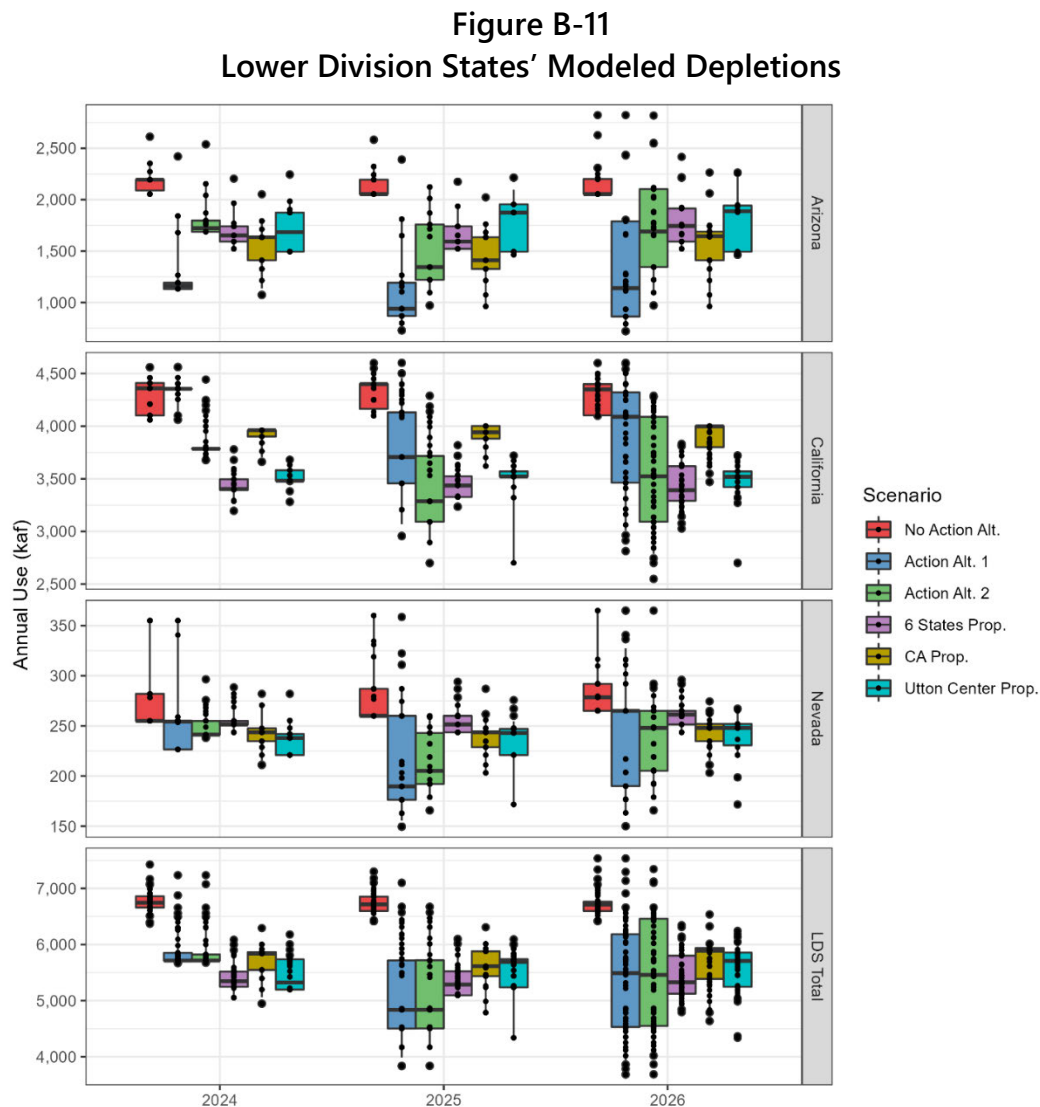


Figure B-10 shows that under the No Action Alternative, the modeled releases from Hoover Dam in 2024 and 2025 have ranges of approximately 1.5 maf, with medians that decline slightly from approximately 8.51 to 8.46 maf. In 2026 the median release again declines slightly, but the bottom of the range extends down to approximately 5.3 maf because releases are limited by the amount of water physically available when Lake Mead is at dead pool. In 2024, the two SEIS action alternatives have a higher overall range of releases with less variability than the submitted proposals, but this relationship changes in 2025 when the two action alternatives' additional shortage volumes take effect below Lake Mead elevation 1,040 feet. Because the three submitted proposals have a provision that protects Lake Mead elevation 1,000 feet, the distributions for all three have multiple traces where less than 5.0 maf is released in 2024 and 2025. In 2026, the medians of releases under the five action alternatives/proposals are all between approximately 7.1 and 7.6 maf and the median modeled release from Hoover Dam under the No Action Alternative is approximately 8.4 maf.

B.4.3 Shortage Sharing and Water Delivery

Lower Division Depletions by State

Figure B-11 shows the distributions of modeled Lower Division States' depletions⁷ in 2024, 2025, and 2026. Each dot is the volume of water requested during that year under a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines. From top to bottom, the four panels display depletions for Arizona, California, Nevada, and Lower Division States total, respectively. The figure is oriented to facilitate the comparison of a single state's modeled depletions across each alternative/proposal over the period of analysis. **Figure B-11** reports the depletions that would occur after adjustments to demands based on ICS delivery or creation, shortages, and DCP contributions but before any system or unassigned shortages occur.



⁷ Modeled depletions, that is, modeled consumptive use

In the top panel of **Figure B-11**, Arizona's modeled annual depletions are highest under the No Action Alternative and lowest under Action Alternative 1. Part of the reason for the seemingly high depletions under the No Action Alternative is that the reductions that result from Lake Mead being at dead pool, where deliveries are limited to inflow minus evaporation, are not recorded under this metric. In Action Alternative 1, shortages are applied based exclusively on the concept of priority, so Arizona's junior users are significantly impacted. When the additional shortage volumes in the action alternatives take effect starting in 2025, the distributions of modeled Arizona depletions shift further down. Action Alternative 2 and the three submitted proposals have median depletion volumes that are generally more like each other while the other two alternatives (No Action Alternative and Action Alternative 1) bound the extremes.

In the second panel of **Figure B-11**, modeled annual depletions for California are highest in the No Action Alternative throughout the period of analysis (see discussion about Arizona depletions for additional context). In 2024, Action Alternative 1 shows the same median and range of depletions, but the medians and ranges for this alternative decrease when additional shortage volumes take effect starting in 2025. The medians and ranges of California depletions under Action Alternative 2 are lower than the other two SEIS alternatives due to the assumption that shortages would be distributed in the same percentage across all Lower Basin water users. Because the shortage volumes in the submitted proposals are consistent throughout the period of analysis, the distributions relative to one another are consistent, with the CA Proposal resulting in higher depletions than the other two proposals because it assumes that shortages will be distributed in a way that is more aligned with priority than proportionality.

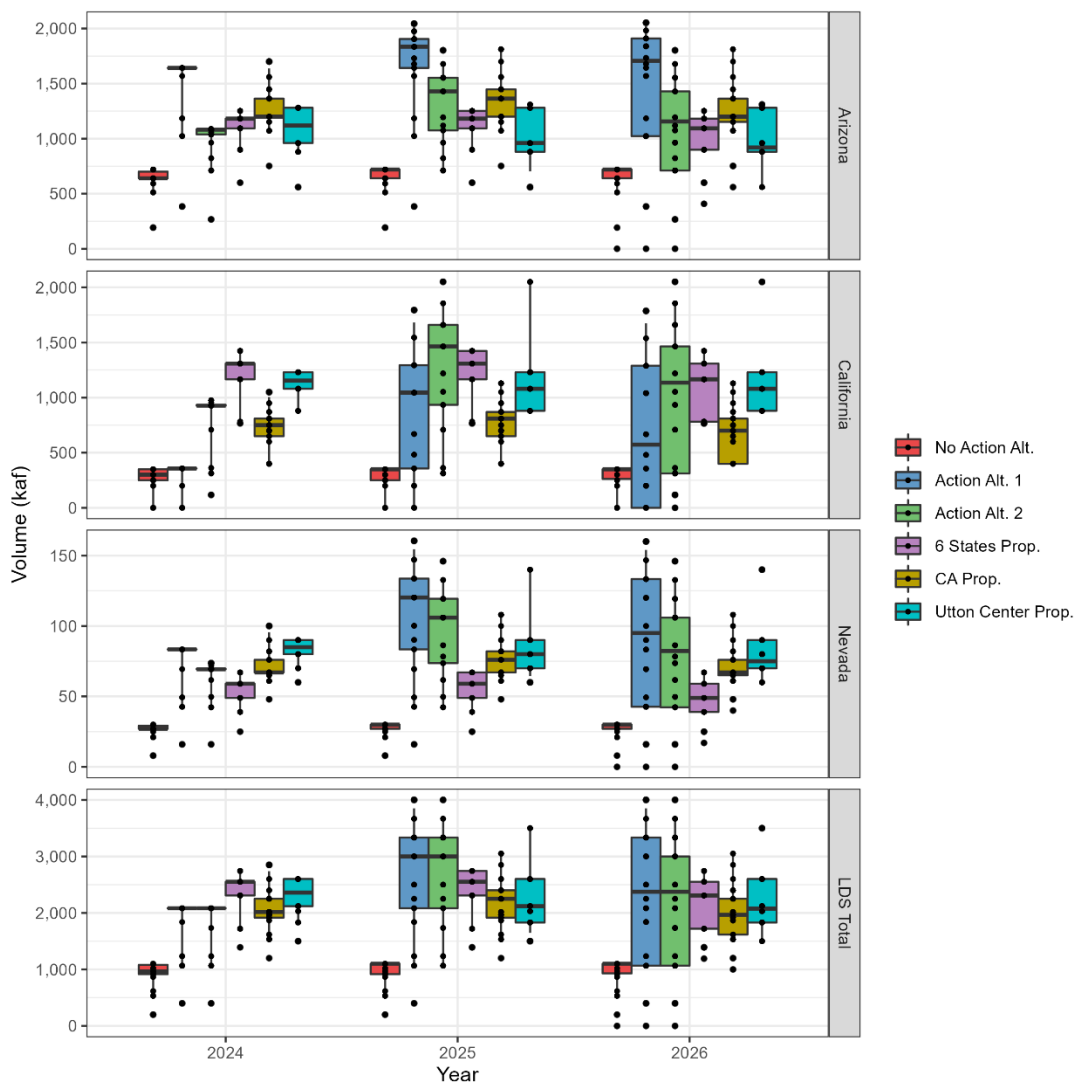
The modeled annual depletions for Nevada are shown in the third panel of **Figure B-11**. As in the other two states, the No Action Alternative has higher medians and ranges than the five action alternatives/proposals but the differences are smaller because, for most traces under the No Action Alternative, the model assumes that Nevada does not request the maximum amount of water available to it. The medians and distributions under the two SEIS action alternatives decline from 2024 to 2025 due to the additional shortage volumes, but the medians rebound in 2026 and are similar to the medians of the three submitted proposals. The absolute and relative medians and ranges for the three submitted proposals are steady over time.

The bottom panel of **Figure B-11** shows a comparison of how total modeled Lower Division States' depletions were impacted by different alternatives/proposals. In 2024, the two SEIS action alternatives show approximately the same median depletions as the three submitted proposals. In 2025, when the additional shortages take effect, the medians and distributions of the two SEIS action alternatives decline and, while the medians rebound in 2026, the variability increases and approximately 50 percent of modeled traces result in depletions lower than 5.5 maf. The medians and ranges for the three submitted proposals are relatively consistent throughout the period of analysis but do not reflect the unassigned shortages necessary to protect elevation 1,000 feet at Lake Mead.

Annual Shortage and DCP Contribution Volumes by State

Figure B-12 shows the distributions of modeled shortages plus DCP contributions to Lower Division States in 2024, 2025, and 2026. Each dot is the volume of water required to meet DCP contributions, 2007 ROD shortages, and additional proposed shortages during that year under a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines. From top to bottom, the four panels display shortage and DCP contributions for Arizona, California, Nevada, and Lower Division States total, respectively. The figure is oriented to facilitate the comparison of a single state's shortage and DCP contributions across each alternative/proposal over the period of analysis.

Figure B-12
Distribution of Lower Division Shortages and DCP Contributions



The distributions of modeled Arizona shortages and DCP contributions shown in the top panel of **Figure B-12** reflect dynamics over time and between alternatives/proposals that have been observed in previous figures and discussion. The No Action Alternative consistently applies magnitudes that are approximately half or less of the magnitudes that are applied in the five action alternatives/proposals. The magnitudes of reductions applied under the two SEIS action alternatives generally increase in 2025 and 2026 when additional volumes below Lake Mead elevation 1,040 feet take effect. Delivery reductions under Action Alternative 1 and the CA Proposal are higher than under the other three alternatives/proposals because they distribute 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 second panel in **Figure B-12** shows the same dynamics in modeled distributions of California's shortages and DCP contributions that were described for Arizona, except that the relative higher and lower magnitudes between the five action alternatives/proposals are reversed: distributing shortages based fully or largely on proportionality results in higher reductions for California under Action Alternative 2, the 6-States Proposal, and the Utton Center Proposal, and using the priority system as a basis as Action Alternative 1 and the CA Proposal result in lower delivery reduction volumes for California.

With respect to modeled shortages and DCP contributions assigned to Nevada, panel three of **Figure B-12** shows that distributing shortages based on the concept of priority vs. 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. While Action Alternative 1 shows greater reductions for Nevada than Action Alternative 2 (priority and percentage, respectively), and the CA Proposal imposes more reductions than the 6-States Proposal (priority vs. proportionality, respectively), the Utton Center Proposal, which is more closely aligned with proportionality with respect to Arizona and California, assigns more shortage to Nevada than the other proportionally based alternatives/proposals. Relatively small magnitudes of differences between alternatives/proposals have an outsized effect on Nevada shortages and DCP contributions because the basic apportionment is much smaller than for the other states.

Panel four of **Figure B-12** shows that in 2024 and 2026, overall shortages and DCP contributions across all states have similar medians among all action alternatives/proposals. In 2025, the two SEIS action alternatives have median reductions that are 450,000 to 880,000 af higher than those of the other action alternatives/proposals when the additional shortage volumes below Lake Mead elevation 1,040 feet take effect. These higher shortage volumes rapidly boost Lake Mead's elevation in the modeled traces such that in 2026, lower shortages resulting from higher tiers cause the median delivery reductions under the two SEIS action alternatives to fall closer to those of the other three action alternatives/proposals. Additionally, the additional unassigned shortages necessary to protect Lake Mead elevation 1,000 feet in the submitted proposals are not reflected in **Figure B-12**, while the larger additional specified shortages at lower Lake Mead levels included in the action alternatives are reflected in **Figure B-12**.

System Shortages and Unassigned Shortages

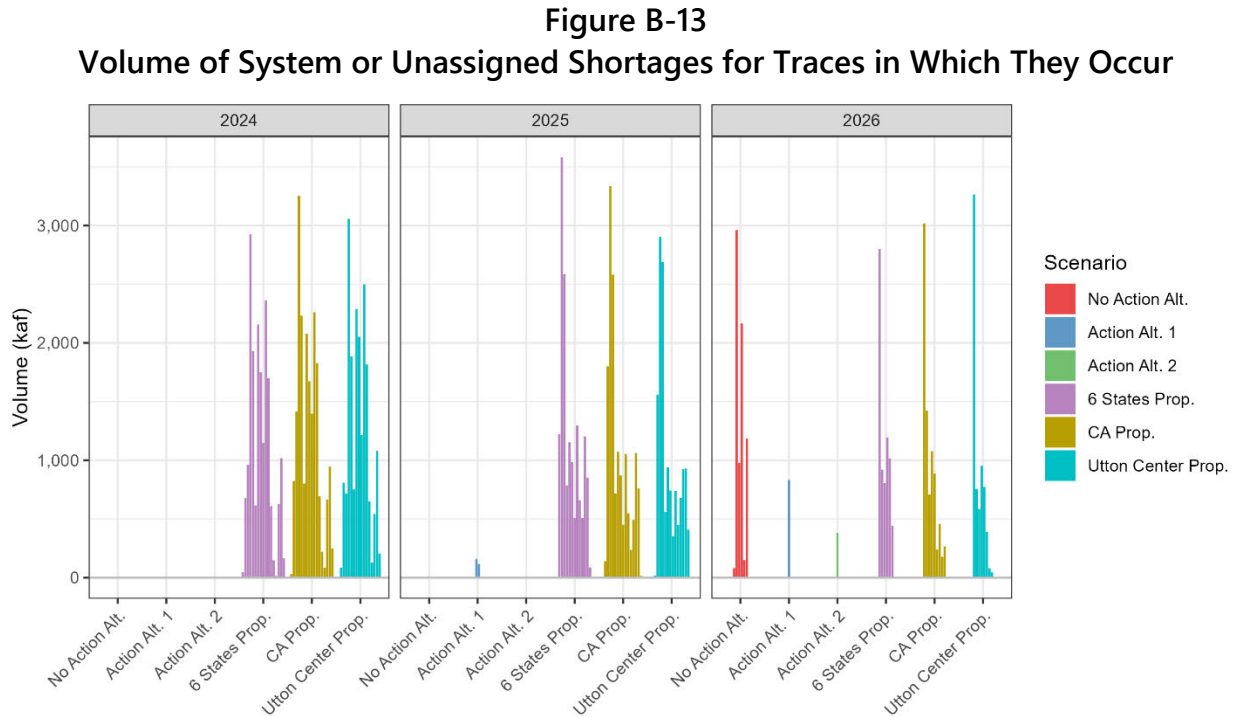
The previous figures in this section only showed the impacts of the different alternatives/proposals based on specified shortage volumes and DCP contributions that were assumed to be taken by a specific water user within a distinct elevation band in Lake Mead. There are two ways that shortages other than those specified can occur. Under the three SEIS alternatives, if Lake Mead reaches dead pool and user depletion requests cannot be fully met because there is not enough water in the reservoir, “system shortage” at dead pool occurs. The three submitted proposals all have a provision that protects Lake Mead elevation 1,000 feet, but they do not specify what users take the shortages necessary to achieve the protection. These are called “unassigned shortages.” **Table B-4** shows the percentages of modeled traces under each alternative/proposal that result in either system shortage or unassigned shortage in each year of the analysis period.

Table B-4
Percent of Traces with System or Unassigned Shortages

Alternative/Proposal	2024	2025	2026
No Action Alternative	0%	0%	7%
Action Alternative 1	0%	2%	1%
Action Alternative 2	0%	0%	1%
6-States Proposal	19%	14%	7%
CA Proposal	19%	17%	10%
Utton Center Proposal	18%	16%	9%

Table B-4 shows that all three submitted proposals result in significant incidence of unassigned shortages in 2024 and 2025, with some decline in prevalence in 2026. This is because approximately 50 percent of modeled traces in 2024 start below elevation 1,025 feet (see **Figure B-7**) and, therefore, are already close to requiring more than the specified shortage volumes within the year. The No Action Alternative does not result in system shortages until 2026, but the 7 percent of traces that reach dead pool require significant additional reductions, as shown in **Figure B-13**.

For each alternative/proposal, **Figure B-13** shows the modeled volume of system or unassigned shortage that resulted from each trace in which it occurred in 2024, 2025, and 2026. In every year, the three submitted proposals show nearly identical patterns and volumes of unassigned shortage. The maximum volumes of unassigned shortages under the proposals range from 2.8 to 3.6 maf with a median of approximately 1.0 maf. While the frequency of traces resulting in unassigned shortages declines over time, the ranges of all three submitted proposals are consistent with the values exhibited in 2024. In 2026, the No Action Alternative results in a max system shortage of approximately 3.0 maf and a median of approximately 1.0 maf. Action Alternative 1 results in two



traces where an average of approximately 140 kilo acre feet (kaf) of system shortage occurs in 2025. In 2026, Action Alternative 1 and Action Alternative 2 each result in a single trace with 832 and 380 kaf of system shortage, respectively.

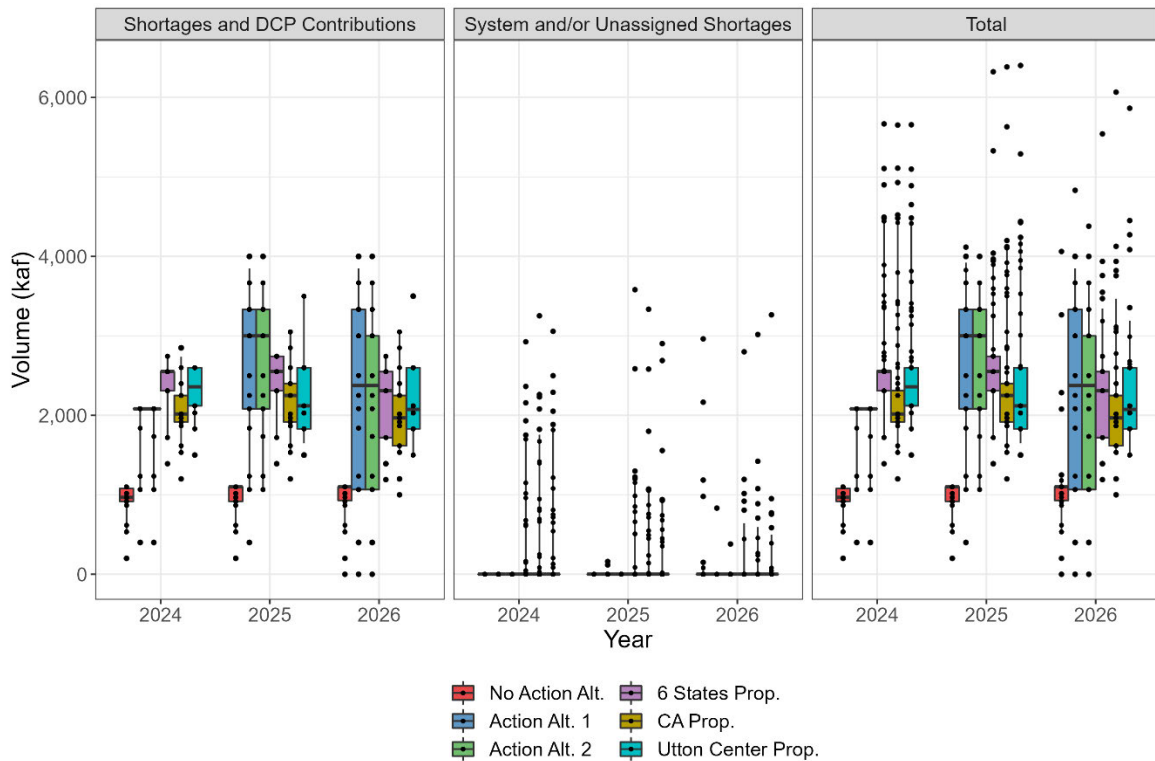
Total Shortages

Figure B-14 shows the distributions of modeled shortages and DCP contributions in 2024, 2025, and 2026. Each dot is the volume of water reduced during that year under a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines.

From left to right, panels one, two, and three of **Figure B-14** show modeled shortages and DCP contributions that are specified in the alternatives/proposals, system and/or unassigned shortages, and the sum of these two categories (total shortages and DCP contributions), respectively.

The left panel of **Figure B-14** shows the same distributions of modeled shortages and DCP contributions that were presented in the bottom panel of **Figure B-12**. See that description for discussion. The center panel shows, in boxplot form, the modeled traces that resulted in system or unassigned shortages that were described in **Figure B-13**. See that description for discussion. These two panels are included in **Figure B-14** to provide context for the right panel.

Figure B-14
Lower Division States' Total Shortages



The right panel of **Figure B-14** shows how the ranges of overall shortages and DCP contributions shift when system or unassigned shortages are added to the shortages and DCP contributions specified in each alternative/proposal. In the left panel, the No Action Alternative appears to only result in a maximum of approximately 1.1 maf in any modeled trace. However, when system shortage is included, in 2026, reductions up to 4.0 maf occur because Lake Mead is at dead pool. The distributions of total reductions for the two SEIS action alternatives are nearly identical in the left and right panels because annual deliveries are almost never affected by Lake Mead reaching dead pool (even though both alternatives do rarely fall to dead pool in 2025 and or 2026; see **Table B-4** and **Figure B-7**).

The ranges of modeled shortages and DCP contributions for the three submitted proposals expand significantly in the right panel of **Figure B-14** when compared with the distributions in the left panel. Without accounting for unassigned shortages, the maximum reductions in 2025 and 2026 for the 6-States Proposal, the CA Proposal, and the Utton Center Proposal are 2.7, 3.0, and 3.5 maf, respectively. **Figure B-13** and the middle panel of **Figure B-14** show that the magnitudes of unassigned shortages can be as high as the specified shortages and DCP contributions. The distributions of total shortages and DCP contributions in the right panel show that the maximum volumes for all three proposals are near or above 6.3 maf throughout the period of analysis.

B.5 Summary

At Lake Powell, modeling under the five action alternatives/proposals shows similar monthly and EOWY elevation ranges and identical frequencies of reaching the critical elevation of 3,490 feet. Compared with the No Action Alternative, all five action alternatives/submitted proposals have much higher lower bounds of elevations and minimal incidence of reaching 3,490 feet because they explicitly protect elevation 3,500 feet. The five action alternatives/proposals show variation over time and are compared with one another in their distributions of Glen Canyon Dam releases based on whether they include balancing releases below Lake Powell elevation 3,575 feet and the volumes of specified releases below 3,575 feet, where Lake Powell sits for the majority of analyzed traces throughout the period of analysis. The two SEIS action alternatives, the 6-States Proposal, and the CA Proposal have no or minimal balancing below 3,575 feet and their modeled median releases under are stable over time at 7.0 or 7.48 maf with ranges that tend to increase over time; the Utton Center Proposal median modeled Glen Canyon Dam releases are on average 7.8 maf throughout, but the variability is wider because Lake Powell always balances volumes above certain elevations. The medians of the No Action Alternative are similar to the medians of the other five alternatives/proposals, but the ranges in each year are generally smaller. Because of the assumption of protecting Lake Powell elevation 3,500 feet, the driest modeled traces result in 10-year Lees Ferry gage flows less than 82.3 maf in 2024 under the five action alternatives/proposals, with the share of these traces growing through 2026. In 2026, 3 to 5 percent of traces fall below 75 maf over 10 years under the action alternatives/proposals. The different assumptions about balancing below Lake Powell elevation 3,575 feet cause more varied behavior at the medians of 10-year flows under the action alternatives/proposals.

At Lake Mead, the submitted proposals differ from the SEIS alternatives because they explicitly protect elevation 1,000 feet. Thus, while 10 percent or more of the traces modeled under the three SEIS alternatives fall below 1,000 feet and some fall to dead pool, no traces do so under the submitted proposals. Median elevations at Lake Mead are higher for the submitted proposals than for the two SEIS action alternatives because they assume higher shortage volumes in 2024 (and in the case of the Utton Center Proposal, it is higher than all action alternative/proposals because it releases more water from Lake Powell due to balancing releases). When additional shortage volumes below elevation 1,040 feet take effect in 2025, median modeled Lake Mead elevations under the two SEIS action alternatives catch up to the submitted proposals. In 2026, median monthly and end-of-calendar year elevations under the No Action Alternative are approximately 10 and 40 feet lower, respectively, than the medians under the other alternatives/proposals. Under the No Action Alternative, 77 percent of modeled traces fall below Lake Mead elevation 1,020 in 2026 compared with approximately 30 to 50 percent of traces under the other alternatives/proposals. Releases from Hoover Dam are significantly lower under the five action alternatives/proposals than the releases modeled under the No Action Alternative because they apply additional shortages. The release medians and ranges for the three submitted proposals are generally consistent over the period of analysis, while the releases under the two SEIS action alternatives decrease and vary more widely after additional shortage volumes take effect in 2025.

In terms of shortage sharing and water deliveries to the Lower Division States, there are three major factors that drive the differences among the five action alternatives/proposals: (1) when shortages

take effect, (2) how shortages are distributed among users, and (3) whether Lake Mead elevation 1,000 feet is protected. Overall, the submitted proposals result in higher modeled shortages (and lower modeled depletions) in 2024 than the two SEIS action alternatives because the volumes they specify are greater than those of the two SEIS action alternatives for the same elevation bands in Lake Mead. In 2025 these positions reverse, and the delivery reductions under the two SEIS action alternatives are significantly higher because additional shortage volumes below Lake Mead elevation 1,040 feet are modeled. The result of these larger volumes is that Lake Mead elevations increase rapidly in 2026, leading to declines in delivery reduction volumes under the two SEIS action alternatives. The 2026 volumes under the two SEIS action alternatives are similar to the volumes modeled under the three submitted proposals.

The additional shortages applied to individual states vary among the five action alternatives/proposals depending on how the additional shortage volumes are distributed. Action Alternative 1 and the CA Proposal use the concept of priority as the full or partial basis for distributing shortages. The result of this is that modeled shortages and DCP contributions are relatively higher in Arizona and lower in California compared with the other three action alternatives/proposals. In contrast, Action Alternative 2, the 6-States Proposal, and the Utton Center Proposal base shortage distributions fully or primarily on the proportions of water apportioned to different states or users, and this results in relatively higher magnitudes of reductions in California and lower reductions in Arizona. The effects on Nevada of the two approaches to distributing shortages follow similar patterns to the effects on Arizona, though the Utton Center Proposal deviates from this.

The two SEIS action alternatives approach shortages at Lake Mead elevations below 1,000 feet differently from the three submitted proposals: the action alternatives define specific shortage volumes down to dead pool in Lake Mead and distribute them to users; the submitted proposals protect Lake Mead elevation 1,000 feet by reducing deliveries as much as necessary to protect that elevation. When reductions to protect 1,000 feet are required, the submitted proposals do not specify which users take these shortages, resulting in large volumes of unassigned shortage in nearly 20 percent of modeled traces in 2024. The percentages decline slightly in 2025 and again in 2026, though they are still required 7 to 10 percent of the time depending on the proposal. When these shortages are required they can exceed 3.0 maf, meaning that the unassigned shortages can be as large as the specified shortages. When shortages and unassigned shortages are combined, the submitted proposals' maximum modeled shortages are near or above 6.0 maf in all years during the period of analysis. The two SEIS action alternatives also exhibit additional shortages when Lake Mead does not physically have enough water to meet deliveries because it is at dead pool (system shortages). These system shortages are not attributed to any specific user, so they are similar to unassigned shortages in that they do not necessarily show up in analyses of shortages and DCP contributions. In the few modeled traces that system shortages occur, the magnitudes are between 117 kaf and 832 kaf. The No Action Alternative also includes system shortages that are more frequent and larger magnitude than the action alternatives.

Attachment B-1

Sensitivity Analysis of Potential DROA Contributions
from 6-States Proposal

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Attachment B-1. Sensitivity Analysis of Potential DROA Contributions from 6-States Proposal

This attachment analyzes annual releases from Glen Canyon Dam and Hoover Dam to compare two different assumptions about potential DROA contributions that were used in the 6-States Proposal. The analysis is limited to releases from Glen Canyon Dam and Hoover Dam because these are the variables that best show the differences due to the potential DROA contributions and because these variables aggregate the effects of potential DROA contributions on other variables, for example, Hoover Dam releases encompass changes to shortage tiers and volumes for all Lower Division States.

The “6-States Proposal: 500 kaf” scenario is identical (renamed for clarity of comparisons) to the “6-States Proposal” described previously in Appendix B and uses all the same assumptions described in **Section B.3.2** for the 6-States Proposal, including potential DROA contributions up to 500 kaf per DROA year. The “6-States Proposal: 100 kaf” scenario uses all of the same assumptions as the “6-States Proposal: 500 kaf” scenario, except it assumes potential DROA contributions up to 100 kaf per DROA year.

B-1.1 Annual Releases

Figure Attachment B-1-1 shows the distributions of modeled Glen Canyon Dam water year releases in 2024, 2025, and 2026. Each dot is annual release resulting from a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines.

Figure Attachment B-1-1 shows minimal differences in modeled water year releases from Glen Canyon Dam resulting from the 100-kaf assumption about potential DROA releases vs. the 500-kaf assumption. In the driest traces 5 percent of traces, releases are approximately 400 kaf higher in the 500 kaf assumption throughout the period of analysis, and this effect also shifts the median in 2026.

Figure Attachment B-1-2 shows that the different releases from Glen Canyon Dam that result from the 100-kaf vs. the 500-kaf assumptions have minimal impacts on releases from Hoover Dam. The differences in Glen Canyon Dam releases in the driest traces can propagate to larger magnitude differences in more traces if the additional volumes impact tiers of delivery reductions.

Figure Attachment B-1-1 Glen Canyon Dam Water Year Releases

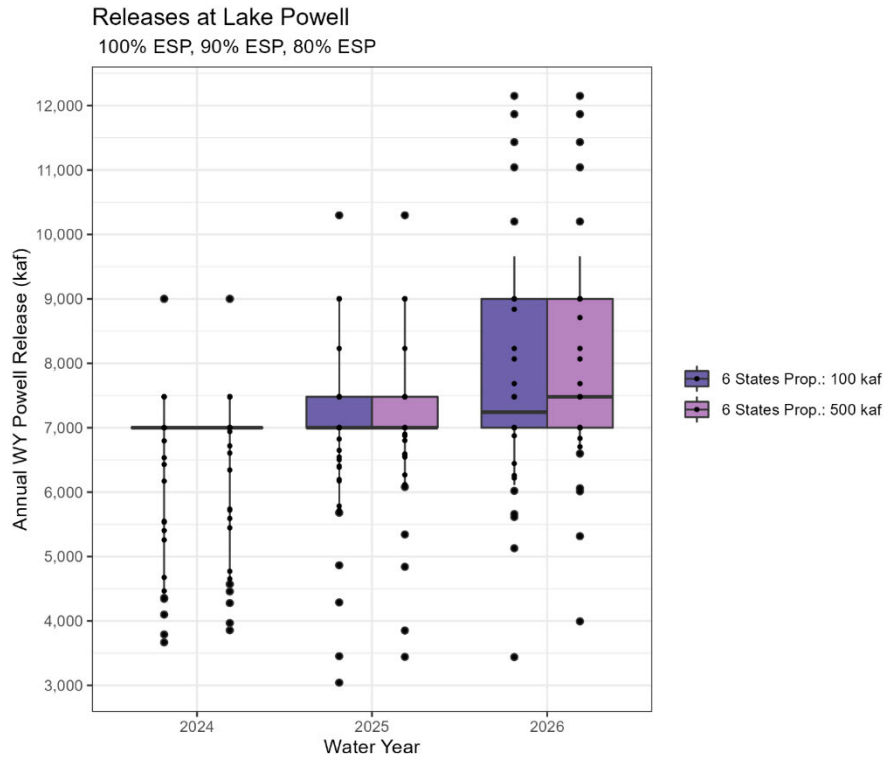
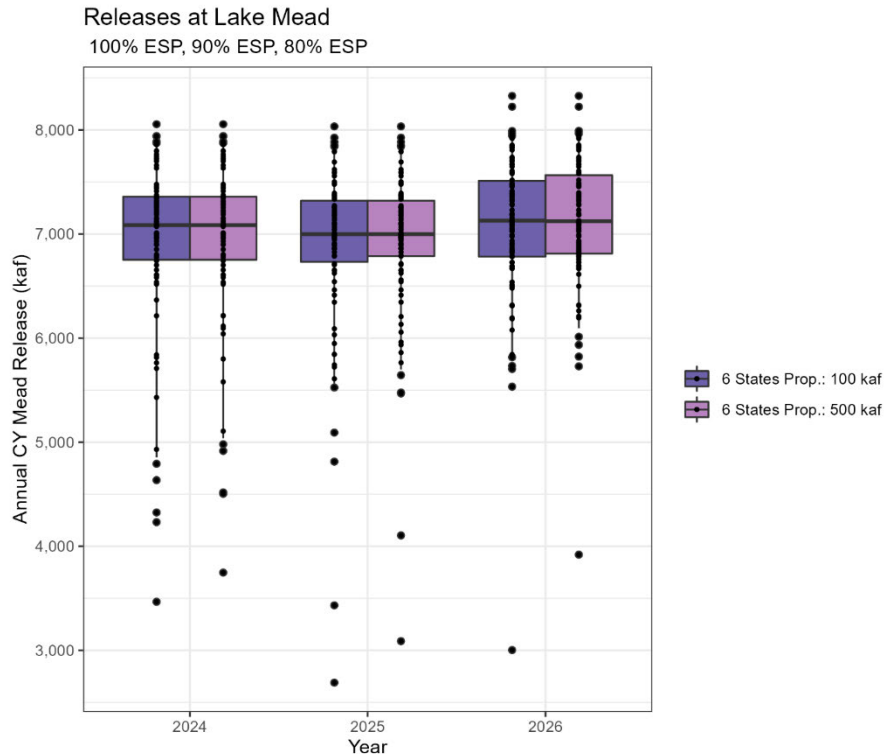


Figure Attachment B-1-2
Hoover Dam Calendar Year Releases



B-1.2 Summary

The different assumptions regarding potential DROA contributions have minimal impacts on Glen Canyon Dam releases except under the driest modeled traces. In the driest traces, the 500 kaf assumption results in the possibility for higher releases from Glen Canyon Dam than the 100 kaf assumption. When releases from Glen Canyon Dam are increased as a result of assuming 500 kaf potential DROA contributions instead of 100 kaf potential DROA contributions, releases from Hoover Dam also increase in some instances, with more pronounced effects if they result in a change in shortage tier.

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Attachment B-2

Submitted Proposals

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**Colorado River Basin State Representatives of
Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming**

January 31, 2023

The Honorable Tanya Trujillo
Assistant Secretary, Water & Science
U. S. Department of the Interior
Washington, DC 20240

The Honorable Camille Calimlim Touton
Commissioner
Bureau of Reclamation
Washington, DC 20240

Re: Notice of Intent to Prepare a Supplemental Environmental Impact Statement

Dear Assistant Secretary Trujillo and Commissioner Touton:

Consistent with the Department of the Interior (Interior), Bureau of Reclamation's (Reclamation) November 17, 2022, *Notice of Intent To Prepare a Supplemental Environmental Impact Statement for December 2007 Record of Decision Entitled Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations For Lake Powell and Lake Mead* (Notice), 87 FR 69043 (November 17, 2022), the undersigned Governors' Representatives submit this set of modeling assumptions for an alternative to be evaluated as a potential consensus-based set of actions consistent with the purpose and need set forth in the Notice (Consensus-Based Modeling Alternative or CBMA).

We ask that Reclamation model and evaluate CBMA impacts in the Draft Supplemental Environmental Impact Statement (SEIS) to be issued pursuant to the National Environmental Policy Act of 1969 (NEPA) before identifying a preferred alternative. The CBMA will promote NEPA's goal of fostering more informed decision-making. Therefore, we request that Reclamation advance the CBMA for further evaluation in the NEPA process for comparative purposes. We recognize that impediments may ultimately preclude the CBMA from being incorporated into a consensus-based set of actions to guide the operation of Glen Canyon and Hoover Dams.

Negotiations to implement actions contemplated by this CBMA, both by and between the undersigned and by and between other necessary parties, have not yet been completed, and in many cases have not yet begun. Accordingly, the States and water users expressly reserve their rights under applicable law, including, but not limited to, the Law of the River as broadly defined, and this submittal is not intended to be and shall not be construed in any way as a waiver of any such rights.

EXECUTIVE SUMMARY

The Notice anticipates that alternatives would make specific modifications to Lake Powell and Lake Mead operations governed by the Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead ('07 Guidelines) to prevent Lake Powell and Lake Mead from falling to critically low elevations impacting water delivery or power production from either reservoir in 2023 and 2024. In particular, Reclamation anticipates that alternatives will propose revisions to reduce annual Lake Powell release volumes governed by Sections 6.C. (Mid-Elevation Release Tier) and

6.D. (Lower Elevation Balancing Tier) of the '07 Guidelines to protect Glen Canyon Dam to ensure the deliverability of water downstream and power production. The Notice further anticipates that alternatives would provide for increased Lower Division State (Arizona, California, and Nevada) delivery reductions when Lake Mead is below elevation 1050 ('07 Guidelines Section 2.D.1.b.) or 1025 ('07 Guidelines Section 2.D.1.c.).¹

As more fully set forth below, the CBMA includes the elements anticipated by Reclamation's Notice. In addition to revising the specific '07 Guidelines provisions referenced in the Notice, the CBMA assesses 1.543 million acre-feet (maf) per year of reductions among all Lower Basin Contractors when Lake Mead is below elevation 1145 for the protection of critical infrastructure (Infrastructure Protection Volumes, hereinafter referred to as IPV). The undersigned believe implementation of the CBMA would protect Glen Canyon Dam infrastructure, water deliveries, and power production, and adequately mitigate the risk that either Lake Powell or Lake Mead reaches dead pool.

LAKE POWELL OPERATIONS

Reduced releases at Glen Canyon Dam would be accomplished by modeling operations under Sections 6.C. and 6.D. of the '07 Guidelines as follows:

1. Raise the lower elevation of the Mid-Elevation Release Tier (MERT) from elevation 3525 to elevation 3550 and fix the annual release volume in the MERT at 7.48 maf.
2. Raise the upper elevation of the Lower Elevation Balancing Tier (LEBT) from elevation 3525 to elevation 3550 and fix the annual release at 7.0 maf without balancing releases.
3. Reduce releases as necessary to protect elevation 3500.

LAKE MEAD OPERATIONS

Reduced deliveries from Lake Powell must be coupled with reduced deliveries from Lake Mead or Lake Mead's existing storage will be quickly depleted. The CBMA incorporates the following modeling adjustments to the '07 Guidelines and to elevation-dependent Drought Contingency Plan (DCP) contributions required under the Lower Basin Drought Contingency Plan Agreement Dated May 20, 2019, and the incorporated LBOPs, to reduce Lake Mead outflows:

1. When Lake Mead is below 1145, Infrastructure Protection Volumes (IPV) consisting of evaporation and system losses in the amount of 1.543 maf are apportioned among all Contractors (as such term is defined in Section XI.F.9. of the '07 Guidelines) in accordance with the methodology outlined in Attachment 1, hereto.
2. Section 2.D.1.a. – no changes.
3. Section 2.D.1.b. – no longer applicable (see 4. below).

¹References to reservoir elevations throughout this correspondence are to January 1 most probable elevations as predicted by the preceding August 24-month study.

4. Section 2.D.1.c. – This provision, involving “Tier 3” shortages below elevation 1025, is moved up to elevation 1050 (i.e., elevation 1025 is replaced with elevation 1050), such that Arizona is apportioned 2.32 maf at elevation 1050 and below, and Nevada is apportioned 280,000 at elevation 1050 and below.
5. Arizona, California, Nevada, and Mexico would make DCP contributions in the amounts set forth in Table 1 of the LBOs as if Lake Mead is at or below elevation 1025 when the actual elevation of Lake Mead is at or below 1050. This would require for years when Lake Mead’s elevation is below 1050 feet DCP Contributions from Arizona in the amount of 240,000 acre-feet, from California in the amount of 350,000 acre-feet, and from Nevada in the amount of 10,000 acre-feet. To maintain parity and alignment of operations during those same years, Mexico would contribute 150,000 acre-feet towards Mexican Water Reserve (under the Binational Water Scarcity Plan of Minute 323).
6. In addition to the above, reductions at elevation 1030 and below and elevation 1020 and below are also part of this CBMA as follows:
 - a. At elevation 1030, a 250,000 acre-feet apportionment reduction in addition to all reductions at higher elevations that shall be apportioned 93,000 acre-feet to Arizona, 10,000 acre-feet to Nevada, and 147,000 acre-feet to California.
 - b. At elevation 1020, a 200,000 acre-feet apportionment reduction in addition to all reductions at higher elevations that shall be apportioned 75,000 acre-feet to Arizona, 8,000 acre-feet to Nevada, and 117,000 to California.
 - c. Additional reductions as necessary to protect elevation 1000.

Lake Powell and Lake Mead cannot be further diminished without unacceptable risk to the Colorado River System. Accordingly, to satisfy the Notice’s purpose and need, any preferred alternative must be sufficiently certain that system storage is maintained without reliance upon remote or speculative actions by third parties.

PARALLEL ACTIVITIES

The undersigned recognize that modifying the ’07 Guidelines is an important piece of the puzzle that might be formulated to protect and maintain the Colorado River’s ability to support 40,000,000 people in the Basin. However, other methods that help secure the water supply of the Basin have been proposed by Reclamation and others. These additional actions should be pursued with alacrity and in parallel with the operational changes contemplated by the SEIS.

One such action is beneficial use definitions and determinations under 43 C.F.R. Part 417 (Procedural Methods for Implementing Colorado River Water Conservation Measures with Lower Basin Contractors and Others). Each industrial, municipal, and agricultural user should be held to the highest industry standards in handling, using, and disposing of water; there is precious little water left to waste.

The Lower Colorado River Multi-Species Conservation Program provides Endangered Species Act compliance for operations of the Lower Colorado River, including water deliveries and hydropower. The actions contemplated in the preferred alternative will likely necessitate expanded compliance for lower Lake Mead elevations and reduced deliveries to all water users, including reductions to only those delivery volumes necessary to protect elevation 1,000 in Lake Mead. It is imperative this compliance moves swiftly and in parallel with this SEIS.

In addition to limiting releases from Glen Canyon Dam when Lake Powell drops below elevation 3550, measures to increase flows into Lake Powell may be needed to help protect water delivery infrastructure and hydropower operations. Accordingly, at appropriate elevations in the modified LEBT, there are parallel complementary actions that are not within the scope of this federal action. However, a reasonable range of their impacts, as further described below, should inform the modeling effort. Those actions include operations pursuant to the Drought Response Operations Agreement (DROA) and additional Upper Division State (UDS) considerations.

DROA planning and operations, including recovery, are conducted consistently with the DROA and existing authorities.² The CBMA includes assumptions regarding DROA releases from zero to 500,000 acre-feet per DROA Year (May 1 – April 30), which will conform to the DROA and its implementing documents and will be made only to help protect Lake Powell elevation 3500 feet.

Additional UDS considerations:

1. Hydrologic shortages are involuntary reductions in consumptive water use due to the lack of physical and legal availability of water. Hydrologic shortages occur to varying degrees annually and on a regular basis. Though hydrologic shortage quantification is complex and unique to each sub-basin each year, it should be estimated to inform this SEIS process using the best available science.
2. Voluntary contributions are voluntary reductions of consumptive use approved by the UDS to help protect elevations in Lake Powell for the duration of this SEIS. Voluntary contributions are generated from programs that result in reductions in consumptive use, such as the System Conservation Pilot Program, an Upper Basin Demand Management Program (if established), or similar actions. Voluntary contribution volumes will likely vary widely based on hydrologic conditions.

Finally, the SEIS should include modeling for the reconciliation of the 480,000 acre-feet withheld by the Secretary in Lake Powell in 2022, without making a final determination.

INCLUSION OF MEXICO

Mexico has been a progressive and dependable partner to the United States and Colorado River water users within the United States even as the worsening supply/demand imbalance has depleted storage within the system. In 2017's Minute 323 to the "United States-Mexico Treaty on Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande" signed February 3, 1944 ("1944 Water Treaty") for example, the United States and Mexico agreed on the "importance of aligning operations for

² 2019 Colorado River Drought Contingency Plan Authorization Act (Pub. L. 116-14).

both countries” and the need for their respective “governments and stakeholders to seek mechanisms to avoid reaching critically low reservoir elevations.” Glen Canyon dam’s infrastructure is currently threatened by significantly reduced inflows over the past two decades, in turn threatening to make deliveries to users in the Lower Basin difficult or impossible. We recognize that the Record of Decision will not determine actions regarding Mexico, and any participation shall be coordinated through the U.S. Section of the International Boundary and Water Commission. However, it is critical to consider the potential impacts of a range of actions including Mexico’s participation.

Accordingly, this CBMA and Attachment 1 hereto contemplate continued alignment of operations for users in both countries. Specifically, for modeling purposes, Mexico is allocated approximately 356,000 acre-feet of IPV reductions when Lake Mead’s elevation is below 1145, Mexico’s shortage volume and Mexico’s Water Reserve savings under Minute 323 is moved to Tier 3 along with the U.S. Contractors any time Lake Mead’s elevation is below 1050.

TERM

The Notice anticipates operational changes in 2024 but indicates that a selected alternative may “inform potential operations in the 2025 and 2026 operating years.” To protect the system through the expiration of the ’07 Guidelines, the undersigned suggest that any preferred alternative be sufficiently robust, even under very dry hydrology, to maintain Lake Powell at elevation 3500 and Lake Mead at elevation 1000 through at least 2026 or the establishment of new guidelines. The NEPA evaluation should similarly be robust enough to avoid a further supplementation process for years 2025 and 2026.

RESERVATION OF RIGHTS

By providing this CBMA, we do not waive any rights, including any claims or defenses, we may have or that may accrue under any existing federal or state law or administrative rule, regulation, or guidelines, including without limitation the Colorado River Compact of 1922, the Boulder Canyon Project Act, the Mexican Water Treaty of 1944, the Upper Colorado River Basin Compact of 1948, the Consolidated Decree of the U.S. Supreme Court in *Arizona v. California*, the Colorado River Storage Project Act of 1956, the Colorado River Basin Project Act of 1968, and any other applicable provision of federal law, rule, regulation, or guideline, including the Administrative Procedure Act. Any failure by the undersigned to address specific aspects of the SEIS, shall not be construed as an endorsement or an admission with respect to any factual or legal issue for the purposes of any future legal, administrative, or other proceeding. Moreover, we reserve the right to provide further comments and engage with Reclamation as it proceeds with subsequent phases of the SEIS process.

CONCLUSION

We appreciate the opportunity to provide this Consensus Based Modeling Alternative for Reclamation’s review within its SEIS process. While Reclamation is preparing the draft SEIS, we commit to continue to work with Reclamation on the CBMA and any additional development and refinement.

We recognize that over the past twenty-plus years there is simply far less water flowing into the Colorado River system than the amount that leaves it, and that we have effectively run out of storage to deplete. Accordingly, we will continue to work together and with the federal government, water users,

Basin Tribes, non-governmental organizations, and other Colorado River stakeholders to reach consensus on how best to share the burden of protecting the system from which we all derive so many benefits.

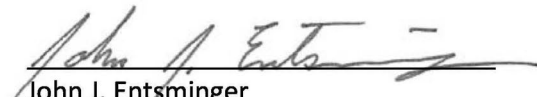
Sincerely,



Thomas Buschatzke
Governor's Representative
State of Arizona



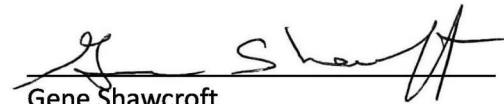
Rebecca Mitchell
Governor's Representative
State of Colorado



John J. Entsminger
Governor's Representative
State of Nevada



Estevan Lopez
Governor's Representative
State of New Mexico



Gene Shawcroft
Governor's Representative
State of Utah



Brandon Gebhart
Governor's Representative
State of Wyoming

cc: David M. Palumbo, Deputy Commissioner – Operations, Bureau of Reclamation
Reclamation 2007 Interim Guidelines SEIS Project Manager, Upper Colorado River Basin Region
Via email: CRinterimops@usbr.gov

Attachments

Attachment 1 - Distribution of Infrastructure Protection Volumes

The modelling assumptions for the Consensus Based Modelling Alternative (CBMA) should allocate Infrastructure Protection Volumes (IPV) and additional reductions among Contractors in the Lower Basin and Mexico using the following method. Please consult with Arizona and Nevada's technical representatives for details or questions.

1. A Contractor's recent Historical Baseline Consumptive Use (Historical Baseline), representative of non-shortage conditions, will be determined in the following manner:
 - a) Compute baseline consumptive use for each Contractor as its 3-year average consumptive use for the 2019-2021 period.
 - b) Any approved (intrastate forbearance) conservation activities, including ICS creation, and system conservation should be added to consumptive uses for each year.
2. Once Lake Mead operating conditions and associated reductions are determined in accordance with the 2007 Interim Guidelines and DCP, Historical Baseline shall be modified to reflect shortage and DCP conditions on the Central Arizona Project, Southern Nevada Water Authority and the Metropolitan Water District of Southern California (CAP/SNWA/MWD) consumptive use. Using the shortage schedules, compute the total shortage assigned to each State as the sum of the 2007 Interim Guidelines and DCP. Compute the adjusted CAP/SNWA/MWD entitlement by subtracting the total state shortage from their respective entitlement. DCP contributions being satisfied with stored ICS shall not be included in this calculation.
3. Historical Baseline shall be modified based upon the water available for consumptive use in the upcoming year (Modified Historical Baseline). *For example, if Nevada is taking 20,000 acre-feet (af) of shortage reductions and 10,000 af of DCP contributions, the historical baseline shall be adjusted such that Nevada is not being assessed an IPV charge for more water than is available to Nevada in the coming year (270,000 af).* If the Historical Baseline is less than the Modified Historical Baseline, carry the Historical Baseline forward.
4. Below elevation 1145' System losses will be assessed as follows:
 - Reach 1 Lee's Ferry to Hoover Dam (580,000 af)
 - Reach 2 Hoover Dam to Davis Dam (193,000 af)
 - Reach 3 Davis Dam to Parker Dam (329,000 af)
 - Reach 4 Parker Dam to Imperial Dam (365,000 af), and
 - Reach 5 Imperial Dam to the NIB (76,000 af)
5. For each reach, the Contractors that rely on the reach to store and/or transmit water deliveries would share proportionally in the system loss for the reach based on their fraction of the total water deliveries within the reach as modified for the upcoming year.
6. The system loss reduction shall be applied to the anticipated consumptive use for the year in which reductions will be applied. Anticipated consumptive use shall be based on the Modified Historical Baseline.

7. Between elevations 1030' and 1020' additional reductions will be assessed pro rata to Contractors' remaining allocations in each State as follows:
Arizona (93,000 af), Nevada (10,000 af), and California (147,000 af)
8. Below elevation 1020' additional reductions will be assessed pro rata to Contractors' remaining allocations in each State as follows:
Arizona (168,000 af), Nevada (18,000 af), and California (264,000 af)

A table of the anticipated Lower Basin and state level reductions is included below. Because past consumptive use, ICS, shortage, and DCP obligations all impact the IPV, these are estimates that should be updated and refined with the help of Reclamation staff.

Lower Basin Totals (all reductions in 1000 acre-feet)						
Tier	Elevation	IG	DCP	IPV	Add'l Reductions	Total
Tier 0	1090-1075	0	241	1,543	0	1,784
Tier 1	1075-1050	383	230	1,543	0	2,156
Tier 2a	1050-1045	625	750	1,543	0	2,918
Tier 2b	1045-1040	625	750	1,543	0	2,918
Tier 2c	1040-1035	625	750	1,543	0	2,918
Tier 2d	1035-1030	625	750	1,543	0	2,918
Tier 2e	1030-1025	625	750	1,543	250	3,168
Tier 3a	1025-1020	625	750	1,543	250	3,168
Tier 3b	1020-1015	625	750	1,543	450	3,368
Tier 3c	1015-1000	625	750	1,543	450	3,368

Tier	Elevation	Arizona					Nevada					California					Mexico				
		IG	DCP	IPV	Add'l Reductions	Total	IG	DCP	IPV	Add'l Reductions	Total	IG	DCP	IPV	Add'l Reductions	Total	IG	DCP	IPV	Add'l Reductions	Total
Tier 0	1090-1075	0	192	408	0	600	0	8	17	0	25	0	0	766	0	766	0	41	351	0	392
Tier 1	1075-1050	320	192	387	0	899	13	8	18	0	39	0	0	782	0	782	50	30	356	0	436
Tier 2a	1050-1045	480	240	374	0	1,094	20	10	19	0	49	0	350	816	0	1,166	125	150	335	0	610
Tier 2b	1045-1040	480	240	374	0	1,094	20	10	19	0	49	0	350	816	0	1,166	125	150	335	0	610
Tier 2c	1040-1035	480	240	374	0	1,094	20	10	19	0	49	0	350	816	0	1,166	125	150	335	0	610
Tier 2d	1035-1030	480	240	374	0	1,094	20	10	19	0	49	0	350	816	0	1,166	125	150	335	0	610
Tier 2e	1030-1025	480	240	369	93	1,182	20	10	19	10	59	0	350	813	147	1,309	125	150	343	0	618
Tier 3a	1025-1020	480	240	369	93	1,182	20	10	19	10	59	0	350	813	147	1,309	125	150	343	0	618
Tier 3b	1020-1015	480	240	364	168	1,252	20	10	19	18	67	0	350	810	264	1,424	125	150	350	0	625
Tier 3c	1015-1000	480	240	364	168	1,252	20	10	19	18	67	0	350	810	264	1,424	125	150	350	0	625

* All values are in 1000 acre-ft

January 31, 2023

Deputy Interior Secretary Tommy Beaudreau
Assistant Secretary for Water and Science Tanya Trujillo
Bureau of Reclamation Commissioner Camille Calimlim Touton

Dear Deputy Secretary Beaudreau, Assistant Secretary Trujillo, and Commissioner Touton:

The Colorado River Board of California (CRB)¹ appreciates the opportunity to submit an alternative for the Bureau of Reclamation (Reclamation) to analyze as part of Reclamation's preparation of a Supplemental Environmental Impact Statement (SEIS) for the December 2007 Record of Decision entitled "Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead."

As described in the Notice of Intent (NOI) to prepare this SEIS, if low runoff conditions into Lake Powell and Lake Mead continue, Reclamation's ability to protect dam infrastructure, make full water deliveries, and generate hydropower could be significantly impacted and result in the need to operate Glen Canyon and/or Hoover Dam in a manner beyond the scope of the 2007 Guidelines Record of Decision (2007 Guidelines ROD). 87 FR 69043 (November 17, 2022). Any modifications made to the operations of Lake Powell and Lake Mead as part of this process — particularly in the absence of a true consensus approach — need to be consistent with applicable federal laws, interstate compacts, and decrees and provide certainty to water contractors, protection of stored Intentionally Created Surplus and public health, safety, and welfare (as determined by each state) through the interim period.

Since Reclamation published the NOI in November, California has worked with the other Colorado River Basin States in an attempt to develop a joint Framework Agreement Alternative. Unfortunately, despite numerous meetings and intensive good-faith efforts, a seven-state consensus was not reached. Therefore, California respectfully submits the attached alternative for Reclamation's consideration, modeling, and analysis. The development of alternatives is the first step of the SEIS process. California looks forward to continuing collaborative work with the Basin States,

¹ Established in 1937, the Board protects the interests and rights of the agencies and citizens of the State of California to the water and power resources of the Colorado River System. The ten-person Colorado River Board is comprised of representatives from the Coachella Valley Water District, Imperial Irrigation District, Los Angeles Department of Water and Power, The Metropolitan Water District of Southern California, Palo Verde Irrigation District, San Diego County Water Authority, California Department of Water Resources, California Department of Fish and Wildlife, and members of the public.

Reclamation, and the Interior Department to develop consensus-based approaches. California appreciates Reclamation's recognition of the need to initiate this process. Our state's proposed alternative makes a constructive effort to uphold the Law of the River while making substantial efforts to protect the Colorado River system with voluntary reductions far beyond California's legal obligations. The 40 million people, nearly 6,000,000 acres of agriculture, and 30 Indian tribes that rely on the Colorado River require us to be successful in this effort. As this process moves forward, the State of California and California's Colorado River Contractors remain committed to continuing to work with you and others across the basin to protect the system. Now is the time to step up and demonstrate leadership through action and the development of other collaborative, innovative opportunities for basin-wide solutions.

Development and Evaluation of Alternatives

California proposes the attached alternative for Reclamation to analyze as part of the SEIS. California's alternative includes actions that build on the existing Colorado River reservoir management and operations framework. The NOI identifies that Reclamation may propose modifications to Sections 2, 6, and 7 of the 2007 Guidelines ROD for 2023, 2024, and possibly through the expiration of the 2007 Guidelines in 2026. The NOI anticipates that Reclamation will analyze alternatives, including a No Action Alternative and a Reservoir Operations Modification Alternative to be developed by Reclamation as a set of actions and measures adopted under Secretarial authority pursuant to applicable federal law. Given the brief period of time before the 2007 Guidelines ROD expires, California's alternative emphasizes additional voluntary reductions in water use.

California intends through its alternative proposed modifications to the 2007 Guidelines ROD to protect Lake Mead elevation of 1,000 feet and Lake Powell elevation of 3,500 feet by discontinuing the use of operational neutrality described in the May 3, 2022 letter regarding actions to protect Lake Powell, making changes to Lake Powell operational tiers and releases, modifying shortage conditions, and other changes described in the attachment. This alternative provides a realistic and implementable framework to address reduced inflows and declining reservoir elevations by building on voluntary agreements and past collaborative efforts in order to minimize the risk of legal challenge or implementation delay. California's alternative uses adaptive management to protect critical reservoir elevations through the interim period.

California's Actions Benefitting Lake Mead

California's Colorado River Contractors committed to conserving up to an additional 1,600,000 acre-feet of Colorado River water starting in 2023 and continuing until 2026, as described in CRB's October 5, 2022 letter. California was the first state to commit to conserving specific volumes of additional water after Commissioner Touton's call for further basin-wide conservation in June 2022. The State of California and California's Colorado River Contractors appreciate the Interior Department's collaboration and partnership at the Salton Sea, which will help facilitate this additional conservation of

Colorado River water in California. In 2019, California also agreed to participate in the Drought Contingency Plan (DCP), committing to make up to 350,000 acre-feet of DCP contributions annually. Between these two commitments, California could voluntarily reduce its use of Colorado River water by up to 750,000 acre-feet annually — even though California is not required to take shortages under the 2007 Guidelines ROD. Since the 2007 Guidelines ROD was adopted, California's investments and conservation in various efforts including Intentionally Created Surplus, the 500+ Plan, and other forms of voluntary conservation raised the elevation of Lake Mead by more than 20 feet preventing Lower Basin shortage conditions for years before the first shortage was declared in 2022.

California's Quantification Settlement Agreement

Prior to 2003, California historically relied on and put to beneficial use surplus Colorado River water. As Arizona and Nevada fully developed their allocations, this surplus water was no longer available. Federal action to ensure that California reduced its use of Colorado River water to the state's legal entitlement triggered a difficult and expensive intra-state process that necessitated transfers and exchanges of Colorado River water from agricultural to urban uses through a complex set of agreements. California's 2003 Quantification Settlement Agreement (QSA), the Colorado River Water Delivery Agreement (Federal QSA), and associated agreements permanently reduced California's Colorado River water use by 800,000 acre-feet per year — even after decades of dependence on that supply by millions of urban users — through various water management programs that form the nation's largest agricultural-to-urban water conservation and transfer agreement. These agreements also include shortage sharing provisions and obligations between California water providers that could be affected by the SEIS and related modifications to the 2007 Guidelines ROD in ways that cause disproportionate and unintended consequences on these California water providers. These shortage sharing provisions in California's intrastate agreements are not well understood outside of California.

Just as the State of California was able to find ways to develop and implement intra-state agreements to drastically reduce water use and live within the state's limited Colorado River water supply, so too may the State of Arizona be required to make similar arrangements to live within its available Colorado River water supplies. While California was able to complete the QSA only after a highly contentious legal, political, and policy process between various parties driven by the threat of unilateral federal action. Twenty years later the QSA serves as an example of temporary conflict caused by scarcity leading to long-term cooperation for sustainability — a model that other basin states and Reclamation should strongly consider.

The Absence of Consensus Agreement Between States Defaults to the Law of the River

In the absence of a seven-state consensus proposal, the SEIS process and the preferred alternative should maintain existing protections to California's senior entitlements, protect stored ICS, and protect public health, safety, and welfare as

determined by each state (and particularly for disadvantaged communities with no alternative water supplies) through the interim period. The SEIS documents should address the manner in which the water demands within the states affected by a shortage declaration will be managed pursuant to the 1968 Colorado River Basin Project Act and the *Arizona v. California* consolidated decree. This approach would be comparable to the one used to develop Exhibit B contained in the 2003 Colorado River Water Delivery Agreement executed by the Department of the Interior pursuant to the Interim Surplus Guidelines.

The CRB appreciates the opportunity to provide California's alternatives for analysis in the SEIS and looks forward to working with Reclamation, the Interior Department, the Basin States, and Basin State Tribes throughout this process.

In partnership,

A handwritten signature in black ink, appearing to read "JB Hamby". The signature is fluid and cursive, with the "JB" being particularly prominent.

JB Hamby
Chairman, Colorado River Board of California
Colorado River Commissioner, State of California

ATTACHMENT 1

CALIFORNIA SEIS MODELING FRAMEWORK ALTERNATIVE

PROPOSED LAKE POWELL & GLEN CANYON DAM OPERATIONS

1. Remove Operational Neutrality (i.e., use Powell actual water surface elevation to determine release tier).
2. EQUALIZATION TIER – Operations in this Tier conducted pursuant to the 2007 Interim Shortage Guidelines (ISG) Record of Decision (ROD).
3. UPPER ELEVATION BALANCING TIER – Below Equalization Tier to 3,575'. Balancing releases range between 9.0-7.0 MAF. Potential for recovery of prior Drought Operations Agreement (DROA) releases and the WY-2022 reduced Lake Powell release volume of 480 KAF.
4. MIDDLE ELEVATION RELEASE TIER – Spans Lake Powell elevations 3,575' to 3,550'. Annual releases from Glen Canyon Dam range between 8.23-7.48 MAF. Implement up to 100 KAFY of Upper Basin Demand Management activities to create additional protection volume for Lake Powell.
5. LOWER ELEVATION BALANCING TIER – Spans Lake Powell elevations 3,550' to 3,500'. Lake Powell annual release ranges between 7.48 - 7.0 MAF, unless lower releases are necessary to keep Lake Powell above elevation 3,500'. Implement up to 500 KAF DROA releases and up to 500 KAF of Upper Basin Demand Management activities to create additional protection volume for Lake Powell to absolutely protect elevation 3,500'.
6. $\leq 3,500'$ – Lake Powell releases restricted to maintain absolute Lake Powell protection of elevation 3,500'.

PROPOSED LAKE MEAD & HOOVER DAM OPERATIONS

1. Remove Operational Neutrality (i.e., use Mead actual water surface elevation to determine operating condition). This will increase the frequency and volume of shortage and Lower Basin Drought Contingency Plan (DCP) contributions without the need to modify agreements.
2. At all elevations below 1,145', provide 1.0 MAFY of additional interim period protection volumes. These volumes could be achieved through voluntary or mandatory means. California has proposed to conserve 400 KAFY of this volume through voluntary actions and its water districts are developing programs to initiate this plan in 2023. Proposed allocation of the remaining volume is based

on previous negotiations among the states: 560 KAFY to Arizona and 40 KAFY to Nevada.

3. Implement reductions described in the ISG, DCP, and Minute No. 323 using the existing schedules and volumes specified in those agreements, except that stored ICS may be delivered below 1,025' to meet human health and safety requirements .
4. If Lake Mead elevations decline further, Reclamation should reduce releases from Lake Mead in addition to the above volumes as follows:
 - a. $\leq 1,025'$: 150 KAFY
 - b. $\leq 1,020'$: 300 KAFY
 - c. $\leq 1,015'$: 500 KAFY
 - d. $\leq 1,010'$: 750 KAFY
 - e. $\leq 1,005'$: 950 KAFY

These reductions should be applied using existing authorities or implemented through additional voluntary compensated conservation agreements.

5. If these actions are insufficient, Lake Mead releases should be further restricted in order to preserve elevation 1,000'. Utilize the existing framework of the "Law of the Colorado River" and Priority System to deliver available supply to Present Perfected Rights, Federal Reserved Rights, and other senior water rights until available annual supply exhausted. If additional water is required to meet human health and safety requirements, stored ICS water may be released below 1,000'. Facilitate development of intrastate partnerships and/or temporary transfers to meet outstanding HHS needs if contractor's alternative water supplies are insufficient.
6. If necessary to keep Lake Mead above elevation 1,000', consider utilization of a periodic release (e.g., 250-500 KAF) from Lake Mohave to assist in meeting the annual U.S./Mexico Water Treaty delivery obligation.

Table 1: Proposed Lower Basin Reductions

Lake Mead Elevation	Baseline Reductions (ISG, DCP, Minute 323) (KAF)	Additional 1.0 MAF below 1,145' (KAF)	Additional Protection Volumes (KAF)	Cumulative Protection Volumes (KAF)
1,145	-	1,000	-	1,000
1,090	241	1,000	-	1,241
1,075	613	1,000	-	1,613
1,050	721	1,000	-	1,721
1,045	1,013	1,000	-	2,013
1,040	1,071	1,000	-	2,071
1,035	1,129	1,000	-	2,129
1,030	1,188	1,000	-	2,188
1,025	1,375	1,000	150	2,525
1,020	1,375	1,000	300	2,675
1,015	1,375	1,000	500	2,875
1,010	1,375	1,000	750	3,125
1,005	1,375	1,000	950	3,325
1,000*	1,375	1,000	950	3,325

*Additional reductions would be implemented to prevent Lake Mead from declining below elevation 1,000'.

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Dec. 20, 2022

Comments on preparation of a Supplemental Environmental Impact Statement for 2007 Record of Decision Entitled Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations For Lake Powell and Lake Mead

Sent via email to CRinterimops@usbr.gov

Reclamation 2007 Interim Guidelines SEIS Project Manager
Upper Colorado Basin Region, 125 South State Street, Suite 8100
Salt Lake City
Utah 84138

Dear SEIS Project Manager -

I thank you for this opportunity to contribute my suggestions to your efforts to save the Colorado River Basin and the economy and culture of the Western United States from the risk of catastrophe. What is at stake here is no less than that – the fate of this beloved region.

We as a community have made mistakes in managing the Colorado River, and we are now at the mercy of those mistakes. We cannot undo them, but we must learn from them.

The heart of our mistakes is this: we have obeyed a Law of the River that, year after year, permitted us to remove more water from the Colorado River than nature provided.

We now understand, to our great regret and peril, that the law is an ass.

As reservoirs reach critical elevations, we must be willing, if needed, to manage the Colorado River as an inflow-outflow system: the amount we take out for our communities' uses cannot continue to exceed the amount nature puts in.

My proposal, which I hope might be considered in your analysis, is four-fold

- sharply curtail water use in the Lower Colorado River Basin through a restructuring of section 2D of the 2007 Interim Guidelines, immediately;
- structure the Lower Basin cuts in a way that even deeper reductions *shall* be made if the hydrology demands it;
- adjust the framework for calculating releases from Glen Canyon Dam in order to protect critical elevations at the dam and, more importantly, begin refilling the reservoir;

- create a framework that leaves the door open for additional contributions from water users in the Upper Basin and Mexico toward the shared goal of saving the system and the West.

The problem

At least a dozen years ago, the Bureau of Reclamation began decorating its presentations with a slide that would be repeated in various forms in ensuing years. It showed what came to be known as “the structural deficit”¹ – the 1.2 million acre foot imbalance between the Upper Colorado River Basin’s deliveries from Lake Powell and the Lower Colorado River Basin’s use of water from Lake Mead. By failing to consider evaporation and system losses, the Supreme Court pointed the river’s management bus toward a ditch. In the years since, we were unable to grab the wheel and turn it. We are now in that ditch.

Modeling done in the years that followed suggested that the 2007 Interim Guidelines – the rules at issue again today in this Supplemental Environmental Impact Statement – were insufficient to protect the Colorado River system from crashing.²

An agreement calling for additional reductions, the “Drought Contingency Plan”, negotiated in the ensuing years but not signed until 2019, was similarly insufficient. Scenarios from Reclamation’s modelers presented during the agency’s Nov. 29 and Dec. 2, 2022, Supplemental Environmental Impact Statement briefings show that, under a credible low flow scenario (responsive to the changes in the climate that we have seen in the last two decades), elevations at Lake Powell could drop by summer 2023 below elevation 3,490. Absent steps to reduce Lake Powell releases to prevent that, Reclamation would be forced to use Glen Canyon Dam’s “river outlets”, which were not designed for sustained operations.³

Avoiding those risks by decreasing releases from Glen Canyon Dam would then, under this modeling scenario, send Lake Mead into free fall – to “dead pool”, the point at which the only water that leaves the reservoir is the amount flowing in - within two years. At that point hydrologic reality will dictate

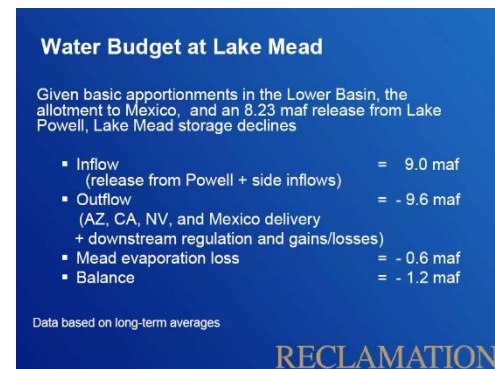


Figure 1 Fleck, May 2010; River Beat: Why is Lake Mead Dropping?;
<https://www.inkstain.net/2010/05/river-beat-why-is-lake-mead-dropping/>

¹ Kuhn, Eric, and John Fleck. *Science be Dammed: how ignoring inconvenient science drained the Colorado River*. University of Arizona Press, 2019; p. 7

² *ibid.*, p. 205-07

³ Comments by Assistant Secretary of Interior Tanya Trujillo, Wallace Stegner Center Symposium, March 17, 2022

releases to water users in the Lower Basin – municipalities, tribes, farm communities, and Mexico – far less than contemplated in Section 2D of the 2007 Interim guidelines.

I detail my specific suggested revisions in detail below, but in narrative form, I ask that you analyze the following possible changes to the Colorado River’s operation:

Suggested Actions

Lake Powell Releases

The current “Mid-Elevation Release Tier” and “Lower Elevation Release Tier” should be replaced with a single “balancing tier” beginning at elevation 3,575 in Lake Powell. Below that point, Reclamation should “balance” the active storage in Lake Mead and Lake Powell, where “active storage” is redefined as the total available storage above elevation 3,515 in Lake Powell and 975 in Lake Mead – in each case, preserving 25 feet of risk mitigation water above minimum power pool in each reservoir.

Mead and Powell would then rise and fall together based on hydrology and use.

Importantly, there will be no minimum Powell release set in the new guideline – the risk of bad hydrology would be shared equally between the two basins.

Other numbers could be chosen for the elevations in Mead and Powell to protect, reflecting tradeoffs. Higher elevations would require cutting uses more now to protect against future risk. Lower elevations would trade allow more use now, at the expense of creating greater risk later.

Lake Mead Releases

Accepting the reality of the old “structural deficit” slide requires the immediate reduction of 1.2 million acre feet in use by the Lower Basin states, *now*. But the slide’s analysis falls short, presuming the river can continue to deliver 9 million acre feet per year in Lee Ferry flows and side inflows between Glen Canyon Dam and Lake Mead. We can no longer rely on that.

I recommend a release table that reduces the allocation available to the Lower Basin States by 1.5 million acre feet, to be shared proportionally by the three basin states relative to their full Arizona v. California allocation.

- California: 3.52 million acre feet
- Arizona: 2.24 million acre feet
- Nevada: 240,000 acre feet

As Lake Mead drops, the allocations would be reduced by the amount already negotiated by the states in the Interim Guidelines and Drought Contingency Plan. Should Lake Mead rise above elevation 1,125, the allocations would revert to their normal levels. Below that point, the Secretary would make a finding

under the 2006 Supreme Court Decree in the case of Arizona v. California that insufficient mainstream water is available to satisfy annual consumptive use of 7,500,000 in the Lower Basin states.

elevation	total	CA	AZ	NV
>1125	7.5	4.4	2.8	0.3
1125-1075	6.00	3.52	2.24	0.24
1075-1050	5.67	3.52	1.92	0.23
1050-1025	5.38	3.32	1.84	0.22
1025-1000	4.90	3.17	1.52	0.21
<1000	4.00	2.35	1.49	0.16

To be clear, this proposal if implemented will help guard against Lake Mead ever dropping into those lowest tiers. But we must not repeat a crucial mistake of the past. We need to know, today, what our plan is if, despite our best efforts, the hydrology takes us there.

Upper Basin Contribution

By permitting annual Lee Ferry releases to drop as far as it does, this plan creates a real risk for the states of the Upper Colorado River Basin that flows at Lee Ferry could drop below 82.5 million acre feet over a 10 year period, or even 75 million acre feet over a ten year period. That creates real risk of Colorado River Compact litigation that, depending on its outcome, might force curtailment of post-Compact rights in the Upper Basin.

In its NEPA analysis, Reclamation must model this risk.

In focusing on Sections 2D, 6C, 6D, and 7C of the Interim Guidelines, the Department of Interior leaves little space for imposing mandatory reductions in the Upper Basin. But the scenario outlined above or something very much like it - inevitable given hydrologic reality - suggests space for the sort of “grand bargain” that has been talked about in the basin for years: an Upper Basin contribution of water use reductions of some sort in return for a Lower Basin agreement not to pursue litigation as Lee Ferry deliveries fall.⁴

Both Upper and Lower Basin have strong incentives for a “consensus plan”, as encouraged by the Department of Interior, that would include concessions on both sides and would serve the basin well.

⁴ Kuhn, 2012, Risk Management Strategies for the Upper Colorado River Basin

Given the clear advantages of such a solution, I ask that you model the effect of a variety of hypothetical Upper Basin contributions ranging from 100,000 to 500,000 acre feet per year in foregone consumptive use to the resulting storage balances in Lake Powell and Lake Mead under a variety of hydrologies.

Impact on the Tribes

The analysis to be done in support of this decision must include analyses of the impact of the alternatives on the 30 Native American Sovereigns in the Colorado River Basin, including but not limited to those tribes with quantified and fully used water rights, those with water rights that have been quantified but not yet put to use, and those whose rights have not yet been quantified.

The Specifics

Rewrite Section 2.A of the interim Guidelines as follows:

1. Lake Mead above elevation 1,125 and below elevation 1,145

In Years when Lake Mead elevation is projected to be above 1,125 and below elevation 1,145 on January 1, the Secretary shall determine either a Normal Condition, or, under Section 2.B.5, an ICS Surplus Condition.

Rewrite Section 2.D.1 of the Interim Guidelines as follows:

- a. In years when Lake Mead content is projected to be at or below elevation 1,125 feet and at or above 1,075 feet on January 1, a quantity of 6 maf shall be apportioned for consumptive use in the Lower Division States of which 2.24 maf shall be apportioned for use in Arizona and 240,000 af shall be apportioned for use in Nevada in accordance with the Arizona-Nevada Shortage Sharing Agreement dated February 9, 2007, and 3.52 maf shall be apportioned for use in California.
- b. In years when Lake Mead content is projected to be at or below elevation 1,075 feet and at or above 1,050 feet on January 1, a quantity of 5.67 maf shall be apportioned for consumptive use in the Lower Division States of which 1.92 maf shall be apportioned for use in Arizona and 230,000 af shall be apportioned for use in Nevada in accordance with the Arizona-Nevada Shortage Sharing Agreement dated February 9, 2007, and 3.52 maf shall be apportioned for use in California.
- c. In years when Lake Mead content is projected to be at or below elevation 1,050 feet and at or above 1,025 feet on January 1, a quantity of 5.38 maf shall be apportioned for consumptive use in the Lower Division States of which 1.84 maf shall be apportioned for use in Arizona and 220,000 af shall be apportioned for use in Nevada in accordance with the Arizona-Nevada Shortage Sharing Agreement dated February 9, 2007, and 3.17 maf shall be apportioned for use in California.

- d. In years when Lake Mead content is projected to be at or below elevation 1,025 feet and at or above 1,000 feet on January 1, a quantity of 4.90 maf shall be apportioned for consumptive use in the Lower Division States of which 1.52 maf shall be apportioned for use in Arizona and 210,000 af shall be apportioned for use in Nevada in accordance with the Arizona-Nevada Shortage Sharing Agreement dated February 9, 2007, and 3.17 maf shall be apportioned for use in California.
- e. In years when Lake Mead content is projected to be at or below elevation 1,000 feet, a quantity of 4 maf shall be apportioned for consumptive use in the Lower Division States of which 1.52 maf shall be apportioned for use in Arizona and 210,000 af shall be apportioned for use in Nevada in accordance with the Arizona-Nevada Shortage Sharing Agreement dated February 9, 2007, and 2.35 maf shall be apportioned for use in California.

Rewrite Section 6.C of the Interim Guidelines as follows:

- 1. In Water Years when the projected Jan. 1 Lake Powell elevation is below 3,575 feet, the Secretary shall balance the contents of Lake Mead and Lake Powell, where the balancing volume is determined by the total storage in Lake Mead above elevation 975 feet and the balancing volume in Lake Powell is the total storage above elevation 3,515 feet.

Eliminate Section 6.D of the Interim Guidelines

Rewrite the final sentence of Section 7.C. of the Interim Guidelines as follows (additional language underline)

For Lake Mead, the Secretary in any mid-year review for the current Year to allow for additional or reduced deliveries from Lake Mead pursuant to Section 2 of these guidelines to prevent Lake Mead from dropping below elevation 975 in the remainder of the year.

Conclusion

I have long argued that it does not matter what I, a writer and quasi-academic, thinks should be done to solve the problems of the Colorado River Basin. What matters, I have argued, is what can emerge from the consensus of the basin water users.

But that consensus has failed us, left us with wrecked speedboats emerging from the depths of Lake Mead as the reservoir drops away from its old shorelines.

That consensus process has left us with reasonable near-term projections from Reclamation's scientists of reservoirs reaching dead pool if we see a repeat of dry years we all have already lived through.

I still believe a consensus plan from the States is a preferred alternative. But a credible alternative plan will be needed – to encourage the States to come up with their own, better plan. And to save the Colorado River if they do not.

Title I of the National Environmental Policy Act nicely frames the task ahead. It calls on us to “fulfill the responsibilities of each generation as trustee of the environment for succeeding generations”. That is our charge at this critical moment.

Sincerely,

A handwritten signature in dark ink, appearing to read "John Fleck". The signature is fluid and cursive, with the first name "John" and the last name "Fleck" clearly distinguishable.

John Fleck

The Chemehuevi Indian Tribe, the Colorado River Indian Tribes, the Quechan Tribe and the Cocopah Tribe

The above named four tribes with mainstream allocations to the Colorado River as decreed in Arizona v. California submit the following principles and modeling assumptions with the request that Reclamation develop an alternative for the Supplemental EIS that includes each of these.

February 15, 2023

Submitted to: Genevieve Johnson at: gjohnson@usbr.gov; CRinterimops@usbr.gov

Principles:

1. Reductions to tribal water allocations and use must be voluntary and compensated. *See also December 20, 2022, comments Yuma County Agriculture Water Coalition; See December 20, 2022, comments from Pacific Institute and NRDC.*
2. Existing mechanisms should be used and expanded to help stabilize the Lower Basin including compensated forbearance (e.g. Quechan-MWD Agreement) and compensated rotational fallowing programs (CRIT System Conservation and the PVID-MWD agreements) *See January 31, 2023, proposal from the Colorado River Board of California.*
3. Lower basin system losses must be assessed according to existing contract provisions and possible new rules or regulations that may be adopted after public review.
 - a. The Six-States proposal does not include or reference the data or analysis that resulted in 1.543maf of system losses from evaporation and evapotranspiration. As of February 10, this information is not being provided by Arizona or Nevada.
 - b. There are many alternate ways to assess system losses from evaporation including reservoir evaporation assessed against the users, evaporation losses tied to atmospheric conditions and lake elevations, and a calculation of total evaporation loss or net evaporation loss from a reservoir as opposed to a pre-dam River.
 - c. System losses for evapotranspiration do not appear to distinguish from habitat for endangered species that may or may not be assessed against a water user and other vegetation and may encourage an ultimate result of eliminating the vegetation along the river to eliminate these losses.
4. The Six-States proposal inequitably affects tribal first-priority present perfected water rights and disproportionately impacts tribal governments who rely on the direct and indirect use of their water rights to fund critical governmental functions.

Requested assumptions to be included in Lower Basin Modeling

1. Convert the compensated system conservation that Reclamation is funding and creating to Intentionally Created Surplus in a Reclamation account for purposes of modeling. The goal is to determine if the water that Reclamation funds as system conservation can be carried over in Lake Mead from year-to-year to create a volume of water to maintain a minimum pool at Lake Mead and thereby protect critical infrastructure. This could be a true protection volume (PV)
 - a. The PV would be assessed evaporation losses annually as provided in the 2007 Interim Guidelines, not the one-time assessment as provided in the DCP.
 - b. Reclamation would continue the compensated program to increase the base amount of water in Lake Mead to replenish evaporation losses and to target critical elevations
 - c. It is hoped that the modeling will indicate the avoidance of having to make very large cuts each year and continuously having to fund system conservation to stabilize Lake Mead.
2. Maintain sufficient flow in the Colorado River below Lee Ferry and below Hoover Dam for the Colorado to be a living River through all reaches. This will require coordination with the Adaptive Management Work Group and minimum flows for compliance with the Grand Canyon Protection Act. *See December 20, 2022, City of Phoenix Comments, December 20, 2022, NGO Comments*
 - a. Preserve habitat and species and the cultural connections between and among tribes, other communities, and the River.
 - b. Provide additional funding for habitat protection and restoration and ensure that the water used for this purpose is not accounted for as losses from evapotranspiration or transmission.
 - c. Determine if DROA releases or compensated system conservation as described in number 1 above would provide protection volumes or water for minimum flows from Lake Powell

Assess the impacts to the five mainstream tribes in the Lower Basin as a unitary amount without regard to state lines. The tribal water rights are to serve each Reservation and are accounted for against the state apportionments. Reclamation should model each Reservation as one unit and provide the information about the impacts from extremely low conditions on the River to each tribe from the Ft. Mohave reservation near Hoover Dam to the Cocopah reservation south of the Northly International Border.

Appendix C

CRMMS Model Documentation

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Appendix C. CRMMS Model Documentation

C.1 Introduction

The Bureau of Reclamation's (Reclamation's) Colorado River Mid-term Modeling System (CRMMS) for the Colorado River Basin (Basin) is a Basin-wide operations model utilized to evaluate future system conditions for out to five years into the future. Specifically, the September 2022 CRMMS version is used for hydrology modeling for this Supplemental Environmental Impact Statement (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. These are (1) CRMMS and (2) the Colorado River Simulation System (CRSS). The CRMMS is run in two modes, the 24-Month Study Mode and Ensemble Mode. 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 two-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 risk and uncertainty for operations. CRSS, which is used in long-term planning studies (for example, the 2007 Interim Guidelines Final EIS [2007 FEIS]), and 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 timeframe. By supplementing the most probable projection of Basin conditions developed in the 24-Month Study, the CRMMS provides a wider range of information for planning, risk analysis, and operational decision-making in the short- to mid-term planning horizons.

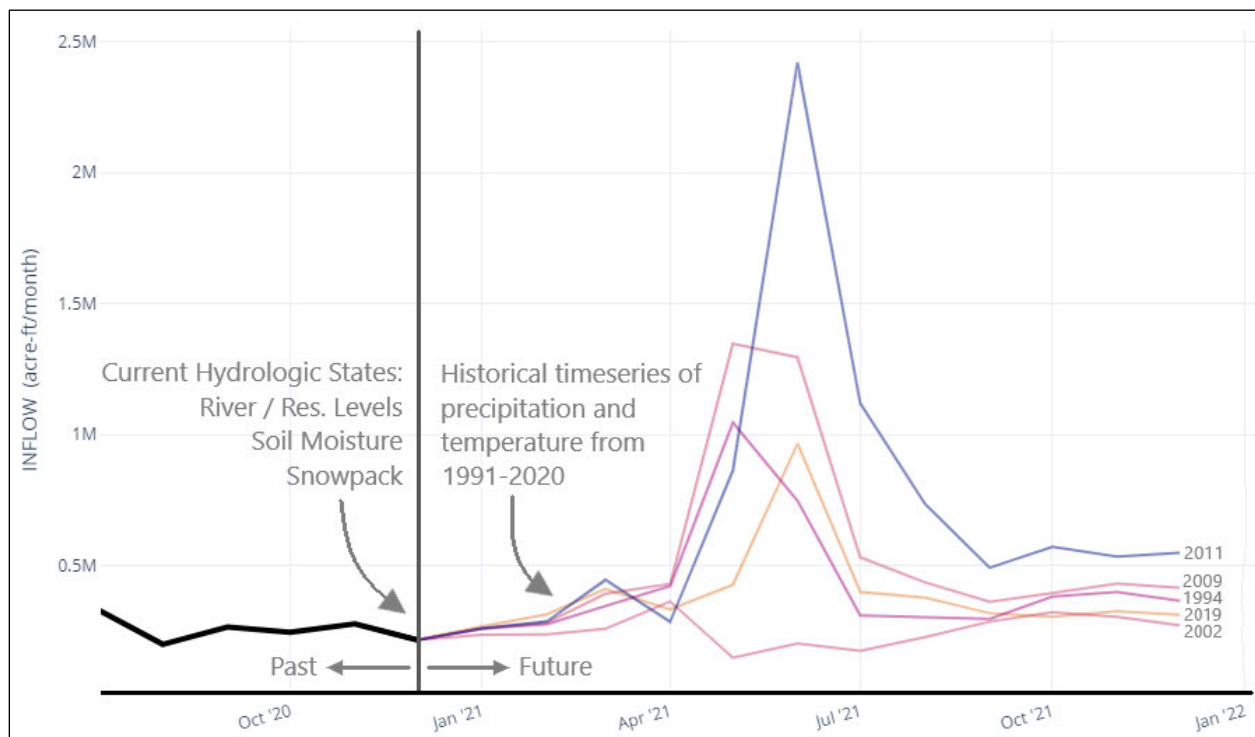
C.2 Overview

CRMMS is implemented in the commercial river modeling software called RiverWareTM developed by the Center for Advanced Decision Support for Water and Environmental Systems at the University of Colorado Boulder. The models are updated and maintained continually by Reclamation's Upper and Lower Basin Regions.

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 includes physical parameters (e.g., 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 as the unregulated streamflow forecasts provided by the CBRFC include the impact of most Upper Basin depletions except for three diversions: Gunnison Tunnel, the 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 one- to five-year planning horizon. CRMMS uses an ensemble of unregulated streamflow forecasts developed by the CBRFC using ESP forecasts. **Figure C-1** depicts an example of ESP forecasts of future potential hydrologic inflows.

Figure C-1
Process for Developing ESP Forecasts



Source: Reclamation 2022

C.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 C.5 through C.8.

In understanding how CRMMS simulates operations, it is helpful to first understand the modeling process used in production of the 24-Month Study, which CRMMS attempts to replicate. In production of the 24-Month Study, Reclamation modelers first manually set releases for the reservoirs at the Upper Basin headwaters (**Table 3**). Once operations are set for reservoirs furthest 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 because a full year of projected regulated inflow is needed for planning 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/storages.

In order to simulate operations in CRMMS in a manner similar to the manual process used in production of 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 timestep to the last timestep) 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 C-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, similar to the iterative process completed manually in the production of the 24-Month Study.

Table C-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; Flood Control, Surplus, Shortage, and hydrologic demand variability first solve 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 in order to complete Lake Powell operations for the entire operating year (October through September) in the last year of the model run. The duration of each model run is specified in **Table C-2**. The modeling analysis for the SEIS uses the September 2022 version of CRMMS but limits the analysis period to September 2022 – December 2026.

Table C-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

C.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 hydrology, water demand, and policy/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 thirty years (i.e., 1991-2020), allowing evaluation of the proposed action under a wide range of future flows.

The further out projections look, the more uncertainty exists. This is apparent when comparing the different ranges of possible conditions in the next 1-5 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 are reflective of the hydrology scenarios and other assumptions used in modeling for this SEIS and are not intended to suggest actual probabilities of any events occurring. However, it is meaningful to compare statistics across alternatives to differentiate performance.

C.3 Hydrology

In order to simulate reservoir operations for up to 5 years, a hydrologic forecast of 60-68 months at twelve Upper Basin forecast points and seven 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 located 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.

Lower Basin hydrology inputs are developed by Reclamation and are generated 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 C.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.

C.3.1 Upper Basin Hydrology

The CBRFC provides ESP forecasts at 12 Upper Basin forecast points (**Table C-3**). The ESP method generates multiple time series, i.e., traces, of forecasted streamflow. 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 matches 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 C-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

C.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 Lees Ferry Gage are included in this section. The hydrology inputs for the Lower Basin are intervening flows (**Table C-4**) which may be positive, representing a gain in the reach, or negative, representing a loss in the reach.

Table C-4
Lower Basin Intervening Flow Points

Glen Canyon Dam to Lees Ferry
Lees Ferry to 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 is the historical calculated intervening inflows from 1991 through 1995.

C.3.3 Hydrology used in CRMMS SEIS Modeling

The hydrologies used in the SEIS are derived from the September 2022 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

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:

$$\text{AdjustedMonthlyStreamflow}_i = \text{MonthlyStreamflow}_i - |\text{MonthlyStreamflow}_i| \times \text{PercentReduction}$$

where, *PercentReduction* is the percent reduction (i.e., 0.1 or 0.2 for 90-percent ESP and 80-percent ESP, respectively), and *i* is a single forecast location for all locations described in Sections C.3.1 and C.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 hydrology scenario for SEIS analysis purposes. The three sets of ESPs allow for analysis of a wider range of low flow hydrologic scenarios beyond those experienced during the recent thirty 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.

C.4 Initial Reservoir Conditions

CRMMS was initialized with observed August 2022 end-of-month reservoir conditions shown in Table C-5.

Table C-5
End-of-Month Reservoir Conditions used as Initial Conditions

Reservoir	Elevation (feet above mean sea level [msl])	Storage (af)
Fontenelle	6,502.43	306,420
Flaming Gorge	6,014.73	2,735,239
Taylor Park	9,310.33	70,421
Blue Mesa	7,455.69	341,476
Morrow Point	7,152.25	110,833

Reservoir	Elevation (feet above mean sea level [msl])	Storage (af)
Crystal	6,751.42	16,524
Vallecito	7,637.64	59,556
Navajo	6,023.95	902,138
Powell	3,531.69	5,937,930
Mead	1,044.28	7,275,375
Mohave	642.87	1,695,022
Havas	448.16	582,945

C.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 and 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.

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.

The operations of the Upper Basin reservoirs above Lake Powell are modeled the same in the No Action Alternative and Action Alternative 1. Action Alternative 2 includes modeling assumptions regarding contributions from the Upper Initial Units for releases from zero to 500,000 af per Drought Response Operations Agreement (DROA) Year (May 1 – April 30), which will conform to the DROA and its implementing documents and will be made only to help protect Lake Powell elevation 3,500 feet. The analysis refers to these as “potential DROA contributions.” Section C.5.8 details about the potential DROA contributions modeling assumptions and how they may affect modeled operations of Flaming Gorge, Aspinall, and Navajo.

C.5.1 Fontenelle Reservoir

Fontenelle Reservoir is located 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.

C.5.2 Flaming Gorge Reservoir

Flaming Gorge Reservoir is located 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. April – 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 1st storage target. Actual annual operations at Flaming Gorge are determined in a consultation process with other agencies; 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.

C.5.3 Taylor Park Reservoir

Taylor Park Reservoir is located 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.

C.5.4 Aspinall 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 7,153.73 feet and 6,753.04 feet, respectively.

C.5.5 Vallecito Reservoir

Vallecito Reservoir is on the Pine River which flows into the San Juan River. The reservoir is located 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.

C.5.6 Navajo Reservoir

Navajo Reservoir is located 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 which point the NIIP can no longer divert water.

Navajo Reservoir operations are modeled to first meet 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 30th 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.

C.5.7 DROA Year 2022 Contribution Assumptions

The CRMMS modeling assumes Flaming Gorge DROA releases consistent with the September 2022 CRMMS simulation for DROA Year 2022 (i.e., May 2022 through April 2023). The DROA releases from Flaming Gorge are a projected 500,000 af for May 2022 through April 2023¹ and are added to the Flaming Gorge releases solved for CRMMS using the operations described in **Section C.5.2**. At the end of run cycle 2, CRMMS has completely solved for reservoir operations above Lake Powell, including Flaming Gorge. At the beginning of run cycle 3, the input DROA releases, which are populated from the September 2022 24-Month Study, are added to Flaming Gorge releases for September 2022 through May 2023, resulting in an increased release from Flaming Gorge. This assumption is included in modeling of all SEIS alternatives.

C.5.8 Potential DROA Contribution Assumptions in Action Alternative 2

Action Alternative 2 includes modeling assumptions for potential DROA contributions to Lake Powell for DROA Years 2024 through 2026 (i.e., May 2024 through the end of the simulation).

¹ The projected 500,000af DROA release was reduced in March 2023 but is not reflected in the modeling assumptions. It may be updated for the Final SEIS.

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 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 higher priority than the Lake Powell operations and therefore 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 Release Tier (see **Section C.6.3** for more details); this also results in a modeled 6.0 million acre-feet (maf) or less release from Lake Powell. 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, the storage available for a DROA contribution is calculated by taking the difference between the projected storage at end of the DROA year (i.e., 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 DROA contribution is calculate 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, the storage available for 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 NIIP diversion intake). The total available storage for DROA contribution is calculated as the sum of each reservoir's available storage volume. If the total available storage for DROA contribution 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 non-negative.

The percent 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 C-6**. These monthly distributions are based off the monthly distribution of DROA releases in past planned DROA releases (i.e., DROA Year 2022 for Flaming Gorge Reservoir and 2021 for Blue Mesa and Navajo Reservoirs).

Table C-6
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 release 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 NIIP 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.

C.6 Lake Powell Operation

Lake Powell is the most downstream reservoir in the Upper Basin and is impounded by Glen Canyon Dam. Glen Canyon Dam is near Page, Arizona and is located 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. These operations are summarized in the sections below. **Section C.6.1** describes modeling assumptions common to all alternatives. **Section C.6.2** describes model assumptions for Lake Powell operating tiers used only in the No Action Alternative, and **Section C.6.3** includes model assumptions for operating tiers used in Action Alternative 1 and Action Alternative 2.

C.6.1 Assumptions Common to All Alternatives

CRMMS solves for Lake Powell operating tiers in CRMMS run cycles 3 and 4. The following rules are solved for in run cycles 3 and 4. In August, operations of Lake Powell are set for the entire following operating year (i.e., October through September). An initial operating year release of 8.23 maf is used to solve for the end-of-calendar year (EOCY) 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 C-1**.

The monthly releases solved using **Table Attachment C-1** can be constrained due to physical limitations at Glen Canyon Dam. Water can be released through the power plant turbines until the pool elevation drops below 3,490 feet. Once 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 C-7** and interpolates for the capacity between elevations list in **Table C-7**. For the SEIS modeling, three out of four river outlet works are assumed available for use at any given time because of the need for periodic inspections and any associated maintenance activities. Reclamation believes this is a conservative and prudent estimation given the historical and future operations and maintenance requirements for the river outlet works.

Table C-7
CRMMS modeled river outlet work capacity by Lake Powell Elevation

Lake Powell Elevation	Capacity (1 river outlet work)		Capacity (3 river outlet works)	
	feet	cubic feet/ second (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/month.

C.6.2 No Action Alternative

Lake Powell operating tiers are determined based on projected EOCY pool elevation at Lake Powell. In operating year 2022, the Lake Powell annual release was reduced from 7.48 maf to 7.00 maf, resulting in a reduced release volume of 0.480 maf that normally would have been released from Glen Canyon Dam to Lake Mead as part of the 7.48 maf annual release volume, consistent with routine operations under the 2007 Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead (2007 Interim Guidelines). The reduction of releases from Glen Canyon Dam in operating year 2022 (resulting in increased storage in Lake Powell) is accounted for “as if” this volume of water had been delivered to

Lake Mead. Therefore, operating tiers in the No Action Alternative are determined based on an ‘effective’ EOCY pool elevation. The effective pool elevation at Lake Powell is determined by subtracting 0.480 maf to the EOCY storage, then determining the pool elevation associated with the effective storage.

For operating year 2023, the August 2022 24-Month Study projected the January 1, 2023, effective 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 for Lake Powell to solve for the releases for the entire operating year and allows Lake Powell to solve for storage and other parameters since inflow is solved for in run cycle 2. This includes the EOCY pool elevation, which is used to set the Lake Powell operating tier.

The effective EOCY pool elevation is calculated by subtracting 480,000 af from the EOCY storage. Then, the Lake Powell operating tier is solved for as follows using the projected effective EOCY pool elevation:

- If the effective Lake Powell EOCY pool elevation is greater than or equal to the Equalization Level (**Table C-8**), the operating year releases are governed by Equalization Tier operations.
- If the effective Lake Powell EOCY pool elevation is less than the Equalization Level and greater than or equal to 3,575 feet, the operating year releases are governed by the Upper Elevation Balancing Tier.
- If the effective Lake Powell EOCY pool elevation is less than 3,575 feet and greater than or equal to 3,525 feet, the operating year releases are governed by the Mid-Elevation Release Tier.
- If the effective Lake Powell EOCY pool elevation is less than the 3,525 feet, the operating year releases are governed by the Lower Elevation Balancing Tier.

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 C-8
Lake Powell Equalization Level Table

Year	Equalization Elevation (feet msl)
2023	3,662
2024	3,663
2025	3,664
2026	3,666

In the following sections for the No Action Alternative, references to Lake Powell or Lake Mead pool elevation or storage are assumed to be the effective pool elevation or storage. This includes balancing volume calculations and end of year elevations.

C.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 equalized Lakes Powell and Mead. The release for equalization is computed by taking half of the difference between the predicted End of Water Year (EOWY) 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 Powell are then calculated for the operating year using **Table Attachment C-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 Upper Elevation Balancing equalization releases. The rule calculates the volume deviation of the EOWY storage at Lake Powell and Lake Mead from target levels (i.e., 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 EOWY target, subject to a minimum release of 8.23 maf. This rule is allowed to iterate so that EOWY target elevations are achieved to within a specified tolerance.

C.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 EOWY pool elevation at the end of the next operating year, e.g., 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 EOWY 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 is constrained to a minimum of 8.23 maf.

Otherwise, (Lake Powell's projected EOWY 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 are dependent on Lake Mead's EOWY pool elevation:

- If the Lake Mead EOCY pool elevation is greater than or equal to 1,075 feet, the operating year release necessary to balance Lake Powell and Lake Mead's EOWY storage is calculated but constrained to be within the range of 8.23 maf to 9.0 maf.
- If Lake Mead EOCY pool elevation is greater than 1,075 feet and the Lake Powell EOWY pool elevation is less than or equal to 3,575 feet, the operating year release is 8.23 maf.

- If the Lake Mead EOCY pool elevation is less than 1,075 feet, the operating year release necessary to balance Lake Powell and Lake Mead EOWY storage is calculated but constrained to be within the range of 7.0 maf to 9.0 maf.

C.6.2.4 Mid-Elevation Release Tier

The Mid-Elevation Release Tier modeled by first checking Lake Mead's projected EOCY pool elevation. If the Lake Mead EOCY 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.

C.6.2.4 Lower Elevation Balancing Tier

For operating year 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 elevation 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 releases are calculated with different constraints dependent on the operating year, as previously described:

- In operating years 2023-2024
 - If the Lake Powell EOWY pool elevation is greater than the protection threshold of 3,535 feet², two potential annual releases are calculated: (1) the operating year release necessary to balance Lake Powell and Lake Mead's EOWY storage is calculated but constrained to be within the range of 7.0 maf to 9.5 maf. and (2) the release needed so that Lake Powell's EOWY pool elevation is 3,535 feet. The minimum of these two releases is used to set Lake Powell's annual release. If the EOWY 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 EOWY storage is calculated but constrained to be within the range of 7.0 maf to 9.5 maf.

C.6.2.4 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 the **Table Attachment C-1**; for operating year releases between

² The protection threshold of 3,535 feet was used for modeling purposes since it is the EOWY elevation needed during an average year to achieve an EOCY elevation of 3,525 feet (or higher).

set values, the monthly releases are interpolated between the two columns with the closest operating year release.

There are a few special cases where the monthly releases are not interpolated directly from **Table Attachment C-1**. If there is an equalization outflow in the Upper Elevation Balancing Tier, then the outflows from the October until March follow a path of a 9.0-maf release and then will be either the maximum power plant 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 power plant 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 C-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.

C.6.3 Action Alternatives

The Lake Powell operations for Action Alternatives 1 and 2 are the same. For operating year 2023, Lake Powell operations are solved for as described in the No Action Alternative, where effective pool elevation is used to calculate the annual release. For operating years 2024 to 2026, the Lake Powell operating tier and operating year release are assumed to use the physical elevations at Lake Powell and Lake Mead. The Lake Powell operating tier is solved for as follows using the projected physical pool elevation:

- If the projected Lake Powell EOCY pool elevation is greater than or equal to the Equalization Level (**Table C-8**), the operating year releases are governed by Equalization Tier operations (see **Section C.6.3.1**).
- If the Lake Powell EOCY pool elevation is less than the Equalization Level and greater than or equal to 3,575 feet, the operating year releases are governed by the Upper Elevation Balancing Tier (see **Section C.6.3.2**).
- If the Lake Powell EOCY pool elevation is less than 3,575 feet, the operating year releases are governed by the new Lower Elevation Release Tier (see **Section C.6.3.3**).

The operating year release calculation for each tier is described below for the action alternatives.

C.6.3.1 Equalization Tier

The Equalization Tier method for Lake Powell under the action alternatives is identical to that of the No Action Alternative.

C.6.3.2 Upper Elevation Balancing Tier

The Upper Elevation Balancing Tier method for Lake Powell under the action alternatives is identical to that of the No Action Alternative.

C.6.3.3 Lower Elevation Release Tier

Operating year 2023 is 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 the No Action Alternative.

For operating years beyond 2023, 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 if the projected Lake Powell EOWY pool elevation (e.g., September 30, 2024, when the model is executing in August 2023) and sets the operating year release as follows:

- If the projected Lake Powell EOWY 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 EOWY 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 EOWY 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 EOWY pool elevation is less than 3,525 feet, set the operating year release to 6.00 maf.

C.6.3.4 Protection Level

The action alternatives 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 Long-term Experimental and Management Plan 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 and is also constrained by river outlet works capacity³. 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 previously constrained volume such that Lake Powell remains at or above 3,500 feet at the end of the month.

³ This is possible because the action alternatives are assumed to not begin until October 2023, so there are traces analyzed that drop below elevation 3,500 feet before this protection level logic is modeled.

C.6.3.5 Disaggregation from Annual to Monthly Release

Lake Powell operating year releases are disaggregated to monthly releases using the same method as the No Action Alternative. To assist in the solution of monthly releases, an additional column was added to **Table Attachment C-1** for a 6.0-maf annual release (**Table C-9**). This monthly distribution is used for modeling purposes only.

Table C-9
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

C.7 Lake Mead Operation

Lake Mead is the upper-most 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 C.7.1** describes modeling assumptions common to all alternatives. **Sections C.7.2, C.7.3, and C.7.4** describe Lake Mead operations for the No Action Alternative, Action Alternative 1, and Action Alternative 2, respectively.

C.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 (i.e., 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 timestep. 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 Drought Contingency Plans (DCPs), and Minute 323. 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, reductions under low elevation reservoir conditions and BWSCP contributions per Minute 323, and/or additional shortages in the action alternatives) reduce these “baseline/normal” depletion schedules. Depletion schedules for CRMMS water users that were used in the September 2022 CRMMS modeling are summarized in **Attachment C-2**.

C.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. There are three flood control procedures 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 September 2022 conditions and inflow forecast ensemble, there were no instances of simulating flood control operations in the SEIS modeling through 2026.

C.7.2 No Action Alternative

Lake Mead operations and Lower Basin conditions are modeled based on projected EOCY pool elevation at Lake Mead. In operating year 2022, the Lake Powell annual release was reduced from 7.48 maf to 7.00 maf, resulting in a reduced release volume of 0.480 maf that normally would have been released from Glen Canyon Dam to Lake Mead as part of the 7.48-maf annual release volume, consistent with routine operations under the 2007 Interim Guidelines.

The operating year 2022 reduced release from Glen Canyon Dam (discussed in **Section C.6.2**) resulted in decreased storage in Lake Mead. For Lower Basin condition determination, the 2022 release adjustment is accounted for “as if” this volume of water had been delivered to Lake Mead. Therefore, Lower Basin operating conditions in the No Action Alternative are determined based on an ‘effective’ EOCY pool elevation. The effective pool elevation at Lake Mead is determined by adding 0.480 maf to the EOCY storage, then determining the pool elevation associated with the effective storage.

In the following sections for the No Action Alternative, references to Lake Mead pool elevation or storage are assumed to be the effective pool elevation or storage.

C.7.2.1 Surplus

The Lower Basin operates in a Surplus Condition if the Lake Mead elevation is above elevation 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 Army Corps of Engineers (described in **Section C.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.

C.7.2.2 Normal Conditions

The Lower Basin operates in a Normal Condition if the Lake Mead elevation is above elevation 1,075 feet and below elevation 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 in the range above and there is an ICS Creation Plan in place for at least one Lower Basin entity.

C.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 EOY pool elevation to defined pool elevations as shown in **Table C-10**.

Once the Shortage Condition is set, shortage volumes (**Table C-10**) are assigned to users proportionally to a user's monthly and annual scheduled water user:

$$MonthlyShortage_i = AnnualShortage_i * \left(\frac{MonthlyWaterUse_i}{AnnualWaterUse_i} \right)$$

where i is an individual water user.

Diversions for water users are then adjusted with the user's monthly shortage. In Nevada, the entire shortage volume is incurred by Southern Nevada Water Project (SNWP) users (Nevada), and in Arizona, the entire shortage volume is modeled to be incurred by Central Arizona Water Conservation District (CAWCD).

Table C-10
Lower Division State Shortage Volumes

Lake Mead Elevation (feet)	AZ Shortage (af)	NV 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

C.7.2.4 Minute 323 High and Low Elevation Reservoir Conditions

The Minute 323 defines reductions to Mexico under low elevation reservoir conditions based on projected Lake Mead EOY pool elevation. Mexico's reductions are shown in **Table C-11**. 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 C.7.2.3**).

Table C-11
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 Lake Mead EOY is at or above elevation 1,145 feet.

C.7.2.5 2019 DCPs and Binational Water Scarcity Contingency Plan

The CRMMS models 2019 DCP contributions in accordance with Exhibit 1 to the Lower Basin DCP Agreement and the Minute 323 BWSCP. The contribution volumes (**Table C-12**) are based on the projected Lake Mead EOY 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 C.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, 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 C-12
2019 DCP and Minute 322 BWSCP Contribution Volumes

Lake Mead Elevation (feet msl)	DCP (1,000 af)			Minute 323 BWSCP (1,000 af)
	Arizona	Nevada	California	
>1,090	0	0	0	0
1,075 – 1,050	192	8	0	41
<1,050 – >1,045	192	8	0	30
1,045 – >1,040	192	8	0	34
1,040 – >1,035	240	10	200	76
1,035 – >1,030	240	10	250	84
1,030 – 1,025	240	10	300	92
1,075 – 1,050	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 bank space exists to create DCP-ICS, then contributions are made via system water.

In California, the agreement between Metropolitan Water District of Southern California (MWD) and Coachella Valley Water District (Coachella) is modeled in CRMMS; however, the entire DCP-ICS balance in the 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 converts it to DCP-ICS in the year it is required. If the ICS bank is full, and/or there is insufficient EC-ICS to meet the entire DCP contribution, then the MWD creates non-ICS water (i.e., 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 the ICS bank is full, then 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 (i.e., via system water), unless other input and assumptions are provided by Mexico.

C.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 bank sharing. Bank 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 bank 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.

C.7.2.6.1 Constants

Table C-13 list the ICS related assumptions used in CRMMS.

Table C-13
Annual Creation and Delivery Limits

State	Max Annual Creation (1,000 af)	Max Annual Delivery (1,000 af)
Arizona	100	300
California	400	400
Nevada	125	300

CRMMS models the ICS bank sharing agreements from 2020 and 2021. Therefore, the accumulation limits (**Table C-14**) 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. Annual ICS assessments for evaporation are entity and year dependent (**Table C-15**).

Table C-14
Accumulation Limits by Entity in CRMMS

Bank Size (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 C-15
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.

C.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 future ICS delivery and type of ICS created.

ICS creation volumes for all entities in Arizona are generally input based on existing and anticipated ICS Creation Plans (**Table C-16**). The 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 if CAWCD's ICS creation is EC-ICS or DCP ICS based on the operating condition of the current year.

Assumed ICS delivery volumes for all entities in Arizona except CAWCD and Gila River Indian Community (GRIC) are also input. Delivery volumes for CAWCD include 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 their 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 1025 feet on January 1.

Table C-16
Assumed ICS Creation and Delivery Volumes in Arizona based on the September 2022 CRMMS

		2022	2023	2024	2025	2026
CAWCD	EC/DCP Creation (af)	100,000	60,000	60,000	0	0
	Binational Creation (af)	0	9,092	0	0	9,092
	System Efficiency Creation (af)	0	0	0	0	0
	Default Delivery ¹ (af)	49,496	27,500	30,000	0	0
GRIC	EC Creation (af)	78,565	0	0	0	0
	Delivery (af)	0	0	0	0	0

¹CAWCD delivers an additional 60,000 af when the operating condition is a between 1,075 and 1,025 feet for mitigation purposes. Starting in 2026, CAWCD will also try to take delivery of their remaining ICS by 2036, based on the operating condition.

C.7.2.6.3 California ICS Assumptions

CRMMS includes ICS assumptions in California for the Imperial Irrigation District (IID) and MWD (**Table C-17**). 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 C-17
Assumed ICS creation volumes by IID and MWD (af)

		2022	2023	2024	2025	2026
MWD	Binational ICS Creation (af)	0	9,092	0	0	9,092
	System Efficiency ICS Creation (af)	0	0	0	0	0
IID	Binational ICS Creation (af)	0	9,092	0	0	9,092

In general, IID tries to keep their ICS bank full (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 bank at capacity and cover the annual evaporative assessment (**Table C-15**).

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 Sacramento River Water Year Classification (SRWYC). The SRWYC index is obtained at <http://cdec.water.ca.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 C-18** in Normal and Shortage conditions, subject to bank space and annual creation limits. ICS creation is also limited to make sure the MWD's annual diversion does not fall below their specified annual minimum diversion of 500,000 af. No creation occurs during surplus or flood control conditions.

Table C-18
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 their contribution. If there is not enough EC-ICS 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 bank space exists to create DCP-ICS, then contributions are made via system water.

C.7.2.6.4 Nevada ICS Assumptions

Creation of tributary conservation, imported ICS, and Binational ICS are all inputs in CRMMS (**Table C-19**).

If a DCP contribution is needed, the SNWP converts EC-ICS to meet their 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 bank space exists to create DCP-ICS, then contributions are made via system water.

Table C-19
Assumed ICS creation volumes by the SNWP

	2022	2023	2024	2025	2026
Tributary Conservation (af)	30,000	30,000	30,000	30,000	30,000
Imported ICS Creation (af)	0	0	0	0	0
Bination ICS Creation (af)	0	9,092	0	0	9,092

EC-ICS is assumed to be created from Nevada’s unused apportionment as long as there is bank 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 their annual normal demand.

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 September 2022 CRMMS run, the demands do not exceed the SNWP’s apportionment.

C.7.3 Action Alternative 1

The Lake Mead operations and Lower Basin conditions for Action Alternative 1 are similar to the No Action Alternative, i.e., shortage and DCP contribution volumes are based on Lake Mead elevations. For operating year 2023, Lake Mead operations are solved for as described in the No Action Alternative, where effective pool elevation is used to calculate Lake Mead operations and the Lower Basin condition. For operating years 2024 to 2026, the Lake Mead operations and Lower Basin conditions are solved for using the physical elevations at Lake Mead.

C.7.3.1 Surplus

The Surplus model assumptions for the Lower Basin under the Action Alternative 1 is identical to that of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.7.3.2 Normal Conditions

The Normal Condition model assumptions for the Lower Basin under the Action Alternative 1 is identical to that of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.7.3.3 Shortage Condition

Under Action Alternative 1 for operating years 2024 through 2026, the Lower Basin is modeled to operate in a Shortage Condition when projected Lake Mead EOCY pool elevation is at or below 1,090 feet. For 2023, operations are identical with the No Action Alternative. In CRMMS, a rule solves for the Shortage Condition in January by comparing Lake Mead’s previous EOCY pool elevation to defined pool elevations in the **Table C-20**; the total Lower Division States shortage volumes correspond to the Shortage Condition and operating year in **Table C-20**. 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 D**).

Table C-20
Lower Division States' Shortages and DCP Contributions

Lake Mead Elevation (feet)	Shortages	DCP Contributions	Additional Shortages in Action Alternatives		Total Combined (Shortages + DCP Contributions)	
	2007 Interim Guidelines	2019 DCPs	Additional Shortage in 2024	Additional Shortage in 2025-2026	Action Alts 2024	Action Alts 2025-2026
1,090 to > 1,075	0	200	200	200	400	400
1,075 to 1050	333	200	533	533	1,066	1,066
< 1,050 to > 1,045	417	200	617	617	1,234	1,234
1,045 to > 1,040	417	450	867	867	1,734	1,734
1,040 to > 1,035	417	500	1,166	1,166	2,083	2,083
1,035 to > 1,030	417	550	1,116	1,283	2,083	2,250
1,030 to 1,025	417	600	1,066	1,483	2,083	2,500
< 1,025 to 1,000	500	600	983	1,900	2,083	3,000
< 1,000 to 975	500	600	983	2,233	2,083	3,333
< 975 to 950	500	600	983	2,567	2,083	3,667
< 950	500	600	983	2,900	2,083	4,000

The distribution of shortages among water users was computed outside of CRMMS and is applied in two stages. When distributing shortage volumes by priority using the Shortage Allocation Model method, total reductions are inclusive of 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 (i.e., 300 kaf/7,500 kaf). 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 (i.e., water use is set to zero), Stage 2 is entered.

In Stage 2, all Lower Division States' uses are reduced proportional 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 (i.e., 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 modeled shortage by state and priority for Action Alternative 1 is in **Attachment C-4, Table Attachments C-6, C-7, and C-8**. Tables are provided for 2024, 2025, and

2026 separately because CRMMS depletion schedules vary slightly each year, which results in slightly different distributions of shortage.

Within each state, reductions are distributed 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 C-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.

In **Appendix D**, an alternative method to the Action Alternative 1 Shortage Allocation Model is analyzed. The proposed revision adjusts how the Lower Division States' shortage is distributed. This revised method was applied to CRMMS and is analyzed in **Attachment C-5**.

C.7.3.4 Minute 323 High and Low Elevation Reservoir Conditions

The Minute 323 model assumptions for the Lower Basin under the Action Alternative 1 are identical to that of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.7.3.5 DCP and BWSCP

The DCP and BWSCP model assumptions for the Lower Basin under the Action Alternative 1 are identical to that of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.7.3.6 ICS Assumptions

The ICS model assumptions for the Lower Basin under the Action Alternative 1 are identical to that of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.7.4 Action Alternative 2

The Lake Mead operations and Lower Basin conditions for Action Alternative 2 are similar to the No Action Alternative, i.e., shortage and DCP contribution volumes are based on Lake Mead elevations. For operating year 2023, Lake Mead operations are solved for as described in the No Action Alternative, where effective pool elevation is used to calculate Lake Mead Operations and Lower Basin condition. For operating years 2024 to 2026, the Lake Mead operations and Lower Basin conditions are solved for using the physical elevations at Lake Mead.

C.7.4.1 Surplus

The Surplus model assumptions for the Lower Basin under Action Alternative 2 are identical to those of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.7.4.2 Normal Conditions

The Normal Condition model assumptions for the Lower Basin under Action Alternative 2 are identical to those of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.7.4.3 Shortage Condition

Under Action Alternative 2, the Lower Division States' total shortage volumes are the same as Action Alternative 1 (**Table C-20**) but the shortage distribution between states and water users is different. For Action Alternative 2, shortages in addition to the 2007 ROD and 2019 DCPs are distributed in the same percentage across all Lower Basin water users based on 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 shortage to individual water users is performed outside of the CRMMS. Specific shortage volumes for each water user and Shortage Conditions are input into the 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 States' water user modeled in the 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 each water user by spreading the annual shortage out over all months proportional 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 modeled shortage by state for Action Alternative 2 is in **Attachment C-4, Table Attachments C-9 and C-10**.

C.7.4.4 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 of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.7.4.5 DCP and BWSCP

The DCP and BWSCP model assumptions for the Lower Basin under Action Alternative 2 are identical to those of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.7.4.6 ICS Assumptions

The ICS model assumptions for the Lower Basin under Action Alternative 2 are identical to those of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.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 remained consistent for all alternatives. The storage targets and the corresponding elevations for Lake Mohave and Lake Havasu are presented in the following sections.

C.8.1 Lake Mohave/Davis Dam

Lake Mohave is operated to meet monthly elevation targets (**Table C-21**). These elevation targets are based on effective storage space targets set by the Army Corps of Engineers for Lower Basin flood control purposes, as well as endangered species operations developed in conjunction with the Fish and Wildlife Service.

Table C-21
Lake Mohave Monthly Elevation/Storage Targets

Month	Lake Mohave Target Elevation (feet msl)	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

C.8.2 Lake Havasu/Parker Dam

Lake Havasu is operated to meet monthly elevation targets (**Table C-22**). These elevation targets are based on effective storage space targets set by the Army Corps of Engineers for Lower Basin flood control purposes, as well as seasonal needs to meet downstream water demands.

Table C-22
Lake Havasu Monthly Elevation/Storage Targets

Month	Lake Havasu Target Elevation (feet msl)	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

C.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.

C.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 msl, there is no power or energy generated for the current month. This elevation reflects the minimum power pool elevation at Lake Powell.

C.9.2 Hoover Dam

The method that computes power and energy generated at the Hoover Dam, which is the same method used in the 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 peaking flow is the most efficient flow through the turbines for the current operating head while the baseflow represents the minimum flow through the turbines to produce energy.

The base flow and corresponding power generation is 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 base flow is computed by applying the base flow over the month. The monthly release volume at peak flow is computed as

$$PeakFlowVolume = TurbineReleaseVolume - BaseFlowVolume$$

Next, the number of hours required for operation at base and peak flows are then computed as

$$PeakHours = \frac{PeakFlowVolume}{(PeakFlow - BaseFlow) * 3600}$$

$$BaseHours = \frac{SecondsInMonth}{3600} - PeakHours$$

where 3600 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 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 generation at elevations below approximately 950 feet msl, 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 msl. Because there is no operating experience at these elevations, it is impossible to verify if 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) given an operating head. This is computed to distinguish between actual power production and the power that could be produced.

C.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. Energy is computed using this empirical relationship as:

$$\begin{aligned} Energy (MWH) &= \left(C_1 * \frac{62.4}{737.5} * Outflow (1000 cfs) * HoursInMonth \right. \\ &\quad \left. * \frac{OperatingHead (ft)}{1000} - C_2 \right) * eff * 1000 \end{aligned}$$

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 typically set to 1.0.

This energy method is different from the method used in CRSS for the 2007 FEIS because analysis of energy methods in RiverWare indicated that the new method simulates historical energy generation better than the method previously used in CRSS. This method does not currently estimate the power capacity at Davis Dam, which was computed by the method used for the 2007 FEIS.

C.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 estimated to be 1.0; C_2 is estimated to be 0; and eff varies by month as shown in **Table C-23**. The monthly efficiency coefficients are based on analysis of historical data from PO&M reports.

Table C-23
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

This energy method was implemented in CRMMS for Parker Dam in June 2022 after performing analysis of different methods in RiverWare and comparing the simulated energy to actual energy as reported in historical reports. The new method was shown to out-perform the previous method (used in the 2007 FEIS), particularly at higher flow/generation levels.

C.10 References

- Muth, R. T., L. W. Crist, K. E. LaGory, J. W. Hayse, K. R. Bestgen, T. P. Ryan, J. K. Lyons, and R. A. Valdez (2000), Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam.
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- _____. 2006b. Record of Decision for the Navajo Reservoir Operations, Navajo Unit–San Juan River New Mexico, Colorado, Utah, Final Environmental Impact Statement.
- _____. 2012. Record of Decision for the Aspinall Unit Operations, Final Environmental Impact Statement.
- _____. 2022. General Modeling Information. Internet website:
<https://www.usbr.gov/lc/region/g4000/riverops/model-info.html>
- Western Water Assessment. 2020. Colorado River Basin Climate and Hydrology State of the Science. Western Water Assessment. Chapter 3 Primary Planning Tools. April 2020.

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Attachment C-1

CRMMS Lake Powell Assumed Monthly Releases

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Attachment C-1. CRMMS Lake Powell Assumed Monthly Releases

Table Attachment C-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 of this range are interpolated from LTEMP patterns for modeling purposes.

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Attachment C-2

CRMMS Lower Basin Water User
Depletion Schedules

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Attachment C-2. CRMMS Lower Basin Water User Depletion Schedules

Table Attachment C-2
CRMMS Input Annual Lower Basin Water User Depletion Schedules (Values in af)

State	CRMMS Water User	2023	2024	2025	2026
Arizona	AzPumpersAbvImp	5,237	5,237	5,237	5,237
	AzPumpersBlwImp	9,240	9,240	9,240	9,240
	AzPumpersDvsToPkr	896	896	896	896
	BrookeWater	324	324	324	324
	BullheadCity	8,799	8,799	8,799	8,799
	CAP	1,547,318	1,545,964	1,547,318	1,547,318
	CibolaNWR	14,264	14,264	14,264	14,264
	CibolaValleyIID	13,637	13,637	13,637	13,637
	City of Parker	424	424	424	424
	City of Yuma	15,833	15,833	15,833	15,833
	Cocopah Indian Res	1,725	1,725	1,725	1,725
	CRIRAz	335,969	335,969	335,969	335,969
	DavisDamProject	2	2	2	2
	DesertLawnMemorial	26	26	26	26
	Ehrenberg	252	252	252	252
	Ft Yuma	1,553	1,553	1,553	1,553
	FtMohaveAz	44,550	44,550	44,550	44,550
	Gila Monster Farms	4,888	4,888	4,888	4,888
	GoldenShores	286	286	286	286
	HavasunWR	3,564	3,564	3,564	3,564
	ImperialNWR	3,799	3,799	3,799	3,799
	LakeHavasucity	9,052	9,052	9,052	9,052
	LMNRA Az Mead	63	63	63	63
	LMNRA Az Mohave	214	214	214	214
	MCAirStation	1,300	1,300	1,300	1,300
	MohaveValleyIID	21,464	22,818	21,464	21,464
	MohaveWaterConsDist	692	692	692	692
	NGVIDD	10,674	10,674	10,674	10,674
	SouthernPacific	29	29	29	29
	UnitB	13,129	13,129	13,129	13,129
	UofA	852	852	852	852
	WMIDD	278,000	278,000	278,000	278,000
	YAO	195	195	195	195
	YCWUA	275,560	275,560	275,560	275,560
	YID	39,569	39,569	39,569	39,569
	YMIDD	110,859	110,859	110,859	110,859
	YumaProvingGround	517	517	517	517
	YumaUnionHighScl	150	150	150	150

C-2. CRMMS Lower Basin Water User Depletion Schedules

State	CRMMS Water User	2023	2024	2025	2026
Nevada	LMNRA Mead	182,623	182,624	182,625	182,626
	BasicManagement	229,579	229,580	229,581	229,582
	City of Henderson	283,269	283,270	283,271	283,272
	NvDeptFishGame	172,207	172,208	172,209	172,210
	BoulderCanyonProject	174,223	174,224	174,225	174,226
	PacificCoastBuilding	178,619	178,620	178,621	178,622
	FtMohaveNv	204,484	204,485	204,486	204,487
	SCE	172,123	172,124	172,125	172,126
	BigBend	205,478	205,479	205,480	205,481
	LMNRA Mohave	175,623	175,624	175,625	175,626
	SNWADiversion	3,538,116	3,538,117	3,538,118	3,538,119
	LVWashReturns	1,734,239	1,734,240	1,734,241	1,734,242
	SNWP	1,873,545	1,873,546	1,873,547	1,873,548
California	CaPumpersAbvImp	47	47	47	47
	CaPumpersDvsToPkr	407	407	407	407
	Chemehuevi	183	183	183	183
	Coachella	384,000	394,000	419,000	409,000
	CRIRCa	5,014	5,014	5,014	5,014
	FtMohaveCa	8,996	8,996	8,996	8,996
	FYIR_Ranches	2,224	2,224	2,224	2,224
	IID	2,617,800	2,612,800	2,612,800	2,622,800
	MWD	1,092,328	1,092,328	797,400	797,400
	MWDDiversion	1,094,928	1,094,928	800,000	800,000
	MWDReturns	2,600	2,600	2,600	2,600
	Needles	1,605	1,605	1,605	1,605
	PaloVerde	362,104	386,321	362,104	362,104
	SaltonSea	0	0	0	0
	Winterhaven	61	61	61	61
	Yumalsland	1,629	1,629	1,629	1,629
	YumaProject	48,606	48,606	48,606	48,606
Mexico	MexicoSched	1,500,000	1,500,000	1,500,000	1,500,000
	MexicoBypass	116,633	116,633	116,633	116,633
	MexicoExcess	25,039	25,039	25,039	25,039
	MexicoTJ	1,154	1,154	1,154	1,154

Footnotes:

Water user names in the table reflect the water user names in the September 2022 CRMMS. Water user names may have been updated in and/or not match the Lower Basin Water Accounting Reports.

Attachment C-3

CRMMS Lower Basin Water User Priorities

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Attachment C-3. CRMMS Lower Basin Water User Priorities

Table Attachments C-3 through C-5 list the CRMMS users and the corresponding assumed priorities that are used for purposes of distributing shortages in Action Alternative 1. The water user names are provided exactly as they show up in CRMMS and abbreviations are not defined.

Table Attachment C-3
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 C-4
CRMMS Water Users by Priority for Nevada

Nevada		
Present Perfected Rights (PPR)	SNWP non-Present Perfected Rights	Non-Present Perfected Rights, 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 C-5
CRMMS Water Users by Priority for California

California					
Present Perfected Rights (PPR)	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					Yumalsland
FYIR_Ranches					
IID – PPR					
Needles					
PaloVerde PPR					
Winterhaven					
YumaProject					

Attachment C-4

CRMMS Action Alternatives Shortages and
DCP Contributions

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Attachment C-4. CRMMS Action Alternatives Shortages and DCP Contributions

Table Attachments C-6 through C-11 include the assumed shortages and DCP contributions by state and priority (for Action Alternative 1) that were computed using the methods described in Sections C.7.3.3 and C.7.4.3. These shortage volumes are imported to CRMMS to model the action alternatives.

Table Attachment C-6
2024 Action Alternative 1 CRMMS Shortages and DCP Contributions Table by State and Priority (values in acre-ft)

Lake Mead (feet)	Interim Guidelines Shortages		DCP Contributions			Additional Shortages								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	0	0	0	0	384,000	16,000	0	400,000
1,075 - 1,050	320,000	13,000	192,000	8,000	0	511,360	0	21,640	0	0	0	0	0	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	0	0	0	0	1,184,640	49,360	0	1,234,000
1,045 - 1,040	400,000	17,000	240,000	10,000	200,000	902,229	26,779	42,385	0	0	0	0	0	1,569,008	69,385	200,000	1,838,393
1,040 - 1,035	400,000	17,000	240,000	10,000	250,000	902,229	100,073	56,413	107,285	0	0	0	0	1,642,302	83,413	357,285	2,083,000
1,035 - 1,030	400,000	17,000	240,000	10,000	300,000	902,229	100,073	56,413	57,285	0	0	0	0	1,642,302	83,413	357,285	2,083,000
1,030 - 1,025	400,000	17,000	240,000	10,000	350,000	902,229	100,073	56,413	7,285	0	0	0	0	1,642,302	83,413	357,285	2,083,000
1,025 - 1,000	480,000	20,000	240,000	10,000	350,000	822,229	100,073	53,413	7,285	0	0	0	0	1,642,302	83,413	357,285	2,083,000
1,000 - 975	480,000	20,000	240,000	10,000	350,000	822,229	100,073	53,413	7,285	0	0	0	0	1,642,302	83,413	357,285	2,083,000

C-4. CRMMS Action Alternatives Shortages and DCP Contributions

Lake Mead (feet)	Interim Guidelines Shortages		DCP Contributions			Additional Shortages								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	
975-950	480,000	20,000	240,000	10,000	350,000	822,229	100,073	53,413	7,285	0	0	0	0	1,642,302	83,413	357,285	2,083,000
< 950	480,000	20,000	240,000	10,000	350,000	822,229	100,073	53,413	7,285	0	0	0	0	1,642,302	83,413	357,285	2,083,000

Footnotes:

¹In this elevation tier, the 2019 DCP contributions for California exceed what would be required under the Action Alternative 1. As a result, no additional shortage is required in this elevation tier for California.

²AZ-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)

³CRMMS users are categorized by priority in Table Attachments C-3, C-4, and C-5.

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 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 modeled methodology is not a substitute for the annual process of reviewing water orders and determining which can be filled and cannot replicate the precision required of that process.

Table Attachment C-7
2025 Action Alternative 1 CRMMS Shortages and DCP Contributions Table by State and Priority (values in acre-ft)

Lake Mead (feet)	Interim Guidelines Shortages		DCP Contributions			Additional Shortages								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	0	0	0	0	384,000	16,000	0	400,000
1,075 - 1,050	320,000	13,000	192,000	8,000	0	511,360	0	21,640	0	0	0	0	0	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	0	0	0	0	1,184,640	49,360	0	1,234,000
1,045 - 1,040	400,000	17,000	240,000	10,000	200,000	902,229	26,779	42,385	0	0	0	0	0	1,569,008	69,385	200,000	1,838,393
1,040 - 1,035	400,000	17,000	240,000	10,000	250,000	902,229	100,073	56,413	107,285	0	0	0	0	1,642,302	83,413	357,285	2,083,000
1,035 - 1,030	400,000	17,000	240,000	10,000	300,000	902,229	135,145	63,125	182,501	0	0	0	0	1,677,374	90,125	482,501	2,250,000
1,030 - 1,025	400,000	17,000	240,000	10,000	350,000	902,229	187,648	73,174	319,949	0	0	0	0	1,729,877	100,174	669,949	2,500,000
1,025 - 1,000	480,000	20,000	240,000	10,000	350,000	822,229	292,654	90,271	613,713	81,133	0	0	0	1,834,883	120,271	1,044,846	3,000,000
1,000 - 975	480,000	20,000	240,000	10,000	350,000	822,229	362,588	103,656	613,713	330,815	0	0	0	1,904,817	133,656	1,294,527	3,333,000
975-950	480,000	20,000	240,000	10,000	350,000	822,229	432,732	117,081	613,713	407,300	30,375	143,570	0	1,974,961	147,081	1,544,958	3,667,000
< 950	480,000	20,000	240,000	10,000	350,000	822,229	502,666	130,466	613,713	407,300	30,375	262,083	131,169	2,044,895	160,466	1,794,640	4,000,000

Footnotes:

¹In this elevation tier, the 2019 DCP contributions for California exceed what would be required under the Action Alternative 1. As a result, no additional shortage is required in this elevation tier for California.

²AZ-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)

³CRMMS users are categorized by priority in Table Attachments C-3, C-4, and C-5.

⁴Different tables are provided for 2025 and 2026 because CRMMS depletion schedules vary slightly between 2025 and 2026 which cause slightly different distributions of shortage.

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Table Attachment C-8
2026 Action Alternative 1 CRMMS Shortages and DCP Contributions Table by State and Priority (values in acre-ft)

Interim Guidelines Shortages		DCP Contributions			Additional Shortages								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	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	192,000	8,000	0	192,000	0	8,000	0	0	0	0	0	384,000	16,000	0	400,000
320,000	13,000	192,000	8,000	0	511,360	0	21,640	0	0	0	0	0	1,023,360	42,640	0	1,066,000
400,000	17,000	192,000	8,000	0	592,640	0	24,360	0	0	0	0	0	1,184,640	49,360	0	1,234,000
400,000	17,000	240,000	10,000	200,000	902,229	27,213	42,360	0	0	0	0	0	1,569,442	69,360	200,000	1,838,802
400,000	17,000	240,000	10,000	250,000	902,229	101,695	56,320	105,756	0	0	0	0	1,643,924	83,320	355,756	2,083,000
400,000	17,000	240,000	10,000	300,000	902,229	137,336	63,000	180,435	0	0	0	0	1,679,565	90,000	480,435	2,250,000
400,000	17,000	240,000	10,000	350,000	902,229	190,690	73,000	317,081	0	0	0	0	1,732,919	100,000	667,081	2,500,000
480,000	20,000	240,000	10,000	350,000	822,229	297,398	90,000	612,134	78,239	0	0	0	1,839,627	120,000	1,040,373	3,000,000
480,000	20,000	240,000	10,000	350,000	822,229	368,466	103,320	612,134	326,852	0	0	0	1,910,694	133,320	1,288,986	3,333,000
480,000	20,000	240,000	10,000	350,000	822,229	439,747	116,680	612,134	407,300	30,375	138,535	0	1,981,975	146,680	1,538,345	3,667,000
480,000	20,000	240,000	10,000	350,000	822,229	510,814	130,000	612,134	407,300	30,375	262,083	125,065	2,053,043	160,000	1,786,957	4,000,000

Footnotes:

¹In this elevation tier, the 2019 DCP contributions for California exceed what would be required under the Action Alternative 1. As a result, no additional shortage is required in this elevation tier for California.

²AZ-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)

³CRMMS users are categorized by priority in Table Attachments C-3, C-4, and C-5.

⁴Different tables are provided for 2025 and 2026 because CRMMS depletion schedules vary slightly between 2025 and 2026 which cause slightly different distributions of shortage.

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 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 modeled methodology is not a substitute for the annual process of reviewing water orders and determining which can be filled and cannot replicate the precision required of that process.

Table Attachment C-9
2024 Action Alternative 2 CRMMS Shortage Volume Table (values in acre-ft)

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 - 1,000	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
1,000 - 975	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
975-950	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
< 950	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 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 modeled methodology is not a substitute for the annual process of reviewing water orders and determining which can be filled and cannot replicate the precision required of that process.

Table Attachment C-10
2025-2026 Action Alternative 2 CRMMS Shortage Volume Table (values in acre-ft)

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	478,986	51,320	752,694	1,118,986	78,320	1,052,694	2,250,000
1,030 - 1,025	400,000	17,000	240,000	10,000	350,000	553,654	59,320	870,026	1,193,654	86,320	1,220,026	2,500,000
1,025 - 1,000	480,000	20,000	240,000	10,000	350,000	709,330	76,002	1,114,668	1,429,330	106,002	1,464,668	3,000,000
1,000 - 975	480,000	20,000	240,000	10,000	350,000	833,652	89,321	1,310,027	1,553,652	119,321	1,660,027	3,333,000
975-950	480,000	20,000	240,000	10,000	350,000	958,346	102,681	1,505,973	1,678,346	132,681	1,855,973	3,667,000
< 950	480,000	20,000	240,000	10,000	350,000	1,082,666	116,000	1,701,334	1,802,666	146,000	2,051,334	4,000,000

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 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 modeled methodology is not a substitute for the annual process of reviewing water orders and determining which can be filled and cannot replicate the precision required of that process.

Attachment C-5

Comparison of Action Alternative 1
Shortage Distribution Methods

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Attachment C-5. Comparison of Action Alternative 1 Shortage Distribution Methods

In the Shortage Allocation Model Appendix (**Appendix D**), an alternative approach for distributing shortage was analyzed for Action Alternative 1 (see **Section D.4.4**). This attachment compares the hydrologic modeling results from different methods for distributing shortage in Action Alternative 1. First, the method for translating shortage volumes to CRMMS inputs is described. Then, the differences in Lake Mead operations and Lower Division States use and shortage volumes are explored for 2024, 2025, and 2026. Refer to **Section C.7.3.3** for a description of how shortages are modeled in Action Alternative 1.

C-5.1 CRMMS Shortage Assumptions for the Alternative Approach to Action Alternative 1

The Action Alternative 1 Shortage Allocation Model that was used in **Chapter 3** of the SEIS resulted in shortages being applied to California PPR entitlements before Arizona or Nevada's non-PPR entitlements were fully shorted. This also occurred when translating the Shortage Allocation Model method to CRMMS inputs (e.g., **Attachment Tables C-6, C-7, and C-8**). The alternative approach to the Action Alternative 1 Shortage Allocation Model treats each state's non-PPR entitlements as co-equal. Therefore, all non-PPR entitlements will be completely shorted before any PPR entitlements are shorted.

The distribution of shortage volumes among water users in CRMMS for the alternative approach to the Action Alternative 1 method was computed outside of CRMMS and uses the same approach as the alternative approach to the Shortage Allocation Model. In developing the Stage 1 and Stage 2 percentages for the sharing of shortages among the Lower Division States, the CRMMS depletion schedules of PPR entities were removed from each state's total depletion schedule volumes.

The distribution of shortages among water users was computed outside of CRMMS and was applied in two stages. When distributing shortage volumes by priority using the Shortage Allocation Model method, total shortages and DCP contributions are inclusive of the 2007 ROD and 2019 DCP. As in Action Alternative 1, Stage 1 reductions are applied to Nevada and Arizona.

- Nevada: The Nevada Stage 1 shortage volume is total Nevada non-PPR depletion schedule divided by the total Lower Division States' non-PPR depletion schedule:

$$Stage1ShortagePercent = \frac{NevadaNonPPRVolume}{LDSNonPPRVolume} = 7.1\%$$

- Arizona: The remainder of the total shortage is assigned to Arizona, which is 92.9% of the total shortage.

Once Arizona Priority 4 entitlements are fully shorted (i.e., water use is set to zero), Stage 2 begins.

In Stage 2, all Lower Division States are shorted proportional to the remaining depletion scheduled in CRMMS. Shortages taken by Nevada and Arizona in Stage 1 are subtracted from each state's annual scheduled depletion when determining state level reductions.

$$\begin{aligned} \text{Stage2SReduction}_n &= \text{Stage2Reduction} \\ &\quad * \left(\frac{\text{ScheduledUse}_n - \text{Stage1Reduction}_n - \text{ScheduledPPRUse}_n}{\text{LDSTotalUse} - \text{Stage1Reduction} - \text{LDSScheduledPPRUse}} \right) \end{aligned}$$

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 (i.e., 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 modeled shortage by state and priority for the alternative approach to Action Alternative 1 is in **Table Attachments C-11, C-12, and C-13**. Tables are provided for 2024, 2025, and 2026 because CRMMS depletion schedules vary slightly each year, which causes slightly different distributions of shortage.

Table Attachment C-11
2024 Action Alternative 1 CRMMS Shortage Volume Table by State and Priority (values in acre-ft)

Lake Mead (feet)	Interim Guidelines Shortage		DCP Contributions			Additional Shortage								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	179,571	0	20,429	0	0	0	0	0	371,571	28,429	0	400,000
1,075 - 1,050	320,000	13,000	192,000	8,000	0	478,237	0	54,763	0	0	0	0	0	990,237	75,763	0	1,066,000
1,050 - 1,045	400,000	17,000	192,000	8,000	0	554,297	0	62,703	0	0	0	0	0	1,146,297	87,703	0	1,234,000
1,045 - 1,040	400,000	17,000	240,000	10,000	200,000	902,229	19,312	96,239	0	0	0	0	0	1,561,541	123,239	200,000	1,884,779
1,040 - 1,035	400,000	17,000	240,000	10,000	250,000	902,229	110,668	121,043	32,061	0	0	0	0	1,652,896	148,043	282,061	2,083,000
1,035 - 1,030	400,000	17,000	240,000	10,000	300,000	902,229	110,668	121,043	0	0	0	0	0	1,652,896	148,043	300,000	2,100,939
1,030 - 1,025	400,000	17,000	240,000	10,000	350,000	902,229	110,668	121,043	0	0	0	0	0	1,652,896	148,043	350,000	2,150,939
1,025 - 1,000	480,000	20,000	240,000	10,000	350,000	822,229	110,668	118,043	0	0	0	0	0	1,652,896	148,043	350,000	2,150,939
1,000 - 975	480,000	20,000	240,000	10,000	350,000	822,229	110,668	118,043	0	0	0	0	0	1,652,896	148,043	350,000	2,150,939
975-950	480,000	20,000	240,000	10,000	350,000	822,229	110,668	118,043	0	0	0	0	0	1,652,896	148,043	350,000	2,150,939
< 950	480,000	20,000	240,000	10,000	350,000	822,229	110,668	118,043	0	0	0	0	0	1,652,896	148,043	350,000	2,150,939

Footnotes:

¹In this elevation tier, the 2019 DCP contributions for California exceed what would be required under the Action Alternative 1. As a result, no additional shortage is required in this elevation tier for California.

²AZ-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)

³CRMMS users are categorized by priority in Table Attachments C-3, C-4, and C-5.

Disclaimer: These modeling inputs (for alternative approach to 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 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 modeled methodology is not a substitute for the annual process of reviewing water orders and determining which can be filled and cannot replicate the precision required of that process.

Table Attachment C-12
2025 Action Alternative 1 CRMMS Shortage Volume Table by State and Priority (values in acre-ft)

Lake Mead (feet)	Interim Guidelines Shortage		DCP Contributions			Additional Shortage								Total Reductions			Lower Division States Total
	AZ	NV	AZ	NV	CA	AZ-P4	AZ-P2,3	NV	CA-P4 and CA-Phone	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	179,571	0	20,429	0	0	0	0	0	371,571	28,429	0	400,000
1,075 - 1,050	320,000	13,000	192,000	8,000	0	478,237	0	54,763	0	0	0	0	0	990,237	75,763	0	1,066,000
1,050 - 1,045	400,000	17,000	192,000	8,000	0	554,297	0	62,703	0	0	0	0	0	1,146,297	87,703	0	1,234,000
1,045 - 1,040	400,000	17,000	240,000	10,000	200,000	902,229	19,312	96,239	0	0	0	0	0	1,561,541	123,239	200,000	1,884,779
1,040 - 1,035	400,000	17,000	240,000	10,000	250,000	902,229	110,668	121,043	32,061	0	0	0	0	1,652,896	148,043	282,061	2,083,000
1,035 - 1,030	400,000	17,000	240,000	10,000	300,000	902,229	154,382	132,912	93,477	0	0	0	0	1,696,611	159,912	393,477	2,250,000
1,030 - 1,025	400,000	17,000	240,000	10,000	350,000	902,229	219,823	150,680	210,268	0	0	0	0	1,762,052	177,680	560,268	2,500,000
1,025 - 1,000	480,000	20,000	240,000	10,000	350,000	822,229	350,705	183,216	543,851	0	0	0	0	1,892,934	213,216	893,851	3,000,000
1,000 - 975	480,000	20,000	240,000	10,000	350,000	822,229	437,872	206,883	613,713	152,303	0	0	0	1,980,101	236,883	1,116,016	3,333,000
975-950	480,000	20,000	240,000	10,000	350,000	822,229	525,302	230,621	613,713	375,136	0	0	0	2,067,530	260,621	1,338,849	3,667,000
< 950	480,000	20,000	240,000	10,000	350,000	822,229	612,469	254,288	613,713	407,300	30,375	159,627	0	2,154,698	284,288	1,561,015	4,000,000

Footnotes:

¹In this elevation tier, the 2019 DCP contributions for California exceed what would be required under the Action Alternative 1. As a result, no additional shortage is required in this elevation tier for California.

²AZ-P4 (Arizona Priority 4); AZ-P2,3 (Arizona Priority 2 and Priority 3); CA-P4 (California Priority 4); CA-Phone (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)

³CRMMS users are categorized by priority in **Table Attachments C-2, C-3, and C-4**.

Disclaimer: These modeling inputs (for alternative approach to 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 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 modeled methodology is not a substitute for the annual process of reviewing water orders and determining which can be filled and cannot replicate the precision required of that process.

Table Attachment C-13
2026 Action Alternative 1 CRMMS Shortage Volume Table by State and Priority (values in acre-ft)

Lake Mead (feet)	Interim Guidelines Shortage		DCP Contributions			Additional Shortage								Total Reductions			Lower Division States Total
	AZ	NV	AZ	NV	CA	AZ-P4	AZ-P2,3	NV	CA-P4 and CA-Phone	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	179,560	0	20,440	0	0	0	0	0	371,560	28,440	0	400,000
1,075 - 1,050	320,000	13,000	192,000	8,000	0	478,209	0	54,791	0	0	0	0	0	990,209	75,791	0	1,066,000
1,050 - 1,045	400,000	17,000	192,000	8,000	0	554,264	0	62,736	0	0	0	0	0	1,146,264	87,736	0	1,234,000
1,045 - 1,040	400,000	17,000	240,000	10,000	200,000	902,229	19,312	96,286	0	0	0	0	0	1,561,541	123,286	200,000	1,884,826
1,040 - 1,035	400,000	17,000	240,000	10,000	250,000	902,229	110,727	121,099	31,945	0	0	0	0	1,652,956	148,099	281,945	2,083,000
1,035 - 1,030	400,000	17,000	240,000	10,000	300,000	902,229	154,470	132,973	93,328	0	0	0	0	1,696,699	159,973	393,328	2,250,000
1,030 - 1,025	400,000	17,000	240,000	10,000	350,000	902,229	219,954	150,747	210,070	0	0	0	0	1,762,183	177,747	560,070	2,500,000
1,025 - 1,000	480,000	20,000	240,000	10,000	350,000	822,229	350,921	183,297	543,553	0	0	0	0	1,893,150	213,297	893,553	3,000,000
1,000 - 975	480,000	20,000	240,000	10,000	350,000	822,229	438,146	206,973	612,134	153,519	0	0	0	1,980,375	236,973	1,115,653	3,333,000
975-950	480,000	20,000	240,000	10,000	350,000	822,229	525,632	230,720	612,134	376,286	0	0	0	2,067,861	260,720	1,338,420	3,667,000
< 950	480,000	20,000	240,000	10,000	350,000	822,229	612,856	254,396	612,134	407,300	30,375	160,710	0	2,155,085	284,396	1,560,519	4,000,000

Footnotes:

¹In this elevation tier, the 2019 DCP contributions for California exceed what would be required under the Action Alternative 1. As a result, no additional shortage is required in this elevation tier for California.

²AZ-P4 (Arizona Priority 4); AZ-P2,3 (Arizona Priority 2 and Priority 3); CA-P4 (California Priority 4); CA-Phone (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)

³CRMMS users are categorized by priority in Table Attachments C-3, C-4, and C-5.

Disclaimer: These modeling inputs (for alternative approach to 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 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 modeled methodology is not a substitute for the annual process of reviewing water orders and determining which can be filled and cannot replicate the precision required of that process.

C-5.1.1 CRMMS Modeling Results

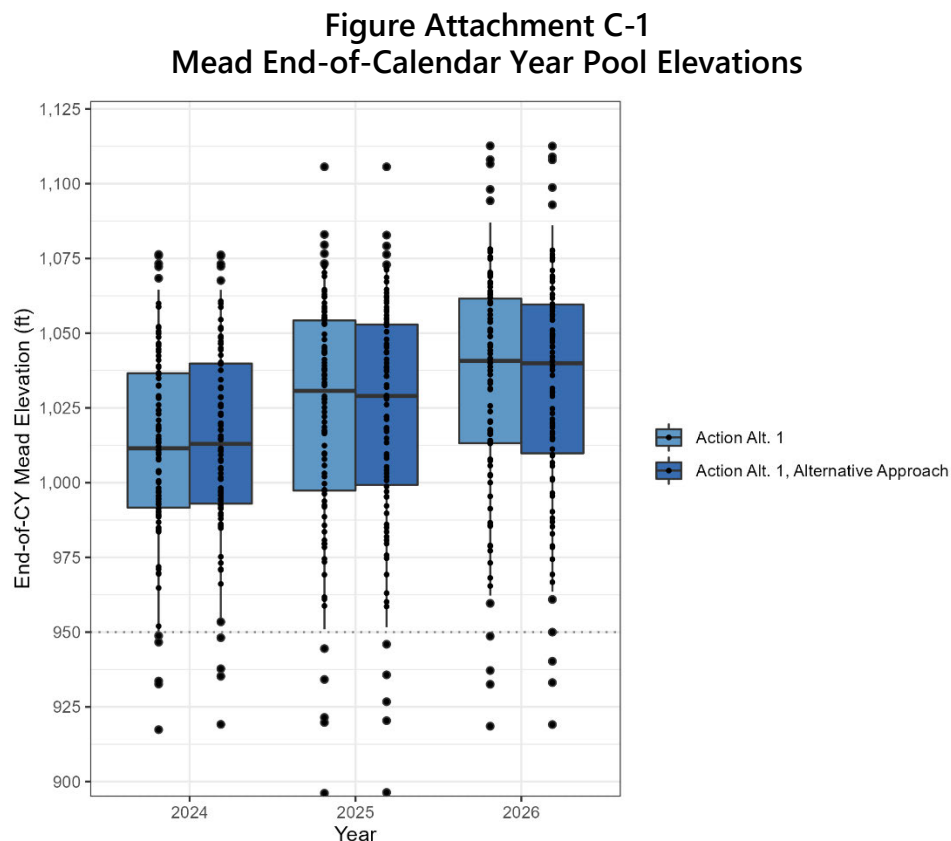
The Action Alternative 1 shortage distribution methods are compared using the following metrics:

- Lake Mead end-of-calendar year (EOCY) pool elevation
- Lower Division States modeled depletions (without system shortage)
- Lower Division States shortage and DCP contributions

This truncated set of metrics and is focused on those that differ the most when comparing the Action Alternative 1 shortage distribution methods. There are other metrics, e.g., Lake Powell pool elevation, that may be indirectly affected by these different methods and/or may have smaller differences than these highlighted metrics.

Lake Mead

Figure Attachment C-1 shows the distributions of modeled EOYC Lake Mead pool elevations in 2024, 2025, and 2026. Each dot is the end-of-calendar year elevation produced by a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines.

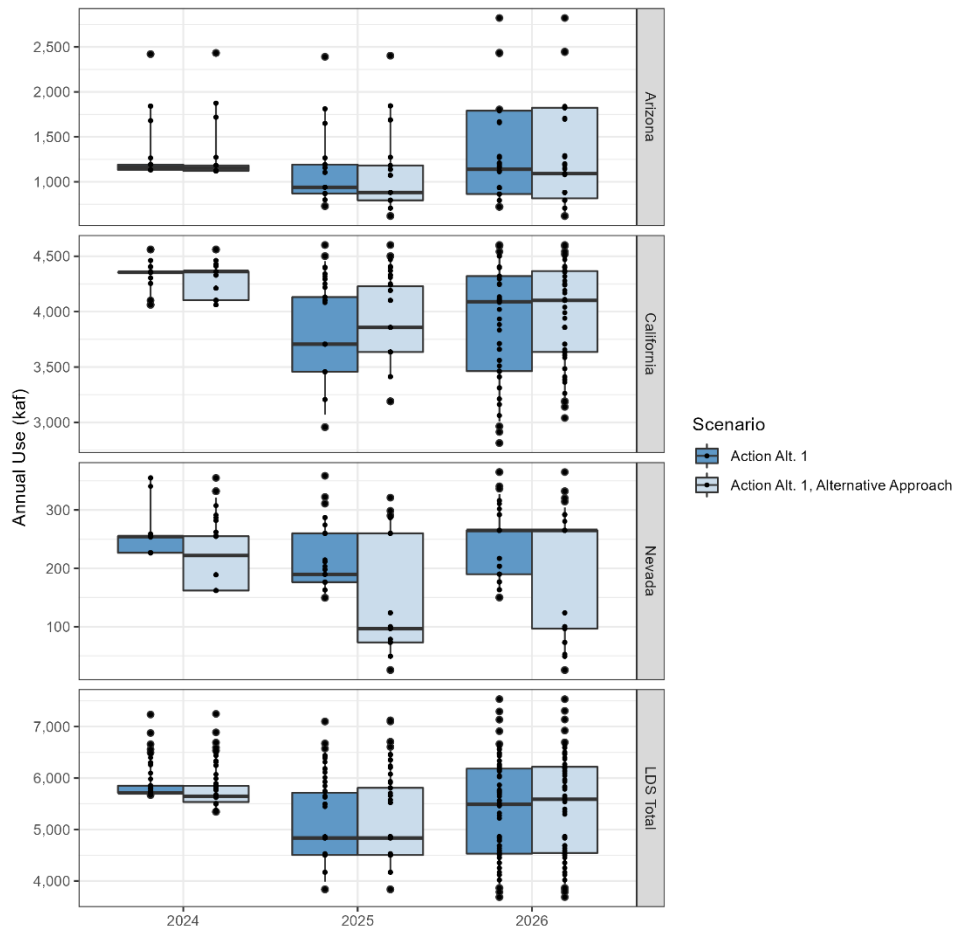


The distributions of modeled EOY Lake Mead elevations for Action Alternative 1 and the alternative approach to Action Alternative 1 which uses state apportionments less PPR entitlements (labeled Action Alt. 1, Alternative Approach) shown in **Figure Attachment C-1** are very similar. The median and 25th to 75th percentiles of the distributions change only slightly. In 2024, the alternative approach to Action Alternative 1 has a slightly higher median than Action Alternative 1, and in 2025 and 2026 the median for the alternative approach to Action Alternative 1 is slightly lower. The minor differences in EOY pool elevation are due to slightly different demands downstream of Lake Mead caused by the differences in shortage distribution. These minor differences cause a few hydrologic traces to be in a different Lower Basin Shortage Condition, which also affects reduction volumes in the following years.

Shortage Sharing and Water Delivery

Figure Attachment C-2 shows the distributions of modeled Lower Division States depletions in 2024, 2025, and 2026. Each dot is the volume of water requested during that year under a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines. Panels one through four display depletions for Arizona, California, Nevada, and Lower Division States total, respectively, that include ICS creation/delivery and other assumptions related to meeting the required DCP contributions. This figure is oriented to facilitate the comparison of a single state's modeled depletions across each alternative over the period of analysis.

Figure Attachment C-2
Lower Division States' Modeled Depletions



In the top panel of **Figure Attachment C-2**, Arizona's modeled annual depletion is similar across the two Action Alternative 1 shortage distribution methods. The alternative approach to Action Alternative 1 has slightly lower annual use for Arizona. In the second panel, modeled annual depletions for California for both scenarios similar. In 2025 and 2026, the alternative approach to Action Alternative 1 has a slightly higher annual depletion and higher minimum annual depletion than Action Alternative 1. The modeled annual depletions for Nevada in the third panel have lower annual depletion with the alternative approach to Action Alternative 1. Since Nevada has a lower proportion of PPR entitlements compared to Arizona and California, Nevada has a higher percentage of the required reductions with the alternative approach to Action Alternative 1. This causes lower use across most of the distribution. In 2025 and 2026, the lowest 50th and 25th percent of projections, respectively, show Nevada's annual depletion at or below 100,000 af.

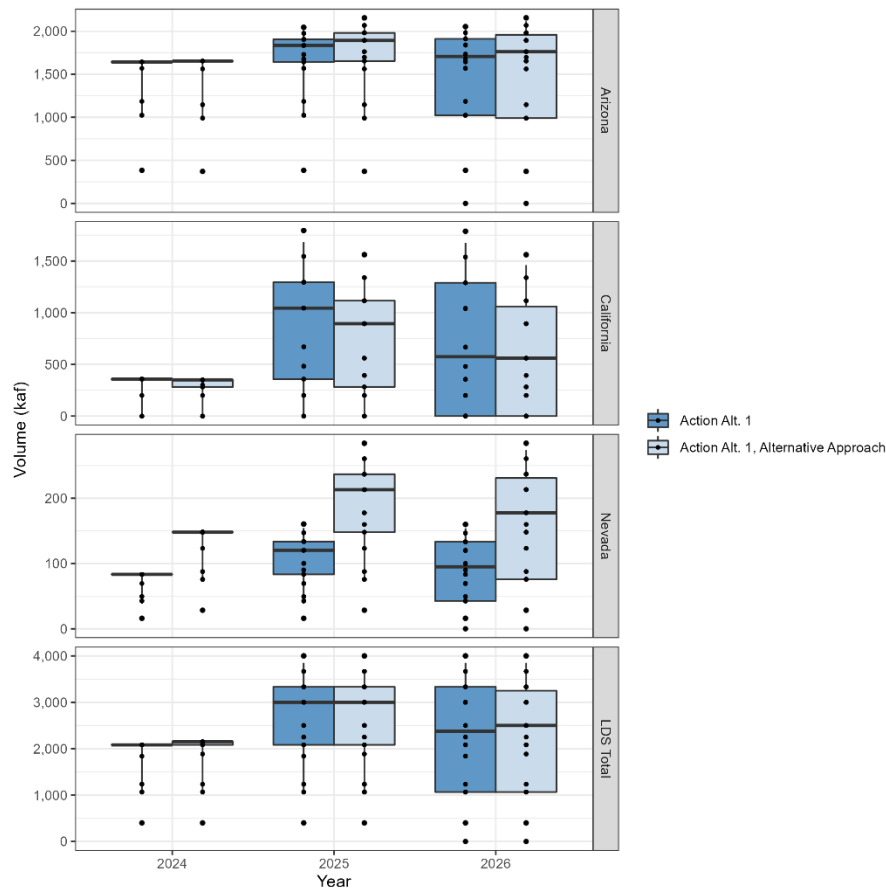
The total modeled Lower Division States annual depletions are compared in the bottom panel of **Figure Attachment C-2**. The median and range of both scenarios are very similar. This is expected since the scenarios have the similar shortage volumes applied at each Lake Mead elevation. The minor differences in total Lower Division States' annual depletion are due to slightly different distributions of shortage which can have minor difference in water use due to ICS activity and the

way users meet their DCP contributions. Additionally, due to the shortage distribution methods certain shortage conditions may have slightly higher required shortages with the alternative shortage distribution approach because California has a required DCP contribution that are greater than the shortage that would have been required in a strict priority system.

The modeled Lower Division States annual depletions in **Figure Attachment C-2** are the requested depletions before any system shortages occur. These are not reported in this attachment because only 1.1 percent of traces have a system shortage in Action Alternative 1 in 2025 and 2026 (**Section 3.7.2**) and because **Figure Attachment C-2** indicate there is very little difference in Lake Mead elevations. This indicates little to no difference in system shortages due to the different Action Alternative 1 shortage distribution methods.

Figure Attachment C-3 shows the distributions of modeled shortages and DCP contributions for Lower Division States in 2024, 2025, and 2026. Each dot is the volume of shortages and DCP contributions modeled during that year under a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines. Panels one through four display modeled shortages and DCP contributions for Arizona, California, Nevada, and Lower Division States total, respectively.

Figure Attachment C-3
Lower Division States Modeled Delivery Reduction Volumes



In the top panel of **Figure Attachment C-3**, Arizona’s modeled shortages and DCP contributions are similar across the two Action Alternative 1 shortage distribution methods. The alternative approach to Action Alternative 1 has slightly higher reduction at the median in 2025 and 2026. In the second panel, modeled shortages and DCP contributions for California are generally lower in the alternative approach to Action Alternative 1. In 2024, both scenarios have similar reductions. In 2025 and 2026, the alternative approach to Action Alternative 1 reductions are lower for the top 90% of reductions. For 2026, the top 25th percent of reductions are lower in the alternative approach to Action Alternative 1. The modeled shortages and DCP contributions for Nevada in the third panel show higher annual shortages and DCP contributions in the alternative approach to Action Alternative 1 in all years due to Nevada’s lower proportion of PPR entitlements compared to the other Lower Division States. Reductions in **Figure Attachment C-3** do not translate directly to annual depletion in **Figure Attachment C-2** because of ICS activity and how states meet their DCP contribution (which can be met through conversion of EC-ICS to DCP-ICS).

The total modeled Lower Division States’ reductions are compared in the bottom panel of **Figure Attachment C-3**. The median and range of both scenarios are very similar. The minor differences in total Lower Division States’ shortages and DCP contributions are due to minor differences in Lower Basin Shortage Conditions and slightly different reduction volumes between Action Alternative 1

and the alternative approach to Action Alternative 1. The slight differences in reaction volumes are due to how California's required DCP contribution is modeled, which causes higher shortage volumes than would have been required in Action Alternative 1 and the alternative approach to Action Alternative 1.

C-5.1.2 Summary

Overall, the different Action Alternative 1 shortage distribution methods compared in this attachment result in only small modeled differences in Lake Mead elevations. The alternative approach results in higher modeled shortages and DCP contributions and lower modeled depletions for Nevada and Arizona, and lower modeled shortages and DCP contributions with higher modeled depletions for California than the method used for Action Alternative 1. This is mostly due to the relative proportion of each state's total modeled depletions that are from PPR entitlements. Because Nevada and Arizona have a lower proportion of PPR entitlements, the alternative approach to Action Alternative 1 models a higher proportion of shortage to Arizona and Nevada than the original Action Alternative 1 method. Conversely, because California has higher proportion of PPR entitlements, the alternative approach to Action Alternative 1 models a lower proportion shortage to California than the original Action Alternative 1 method.

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Appendix D

Shortage Allocation Model Documentation

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Attachments

D-1	Reclamation’s September 14, 2022 letter notifying interested parties of a Tier 2 Shortage Condition and required DCP contributions in calendar year 2023
D-2	Reclamation’s September 28, 2022 letter to the Central Arizona Water Conservation District announcing the calendar year 2023 Available CAP Supply
D-3	Exhibit 5.3.4.1 to the Tohono O’odham Settlement Agreement, <i>Secretary’s Approach for Determining the Amount of Water Available to the Nation During a Time of Shortage Under 1980 Contract</i>

Acronyms and Abbreviations

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
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
SEIS
SNWA

Secretary of the Interior
Supplemental Environmental Impact Statement
Southern Nevada Water Authority

Appendix D. Shortage Allocation Model Documentation

This appendix describes the Shortage Allocation Models 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 Supplemental Environmental Impact Statement (SEIS). Similar material was contained within Appendix G 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).

D.1 Introduction

In order to assess the general socioeconomic effects of potential shortages to water users in the Lower Division States¹ under the action alternatives analyzed in this Draft SEIS, the Bureau of Reclamation developed a Shortage Allocation Model for each alternative and they 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 action alternatives under review in this Draft SEIS.

D.2 Background and Purpose

The Shortage Allocation Models were created to calculate 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. 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 action alternatives under this Draft SEIS and their associated Shortage Allocation Models, which are described in detail in the following sections, require 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 Models are not a substitute for the annual process

¹ The US will conduct all necessary and appropriate discussions regarding the proposed federal action and implementation of the 1944 Treaty with Mexico through the International Boundary and Water Commission in consultation with the Department of State.

of reviewing water orders and determining annual water availability for each water entitlement holder on the lower Colorado River and, as such, cannot replicate the precision required for that process.

The Action Alternative 1 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 Action Alternative 2 Shortage Allocation Model simulates shortage allocations and reduces deliveries of mainstream Colorado River water to water users proportionally, or at the same percentage for each water user relative to their recent history of consumptive use. For this analysis, Calendar Year 2021 consumptive use is the baseline, as adjusted for conservation activities,² without regard to the priority systems within³ and among the Lower Division States. The overall volumes of shortage are the same as Action Alternative 1.

In contrast to the Action Alternative 1 Shortage Allocation Model, in which total volumes of shortage were distributed among the Lower Division States independent of existing commitments under the 2007 Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead (2007 Interim Guidelines) and 2019 Drought Contingency Plan (DCP), the Action Alternative 2 Shortage Allocation Model assigns the responsibility for existing commitments to certain water users, credits those commitments against the total shortage volume, and distributes the remaining additional shortage among those and other water users.

The No Action Alternative Shortage Allocation Model uses the same priority system as Action Alternative 1, but over a limited range of shortage volumes representing current commitments pursuant to the 2007 Interim Guidelines and 2019 Lower Basin 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 shortage at dead pool or "system shortage". The Shortage Allocation Models for each alternative cannot represent the effect of potential system shortages.

None of the Shortage Allocation Models developed for this Draft SEIS are intended as implementation tools, and they should only be used for decision support for Calendar Years 2024-2026 in this Draft SEIS.

² Conservation activities include creation of Intentionally Created Surplus (ICS) under the 2007 Interim Guidelines, system conservation, and contributions under the 2019 Lower Basin DCP.

³ This alternative is formulated to reflect the intra-Central Arizona Project (CAP) priority system.

D.3 Alternative 1 Shortage Allocation Model

The Action Alternative 1 Shortage Allocation Model, similar to that developed for the No Action Alternative in the 2007 FEIS, represents the effect of the priority systems among and within the Lower Division States. As discussed in this section, the Action Alternative 1 Shortage Allocation Model is a set of Microsoft Excel worksheets that (given a volume of total shortage to the Lower Division States) distributes available water first among the states and subsequently among the entitlement holders within each state based on priority.

The discrete volumes (in acre-feet) of total shortage to the Lower Division States considered in the Action Alternative 1 Shortage Allocation Model are:

- 400,000
- 1,066,000
- 1,234,000
- 1,734,000
- 2,083,000
- 2,250,000
- 2,500,000
- 3,000,000
- 3,333,000
- 3,667,000
- 4,000,000

In the Action Alternative 1 Shortage Allocation Model, these volumes of shortage were distributed among the Lower Division States without regard to associated Lake Mead elevations, and without regard to existing commitments at those elevations (such as DCP contributions) that are not derived from an interpretation of priority among the Lower Division States. At certain proposed volumes of shortage, existing contributions under the Lower Basin DCP exceeded the volumes of shortage assigned to California in the Action Alternative 1 Shortage Allocation Model. Volumes of shortage assigned to the Lower Division States are assumed to be first satisfied by existing commitments.

D.3.1 Distribution Among States

With regard to distribution of available water among the Lower Division States, Action Alternative 1 considers their apportionments⁴ as coequal, with the following exceptions.

First, the Colorado River Basin Project Act of 1968 (CRBPA) in Section 301(b) provides that in any year there is “insufficient main stream Colorado River water available for release to satisfy annual consumptive use of seven million five hundred thousand acre-feet in Arizona, California, and Nevada, diversions from the mainstream for the Central Arizona Project shall be so limited as to assure the availability of water in quantities sufficient to provide for the aggregate annual consumptive use by holders of present perfected rights, by other users in the State of California served under existing contracts with the United States by diversion works heretofore construct, and by other existing Federal reservations in that State, of four million four hundred thousand acre-feet of mainstream water, and by users of the same character in Arizona and Nevada. Water users in the State of Nevada shall not be required to bear shortages in any proportion greater than would have been imposed in the absence of this subsection 301(b).” Additionally, the language of the Arizona

⁴ 2,800,000 acre-feet per year (AFY) to Arizona, 4,400,000 AFY to California, and 300,000 AFY to Nevada on a consumptive use basis.

priority system as contained in the CAP Master Repayment Contract⁵ and other Arizona fourth priority Colorado River water delivery contracts, provides that CAP and other post-1968 contracts in Arizona are coequal in priority. For the purpose of the Action Alternative 1 Shortage Allocation Model, these provisions are assumed to reduce CAP and other Arizona fourth priority Colorado River water uses completely before water available to California is reduced below 4,400,000 AFY.

Second, Present Perfected Rights (PPR) are satisfied without regard to state lines, in order by priority in accordance with paragraph 5 of the Appendix to the 2006 Consolidated Decree of the U. S. Supreme Court in *Arizona v. California* (547 U.S. 150). PPR diversion entitlements total approximately 4.1 maf or 3.3 maf of estimated consumptive use and they are treated as a basin-wide senior priority that transcends state lines. In the event that insufficient Colorado River water is available to satisfy the needs of the PPR entitlement holders, a PPR worksheet included with the Action Alternative 1 Shortage Allocation Model shows the order in which the limited water supply would be delivered to the PPR holders (see **Table D-17** in **Section D.3.5**).

D.3.1.1 Stage 1 and Stage 2 Shortage Assumptions

As in the 2007 Shortage Allocation Model, in the Action Alternative 1 Shortage Allocation Model, shortages to the Lower Division States are characterized by two stages, Stage 1 and Stage 2. In Stage 1, shortages are imposed only upon Arizona and Nevada and they continue until the deliveries to the post-1968 water rights holders in Arizona (including the CAP) are reduced to zero (**Table D-1**). The maximum amount of Stage 1 shortage during the period of analysis is dependent on estimated water availability for the post-1968 water entitlement holders in Arizona.

The Stage 1 shortage sharing percentages are computed as follows:

- Nevada bears a reduction of 4.0 percent of the total Lower Division States shortage volume, computed as a ratio of Nevada's apportionment to the sum of the apportionments of the Lower Division States
$$0.3 \text{ maf} / 7.5 \text{ maf} = 4.0 \text{ percent}$$
- Arizona bears a reduction of 96 percent of the total Lower Division States shortage volume, which is the remaining shortage not borne by Nevada
$$1 - 0.04 = 96 \text{ percent}$$

⁵ Contract No. 14-06-W-245 Between the United States and the Central Arizona Water Conservation District for Delivery of Water and Repayment of Costs of the Central Arizona Project, as amended.

Table D-1
Stage 1 Shortage Distribution

"Stage 1" Shortage Distribution	Arizona	California	Nevada	Total
Ratio of Apportionment to Total	=2,800,000/7,500,000 or 37.33%	=4,400,000/7,500,000 or 58.67%	=300,000/7,500,000 or 4%	
Percentage Assignment of Shortage	96.00%	0.00%	4.00%	

Distribution of Available Water Until Arizona Fourth Priority is Eliminated (Threshold Approximated)

Lower Division States Supply (AF)	Lower Division States Shortage Volume (AF)	AZ Shortage Volume (AF)	Water Available to AZ (AF)	CA Shortage Volume (AF)	Water Available to CA (AF)	NV Shortage Volume (AF)	Water Available to NV (AF)	Lower Division States Shortage Volume (AF)
7,500,000	-	-	2,800,000	-	4,400,000	-	300,000	-
7,400,000	(100,000)	(96,000)	2,704,000	-	4,400,000	(4,000)	296,000	(100,000)
7,300,000	(200,000)	(192,000)	2,608,000	-	4,400,000	(8,000)	292,000	(200,000)
7,200,000	(300,000)	(288,000)	2,512,000	-	4,400,000	(12,000)	288,000	(300,000)
7,100,000	(400,000)	(384,000)	2,416,000	-	4,400,000	(16,000)	284,000	(400,000)
7,000,000	(500,000)	(480,000)	2,320,000	-	4,400,000	(20,000)	280,000	(500,000)
6,900,000	(600,000)	(576,000)	2,224,000	-	4,400,000	(24,000)	276,000	(600,000)
6,800,000	(700,000)	(672,000)	2,128,000	-	4,400,000	(28,000)	272,000	(700,000)
6,700,000	(800,000)	(768,000)	2,032,000	-	4,400,000	(32,000)	268,000	(800,000)
6,600,000	(900,000)	(864,000)	1,936,000	-	4,400,000	(36,000)	264,000	(900,000)
6,500,000	(1,000,000)	(960,000)	1,840,000	-	4,400,000	(40,000)	260,000	(1,000,000)
6,434,000	(1,066,000)	(1,023,360)	1,776,640	-	4,400,000	(42,640)	257,360	(1,066,000)
6,400,000	(1,100,000)	(1,056,000)	1,744,000	-	4,400,000	(44,000)	256,000	(1,100,000)
6,300,000	(1,200,000)	(1,152,000)	1,648,000	-	4,400,000	(48,000)	252,000	(1,200,000)
6,266,000	(1,234,000)	(1,184,640)	1,615,360	-	4,400,000	(49,360)	250,640	(1,234,000)
6,200,000	(1,300,000)	(1,248,000)	1,552,000	-	4,400,000	(52,000)	248,000	(1,300,000)
6,100,000	(1,400,000)	(1,344,000)	1,456,000	-	4,400,000	(56,000)	244,000	(1,400,000)
6,000,000	(1,500,000)	(1,440,000)	1,360,000	-	4,400,000	(60,000)	240,000	(1,500,000)
5,900,000	(1,600,000)	(1,536,000)	1,264,000	-	4,400,000	(64,000)	236,000	(1,600,000)
5,800,000	(1,700,000)	(1,632,000)	1,168,000	-	4,400,000	(68,000)	232,000	(1,700,000)
5,766,000	(1,734,000)	(1,664,640)	1,135,360	-	4,400,000	(69,360)	230,640	(1,734,000)
5,759,415	(1,740,585)	(1,670,962)	1,129,038	-	4,400,000	(69,623)	230,377	(1,740,585)

After deliveries to the fourth priority entitlements within Arizona are expected to be reduced to zero, additional reductions are applied to Arizona, California, and Nevada. This Stage 2 shortage is the amount of additional shortage above the Stage 1 shortage volume, and the additional shortage is distributed according to the Stage 2 ratios (**Table D-2**).

The Stage 2 shortage sharing percentages are computed as follows:

- Nevada bears 4.0 percent of the Stage 2 shortage in addition to its Stage 1 shortage, computed as a ratio of Nevada's apportionment less the amount of shortage applied to Nevada under Stage 1, over the sum of the apportionments of the Lower Division States less the total amount shorted to users under Stage 1

$$(0.3 \text{ maf} - \text{Nevada Stage 1 shortage}) / (7.5 \text{ maf} - \text{total Stage 1 shortage}) = 4.0 \text{ percent}$$

- Arizona bears approximately 20 percent of the Stage 2 shortage in addition to its Stage 1 shortage, computed as a ratio of Arizona's apportionment less the amount of shortage applied to Arizona under Stage 1, over the sum of the apportionments of the Lower Division States less the total amount shorted to users under Stage 1

$$(2.8 \text{ maf} - \text{Arizona Stage 1 Shortage}) / (7.5 \text{ maf} - \text{total Stage 1 shortage}) = 19.6 \text{ percent}^6$$

- California bears approximately 76 percent of the Stage 2 shortage, computed as a ratio of California's apportionment over the sum of the apportionments of the Lower Division States less the total amount shorted to users under Stage 1

$$(4.4 \text{ maf}) / (7.5 \text{ maf} - \text{total Stage 1 Shortage}) = 76.4 \text{ percent}$$

⁶ The breakpoint between Stage 1 and Stage 2, when California begins to share in shortage, is a precise point at which no Arizona fourth priority Colorado River water is available. Over the long run, this breakpoint is nonstationary and annually varies based on use by Arizona priorities one through three. For this Action Alternative 1 Shortage Allocation Model, a shortage volume of 1,670,962 af to the State of Arizona is taken as the estimated volume necessary to reduce Arizona fourth priority Colorado River water availability to zero, based on average Arizona priority one through three use of 1,129,038 af over the four highest of the last 5 years of published water accounting data (through 2021). The total volume of Stage 1 shortage is directly dependent on this assumption, as are the state ratios for distribution of Stage 2 shortage. Reclamation will solicit feedback on the suitability of this approach for long-term operations as part of future decision-making processes.

Table D-2
Stage 2 Shortage Distribution

"Stage 2" Shortage Distribution	Arizona	California	Nevada	Total
Ratio of Curtailed Apportionment to Remainder	= (2,800,000-1,670,962)/(7,500,000-1,740,585) or 19.60%	Remainder	= (300,000-69,623)/(7,500,000-1,740,585) or 4%	
Percentage Assignment of Shortage	19.60%	76.40%	4.00%	

Distribution of Available Water After Arizona Fourth Priority is Eliminated (Threshold Approximated)

Lower Division States Supply (AF)	Lower Division States Shortage Volume in Addition to Stage 1 Shortage (AF)	AZ Shortage Volume in Addition to Stage 1 Shortage (AF)	Water Available to AZ (AF)	CA Shortage Volume (AF)	Water Available to CA (AF)	NV Shortage Volume in Addition to Stage 1 Shortage (AF)	Water Available to NV (AF)	Lower Division States Shortage Volume (AF)
5,700,000	(59,415)	(11,647)	1,117,391	(45,391)	4,354,609	(2,377)	228,000	(1,800,000)
5,600,000	(159,415)	(31,251)	1,097,787	(121,787)	4,278,213	(6,377)	224,000	(1,900,000)
5,500,000	(259,415)	(50,854)	1,078,184	(198,184)	4,201,816	(10,377)	220,000	(2,000,000)
5,417,000	(342,415)	(67,125)	1,061,913	(261,593)	4,138,407	(13,697)	216,680	(2,083,000)
5,400,000	(359,415)	(70,457)	1,058,581	(274,581)	4,125,419	(14,377)	216,000	(2,100,000)

The results of these assumptions are summarized in **Table D-3** below showing a distribution of shortage and available water volumes among the Lower Division States over a range of shortage from zero to 2.083 million AFY (as modeled for 2024) and to 4.0 million AFY (as modeled for 2025–2026).

Table D-3
Detailed Distribution by Lower Division State Under the Action Alternative 1 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)
-	-	2,800,000	-	4,400,000	-	300,000
(100,000)	(96,000)	2,704,000	-	4,400,000	(4,000)	296,000
(200,000)	(192,000)	2,608,000	-	4,400,000	(8,000)	292,000
(300,000)	(288,000)	2,512,000	-	4,400,000	(12,000)	288,000
(400,000)	(384,000)	2,416,000	-	4,400,000	(16,000)	284,000
(500,000)	(480,000)	2,320,000	-	4,400,000	(20,000)	280,000
(600,000)	(576,000)	2,224,000	-	4,400,000	(24,000)	276,000
(700,000)	(672,000)	2,128,000	-	4,400,000	(28,000)	272,000
(800,000)	(768,000)	2,032,000	-	4,400,000	(32,000)	268,000
(900,000)	(864,000)	1,936,000	-	4,400,000	(36,000)	264,000
(1,000,000)	(960,000)	1,840,000	-	4,400,000	(40,000)	260,000
(1,066,000)	(1,023,360)	1,776,640	-	4,400,000	(42,640)	257,360
(1,100,000)	(1,056,000)	1,744,000	-	4,400,000	(44,000)	256,000
(1,200,000)	(1,152,000)	1,648,000	-	4,400,000	(48,000)	252,000
(1,234,000)	(1,184,640)	1,615,360	-	4,400,000	(49,360)	250,640
(1,300,000)	(1,248,000)	1,552,000	-	4,400,000	(52,000)	248,000
(1,400,000)	(1,344,000)	1,456,000	-	4,400,000	(56,000)	244,000
(1,500,000)	(1,440,000)	1,360,000	-	4,400,000	(60,000)	240,000
(1,600,000)	(1,536,000)	1,264,000	-	4,400,000	(64,000)	236,000
(1,700,000)	(1,632,000)	1,168,000	-	4,400,000	(68,000)	232,000
(1,734,000)	(1,664,640)	1,135,360	-	4,400,000	(69,360)	230,640
(1,740,585)	(1,670,962)	1,129,038	-	4,400,000	(69,623)	230,377
(1,800,000)	(1,682,609)	1,117,391	(45,391)	4,354,609	(72,000)	228,000
(1,900,000)	(1,702,213)	1,097,787	(121,787)	4,278,213	(76,000)	224,000
(2,000,000)	(1,721,816)	1,078,184	(198,184)	4,201,816	(80,000)	220,000
(2,083,000)	(1,738,087)	1,061,913	(261,593)	4,138,407	(83,320)	216,680
(2,100,000)	(1,741,419)	1,058,581	(274,581)	4,125,419	(84,000)	216,000
(2,200,000)	(1,761,023)	1,038,977	(350,977)	4,049,023	(88,000)	212,000
(2,250,000)	(1,770,824)	1,029,176	(389,176)	4,010,824	(90,000)	210,000
(2,300,000)	(1,780,626)	1,019,374	(427,374)	3,972,626	(92,000)	208,000
(2,400,000)	(1,800,229)	999,771	(503,771)	3,896,229	(96,000)	204,000
(2,500,000)	(1,819,833)	980,167	(580,167)	3,819,833	(100,000)	200,000
(2,600,000)	(1,839,436)	960,564	(656,564)	3,743,436	(104,000)	196,000
(2,700,000)	(1,859,039)	940,961	(732,961)	3,667,039	(108,000)	192,000

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)
(2,800,000)	(1,878,643)	921,357	(809,357)	3,590,643	(112,000)	188,000
(2,900,000)	(1,898,246)	901,754	(885,754)	3,514,246	(116,000)	184,000
(3,000,000)	(1,917,849)	882,151	(962,151)	3,437,849	(120,000)	180,000
(3,100,000)	(1,937,453)	862,547	(1,038,547)	3,361,453	(124,000)	176,000
(3,200,000)	(1,957,056)	842,944	(1,114,944)	3,285,056	(128,000)	172,000
(3,300,000)	(1,976,659)	823,341	(1,191,341)	3,208,659	(132,000)	168,000
(3,333,000)	(1,983,129)	816,871	(1,216,551)	3,183,449	(133,320)	166,680
(3,400,000)	(1,996,263)	803,737	(1,267,737)	3,132,263	(136,000)	164,000
(3,500,000)	(2,015,866)	784,134	(1,344,134)	3,055,866	(140,000)	160,000
(3,600,000)	(2,035,469)	764,531	(1,420,531)	2,979,469	(144,000)	156,000
(3,667,000)	(2,048,604)	751,396	(1,471,716)	2,928,284	(146,680)	153,320
(3,700,000)	(2,055,073)	744,927	(1,496,927)	2,903,073	(148,000)	152,000
(3,800,000)	(2,074,676)	725,324	(1,573,324)	2,826,676	(152,000)	148,000
(3,900,000)	(2,094,280)	705,720	(1,649,720)	2,750,280	(156,000)	144,000
(4,000,000)	(2,113,883)	686,117	(1,726,117)	2,673,883	(160,000)	140,000

Note: At 4,000,000 af or more of shortage using the Action Alternative 1 Shortage Allocation Models' ratios for the distribution of available water between states, not all of the shortage to California can be distributed among non-PPR entitlements. (See **Section D.3.5** for an alternative approach to the Action Alternative 1 Shortage Allocation Model to ensure that PPRs can be satisfied (or reduced) in the prescribed order without regard to state lines.)

D.3.2 Distribution Within States

D.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.

Although some explicit guidance is given by the Supreme Court and Congress with regard to how shortages would be allocated according to priority additional detail, it 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. The action alternatives under this Draft SEIS and their associated Shortage Allocation Models, which are described in detail in the following sections, require certain modeling assumptions with regard to how shortages may be allocated. Reclamation acknowledges there may be other interpretations of how shortages could be distributed and 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 Models are not a substitute for the annual process of reviewing water orders and determining annual water availability for each water entitlement holder on the lower Colorado River and, as such, cannot replicate the precision required for that process.

To determine the hydrologic impacts of the shortage alternatives, assumptions were made with regard to how shortages might be shared. These assumptions are made to facilitate analysis of the full range of potential impacts of each alternative 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.

Unless otherwise noted, these assumptions also apply to the Shortage Allocation Model for the No Action Alternative described in **Section D.5**.

D.3.2.2 General State Assumptions

- Each state is using its entire apportionment each year.
- For the purpose of comparing 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*⁷ or equivalent source data for each entitlement holder (with the exception of 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.
- 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, except as 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, or interstate storage and release are not considered in the Shortage Allocation Model.
- 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 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, 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

⁷ Internet website: <https://www.usbr.gov/lc/region/g4000/4200Rpts/DecreeRpt/2021/2021.pdf>, also known as “Decree Accounting”.

change in a shortage condition due to contract-specific terms and conditions and/or the discretion of the entitlement holder.

D.3.2.3 Nevada Assumptions

- Nevada has eight water delivery priorities⁸ 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. That priority system is assumed to govern the distribution of available water among Nevada entitlement holders. (See **Table D-4.**)
- Shortage to Nevada entitlement holders is calculated relative to their consumptive use entitlement (or equivalent).
- Deliveries to Nevada are no longer assumed to be constrained by Lake Mead surface elevation as assumed in the 2007 FEIS; however, the Action Alternative 1 Shortage Allocation Model does not reflect the effect of potential system shortages.
- Entitlements associated with each Nevada entitlement holder are available at: <https://www.usbr.gov/lc/region/g4000/contracts/entitlements.html>.

⁸ Internet website: https://www.usbr.gov/lc/region/g4000/contracts/entitlements/Entitlements_NV_priority.pdf.

Table D-4
Framework for Priority-Based Distribution of Available Water Within Nevada

Priority	Entitlement Holder	Contract No.	Priority Date	Use	Entitlements		
					Diversion (AFY)	CU or Estimated Equivalent (AFY) ¹	Cumulative CU (AFY)
9 th	Any contracts dated after 3-2-1992, SNWA Contract						
8 th – Balance & Surplus	Southern Nevada Water Authority	2-07-30-W0266	3/2/1992	M&I	balance + surplus	93,975	291,303
	TOTAL					93,975	
8 th	Big Bend Water District	2-07-30-W0269	3/2/1992	M&I	10,000	4,718	
	Robert B. Griffith Project	7-07-30-W0004	3/2/1992	M&I			
	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)				308,000	146,342	
	TOTAL				318,000	151,060	197,327
7 th	Southern Nevada Water Authority (Formerly Boy Scouts of America) ²	9-07-30-W0011	11/9/1998	M&I	10	5	46,267
	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	
					4,310	2,099	
6 th	Las Vegas Valley Water District ²	14-06-300-2130	9/22/1969	M&I	15,407	7,320	44,169
	TOTAL				15,407	7,320	
5 th	Lakeview Company (Hacienda Casino)	14-06-300-1523	2/12/1965	M&I	0	0	36,848
	Pacific Coast Building Products, Inc. (PABCO)	5-07-30-W0089	6/19/1985	M&I	928	928	
		TOTAL				928	

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	35,920
	City of Henderson	0-07-30-W0246	5/22/1990	M&I	15,878	14,503	
	Southern Nevada Water Authority (From Basic Water Company) ²	2-07-30-W0266	3/2/1992	M&I	14,950	7,103	
	TOTAL				39,036	29,814	
3rd	Boulder City ³	14-06-300-978	5/15/1931, 1/4/1960	M&I	5,876	5,876	6,106
	TOTAL				5,876	5,876	
2nd	Lake Mead National Recreation Area ⁴ , Executive Order No. 5339	1964 Decree	4/25/1930	M&I	Unquantified, estimated ~1,500	230	230
	TOTAL				1,500	230	
NEVADA TOTALS					385,057	291,303	

Note: CU means Consumptive Use. All units are in acre-feet per year.

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.

¹2021 Decree Accounting values and Diversion/CU conversion ratios were used to estimate not specified and unquantified entitlements.

²Water 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.

³Though 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.

⁴This unlimited entitlement is estimated based on 2021 use, minus the Lake Mead National Recreation Area PPR.

D.3.2.4 California Assumptions

- Entitlements shown in **Table D-5** 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.
- 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. Therefore, the quantified entitlements in the QSA for the Imperial Irrigation District and the Coachella Valley Water District, minus the amount specified for PPR use, were modeled in the Action Alternative 1 and No Action Shortage Allocation Models.
- QSA transfers and exchanges between Imperial Irrigation District, Coachella Valley Water District, and The Metropolitan Water District of Southern California (MWD) were included and modeled within priority three entitlements.
- Although 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 Action Alternative 1 and No Action Shortage Allocation Models.
- 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 is calculated relative to their consumptive use entitlement (or equivalent).

Table D-5
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	444,352	1,705,724
	TOTAL				0	550,000	444,352	
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	
	Use by CVWD (3a) ²			Ag			394,000	
	Reduction for Misc. PPR Use						-3,000	
	Diverted by MWD (Coachella Canal Lining Project, MWD Exchange with San Diego County Water Authority)	QSA Transfer					-21,500	
	Diverted by MWD (Coachella Canal Lining Project, Supplemental Water delivered to San Luis Rey Settlement)	QSA Transfer					-4,500	
	Transfer from IID to CVWD						93,000	
	Imperial Irrigation District (IID) (3a)	I1r-747	1932			615,000	615,000	
	Use by IID (3a) ³			Ag			137,800	
	Reduction for Misc. PPR Use						-11,500	
	Diverted by MWD (1988 IID-MWD Water Conservation Agreement/1989 Approval Agreement)	QSA Transfer					-105,000	
	Diverted by MWD (All-American Canal Lining Project, MWD Exchange with SDCWA)	QSA Transfer					-56,200	
	Diverted by MWD (All-American Canal Lining Project, Supplemental to San Luis Rey Settlement Parties)	QSA Transfer					-11,500	
	Diverted by MWD (IID transfer to SDCWA, MWD Exchange with SDCWA)	QSA Transfer					-200,000	
	Transfer to CVWD						-93,000	
	MWD Diversions from QSA			M&I			398,700	1,261,372
	Diverted by MWD (Coachella Canal Lining Project, MWD Exchange with San Diego County Water Authority)	QSA Transfer					21,500	
	Diverted by MWD (Coachella Canal Lining Project, Supplemental Water delivered to San Luis Rey Settlement)	QSA Transfer					4,500	
	Diverted by MWD (1988 IID-MWD Water Conservation Agreement/1989 Approval Agreement) ¹	QSA Transfer					105,000	
	Diverted by MWD (All-American Canal Lining Project, MWD Exchange with SDCWA)	QSA Transfer					56,200	
	Diverted by MWD (All-American Canal Lining Project, Supplemental to San Luis Rey Settlement Parties)	QSA Transfer					11,500	
	Diverted by MWD (IID transfer to SDCWA, MWD Exchange with SDCWA)	QSA Transfer					200,000	
	TOTAL					945,000	934,656	

Priority	Entitlement Holder	Contract No.	Priority Date	Use	Diversion (AFY)	CU Entitlement (AFY)	Entitlements	
							CU or Estimated Equivalent (AFY)	Cumulative CU (AFY)
2nd	Yuma Project, Reservation Division (Bard Unit Only – Indian Unit Under PPRs) ⁴	Water Certificates	1905	Ind./Ag	≤25,000 acres		3,459	326,716
	TOTAL				0	0	3,459	
1st	Palo Verde Irrigation District – Valley Lands (1) ⁵	PVID20733C_P2	1933	Ag	≤104,500 acres	Unquantified	323,258	323,258
	TOTAL				0	0	323,258	
	CALIFORNIA TOTALS				291,175	2,458,023	1,705,724	0

Notes: CU means Consumptive Use; all units are in AFY (acre feet per year).

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) and to account for the QSA transfers.

Unless otherwise noted, 2021 Decree Accounting values and Diversion/CU conversion ratios were used to estimate not specified and unquantified entitlements.

At 4maf of shortage, this state distribution may provide insufficient water to fulfill PPRs in the State of California. This analysis assumes no further shortage would be applied to California below that point. PPRs are not included in this table and they are accounted for in a separate PPR worksheet.

¹PVID 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.

²Up to 15,000 af may be delivered by MWD for CVWD, via the Colorado River Aqueduct, pursuant to the terms of the 1988 IID/MWD Conservation Agreement/1989 Approval Agreement. This 15,000 af is accounted for in MWD's Diversions from the QSA as part of the 105,000 af diverted per the 1988 IID-MWD Water Conservation Agreement/1989 Approval Agreement.

³Non-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.

⁴The 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.

D.3.2.5 Arizona Assumptions

- In 2007, consumptive use schedules were provided by 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.
- 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 out of priority in all levels of shortage modeled for Action Alternative 1 and they are not itemized.
- The Shortage Allocation Models do not attempt to redistribute water that may be available within a priority, but they are 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.

D.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.

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 Models do 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 D-6** 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 D-6
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)	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										48,522	
		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 (cemetary)	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	176R-733	1/1/1952	Ag	335	0		
						Sturges, Irma	176R-735	1/1/1952	Ag	385	0		
						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		
		3a5				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										215,886	
		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										278,000	
		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	176r-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										76,645	
		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										69,840	
		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		
						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.⁹

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.¹⁰

The Kaman, City of Yuma (Cemetery), Yuma Mesa Fruit Growers Association, Harold Sturges, and Irma Sturges entitlements¹¹ 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.¹⁰

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.¹¹

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.¹¹ The Camille Allec, Jr. entitlement¹¹ 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 consumptive use (or equivalent) entitlements. The distribution of water is stated in terms of

⁹ Domestic use within each district's entitlement is assumed to be subordinated to irrigation use in the district, but it is not itemized separately.

¹⁰ Water use is subject to availability and it is assumed not to be detrimental to a water service for the project or prior appropriators.

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.

D.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 calendar 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 are coequal.

The Action Alternative 1 and No Action Shortage Allocation Models use 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 calendar year 2023
- Reclamation’s September 28, 2022 letter to the Central Arizona Water Conservation District announcing the calendar year 2023 available CAP supply

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.

D.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 diversion¹¹ volume relative to the current total for the pool, 151,274 AFY, which does not include outstanding ADWR recommendations, unallocated water, or reserved water not yet placed under contract. (See **Table D-7.**)

Contracts and subcontracts are itemized separately, meaning an entity’s total modeled supply may be the sum of multiple distributions.

¹¹ The Bureau of Land Management consumptive use entitlement is shown as a diversion equivalent for parity within the pool.

Table D-7
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 4 th Priority Mainstream Available Supply			
	Contract Number(s)	Date	Type of Use	Diversion Entitlement in AFY	Divided By	Sum of Entitlements 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	13-XX-30-W0571	2013	Irrigation	2,913.30	/	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 estimated)	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%
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%
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 basis, then converted to a consumptive use equivalent using consumptive use to diversion ratios from the calendar year 2021 *Colorado River Accounting and Water Use Report: Arizona, California, and Nevada*¹² 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 Models do not contain data for estimated orders in this priority, and they do not illustrate the potential effect of the pool approach to redistributing water that may be available, but unordered under any specific entitlement.

D.3.2.5.4 CAP Framework and Assumptions

In the Action Alternative 1 and No Action Alternative Shortage Allocation Models, Arizona priority three Colorado River water entitlements delivered through the CAP are modeled alongside other priority three entitlements. Terms and conditions for priority in case of shortage to the CAP relate only to fourth priority water. The Shortage Allocation Models attempt to reflect the legislative and contractual terms and conditions applicable to CAP shortages.

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.

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 contracts and subcontracts are fulfilled¹³, the remaining available water could be ordered under one-year excess contracts; however, none of the Action Alternative 1 shortage volumes provide for enough available supply for excess contracts under the assumptions of the model.

The Action Alternative 1 and No Action Alternative Shortage Allocation Models calculate available CAP supply as described in Reclamation's September 28, 2022 letter to the Central Arizona Water Conservation District. 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 D-8** below showing all of the discrete levels of supply modeled.

¹² Internet website: <https://www.usbr.gov/lc/region/g4000/4200Rpts/DecreeRpt/2021/2021.pdf>, also known as Decree Accounting.

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 contracts and subcontracts are fulfilled; however, there is no unused CAP water at the volumes of shortage modeled for Action Alternative 1.

Table D-8
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
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	-

Available CAP Supply (AF)	Indian Priority Share	Indian Priority Supply (AF)	M&I Priority Supply (AF)	NIA Priority Supply (AF)
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	-
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	-

Available CAP Supply (AF)	Indian Priority Share	Indian Priority Supply (AF)	M&I Priority Supply (AF)	NIA Priority Supply (AF)
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	-
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 a variety of arrangements, contractors and subcontractors may make their water available for end use by others. The Shortage Allocation Models do not replicate those arrangements, and they only provide approximate estimates at the allocation level that interested parties could then consider in planning for administering their respective arrangements during shortage conditions.

The Shortage Allocation Models do 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, 2022¹⁴. Allocations which are currently unused are shown as bearing no shortage.

D.3.2.5.4.1 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. Shortages attributed to Indian Priority allocations in the Shortage Allocation Models form the basis for additional analyses on a case-by-case basis.

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, *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 calendar year, which was not a Time of Shortage.

These assumptions yield the distribution of available Indian Priority water over a range of discrete available CAP supplies shown in **Table D-9** below.

¹⁴ Internet website:

<https://new.azwater.gov/sites/default/files/media/2022.12.15%20Exhibit%207.1%20Public%20Posting.pdf>.

Table D-9
Distribution of CAP Indian Priority Supply

Available CAP Supply (AF)	Post-AWSA Contracts							Pre-AWSA Contracts								
	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 (Homeland)	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
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
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

Available CAP Supply (AF)	Post-AWSA Contracts						Pre-AWSA Contracts									
	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 (Homeland)	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
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
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

	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 (Homeland)	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
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%	-	-	-	-	-	-	-	-	-

D.3.2.5.4.2 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 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 D-10**.) 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.

Table D-10
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%
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%

M&I Contractor or Subcontractor	2024-2026 Orders (AF)	Percentage of Orders
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%

D.3.2.5.4.3 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 Models do not contain data for use in the most recent year that a full supply was available. However, available water is distributed first to NIA Priority contracts and subcontracts executed prior to 2021 (NIA-A) (**Table D-11**), until their orders are fully satisfied, before available water is distributed to NIA Priority contracts and subcontracts executed in 2021 or later (NIA-B) (**Table D-12**). Within each sub-priority, available water is distributed to each allocation in proportion to 2024-2026 projected water orders, relative to total projected orders for the sub-priority.

Table D-11
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 D-12
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%

D.3.3 Shortage Allocation Model Results

The tables in this section summarize the results of the Action Alternative 1 Shortage Allocation Model over a range of total shortages to the Lower Division States between 400,000 AFY and 4,000,000 AFY.

Table D-13 below illustrates the results of the Action Alternative 1 Shortage Allocation Model, showing a progressive loss of supply first to Arizona fifth and sixth priority entitlements, entitlements to unused CAP water, and CAP excess contracts, then to the Arizona fourth priority until it is reduced in full. Significant impacts occur to the Arizona second and third priorities and to Nevada, but all post-Boulder Canyon Project Act entitlements in California are reduced in full and there would be insufficient supply within California to fulfill PPRs at a shortage of 4,000,000 AFY. (See **Section D.3.5** of this appendix for further discussion of this result.)

Table D-13
Action Alternative 1 Shortage Allocation Model Regional Summary

Summary of Shortage Impacts by State and Priority		Range of Analyzed Volumes of Total Shortage to Lower Division States for Action Alternative 1 (AF)										
		400,000	1,066,000	1,234,000	1,734,000	2,083,000	2,250,000	2,500,000	3,000,000	3,333,000	3,667,000	4,000,000
Arizona	Priority											
	5th, 6th, and CAP Agricultural and Other Excess	286,465	333,921	339,609	351,774	365,748	372,121	381,106	394,679	399,838	404,989	410,046
	4th Priority i (Mainstream)	0	32,228	39,643	63,122	63,445	63,445	63,445	63,445	63,445	63,445	63,445
	4th Priority ii (CAP) ¹											
	NIA Priority	97,535	245,633	245,633	245,633	245,633	245,633	245,633	245,633	245,633	245,633	245,633
	M&I Priority	0	265,389	360,827	602,601	602,601	602,601	602,601	602,601	602,601	602,601	602,601
	Indian Priority	0	146,189	198,928	332,533	332,533	332,533	332,533	332,533	332,533	332,533	332,533
	2nd & 3rd Priorities	0	0	0	68,977	128,127	154,492	194,514	278,958	339,078	399,403	459,625
	1st Priority (Present Perfected Rights)	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	384,000	1,023,360	1,184,640	1,664,640	1,738,087	1,770,824	1,819,833	1,917,849	1,983,129	2,048,604	2,113,883
California²	Priority											
	4th Priority (MWD)	0	0	0	0	261,593	389,176	444,352	444,352	444,352	444,352	444,352
	3rd Priority (IID, CVWD, PVID, QSA Diversions by MWD)	0	0	0	0	0	0	135,816	517,799	772,200	934,656	934,656
	2nd Priority (Yuma Project Reservation Division)	0	0	0	0	0	0	0	0	0	3,459	3,459
	1st Priority (PVID)	0	0	0	0	0	0	0	0	0	89,250	323,258
	Present Perfected Rights (PPRs) ³	0	0	0	0	0	0	0	0	0	0	20,393
	Subtotal	0	0	0	0	261,593	389,176	580,167	962,151	1,216,551	1,471,716	1,726,117
Nevada	Priority											
	8th Priority (SNWA - Balance & Unused)	16,000	42,640	49,360	69,360	83,320	90,000	93,975	93,975	93,975	93,975	93,975
	8th Priority (SNWA & Big Bend)	0	0	0	0	0	0	6,025	26,025	39,345	52,705	66,025
	7th Priority (Boy Scouts, USBR, NV Dept of Wildlife)	0	0	0	0	0	0	0	0	0	0	0
	6th Priority (Las Vegas Valley Water District)	0	0	0	0	0	0	0	0	0	0	0
	5th Priority (PABCO & Lakeview Co.)	0	0	0	0	0	0	0	0	0	0	0
	4th Priority (Henderson & Basic Management)	0	0	0	0	0	0	0	0	0	0	0
	3rd Priority (Boulder City)	0	0	0	0	0	0	0	0	0	0	0
	2nd Priority (Lake Mead National Rec Area)	0	0	0	0	0	0	0	0	0	0	0
	1st Priority (PPRs: LMNRA & Fort Mojave Indian Reservation)	0	0	0	0	0	0	0	0	0	0	0
	Subtotal	16,000	42,640	49,360	69,360	83,320	90,000	100,000	120,000	133,320	146,680	160,000
	Total	400,000	1,066,000	1,234,000	1,734,000	2,083,000	2,250,000	2,500,000	3,000,000	3,333,000	3,667,000	4,000,000

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

¹Agricultural and other CAP excess contracts do not confer a Colorado River water entitlement, and they cannot be exercised under any of the scenarios modeled here.

²The first increment of shortage volumes required by Action Alternative 1 is satisfied by 2019 DCP contributions. In some elevation tiers, the 2019 DCP contributions for California exceed the 2024 shortage volume under Action Alternative 1, which follows the priority system. In these instances, the shortage allocation model for the No Action Alternative will show higher shortages to California than the shortage allocation model for Action Alternative 1.

³At 4,000,000 af of shortage using these ratios for the distribution of available water between states, not all of the shortage (20,393 AF) can be distributed among non-PPR entitlements in California. That volume is shown as a shortage to PPRs to call attention to it, but this should not be taken as a statement that the shortage would be applied to those users.

Disclaimer: These modeling results (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 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 they cannot replicate the precision required of that process.

Table D-14 below illustrates the effects of shortage on Tribes under the Action Alternative 1 Shortage Allocation Model. There are no impacts on Tribes with PPRs, significant impacts to the Ak-Chin Indian Community's Arizona third priority entitlement, and a progressive loss of supply to all Tribal entitlements with a basis in the Arizona fourth priority or junior. (The Ak-Chin Indian Community's entitlement up to an additional 10,000 AFY of CAP water is not itemized in this table).

Table D-14
Action Alternative 1 Shortage Allocation Model Tribal Summary

Summary of Consumptive Use Impacts to Tribal Allocations			Range of Analyzed Volumes of Total Shortage to Lower Division States for Action Alternative 1 (AF)										
Arizona			400,000	1,066,000	1,234,000	1,734,000	2,083,000	2,250,000	2,500,000	3,000,000	3,333,000	3,667,000	4,000,000
Priority	Entitlement Holder	County											
4(i)	Hopi Tribe ¹	La Paz County	0	1,769	2,090	3,046	3,059	3,059	3,059	3,059	3,059	3,059	3,059
4(i)	Cocopah Indian Reservation ²	Yuma County	0	0	0	0	0	0	0	0	0	0	0
CAP Indian Priority	Gila River Indian Community ¹	Maricopa and Pinal County	0	93,392	121,074	191,200	191,200	191,200	191,200	191,200	191,200	191,200	191,200
CAP Indian Priority	Tohono O'odham Nation (Schuk Toak & San Xavier Districts) ¹	Pima County	0	12,807	19,880	37,800	37,800	37,800	37,800	37,800	37,800	37,800	37,800
CAP Indian Priority	White Mountain Apache Tribe	Apache, Gila, and Navajo	0	0	0	0	0	0	0	0	0	0	0
CAP Indian Priority	Ak-Chin Indian Community ¹	Pinal County	0	23,607	33,426	58,300	58,300	58,300	58,300	58,300	58,300	58,300	58,300
CAP Indian Priority	Fort McDowell Yavapai Nation	Maricopa County	0	6,177	9,589	18,233	18,233	18,233	18,233	18,233	18,233	18,233	18,233
CAP Indian Priority	Pascua Yaqui Tribe	Pima County	0	169	263	500	500	500	500	500	500	500	500
CAP Indian Priority	San Carlos Apache Tribe	Gila County	0	4,481	6,807	12,700	12,700	12,700	12,700	12,700	12,700	12,700	12,700
CAP Indian Priority	Salt River Pima-Maricopa Indian Community	Maricopa County	0	5,385	7,625	13,300	13,300	13,300	13,300	13,300	13,300	13,300	13,300
CAP Indian Priority	Tohono O'odham Nation Sif Oidak District	Pinal County	0	0	0	0	0	0	0	0	0	0	0
CAP Indian Priority	Tonto Apache Tribe	Gila County	0	0	0	0	0	0	0	0	0	0	0
CAP Indian Priority	Yavapai Apache Nation	Gila County	0	0	0	0	0	0	0	0	0	0	0
CAP M&I Priority	San Carlos Apache Tribe	Gila County	0	7,991	10,865	18,145	18,145	18,145	18,145	18,145	18,145	18,145	18,145
CAP NIA-A Priority	Tohono O'odham Nation (Schuk Toak & San Xavier Districts)	Pima County	7,433	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200
CAP NIA-A Priority	Gila River Indian Community	Maricopa and Pinal County	31,787	120,600	120,600	120,600	120,600	120,600	120,600	120,600	120,600	120,600	120,600
CAP NIA-B Priority	White Mountain Apache Tribe	Apache, Gila, and Navajo	0	0	0	0	0	0	0	0	0	0	0
3	Ak-Chin Indian Community ¹	Pinal County	0	0	0	7,547	12,607	14,862	18,239	24,992	29,489	34,000	38,497

Summary of Consumptive Use Impacts to Tribal Allocations			Range of Analyzed Volumes of Total Shortage to Lower Division States for Action Alternative 1 (AF)										
1 (PPR)	Cocopah Indian Reservation ¹	Yuma County	0	0	0	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	0	0	0
1 (PPR)	Fort Mojave Indian Reservation ¹	Mohave County	0	0	0	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	0	0	0
1 (PPR)	Colorado River Indian Reservation ¹	La Paz County	0	0	0	0	0	0	0	0	0	0	0
Subtotal			39,219	304,579	360,420	509,571	514,644	516,899	520,276	527,029	531,526	536,037	540,534
California³													
Priority	Entitlement Holder	County											
PPR	Chemehuevi Indian Reservation ¹	San Bernardino	0	0	0	0	0	0	0	0	0	0	0
PPR	Fort Mojave Indian Reservation ¹	San Bernardino	0	0	0	0	0	0	0	0	0	0	0
PPR	Fort Yuma Indian Reservation ¹	Imperial	0	0	0	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	0	0	0
Subtotal			0	0	0	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	0	0	0
Subtotal			0	0	0	0	0	0	0	0	0	0	0
Total			39,219	304,579	360,420	509,571	514,644	516,899	520,276	527,029	531,526	536,037	540,534
Summary by County													
Arizona		# of Entitlement Holders /County											
	Coconino County	0	0	0	0	0	0	0	0	0	0	0	0
	Gila County	4.33	0	12,472	17,672	30,845	30,845	30,845	30,845	30,845	30,845	30,845	30,845
	La Paz County	2	0	1,769	2,090	3,046	3,059	3,059	3,059	3,059	3,059	3,059	3,059
	Maricopa County	2.3	9,536	75,760	89,717	125,073	125,073	125,073	125,073	125,073	125,073	125,073	125,073
	Mohave County	1	0	0	0	0	0	0	0	0	0	0	0
	Pima County	3	7,433	41,176	48,343	66,500	66,500	66,500	66,500	66,500	66,500	66,500	66,500
	Pinal County	3.70	22,251	173,401	202,597	284,107	289,167	291,422	294,799	301,552	306,049	310,560	315,057
	Yuma County	4	0	0	0	0	0	0	0	0	0	0	0
	Apache County	0.33	0	0	0	0	0	0	0	0	0	0	0
	Navajo County	0.33	0	0	0	0	0	0	0	0	0	0	0
Subtotal Arizona Tribal		21	39,219	304,579	360,420	509,571	514,644	516,899	520,276	527,029	531,526	536,037	540,534
California													
	San Bernardino	2.5	0	0	0	0	0	0	0	0	0	0	0
	Riverside	0.50	0	0	0	0	0	0	0	0	0	0	0
	Imperial	1	0	0	0	0	0	0	0	0	0	0	0
Subtotal California Tribal		4	0	0	0	0	0	0	0	0	0	0	0
Nevada													
	Clark	1	0	0	0	0	0	0	0	0	0	0	0
Subtotal Nevada Tribal		1	0	0	0	0	0	0	0	0	0	0	0

Note: PPRs are included here to provide a complete list of tribal entitlements, but they should not be impacted 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.

¹Denotes full or substantial use in tribal agricultural operations, which may or may not be impacted according to the terms of related agreements.

²This user also holds a PPR entitlement, which should not be impacted at these levels of shortages.

³At 4,000,000 af of shortage using these ratios for the distribution of available water between states, not all of the shortage (20,393 AF) can be distributed among non-PPR entitlements in California. On the Regional Summary, that volume is shown as a shortage to PPRs to call attention to it, but this should not be taken as a statement that the shortage would be applied to those users.

Disclaimer: These modeling results (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 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 of that process.

As shown in **Table D-15** below from the Action Alternative 1 Shortage Allocation Model, consistent with 2022 and 2023 operations, water supplies to central and mainstream Arizona irrigators via Arizona fifth and sixth priority entitlements, entitlements to unused CAP water, and CAP excess contracts are immediately impacted at all levels of shortage. Irrigation water supplies from the Arizona P4(i) are potentially reduced in full, as are irrigation water supplies to the University of Arizona in the Arizona third priority. Irrigation water supplies from the California first, second, and third priorities are also potentially reduced in full, with significant impacts possible to other water users.

Table D-15
Action Alternative 1 Shortage Allocation Model Irrigation Summary

Summary of Consumptive Use Impacts to Irrigation			Range of Analyzed Volumes of Total Shortage to Lower Division States for Action Alternative 1 (AF)										
Arizona			400,000	1,066,000	1,234,000	1,734,000	2,083,000	2,250,000	2,500,000	3,000,000	3,333,000	3,667,000	4,000,000
Priority	Entitlement Holder	County											
All Other	5th and 6th Priority Contracts, and CAP Agricultural and Other Excess	Maricopa, Pinal, and Pima	286,465	333,921	339,609	351,774	365,748	372,121	381,106	394,679	399,838	404,989	410,046
4(i)	Arizona Game and Fish Commission	La Paz County	0	1,173	1,386	2,021	2,029	2,029	2,029	2,029	2,029	2,029	2,029
4(i)	Arizona State Land Department	Yuma County	0	2,393	2,845	4,187	4,205	4,205	4,205	4,205	4,205	4,205	4,205
4(i)	Beattie Farms, Southwest	Yuma County	0	281	356	582	585	585	585	585	585	585	585
4(i)	Bishop, Alfred F. and Erma Jean Family Trust	La Paz County	0	59	91	185	186	186	186	186	186	186	186
4(i)	Cathcart, Bruce Y. and Lora M. and James Y. and Maria E.	La Paz County	0	25	34	63	63	63	63	63	63	63	63
4(i)	ChaCha, LLC	Yuma County	0	301	445	871	877	877	877	877	877	877	877
4(i)	Cibola Sportsman's Club, Inc.	La Paz County	0	74	90	138	139	139	139	139	139	139	139
4(i)	Cibola Valley Irrigation and Drainage District2	La Paz County	0	3,078	3,637	5,301	5,323	5,323	5,323	5,323	5,323	5,323	5,323
4(i)	Curtis, Armon	Yuma County	0	80	100	161	162	162	162	162	162	162	162
4(i)	Gila Monster Farms, Inc. ³	Yuma County	0	144	229	480	483	483	483	483	483	483	483
4(i)	GM Gabrych Family Limited Partnership	La Paz County	0	1,665	1,972	2,887	2,899	2,899	2,899	2,899	2,899	2,899	2,899
4(i)	GSC Farm, LLC	La Paz County	0	1,204	1,423	2,074	2,083	2,083	2,083	2,083	2,083	2,083	2,083
4(i)	JRJ Partners, L.L.C.	Yuma County	0	366	440	659	662	662	662	662	662	662	662
4(i)	Mohave Valley Irrigation and Drainage District ^{2,3}	Mohave County	0	10,733	12,722	18,641	18,719	18,719	18,719	18,719	18,719	18,719	18,719
4(i)	North Baja Pipeline, LLC ²	La Paz County	0	65	98	196	197	197	197	197	197	197	197
4(i)	Ogram Boys Enterprises, Inc.	Yuma County	0	340	403	591	593	593	593	593	593	593	593
4(i)	Ott, Larry and Gina, and Lee C. and Candace M.	Yuma County	0	94	127	225	226	226	226	226	226	226	226

Summary of Consumptive Use Impacts to Irrigation			Range of Analyzed Volumes of Total Shortage to Lower Division States for Action Alternative 1 (AF)										
4(i)	Pasquinelli, Gary J. and Barbara J.	Yuma County	0	37	70	169	170	170	170	170	170	170	170
4(i)	Red River Land Company, LLC	La Paz County	0	123	145	212	213	213	213	213	213	213	213
4(i)	Western Water, LLC	La Paz County	0	0	0	62	64	64	64	64	64	64	64
3	Sturges, Harold	Yuma County	0	0	0	0	0	0	0	0	0	0	0
3	Sturges, Irma	Yuma County	0	0	0	0	0	0	0	0	0	0	0
3	Yuma Mesa Irrigation & Drainage District (10,000af M&I) ¹	Yuma County	0	0	0	3,698	18,234	24,713	34,411	53,809	66,728	79,686	92,605
3	Yuma Irrigation District (5,000af M&I) ¹	Yuma County	0	0	0	0	0	0	0	3,395	9,537	15,697	21,839
3	North Gila Valley Irrigation District (2,500af M&I) ^{1,3}	Yuma County	0	0	0	542	945	1,124	1,393	1,930	2,288	2,647	3,005
3	Wellton-Mohawk Irrigation and Drainage District (12,000af M&I) ¹	Yuma County	0	0	0	26,080	54,214	66,754	85,527	123,072	148,078	173,158	198,163
3	Gila Monster Farms (formerly Sturges) ³	Yuma County	0	0	0	531	887	1,045	1,283	1,757	2,074	2,391	2,707
3	Yuma County Water Users Association (14,701af M&I includes YAO's 489.95af conversion)	Yuma County	0	0	0	10,392	17,459	20,610	25,326	34,758	41,040	47,341	53,623
3	University of Arizona	Yuma County	0	0	0	974	974	974	974	974	974	974	974
3	Camille Allec, Jr. (Formerly Yuma Mesa Grapefruit Company)	Yuma County	0	0	0	0	0	0	0	0	0	0	0
3	Unit B Irrigation & Drainage District ³	Yuma County	0	0	0	909	2,248	2,845	3,739	5,526	6,716	7,910	9,101
		Subtotal	286,465	356,157	366,223	434,605	500,587	530,064	573,637	659,780	717,151	774,671	831,940
California⁴													
3	Palo Verde Irrigation District (3b) - Lower Palo Verde Mesa Lands	Riverside County	0	0	0	0	0	0	604	2,302	3,434	4,156	4,156
3	Coachella Valley Water District (CVWD) (3a)	Riverside County	0	0	0	0	0	0	57,253	218,276	325,517	394,000	394,000
3	Imperial Irrigation District (IID) (3a)	Imperial County	0	0	0	0	0	0	20,024	76,341	113,848	137,800	137,800
2	Yuma Project, Reservation Division ⁴ (Bard Unit Only - Indian Unit Under PPRs)	Imperial County	0	0	0	0	0	0	0	0	0	3,459	3,459
1	Palo Verde Irrigation District - Valley Lands	Riverside, Imperial	0	0	0	0	0	0	0	0	0	89,250	323,258
		Subtotal	0	0	0	0	0	0	77,880	296,919	442,799	628,665	862,672
Nevada													
None	None		0	0	0	0	0	0	0	0	0	0	0
		Subtotal	0	0	0	0	0	0	0	0	0	0	0
		Total	286,465	356,157	366,223	434,605	500,587	530,064	651,517	956,699	1,159,951	1,403,335	1,694,612
Summary by County													
	Arizona	# of Entitlement Holders /County											
	Coconino County	0	0	0	0	0	0	0	0	0	0	0	0
	La Paz County	10	0	7,467	8,878	13,139	13,196	13,196	13,196	13,196	13,196	13,196	13,196
	Mohave County	1	0	10,733	12,722	18,641	18,719	18,719	18,719	18,719	18,719	18,719	18,719
	Yuma County	20	0	4,036	5,014	51,050	102,924	126,028	160,615	233,186	285,398	337,767	389,979
	Pima County	0.2	57,293	66,784	67,922	70,355	73,150	74,424	76,221	78,936	79,968	80,998	82,009
	Pinal County	0.5	143,233	166,961	169,805	175,887	182,874	186,060	190,553	197,340	199,919	202,494	205,023
	Maricopa County	0.3	85,940	100,176	101,883	105,532	109,724	111,636	114,332	118,404	119,951	121,497	123,014

Summary of Consumptive Use Impacts to Irrigation			Range of Analyzed Volumes of Total Shortage to Lower Division States for Action Alternative 1 (AF)										
	Subtotal Arizona Irrigation	32	286,465	356,157	366,223	434,605	500,587	530,064	573,637	659,780	717,151	774,671	831,940
	California												
	Riverside County	2.5	0	0	0	0	0	0	57,856	220,578	328,951	442,781	559,785
	Imperial County	2.5	0	0	0	0	0	0	20,024	76,341	113,848	185,884	302,888
	Subtotal California Irrigation	5	0	0	0	0	0	0	77,880	296,919	442,799	628,665	862,672
	Nevada												
	None	None	0	0	0	0	0	0	0	0	0	0	0

¹Combined irrigation and domestic entitlement where domestic use is contractually subordinated to irrigation.

²Combined 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.

³This user also holds a PPR entitlement, which is not impacted at these levels of shortages and it was not included here.

⁴The first increment of shortage volumes required by Action Alternative 1 is satisfied by 2019 DCP contributions. In some elevation tiers, the 2019 DCP contributions for California exceed the 2024 shortage volume under Action Alternative 1, which follows the priority system. In these instances, the shortage allocation model for the No Action Alternative will show higher shortages to California than the shortage allocation model for Action Alternative 1.

Note: PPR entitlements are not impacted 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.

Disclaimer: These modeling results (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 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 of that process.

Under the assumptions of the Action Alternative 1 Shortage Allocation Model, as shown in **Table D-16** below, the only domestic use entitlements that are not modeled to be potentially fully reduced are:

- Arizona third priority water delivered to seven cities through the CAP in accordance with the 1988 Salt River Pima-Maricopa Indian Community Water Rights Settlement Agreement
- Department of the Army's Arizona third priority water entitlement for Yuma Proving Ground
- Arizona second priority entitlements for Cibola, Imperial, and Havasu National Wildlife Refuges, Davis Dam, and Lake Mead National Recreation Area
- Uses in Nevada by the second through eighth priorities
- Domestic use PPRs (with the possible exception of California)

Table D-16
Action Alternative 1 Shortage Allocation Model Domestic Summary

Summary of Consumptive Use Impacts to Domestic Uses			Range of Analyzed Volumes of Total Shortage to Lower Division States for Action Alternative 1 (AF)										
Arizona			400,000	1,066,000	1,234,000	1,734,000	2,083,000	2,250,000	2,500,000	3,000,000	3,333,000	3,667,000	4,000,000
Priority	Entitlement Holder	County											
4(i)	Arizona State Land Department	Yuma County	0	0	0	47	51	51	51	51	51	51	51
4(i)	Arizona State Parks Board - Windsor Beach	Mohave County	0	0	0	9	9	9	9	9	9	9	9
4(i)	B&F Investment, LLC	La Paz County	0	0	0	4	4	4	4	4	4	4	4
4(i)	Bullhead City	Mohave County	0	4,351	5,422	8,608	8,650	8,650	8,650	8,650	8,650	8,650	8,650
4(i)	Bullhead City (Mohave County Water Authority (MCWA) Subcontract)	Mohave County	0	0	0	0	0	0	0	0	0	0	0
4(i)	Bullhead City (MCWA Subcontract)	Mohave County	0	0	0	0	0	0	0	0	0	0	0
4(i)	Bureau of Land Management (diversion estimated)	La Paz County	0	0	0	875	892	892	892	892	892	892	892
4(i)	Crystal Beach Water Conservation District	Mohave County	0	37	46	73	73	73	73	73	73	73	73
4(i)	Desert Lawn Memorial Park Association, Inc.	Yuma County	0	0	0	0	0	0	0	0	0	0	0
4(i)	Ehrenburg Improvement District	La Paz County	0	10	66	230	232	232	232	232	232	232	232
4(i)	EPCOR Water Arizona Inc. ¹	Mohave County	0	140	270	657	662	662	662	662	662	662	662
4(i)	Fisher's Landing Water and Sewer Works, L.L.C.	Yuma County	0	0	0	7	7	7	7	7	7	7	7
4(i)	Frontier Communications West Coast Inc.	La Paz County	0	1	1	1	1	1	1	1	1	1	1
4(i)	Gold Dome Mining Corporation	Yuma County	0	0	0	0	0	0	0	0	0	0	0
4(i)	Gold Standard Mines Corp.	Mohave County	0	0	0	0	0	0	0	0	0	0	0
4(i)	Golden Shores Water Conservation District	Mohave County	0	0	0	284	290	290	290	290	290	290	290
4(i)	Hillcrest Water Company	La Paz County	0	0	1	18	18	18	18	18	18	18	18
4(i)	Lake Havasu City	Mohave County	0	2,989	4,239	7,960	8,009	8,009	8,009	8,009	8,009	8,009	8,009
4(i)	Lake Havasu City (MCWA Subcontract)	Mohave County	0	0	0	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	0	0	0
4(i)	La Paz County	La Paz County	0	0	0	0	0	0	0	0	0	0	0
4(i)	McAlister Family Trust	Mohave County	0	0	0	7	7	7	7	7	7	7	7
4(i)	Mohave Valley Irrigation and Drainage District (MCWA Subcontract)	Mohave County	0	390	461	672	675	675	675	675	675	675	675
4(i)	Mohave Water Conservation District	Mohave County	0	300	427	804	809	809	809	809	809	809	809
4(i)	Mohave Water Conservation District (MCWA Subcontract)	Mohave County	0	0	0	0	0	0	0	0	0	0	0
4(i)	Parker, Town of ¹	La Paz County	0	0	0	87	90	90	90	90	90	90	90
4(i)	Quartzsite, Town of	La Paz County	0	0	0	0	0	0	0	0	0	0	0
4(i)	Roy, Estates of Anna R. and Edward P.	Yuma County	0	0	0	0	0	0	0	0	0	0	0
4(i)	Shepard Water Company, Incorporated	Yuma County	0	4	8	18	18	18	18	18	18	18	18
4(i)	Somerton, City of	Yuma County	0	0	0	0	0	0	0	0	0	0	0
4(i)	Springs Del Sol Domestic Water Improvement District	La Paz County	0	0	0	2	2	2	2	2	2	2	2
4(i)	TV Marble Canyon AZ, LLC	Coconino County	0	0	0	9	9	9	9	9	9	9	9
CAP Indian	Scottsdale (Yavapai Prescott Indian Tribe Allocation)	Maricopa County	0	169	263	500	500	500	500	500	500	500	500
CAP M&I	ASARCO	Pima County	0	9,249	12,574	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000
CAP M&I	Avondale	Maricopa County	0	2,385	3,243	5,416	5,416	5,416	5,416	5,416	5,416	5,416	5,416
CAP M&I	Arizona State Land Department (AZSLD)	Maricopa County	0	2,290	3,114	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200

Summary of Consumptive Use Impacts to Domestic Uses			Range of Analyzed Volumes of Total Shortage to Lower Division States for Action Alternative 1 (AF)										
CAP M&I	Arizona Water Company, Casa Grande	Pinal County	0	3,913	5,320	8,884	8,884	8,884	8,884	8,884	8,884	8,884	8,884
CAP M&I	Arizona Water Company, Coolidge	Pinal County	0	881	1,198	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
CAP M&I	Arizona Water Company, Superstition	Pinal County	0	2,768	3,763	6,285	6,285	6,285	6,285	6,285	6,285	6,285	6,285
CAP M&I	Arizona Water Company, White Tank	Maricopa County	0	426	580	968	968	968	968	968	968	968	968
CAP M&I	Buckeye	Maricopa County	0	98	134	223	223	223	223	223	223	223	223
CAP M&I	Central Arizona Groundwater Replenishment District (CAGRD)	Maricopa County	0	2,830	3,848	6,426	6,426	6,426	6,426	6,426	6,426	6,426	6,426
CAP M&I	Carefree Water Company	Maricopa County	0	390	531	886	886	886	886	886	886	886	886
CAP M&I	Cave Creek	Maricopa County	0	1,148	1,560	2,606	2,606	2,606	2,606	2,606	2,606	2,606	2,606
CAP M&I	Chandler	Maricopa County	0	3,811	5,182	8,654	8,654	8,654	8,654	8,654	8,654	8,654	8,654
CAP M&I	Chaparral City Water Company	Maricopa County	0	3,924	5,335	8,909	8,909	8,909	8,909	8,909	8,909	8,909	8,909
CAP M&I	Circle City	Maricopa County	0	0	0	0	0	0	0	0	0	0	0
CAP M&I	El Mirage	Maricopa County	0	224	304	508	508	508	508	508	508	508	508
CAP M&I	Eloy	Pinal County	0	956	1,300	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171
CAP M&I	EPCOR, Agua Fria	Maricopa County	0	4,885	6,642	11,093	11,093	11,093	11,093	11,093	11,093	11,093	11,093
CAP M&I	EPCOR, Paradise Valley	Maricopa County	0	1,423	1,935	3,231	3,231	3,231	3,231	3,231	3,231	3,231	3,231
CAP M&I	EPCOR, Sun City	Maricopa County	0	1,845	2,508	4,189	4,189	4,189	4,189	4,189	4,189	4,189	4,189
CAP M&I	EPCOR, Sun City West	Maricopa County	0	1,045	1,420	2,372	2,372	2,372	2,372	2,372	2,372	2,372	2,372
CAP M&I	Florence	Pinal County	0	902	1,226	2,048	2,048	2,048	2,048	2,048	2,048	2,048	2,048
CAP M&I	Freeport-Miami	Gila County	0	1,280	1,740	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906
CAP M&I	Flowing Wells Irrigation District (FWID)	Pima County	0	1,257	1,709	2,854	2,854	2,854	2,854	2,854	2,854	2,854	2,854
CAP M&I	Gilbert	Maricopa County	0	3,186	4,332	7,235	7,235	7,235	7,235	7,235	7,235	7,235	7,235
CAP M&I	Glendale	Maricopa County	0	7,591	10,321	17,236	17,236	17,236	17,236	17,236	17,236	17,236	17,236
CAP M&I	Goodyear	Maricopa County	0	4,731	6,432	10,742	10,742	10,742	10,742	10,742	10,742	10,742	10,742
CAP M&I	Greater Tonopah, Water Utility	Maricopa County	0	28	38	64	64	64	64	64	64	64	64
CAP M&I	Green Valley Community Water Company	Pima County	0	0	0	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	0	0	0
CAP M&I	Marana	Pima County	0	1,029	1,399	2,336	2,336	2,336	2,336	2,336	2,336	2,336	2,336
CAP M&I	Maricopa County Parks & Recreation	Maricopa County	0	293	398	665	665	665	665	665	665	665	665
CAP M&I	Mesa	Maricopa County	0	19,159	26,049	43,503	43,503	43,503	43,503	43,503	43,503	43,503	43,503
CAP M&I	Metropolitan Domestic Water Improvement District (Includes ICS Creation)	Pima County	0	5,928	8,060	13,460	13,460	13,460	13,460	13,460	13,460	13,460	13,460
CAP M&I	Oro Valley	Pima County	0	4,538	6,170	10,305	10,305	10,305	10,305	10,305	10,305	10,305	10,305
CAP M&I	Peoria	Maricopa County	0	11,944	16,240	27,121	27,121	27,121	27,121	27,121	27,121	27,121	27,121
CAP M&I	Phoenix	Maricopa County	0	53,819	73,174	122,204	122,204	122,204	122,204	122,204	122,204	122,204	122,204
CAP M&I	Pine	Gila County	0	0	0	0	0	0	0	0	0	0	0
CAP M&I	Queen Creek	Maricopa County	0	218	296	495	495	495	495	495	495	495	495
CAP M&I	Rio Verde Utilities	Maricopa County	0	358	486	812	812	812	812	812	812	812	812
CAP M&I	San Tan Irrigation District	Maricopa County	0	0	0	0	0	0	0	0	0	0	0
CAP M&I	Scottsdale	Maricopa County	0	23,258	31,622	52,810	52,810	52,810	52,810	52,810	52,810	52,810	52,810
CAP M&I	Spanish Trail Water Company	Pima County	0	1,338	1,819	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037
CAP M&I	Surprise	Maricopa County	0	4,514	6,137	10,249	10,249	10,249	10,249	10,249	10,249	10,249	10,249
CAP M&I	Tempe	Maricopa County	0	1,900	2,584	4,315	4,315	4,315	4,315	4,315	4,315	4,315	4,315
CAP M&I	Tonopah	Maricopa County	0	0	0	0	0	0	0	0	0	0	0
CAP M&I	Tonto Hills Domestic Water Improvement District	Maricopa County	0	31	43	71	71	71	71	71	71	71	71
CAP M&I	Tucson	Pima County	0	63,503	86,339	144,191	144,191	144,191	144,191	144,191	144,191	144,191	144,191
CAP M&I	Vail Water Company	Pima County	0	818	1,112	1,857	1,857	1,857	1,857	1,857	1,857	1,857	1,857

Summary of Consumptive Use Impacts to Domestic Uses			Range of Analyzed Volumes of Total Shortage to Lower Division States for Action Alternative 1 (AF)										
CAP M&I	Water Utilities Community Facilities District, Apache Junction	Pinal County	0	1,286	1,748	2,919	2,919	2,919	2,919	2,919	2,919	2,919	2,919
CAP NIA-A	Phoenix	Maricopa County	9,826	37,280	37,280	37,280	37,280	37,280	37,280	37,280	37,280	37,280	37,280
CAP NIA-A	Chandler	Maricopa County	1,034	3,924	3,924	3,924	3,924	3,924	3,924	3,924	3,924	3,924	3,924
CAP NIA-A	Gilbert	Maricopa County	405	1,537	1,537	1,537	1,537	1,537	1,537	1,537	1,537	1,537	1,537
CAP NIA-A	Glendale	Maricopa County	180	682	682	682	682	682	682	682	682	682	682
CAP NIA-A	Mesa	Maricopa County	1,463	5,551	5,551	5,551	5,551	5,551	5,551	5,551	5,551	5,551	5,551
CAP NIA-A	Scottsdale	Maricopa County	871	3,306	3,306	3,306	3,306	3,306	3,306	3,306	3,306	3,306	3,306
CAP NIA-A	Tempe	Maricopa County	6	23	23	23	23	23	23	23	23	23	23
CAP NIA-B	Buckeye	Maricopa County	2,786	2,786	2,786	2,786	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	18,185	18,185	18,185	18,185	18,185	18,185	18,185	18,185	18,185	18,185	18,185
CAP NIA-B	Carefree Water Company	Maricopa County	112	112	112	112	112	112	112	112	112	112	112
CAP NIA-B	Cave Creek	Maricopa County	386	386	386	386	386	386	386	386	386	386	386
CAP NIA-B	El Mirage	Maricopa County	1,318	1,318	1,318	1,318	1,318	1,318	1,318	1,318	1,318	1,318	1,318
CAP NIA-B	EPCOR, San Tan (ST)	Pinal County	3,217	3,217	3,217	3,217	3,217	3,217	3,217	3,217	3,217	3,217	3,217
CAP NIA-B	Freeport	Pima County	5,678	5,678	5,678	5,678	5,678	5,678	5,678	5,678	5,678	5,678	5,678
CAP NIA-B	Gilbert	Maricopa County	1,832	1,832	1,832	1,832	1,832	1,832	1,832	1,832	1,832	1,832	1,832
CAP NIA-B	Marana	Pima County	515	515	515	515	515	515	515	515	515	515	515
CAP NIA-B	Queen Creek	Maricopa County	4,162	4,162	4,162	4,162	4,162	4,162	4,162	4,162	4,162	4,162	4,162
CAP NIA-B	Resolution Copper	Maricopa County	2,238	2,238	2,238	2,238	2,238	2,238	2,238	2,238	2,238	2,238	2,238
CAP NIA-B	Rosemont Copper	Pima County	1,124	1,124	1,124	1,124	1,124	1,124	1,124	1,124	1,124	1,124	1,124
CAP NIA-B	SRP	Maricopa County	2,160	2,160	2,160	2,160	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	817	817	817	817	817	817	817	817	817	817	817
3	City of Yuma ¹	Yuma County	0	0	0	13,511	13,511	13,511	13,511	13,511	13,511	13,511	13,511
3	Union Pacific Railroad (formerly Southern Pacific Co.)	Yuma County	0	0	0	29	29	29	29	29	29	29	29
3	Kaman, Inc.	Yuma County	0	0	0	0	0	0	0	0	0	0	0
3	Department of the Navy, MCAS	Yuma County	0	0	0	1,239	1,239	1,239	1,239	1,239	1,239	1,239	1,239
3	City of Yuma (cemetery)	Yuma County	0	0	0	0	0	0	0	0	0	0	0
3	Yuma Mesa Fruit Growers Association	Yuma County	0	0	0	0	0	0	0	0	0	0	0
3	Desert Lawn Memorial Park Association	Yuma County	0	0	0	23	23	23	23	23	23	23	23
3	Chandler (Salt River Pima-Maricopa Exchange)	Maricopa County	0	0	0	646	1,079	1,272	1,561	2,138	2,523	2,909	3,294
3	Gilbert (Salt River Pima-Maricopa Exchange)	Maricopa County	0	0	0	1,021	1,705	2,010	2,467	3,380	3,988	4,598	5,206
3	Glendale (Salt River Pima-Maricopa Exchange)	Maricopa County	0	0	0	453	756	892	1,094	1,499	1,769	2,040	2,310
3	Mesa (Salt River Pima-Maricopa Exchange)	Maricopa County	0	0	0	417	696	820	1,007	1,380	1,628	1,877	2,125
3	Phoenix (Salt River Pima-Maricopa Exchange)	Maricopa County	0	0	0	755	1,261	1,486	1,824	2,499	2,949	3,400	3,850
3	Scottsdale (Salt River Pima-Maricopa Exchange)	Maricopa County	0	0	0	15	25	30	36	50	59	68	77
3	Tempe (Salt River Pima-Maricopa Exchange)	Maricopa County	0	0	0	15	25	30	36	50	59	68	77
3	Department of the Army - Yuma Proving Ground	Yuma County	0	0	0	0	0	0	0	0	0	24	125
3	Yuma Union High School District	Yuma County	0	0	0	117	117	117	117	117	117	117	117
2	Cibola National Wildlife Refuge	La Paz County	0	0	0	0	0	0	554	2,665	4,071	5,482	6,888
2	Lake Mead National Recreation Area	Mohave County	0	0	0	64	93	106	125	164	189	215	240
2	Bureau of Reclamation - Davis Dam	Mohave County	0	0	0	0	0	0	0	0	0	0	0
2	Imperial National Wildlife Refuge	La Paz County	0	0	0	0	0	0	0	0	0	0	0
2	Havas Lake National Wildlife Refuge	Mohave County	0	0	0	0	0	0	0	0	0	0	0

Summary of Consumptive Use Impacts to Domestic Uses			Range of Analyzed Volumes of Total Shortage to Lower Division States for Action Alternative 1 (AF)										
		Subtotal	58,316	362,624	457,998	720,464	722,856	723,861	725,920	731,041	734,452	737,896	741,409
California²													
Priority	Entitlement Holder	County											
4	Metropolitan Water District of Southern California (MWD) (4)	Los Angeles, Orange, San Diego,	0	0	0	0	261,593	389,176	444,352	444,352	444,352	444,352	444,352
3	MWD Diversions from QSA (3a from IID and CVWD)	Riverside, and San Bernardino	0	0	0	0	0	0	57,936	220,880	329,400	398,700	398,700
		Subtotal	0	0	0	0	261,593	389,176	502,287	665,231	773,752	843,052	843,052
Nevada													
Priority	Entitlement Holder	County											
8 – Balance & Surplus	Southern Nevada Water Authority (SNWA)	Clark	16,000	42,640	49,360	69,360	83,320	90,000	93,975	93,975	93,975	93,975	93,975
8	Big Bend Water District	Clark	0	0	0	0	0	0	188	813	1,229	1,646	2,062
8	Robert B. Griffith Project	Clark	0	0	0	0	0	0	5,836	25,212	38,116	51,059	63,963
7	Southern Nevada Water Authority (Formerly Boy Scouts of America)	Clark	0	0	0	0	0	0	0	0	0	0	0
7	Bureau of Reclamation (includes Sportsman Park)	Clark	0	0	0	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	0	0	0
7	U.S. Air Force (4,000af) (Delivery from SNWA)	Clark	0	0	0	0	0	0	0	0	0	0	0
6	Las Vegas Valley Water District	Clark	0	0	0	0	0	0	0	0	0	0	0
5	Lakeview Company (Hacienda Casino)	Clark	0	0	0	0	0	0	0	0	0	0	0
5	Pacific Coast Building Products, Inc. (PABCO)	Clark	0	0	0	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	0	0	0
4	City of Henderson	Clark	0	0	0	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	0	0	0
3	Boulder City	Clark	0	0	0	0	0	0	0	0	0	0	0
2	Lake Mead National Recreation Area, Executive Order No. 5339	Clark	0	0	0	0	0	0	0	0	0	0	0
		Subtotal	16,000	42,640	49,360	69,360	83,320	90,000	100,000	120,000	133,320	146,680	160,000
		Total	74,316	405,264	507,358	789,824	1,067,769	1,203,037	1,330,841	1,519,634	1,645,370	1,731,784	1,748,616
Summary by County													
	Arizona	# of Entitlement Holders /County											
	Coconino County	1	0	0	0	9	9	9	9	9	9	9	9
	Gila County	2	0	1,280	1,740	2,906	2,906	2,906	2,906	2,906	2,906	2,906	2,906
	La Paz County	11	0	11	67	1,217	1,239	1,239	1,793	3,904	5,310	6,721	8,127
	Maricopa County	55	46,965	243,406	300,231	447,506	449,732	450,724	452,210	455,181	457,160	459,145	461,124
	Mohave County	18	0	8,208	10,865	19,138	19,277	19,290	19,309	19,348	19,373	19,399	19,425
	Pima County	13	7,317	94,976	126,499	206,357	206,357	206,357	206,357	206,357	206,357	206,357	206,357
	Pinal County	8	4,034	14,739	18,589	28,341	28,341	28,341	28,341	28,341	28,341	28,341	28,341
	Yuma County	16	0	4	8	14,991	14,995	14,995	14,995	14,995	14,995	15,019	15,120
	Subtotal Arizona Domestic	124	58,316	362,624	457,998	720,464	722,856	723,861	725,920	731,041	734,452	737,896	741,409

Summary of Consumptive Use Impacts to Domestic Uses			Range of Analyzed Volumes of Total Shortage to Lower Division States for Action Alternative 1 (AF)										
	California												
	Los Angeles, Orange, San Diego, Riverside, and San Bernardino	6	0	0	0	0	261,593	389,176	502,287	665,231	773,752	843,052	843,052
	Subtotal California Domestic	6	0	0	0	0	261,593	389,176	502,287	665,231	773,752	843,052	843,052
	Nevada												
	Clark	15	16,000	42,640	49,360	69,360	83,320	90,000	100,000	120,000	133,320	146,680	160,000
	Subtotal Nevada Domestic	15	16,000	42,640	49,360	69,360	83,320	90,000	100,000	120,000	133,320	146,680	160,000

¹This user also holds a PPR entitlement, which is not impacted at these levels of shortages and was not included here.

²The first increment of shortage volumes required by Action Alternative 1 is satisfied by 2019 DCP contributions. In some elevation tiers, the 2019 DCP contributions for California exceed the 2024 shortage volume under Action Alternative 1, which follows the priority system. In these instances, the shortage allocation model for the No Action Alternative will show higher shortages to California than the shortage allocation model for Action Alternative 1.

Note: PPRs are not impacted 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.

Disclaimer: These modeling results (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 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 of that process.

D.3.4 Relationship between CRMMS and the Action Alternative 1 Shortage Allocation Model

The Colorado River Mid-term Modeling System (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 C). The Action Alternative 1 Shortage Allocation Model provides a more detailed allocation of shortages to entitlement holders in the Lower Division States, specifically within Arizona. In CRMMS, Arizona second and third priority users are lumped together and assumed to be coequal and other groups of small users are represented as a single point of diversion. The Action Alternative 1 Shortage Allocation Model provides detail on the users in various priority groups and models some sub-priority groups in accordance with entitlement-specific terms and conditions¹⁵.

The Action Alternative 1 Shortage Allocation Model does not account for the use of Intentionally Created Surplus (ICS) to meet DCP contributions, and it models DCP contributions as shortages to Lower Division States and users; those contributions are assumed to partially or fully satisfy the volumes of shortage assigned to each Lower Division State according to the inter-state assumptions about priority in the Action Alternative 1 Shortage Allocation Model. CRMMS can model conversion of Extraordinary Conversion ICS to DCP ICS for purposes of meeting DCP contributions without reducing diversions in a specific year. The Action Alternative 1 Shortage Allocation Model does not model ICS conversions to meet DCP contributions, and it does not reflect CVWD's agreement to provide 7 percent of California's DCP contributions.

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 Action Alternative 1 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.

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 distributions available water on that basis. For Arizona, the methods for distributing available water vary between priorities in the Action Alternative 1 Shortage Allocation Model, but they are not based on CRMMS schedules.

¹⁵ Internet website: <https://www.usbr.gov/lc/region/g4000/contracts/entitlements.html>.

The significant difference between CRMMS and the Action Alternative 1 Shortage Allocation Model relates to where Stage 1 shortage transitions to Stage 2 as described in **Section D.3.1.1**, and how DCP contributions apply within the Action Alternative 1 Shortage Allocation Model. At a total shortage of 1,734,000 AF, associated with elevations of 1,045 to 1,040 feet above mean sea level in Lake Mead, the Action Alternative 1 Shortage Allocation Model is operating under Stage 1 shortage distribution assumptions and assigning no shortage to California. The 1,734,000 af level of shortage is within Stage 2 in CRMMS according to its projected water depletion schedules as described in the previous paragraph, meaning CRMMS is assigning shortage to California. Additionally, at this Lake Mead elevation tier, CRMMS reflects the State of California's DCP contribution of 200,000 AF, which is not derived from the priority system assumptions of the Action Alternative 1 Shortage Allocation Model, and it is not reflected in that model. This results in a persistent difference in shortage volumes attributed to the State of California between the two modeling approaches. Accordingly, shortage to PPRs within California would be triggered even earlier in CRMMS and reach deeper levels than in the Action Alternative 1 Shortage Allocation Model. (See **Section D.3.5** below for a discussion of an alternative approach that would address this outcome.)

D.3.5 Alternative Approach to the Action Alternative 1 Shortage Allocation Model

The approach used in the Action Alternative 1 Shortage Allocation Model to distribute shortages among the Lower Division States is consistent with the 2007 FEIS. In 2007, the Shortage Allocation Model did not consider shortages larger than 2.5 maf (including Mexico), which was not significant enough to impact PPRs. At deeper shortage volumes such as 4.0 maf, the distribution of water among the Lower Division States using the 2007 methodology is not projected to provide sufficient water to fill all PPRs in the State of California (see **Table D-13** – Action Alternative 1 Shortage Allocation Model Regional Summary). This analysis does not invoke a reduction to PPRs according to the fill order provided below in **Table D-17** (bottom up), interpreted from Paragraph 5 of the Appendix to the Consolidated Decree, and it assumes no further shortage would be applied to California after its first priority is fully reduced.

Table D-17
Present Perfected Right Summary and Assumed Fill Order

Entitlements		CU Equivalent	Diversion				
		(AF)	(AF)				
Arizona, California, and Nevada Summary							
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*).

*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..."

As set forth in the Consolidated Decree, the PPR priority system is administered without regard to state lines. To ensure that PPRs can be satisfied (or reduced) in the prescribed order as a Basin-wide senior priority group, an alternate approach to distributing shortage among the Lower Division States could be employed as described in this section and as shown in **Table D-18**. Instead of setting the entire volume of each state's apportionment as coequal to the others, only state apportionments in excess of PPRs are treated as coequal (but maintaining the assumption that Arizona bears California's share of shortage until the Arizona fourth priority is exhausted). In developing the Stage 1 and Stage 2 percentages for the sharing of shortage among the Lower Division States, the consumptive use (or equivalent) of PPR entitlements would be removed from the apportionment volumes in each ratio, as detailed below. In this alternate approach, the Stage 2 distribution of water among the Lower Division States would end at the volume of total shortage where reductions to PPRs are necessary and all non-PPR entitlements have been fully reduced in each state; at that point, water available to each state would equal the consumptive use (or equivalent) of PPRs within the state. The distribution of water among PPRs might be thought of as a Stage 3, where water available to each state would be an aggregation of the PPR volumes within the state that could be filled at a given level of shortage.

The Stage 1 shortage sharing percentages based on the alternative approach are computed as follows:

- Nevada bears a reduction of about 7.0 percent of the total Lower Division States shortage volume, computed as a ratio of Nevada's apportionment less PPR consumptive use (or equivalent) entitlements within Nevada to the sum of the apportionments of the Lower Division States less all PPR consumptive use (or equivalent) entitlements
 - $(300,000 \text{ af} - 8,697 \text{ af}) / (7,500,000 \text{ af} - 3,270,473 \text{ af}) = 6.89 \text{ percent}$
- Arizona bears a reduction of about 93 percent of the total Lower Division States shortage volume, computed as a ratio of Arizona's and California's apportionments less PPR consumptive use (or equivalent) in both states to the sum of the apportionments of the Lower Division States less all PPR consumptive use (or equivalent) entitlements
 - $(2,800,000 \text{ af} - 567,499 \text{ af} + 4,400,000 \text{ af} - 2,694,276 \text{ af}) / (7,500,000 \text{ af} - 3,270,473 \text{ af}) = 93.11 \text{ percent}$

Table D-18
Alternative Approach to Stage 1 State Distribution Under Action Alternative 1 Shortage Allocation Model

"Stage 1" Shortage Distribution	Arizona	California	Nevada	Subtotals
Ratio of Post-PPR Apportionment to All Post-PPR Apportionments	= (2,800,000-567,499)/(7,500,000-3,270,473) or 52.78%	= (4,400,000-2,694,276)/(7,500,000-3,270,473) or 40.33%	= (300,000-8,697)/(7,500,000-3,270,473) or 6.89%	
Percentage Assignment of Shortage	93.11%	0.00%	6.89%	

Distribution of Available Water Until Arizona Fourth Priority is Eliminated (Based on Sum of P4 Volumes Under Contract)

Lower Division States Supply (AF)	Shortage Volume (AF)	AZ Shortage Volume (AF)	Water Available to AZ (AF)	CA Shortage Volume (AF)	Water Available to CA (AF)	NV Shortage Volume (AF)	Water Available to NV (AF)	Total Shortage to US States (AF)	Percentage Reduction to US States
7,500,000	-	-	2,800,000	-	4,400,000	-	300,000	-	0.00%
7,400,000	(100,000)	(93,113)	2,706,887	-	4,400,000	(6,887)	293,113	(100,000)	-1.33%
7,300,000	(200,000)	(186,225)	2,613,775	-	4,400,000	(13,775)	286,225	(200,000)	-2.67%
7,200,000	(300,000)	(279,338)	2,520,662	-	4,400,000	(20,662)	279,338	(300,000)	-4.00%
7,100,000	(400,000)	(372,451)	2,427,549	-	4,400,000	(27,549)	272,451	(400,000)	-5.33%
7,000,000	(500,000)	(465,563)	2,334,437	-	4,400,000	(34,437)	265,563	(500,000)	-6.67%
6,900,000	(600,000)	(558,676)	2,241,324	-	4,400,000	(41,324)	258,676	(600,000)	-8.00%
6,800,000	(700,000)	(651,789)	2,148,211	-	4,400,000	(48,211)	251,789	(700,000)	-9.33%
6,700,000	(800,000)	(744,901)	2,055,099	-	4,400,000	(55,099)	244,901	(800,000)	-10.67%
6,600,000	(900,000)	(838,014)	1,961,986	-	4,400,000	(61,986)	238,014	(900,000)	-12.00%
6,500,000	(1,000,000)	(931,126)	1,868,874	-	4,400,000	(68,874)	231,126	(1,000,000)	-13.33%
6,434,000	(1,066,000)	(992,581)	1,807,419	-	4,400,000	(73,419)	226,581	(1,066,000)	-14.21%
6,400,000	(1,100,000)	(1,024,239)	1,775,761	-	4,400,000	(75,761)	224,239	(1,100,000)	-14.67%
6,300,000	(1,200,000)	(1,117,352)	1,682,648	-	4,400,000	(82,648)	217,352	(1,200,000)	-16.00%
6,266,000	(1,234,000)	(1,149,010)	1,650,990	-	4,400,000	(84,990)	215,010	(1,234,000)	-16.45%
6,200,000	(1,300,000)	(1,210,464)	1,589,536	-	4,400,000	(89,536)	210,464	(1,300,000)	-17.33%
6,100,000	(1,400,000)	(1,303,577)	1,496,423	-	4,400,000	(96,423)	203,577	(1,400,000)	-18.67%
6,000,000	(1,500,000)	(1,396,690)	1,403,310	-	4,400,000	(103,310)	196,690	(1,500,000)	-20.00%
5,900,000	(1,600,000)	(1,489,802)	1,310,198	-	4,400,000	(110,198)	189,802	(1,600,000)	-21.33%
5,800,000	(1,700,000)	(1,582,915)	1,217,085	-	4,400,000	(117,085)	182,915	(1,700,000)	-22.67%
5,766,000	(1,734,000)	(1,614,573)	1,185,427	-	4,400,000	(119,427)	180,573	(1,734,000)	-23.12%
5,705,440	(1,794,560)	(1,670,962)	1,129,038	-	4,400,000	(123,598)	176,402	(1,794,560)	-23.93%

As in the original Shortage Allocation Model, after deliveries to the fourth priority entitlements within Arizona are expected to be reduced to zero, additional reductions are applied to Arizona, California, and Nevada. This Stage 2 shortage is the amount of additional shortage above the Stage 1 shortage volume, and the additional shortage is distributed according to the Stage 2 ratios.

The Stage 2 shortage sharing percentages are computed as follows, with the PPR volumes the same as in the Stage 1 ratios. (See **Table D-19** below for the full numeric computation and results.)

- Nevada bears about 7.0 percent of the Stage 2 shortage in addition to its Stage 1 shortage, computed as a ratio of Nevada's apportionment less PPRs less the amount of shortage applied to Nevada under Stage 1, over the sum of the apportionments of the Lower Division States less PPRs less the total amount shorted to users under Stage 1
 - $(0.3 \text{ maf} - \text{NV PPRs} - \text{Nevada Stage 1 shortage}) / (7.5 \text{ maf} - \text{total PPRs} - \text{total Stage 1 shortage}) = 6.89 \text{ percent}$
- Arizona bears about 23 percent of the Stage 2 shortage in addition to its Stage 1 shortage, computed as a ratio of Arizona's apportionment less PPRs less the amount of shortage applied to Arizona under Stage 1, over the sum of the apportionments of the Lower Division States less PPRs less the total amount shorted to users under Stage 1
 - $(2.8 \text{ maf} - \text{AZ PPRs} - \text{Arizona Stage 1 shortage}) / (7.5 \text{ maf} - \text{total PPRs} - \text{total Stage 1 shortage}) = 23.06 \text{ percent}$
- California bears about 70 percent of the Stage 2 shortage, computed as a ratio of California's apportionment less PPRs, over the sum of the apportionments of the Lower Division States less PPRs less the total amount shorted to users under Stage 1
 - $(4.4 \text{ maf} - \text{CA PPRs}) / (7.5 \text{ maf} - \text{total PPRs} - \text{total Stage 1 shortage}) = 70.05 \text{ percent}$

Table D-19
Alternative Approach to Stage 2 State Distribution Under Action Alternative 1 Shortage Allocation Model

"Stage 2" Shortage Distribution	Arizona	California	Nevada	Subtotals
Ratio of Curtailed Post-PPR Apportionment to Remainder	= (2,800,000-567,499-1,670,962)/(7,500,000- 3,270,473-1,794,560) or 23.06%	= (4,400,000-2,694,276)/(7,500,000-3,270,473-1,794,560) or 70.05%	= (300,000-8,697-123,598)/(7,500,000-3,270,473-1,794,560) or 6.89%	
Percentage Assignment of Shortage	23.06%	70.05%	6.89%	

Distribution of Available Water After Arizona Fourth Priority is Eliminated (Based on Sum of P4 Volumes Under Contract), but Before PPR Reductions Begin

Lower Division States Supply (AF)	Shortage Volume in Addition to Stage 1 Shortage (AF)	AZ Shortage Volume in Addition to Stage 1 Shortage (AF)	Water Available to AZ (AF)	CA Shortage Volume in Addition to Stage 1 Shortage (AF)	Water Available to CA (AF)	NV Shortage Volume in Addition to Stage 1 Shortage (AF)	Water Available to NV (AF)	Total Shortage to US States (AF)	Percentage Reduction to US States
5,700,000	(5,440)	(1,255)	1,127,783	(3,811)	4,396,189	(375)	176,028	(1,800,000)	-24.00%
5,600,000	(105,440)	(24,316)	1,104,722	(73,862)	4,326,138	(7,262)	169,140	(1,900,000)	-25.33%
5,500,000	(205,440)	(47,377)	1,081,661	(143,913)	4,256,087	(14,149)	162,253	(2,000,000)	-26.67%
5,417,000	(288,440)	(66,518)	1,062,520	(202,056)	4,197,944	(19,866)	156,536	(2,083,000)	-27.77%
5,300,000	(405,440)	(93,500)	1,035,538	(284,016)	4,115,984	(27,924)	148,478	(2,200,000)	-29.33%
5,250,000	(455,440)	(105,031)	1,024,007	(319,041)	4,080,959	(31,368)	145,035	(2,250,000)	-30.00%
5,200,000	(505,440)	(116,562)	1,012,476	(354,067)	4,045,933	(34,811)	141,591	(2,300,000)	-30.67%
5,100,000	(605,440)	(139,623)	989,415	(424,118)	3,975,882	(41,699)	134,703	(2,400,000)	-32.00%
5,000,000	(705,440)	(162,685)	966,353	(494,169)	3,905,831	(48,586)	127,816	(2,500,000)	-33.33%
4,900,000	(805,440)	(185,746)	943,292	(564,221)	3,835,779	(55,474)	120,929	(2,600,000)	-34.67%
4,800,000	(905,440)	(208,808)	920,230	(634,272)	3,765,728	(62,361)	114,041	(2,700,000)	-36.00%
4,700,000	(1,005,440)	(231,869)	897,169	(704,323)	3,695,677	(69,248)	107,154	(2,800,000)	-37.33%
4,600,000	(1,105,440)	(254,930)	874,108	(774,374)	3,625,626	(76,136)	100,267	(2,900,000)	-38.67%
4,500,000	(1,205,440)	(277,992)	851,046	(844,425)	3,555,575	(83,023)	93,379	(3,000,000)	-40.00%
4,400,000	(1,305,440)	(301,053)	827,985	(914,477)	3,485,523	(89,910)	86,492	(3,100,000)	-41.33%
4,300,000	(1,405,440)	(324,115)	804,923	(984,528)	3,415,472	(96,798)	79,605	(3,200,000)	-42.67%
4,200,000	(1,505,440)	(347,176)	781,862	(1,054,579)	3,345,421	(103,685)	72,717	(3,300,000)	-44.00%
4,167,000	(1,538,440)	(354,787)	774,251	(1,077,696)	3,322,304	(105,958)	70,444	(3,333,000)	-44.44%
4,100,000	(1,605,440)	(370,238)	758,800	(1,124,630)	3,275,370	(110,572)	65,830	(3,400,000)	-45.33%
4,000,000	(1,705,440)	(393,299)	735,739	(1,194,681)	3,205,319	(117,460)	58,943	(3,500,000)	-46.67%
3,900,000	(1,805,440)	(416,361)	712,677	(1,264,733)	3,135,267	(124,347)	52,055	(3,600,000)	-48.00%
3,833,000	(1,872,440)	(431,812)	697,226	(1,311,667)	3,088,333	(128,962)	47,441	(3,667,000)	-48.89%

Lower Division States Supply (AF)	Shortage Volume in Addition to Stage 1 Shortage (AF)	AZ Shortage Volume in Addition to Stage 1 Shortage (AF)	Water Available to AZ (AF)	CA Shortage Volume in Addition to Stage 1 Shortage (AF)	Water Available to CA (AF)	NV Shortage Volume in Addition to Stage 1 Shortage (AF)	Water Available to NV (AF)	Total Shortage to US States (AF)	Percentage Reduction to US States
3,800,000	(1,905,440)	(439,422)	689,616	(1,334,784)	3,065,216	(131,234)	45,168	(3,700,000)	-49.33%
3,700,000	(2,005,440)	(462,483)	666,555	(1,404,835)	2,995,165	(138,122)	38,280	(3,800,000)	-50.67%
3,600,000	(2,105,440)	(485,545)	643,493	(1,474,886)	2,925,114	(145,009)	31,393	(3,900,000)	-52.00%
3,500,000	(2,205,440)	(508,606)	620,432	(1,544,937)	2,855,063	(151,897)	24,506	(4,000,000)	-53.33%
3,400,000	(2,305,440)	(531,668)	597,370	(1,614,989)	2,785,011	(158,784)	17,618	(4,100,000)	-54.67%
3,270,473	(2,434,967)	(561,539)	567,499	(1,705,724)	2,694,276	(167,705)	8,697	(4,229,527)	-56.39%

This alternative approach to the Action Alternative 1 Shortage Allocation Model represents one possible method for distributing deep shortages among the Lower Division States in a way that does not reduce PPR water deliveries in one state while fulfilling non-PPR water deliveries in another state. This alternative approach would rapidly increase shortage impacts to Nevada in comparison to the modeled Action Alternative 1 because Nevada has only two PPRs totaling 8,697 af on a consumptive use equivalent basis.

Table D-20 below summarizes the distribution of shortage and available water to the Lower Division States in Stage 1 and Stage 2, in 100,000 af increments, under the alternative approach to the Action Alternative 1 Shortage Allocation Model.

Table D-20
Detailed Distribution (in AF) by State Under Alternative Approach to Action
Alternative 1 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)
-	-	2,800,000	-	4,400,000	-	300,000
(100,000)	(93,113)	2,706,887	-	4,400,000	(6,887)	293,113
(200,000)	(186,225)	2,613,775	-	4,400,000	(13,775)	286,225
(300,000)	(279,338)	2,520,662	-	4,400,000	(20,662)	279,338
(400,000)	(372,451)	2,427,549	-	4,400,000	(27,549)	272,451
(500,000)	(465,563)	2,334,437	-	4,400,000	(34,437)	265,563
(600,000)	(558,676)	2,241,324	-	4,400,000	(41,324)	258,676
(700,000)	(651,789)	2,148,211	-	4,400,000	(48,211)	251,789
(800,000)	(744,901)	2,055,099	-	4,400,000	(55,099)	244,901
(900,000)	(838,014)	1,961,986	-	4,400,000	(61,986)	238,014
(1,000,000)	(931,126)	1,868,874	-	4,400,000	(68,874)	231,126
(1,066,000)	(992,581)	1,807,419	-	4,400,000	(73,419)	226,581
(1,100,000)	(1,024,239)	1,775,761	-	4,400,000	(75,761)	224,239
(1,200,000)	(1,117,352)	1,682,648	-	4,400,000	(82,648)	217,352
(1,234,000)	(1,149,010)	1,650,990	-	4,400,000	(84,990)	215,010
(1,300,000)	(1,210,464)	1,589,536	-	4,400,000	(89,536)	210,464
(1,400,000)	(1,303,577)	1,496,423	-	4,400,000	(96,423)	203,577
(1,500,000)	(1,396,690)	1,403,310	-	4,400,000	(103,310)	196,690
(1,600,000)	(1,489,802)	1,310,198	-	4,400,000	(110,198)	189,802
(1,700,000)	(1,582,915)	1,217,085	-	4,400,000	(117,085)	182,915
(1,734,000)	(1,614,573)	1,185,427	-	4,400,000	(119,427)	180,573
(1,794,560)	(1,670,962)	1,129,038	-	4,400,000	(123,598)	176,402
(1,800,000)	(1,672,217)	1,127,783	(3,811)	4,396,189	(123,972)	176,028
(1,900,000)	(1,695,278)	1,104,722	(73,862)	4,326,138	(130,860)	169,140
(2,000,000)	(1,718,339)	1,081,661	(143,913)	4,256,087	(137,747)	162,253
(2,083,000)	(1,737,480)	1,062,520	(202,056)	4,197,944	(143,464)	156,536
(2,200,000)	(1,764,462)	1,035,538	(284,016)	4,115,984	(151,522)	148,478
(2,250,000)	(1,775,993)	1,024,007	(319,041)	4,080,959	(154,965)	145,035
(2,300,000)	(1,787,524)	1,012,476	(354,067)	4,045,933	(158,409)	141,591
(2,400,000)	(1,810,585)	989,415	(424,118)	3,975,882	(165,297)	134,703
(2,500,000)	(1,833,647)	966,353	(494,169)	3,905,831	(172,184)	127,816
(2,600,000)	(1,856,708)	943,292	(564,221)	3,835,779	(179,071)	120,929
(2,700,000)	(1,879,770)	920,230	(634,272)	3,765,728	(185,959)	114,041
(2,800,000)	(1,902,831)	897,169	(704,323)	3,695,677	(192,846)	107,154
(2,900,000)	(1,925,892)	874,108	(774,374)	3,625,626	(199,733)	100,267
(3,000,000)	(1,948,954)	851,046	(844,425)	3,555,575	(206,621)	93,379

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)
(3,100,000)	(1,972,015)	827,985	(914,477)	3,485,523	(213,508)	86,492
(3,200,000)	(1,995,077)	804,923	(984,528)	3,415,472	(220,395)	79,605
(3,300,000)	(2,018,138)	781,862	(1,054,579)	3,345,421	(227,283)	72,717
(3,333,000)	(2,025,749)	774,251	(1,077,696)	3,322,304	(229,556)	70,444
(3,400,000)	(2,041,200)	758,800	(1,124,630)	3,275,370	(234,170)	65,830
(3,500,000)	(2,064,261)	735,739	(1,194,681)	3,205,319	(241,057)	58,943
(3,600,000)	(2,087,323)	712,677	(1,264,733)	3,135,267	(247,945)	52,055
(3,667,000)	(2,102,774)	697,226	(1,311,667)	3,088,333	(252,559)	47,441
(3,700,000)	(2,110,384)	689,616	(1,334,784)	3,065,216	(254,832)	45,168
(3,800,000)	(2,133,445)	666,555	(1,404,835)	2,995,165	(261,720)	38,280
(3,900,000)	(2,156,507)	643,493	(1,474,886)	2,925,114	(268,607)	31,393
(4,000,000)	(2,179,568)	620,432	(1,544,937)	2,855,063	(275,494)	24,506
(4,100,000)	(2,202,630)	597,370	(1,614,989)	2,785,011	(282,382)	17,618
(4,229,527)	(2,232,501)	567,499	(1,705,724)	2,694,276	(291,303)	8,697

Appendix C (CRMMS) includes a section summarizing results of the hydrologic modeling associated with this alternative approach.

D.4 Action Alternative 2 Shortage Allocation Model

The discrete volumes (in AF) of total shortage to the Lower Division States considered in Action Alternative 2 are the same as those under Action Alternative 1:

- 400,000
- 1,066,000
- 1,234,000
- 1,734,000
- 2,083,000
- 2,250,000
- 2,500,000
- 3,000,000
- 3,333,000
- 3,667,000
- 4,000,000

Under Action Alternative 2, shortage volumes in excess of the 2007 Record of Decision (ROD) for the adoption of Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead ROD and 2019 DCP volumes are not distributed based on priority, but rather on a proportional basis (i.e., at the same percentage reduction from each user's 2021 consumptive use) across all lower Colorado River mainstream water users. As discussed in this section, the Action Alternative 2 Shortage Allocation Model was developed as a set of Microsoft Excel worksheets that simulate shortage allocations and adjust deliveries of Colorado River water to mainstream water users pro-rata on the basis of Calendar Year 2021 consumptive use, including participation in conservation programs. Specific assumptions for Action Alternative 2 were made to facilitate analysis of the full range of potential impacts, and they are not intended to represent current or future policy with respect to shortage sharing. The Action Alternative 2 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.

D.4.1 Distribution Among Water Users

In contrast to the Action Alternative 1 Shortage Allocation Model, in which total volumes of shortage were distributed among the Lower Division States independent of existing commitments under the 2007 Interim Guidelines and 2019 DCP, the Action Alternative 2 Shortage Allocation Model assigns the responsibility for existing commitments to certain water users; credits those commitments against the total shortage volume; and distributes the remaining additional shortage among those and other water users. The range of additional shortages analyzed in the Action Alternative 2 Shortage Allocation Model is shown in **Table D-21** below. The percentages are calculated by dividing the total additional shortage to the Lower Division States by 7,500,000 af.

Table D-21
Shortage Volumes (in AF) Analyzed in the Action Alternative 2 Shortage Allocation Model

Range of Analyzed Volumes of Total Shortage to Lower Division States (AF)	Range of Analyzed Volumes of Total Additional Shortage to Lower Division States (AF)	Percentage Reductions to Each Water User's 2021 Adjusted Consumptive Use
400,000	200,000	2.67%
1,066,000	533,000	7.11%
1,234,000	617,000	8.23%
1,734,000	867,000	11.56%
2,083,000	983,000	13.11%
2,083,000	1,066,000	14.21%
2,083,000	1,116,000	14.88%
2,083,000	1,166,000	15.55%
2,250,000	1,283,000	17.11%
2,500,000	1,483,000	19.77%
3,000,000	1,900,000	25.33%
3,333,000	2,233,000	29.77%
3,667,000	2,567,000	34.23%
4,000,000	2,900,000	38.67%

The Action Alternative 2 Shortage Allocation Model reflects aspects of priority among the Lower Division States in its attribution of 2007 Interim Guidelines shortages and required DCP contributions, but total shortages assigned to each Lower Division State in the Action Alternative 2 Shortage Allocation Model are an aggregation of shortage volumes assigned to individual water users within each state according to the assumptions described in the following section.

D.4.1.1 Assumptions

Existing volumes of shortage and contributions required by the 2007 Interim Guidelines and DCP were attributed to the primary junior priority diverter in each state. In California and Nevada, 2007 Interim Guidelines' shortages and DCP contributions were attributed to MWD¹⁶ and SNWA,

¹⁶ Notwithstanding Coachella Valley Water District's 7 percent contribution pursuant to May 20, 2019 Drought Contingency Plan Implementation Agreement Between Metropolitan Water District of Southern California and Coachella Valley Water District.

respectively. In Arizona, shortages and contributions were administered in 2022 and 2023 as being shared between CAP and other Arizona fourth priority water users, but the burden of wet water reductions was borne solely by CAP. The Action Alternative 2 Shortage Allocation Model does not incorporate the Arizona Shortage Sharing Recommendation or other priority system-based modeling for non-CAP fourth priority water users, and it assumes the burden of the existing commitments continues to be borne by CAP.

Consumptive use data for the distribution of additional shortages were derived from the 2021 *Colorado River Accounting and Water Use Report: Arizona, California, and Nevada*¹⁷. Water used to generate system conservation and intentionally created surplus was added to each user's 2021 actual use to determine an adjusted consumptive use.

The 2021 adjusted consumptive use forms the baseline against which additional shortages are assessed for each water user. Each water user's percentage share of the additional shortage to the Lower Division States (after existing commitments have been subtracted from the total shortage) was calculated as the ratio of their 2021 adjusted consumptive use to the total Lower Basin consumptive use of 7.5 maf. Those percentages were multiplied by the volume of additional shortage to the Lower Division States to determine the volume of additional shortage assigned each water user. PPRs are included in the distribution of shortages in the Action Alternative 2 Shortage Allocation Model.

For the purpose of comparing 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.

At a given level of additional shortage, as a consequence of how that shortage is distributed as described above, all water users bear the same percentage reduction from their 2021 adjusted consumptive use (as shown in the third column in **Table D-21** above). CAP, MWD, and SNWA are assigned a pro-rata share of additional shortage on the same basis as other water users, but they are also assigned the existing commitments on behalf of each Lower Division State, for a total percentage reduction that would be greater for these water users than for others.

Reclamation's mainstream water accounting data do not itemize water use by contractors and subcontractors within CAP; that record is created and maintained by the project operator, CAWCD. The Action Alternative 2 Shortage Allocation Model distributes shortages calculated at the CAP level, as described above, among CAP contractors and subcontractors according to the internal CAP priority system. Arizona third priority water delivered through the CAP is assumed to be made available first, then the other priorities are satisfied (as described for the Action Alternative 1 Shortage Allocation Model in **Section D.3.2.5.4**) from Available CAP Supply. In the Action Alternative 2 Shortage Allocation Model, available CAP supply is calculated as 2021 adjusted consumptive use at the mainstream point of diversion minus:

¹⁷ Internet website: <https://www.usbr.gov/lc/region/g4000/4200Rpts/DecreeRpt/2021/2021.pdf>. This dataset reflects known users of lower Colorado River water as of 2021, not entitlement holders as in the Alternative 1 and No Action Shortage Allocation Models.

- 75,000 af of CAP main system losses
- 809 af of other use in Arizona
- 68,400 af of priority three water delivered via CAP, and
- a variable quantity of 2007 Interim Guidelines' shortages, DCP contributions, and additional shortage volumes depending on Lake Mead elevation.

D.4.2 Shortage Allocation Model Results

The tables in this section summarize the results of the Action Alternative 2 Shortage Allocation Model over a range of total shortages to the Lower Division States between 400,000 AFY and 4,000,000 AFY, with the total additional shortages from this Draft SEIS ranging from 200,000 AFY to 2,900,000 AFY.

The regional summary, **Table D-22**, shows the aggregated shortage for each state by type of use, while individual water users are listed on the irrigation, domestic, and Tribal summary tables¹⁸ that follow. Shortages by irrigation, domestic, and Tribal uses were aggregated by county for the analysis of general socioeconomic effects, including implications for Indian Trust Assets and environmental justice.

Also summarized in the table below, shortage is more broadly distributed under the assumptions of Action Alternative 2, including to PPRs that are not characterized in the Action Alternative 1 Shortage Allocation Model as being subject to the volumes of shortage under analysis.

¹⁸ As in the Action Alternative 1 Shortage Allocation Model, individual water users are assigned to one predominant type of use.

Table D-22
Action Alternative 2 Shortage Allocation Model Regional Summary

Summary of Shortage Impacts by State		Range of Analyzed Volumes for Action Alternative 2 (AF)													
Range of Analyzed Volumes of Total Shortage to Lower Division States:		400,000	1,066,000	1,234,000	1,734,000	2,083,000	2,083,000	2,083,000	2,083,000	2,250,000	2,500,000	3,000,000	3,333,000	3,667,000	4,000,000
Range of Analyzed Volumes of Total Additional Shortage to Lower Division States:		200,000	533,000	617,000	867,000	983,000	1,066,000	1,116,000	1,166,000	1,283,000	1,483,000	1,900,000	2,233,000	2,567,000	2,900,000
Percentage Reductions to Each Water User's 2021 Adjusted Consumptive Use:		2.67%	7.11%	8.23%	11.56%	13.11%	14.21%	14.88%	15.55%	17.11%	19.77%	25.33%	29.77%	34.23%	38.67%
Arizona Shortage	Irrigation ¹	256,590	382,819	390,887	420,840	429,640	435,715	441,984	448,253	466,282	481,479	528,216	556,731	595,447	633,840
	Domestic ¹	1,402	131,899	198,120	261,644	330,406	293,925	300,453	306,980	320,155	352,442	460,377	512,128	557,710	603,284
	Tribal ¹	8,675	196,269	233,339	281,195	326,941	308,333	314,203	320,073	332,550	359,732	440,740	484,794	525,190	565,543
Subtotal		266,667	710,987	822,347	963,680	1,086,987	1,037,973	1,056,640	1,075,307	1,118,987	1,193,653	1,429,333	1,553,653	1,678,347	1,802,667
California Shortage	Irrigation	91,233	243,135	281,452	395,493	448,408	486,269	509,077	531,886	585,257	676,489	866,709	1,018,611	1,170,969	1,322,871
	Domestic ¹	25,827	68,829	79,676	311,960	476,939	487,658	444,114	400,571	465,680	541,507	595,356	638,358	681,489	724,491
	Tribal	274	730	845	1,187	1,346	1,460	1,528	1,597	1,757	2,031	2,602	3,058	3,515	3,971
Subtotal		117,333	312,693	361,973	708,640	926,693	975,387	954,720	934,053	1,052,693	1,220,027	1,464,667	1,660,027	1,855,973	2,051,333
Nevada Shortage	Irrigation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Domestic ¹	15,919	42,104	49,430	61,329	68,922	69,208	71,188	73,168	77,800	85,719	105,230	118,415	131,640	144,825
	Tribal	81	216	250	351	398	432	452	472	520	601	770	905	1,040	1,175
Subtotal		16,000	42,320	49,680	61,680	69,320	69,640	71,640	73,640	78,320	86,320	106,000	119,320	132,680	146,000
Total		400,000	1,066,000	1,234,000	1,734,000	2,083,000	2,083,000	2,083,000	2,083,000	2,250,000	2,500,000	3,000,000	3,333,000	3,667,000	4,000,000

¹ 2007 Interim Guidelines' shortages, DCP contributions, and additional reductions are distributed among irrigation, domestic, and Tribal users as part of the CAP priority system. In California and Nevada, 2007 Interim Guidelines shortages and DCP contributions are attributed to the junior priority domestic diverter.

Disclaimer: These modeling results (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 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 they cannot replicate the precision required for that process.

Table D-23 below summarizes the shortage impacts to Tribes according to the Action Alternative 2 Shortage Allocation Model. More Tribal entitlements are impacted to some degree, but fewer are reduced to zero in comparison to Action Alternative 1.

Table D-23
Action Alternative 2 Shortage Allocation Model Tribal Summary

Summary of Consumptive Use Impacts to Tribes and Communities			Range of Analyzed Volumes for Action Alternative 2 (AF)												
Range of Analyzed Volumes of Total Shortage to Lower Division States:			1,066,000	1,234,000	1,734,000	2,083,000	2,083,000	2,083,000	2,083,000	2,250,000	2,500,000	3,000,000	3,333,000	3,667,000	4,000,000
Range of Analyzed Volumes of Total Additional Shortage to Lower Division States:			533,000	617,000	867,000	983,000	1,066,000	1,116,000	1,166,000	1,283,000	1,483,000	1,900,000	2,233,000	2,567,000	2,900,000
Percentage Reductions to Each Water User's 2021 Adjusted Consumptive Use:			7.11%	8.23%	11.56%	13.11%	14.21%	14.88%	15.55%	17.11%	19.77%	25.33%	29.77%	34.23%	38.67%
Arizona															
Entitlement Holder	% Distribution of Additional Shortage	County													
Fort Mojave Indian Reservation, AZ ²	0.51005333%	Mohave County	2,719	3,147	4,422	5,014	5,437	5,692	5,947	6,544	7,564	9,691	11,389	13,093	14,792
Colorado River Indian Reservation, AZ ²	3.73616000%	La Paz County	19,914	23,052	32,393	36,726	39,827	41,696	43,564	47,935	55,407	70,987	83,428	95,907	108,349
Fort Yuma Indian Reservation ²	0.02204000%	Yuma County	117	136	191	217	235	246	257	283	327	419	492	566	639
Cocopah Indian Reservation ²	0.01670667%	Yuma County	89	103	145	164	178	186	195	214	248	317	373	429	484
PPR No. 7 -Cocopah ²	0.00452000%	Yuma County	24	28	39	44	48	50	53	58	67	86	101	116	131
Hopi Tribe ²	0.04793333%	La Paz County	255	296	416	471	511	535	559	615	711	911	1,070	1,230	1,390
Gila River Indian Community ²	N/A: CAP Indian Priority	Maricopa and Pinal County	23,378	45,411	63,865	84,165	73,092	74,938	76,783	80,474	89,701	121,074	135,837	148,755	161,673
Tohono O'odham Nation (Schuk Toak & San Xavier Districts) ²	N/A: CAP Indian Priority	Pima County	0	546	5,262	10,449	7,619	8,091	8,563	9,506	11,864	19,880	23,653	26,954	30,255
White Mountain Apache Tribe	N/A: CAP Indian Priority	Apache, Gila, and Navajo	0	0	0	0	0	0	0	0	0	0	0	0	0
Ak-Chin Indian Community ²	N/A: CAP Indian Priority	Pinal County	0	6,588	13,133	20,334	16,406	17,061	17,716	19,025	22,298	33,426	38,662	43,244	47,827
Fort McDowell Yavapai Nation	N/A: CAP Indian Priority	Maricopa County	0	263	2,538	5,040	3,675	3,903	4,130	4,585	5,722	9,589	11,409	13,001	14,594
Pascua Yaqui Tribe	N/A: CAP Indian Priority	Pima County	0	7	70	138	101	107	113	126	157	263	313	357	400
San Carlos Apache Tribe	N/A: CAP Indian Priority	Gila County	0	449	2,000	3,706	2,776	2,931	3,086	3,396	4,171	6,807	8,048	9,133	10,219

Summary of Consumptive Use Impacts to Tribes and Communities			Range of Analyzed Volumes for Action Alternative 2 (AF)													
Salt River Pima-Maricopa Indian Community	N/A: CAP Indian Priority	Maricopa County	0	1,503	2,996	4,639	3,743	3,892	4,041	4,340	5,087	7,625	8,820	9,865	10,911	
Tohono O'odham Nation Sif Oidak District	N/A: CAP Indian Priority	Pinal County	0	0	0	0	0	0	0	0	0	0	0	0	0	
Tonto Apache Tribe	N/A: CAP Indian Priority	Gila County	0	0	0	0	0	0	0	0	0	0	0	0	0	
Yavapai Apache Nation	N/A: CAP Indian Priority	Gila County	0	0	0	0	0	0	0	0	0	0	0	0	0	
San Carlos Apache Tribe	N/A: CAP M&I Priority	Gila County	973	3,010	4,926	7,033	5,884	6,075	6,267	6,650	7,608	10,865	12,398	13,739	15,080	
Tohono O'odham Nation (Schuk Toak & San Xavier Districts)	N/A: CAP NIA-A Priority	Pima County	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200	28,200	
Gila River Indian Community	N/A: CAP NIA-A Priority	Maricopa and Pinal County	120,600	120,600	120,600	120,600	120,600	120,600	120,600	120,600	120,600	120,600	120,600	120,600	120,600	
White Mountain Apache Tribe	N/A: CAP NIA-B Priority	Apache, Gila, and Navajo	0	0	0	0	0	0	0	0	0	0	0	0	0	
Ak-Chin Indian Community ²	N/A: Arizona P3 in CAP	Pinal County	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Subtotal	196,269	233,339	281,195	326,941	308,333	314,203	320,073	332,550	359,732	440,740	484,794	525,190	565,543	
California																
Entitlement Holder	% Distribution of Additional Shortage	County														
Fort Mojave Indian Reservation, CA ²	0.09389%	San Bernardino County	500	579	814	923	1,001	1,048	1,095	1,205	1,392	1,784	2,097	2,410	2,723	
Chemehuevi Indian Reservation ²	0.00251%	San Bernardino County	13	15	22	25	27	28	29	32	37	48	56	64	73	
Colorado River Indian Reservation, CA ²	0.00945%	San Bernardino, Riverside	50	58	82	93	101	105	110	121	140	180	211	243	274	
Fort Yuma Indian Reservation - All Ranches ^{1,2}	0.03109%	Imperial County	166	192	270	306	331	347	363	399	461	591	694	798	902	
		Subtotal	730	845	1,187	1,346	1,460	1,528	1,597	1,757	2,031	2,602	3,058	3,515	3,971	
Nevada																
Entitlement Holder	% Distribution of Additional Shortage	County														
Fort Mojave Indian Tribe ²	0.04052%	Clark	216	250	351	398	432	452	472	520	601	770	905	1,040	1,175	

Summary of Consumptive Use Impacts to Tribes and Communities			Range of Analyzed Volumes for Action Alternative 2 (AF)												
		Subtotal	216	250	351	398	432	452	472	520	601	770	905	1,040	1,175
		Total	197,215	234,434	282,734	328,685	310,225	316,184	322,142	334,827	362,363	444,112	488,757	529,746	570,689
Arizona															
Coconino County		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gila County		4	973	3,460	6,926	10,739	8,659	9,006	9,353	10,046	11,779	17,672	20,445	22,872	25,299
La Paz County		2	20,169	23,348	32,808	37,198	40,338	42,230	44,123	48,550	56,118	71,898	84,499	97,138	109,739
Maricopa County		2	43,193	51,569	60,874	71,108	65,526	66,456	67,387	69,247	73,900	89,717	97,160	103,673	110,186
Mohave County		1	2,719	3,147	4,422	5,014	5,437	5,692	5,947	6,544	7,564	9,691	11,389	13,093	14,792
Pima County		3	28,200	28,753	33,531	38,787	35,920	36,398	36,876	37,831	40,220	48,343	52,166	55,510	58,855
Pinal County		2	100,785	122,795	142,259	163,669	151,991	153,937	155,884	159,777	169,509	202,597	218,168	231,793	245,418
Yuma County		3	231	267	375	425	461	483	504	555	642	822	966	1,111	1,255
Apache County		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Navajo County		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal Arizona Tribal		6	196,269	233,339	281,195	326,941	308,333	314,203	320,073	332,550	359,732	440,740	484,794	525,190	565,543
California															
San Bernardino County		2.5	539	624	877	994	1078	1129	1179	1297	1500	1921	2258	2596	2933
Riverside County		0.50	25	29	41	46	50	53	55	61	70	90	106	121	137
Imperial County		0	166	192	270	306	331	347	363	399	461	591	694	798	902
Subtotal California Tribal		3	730	845	1187	1346	1460	1528	1597	1757	2031	2602	3058	3515	3971
Nevada															
Clark		1	216	250	351	398	432	452	472	520	601	770	905	1040	1175
Subtotal Nevada Tribal		1	216	250	351	398	432	452	472	520	601	770	905	1040	1175

Note: Reductions and contributions were administered in 2022 and 2023 as shared between the CAP and other Arizona Fourth Priority water users, but the burden of wet water reductions was borne solely by CAP. This Action Alternative 2 as currently modeled does not incorporate the shortage sharing recommendation or other priority system-based modeling for non-CAP Fourth Priority water users, and it assumes the burden of the existing wet water reductions.

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

¹ Other use by the Fort Yuma Indian Reservation in California is accounted for under the Yuma Project Reservation Division line in the irrigation summary.

² Denotes full or substantial use in Tribal agricultural operations, which may or may not be impacted according to the terms of related agreements.

Disclaimer: These modeling results (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 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 D-24 below summarizes the shortage impacts to irrigation according to the Action Alternative 2 Shortage Allocation Model. More irrigation entitlements are impacted to some degree in comparison to Action Alternative 1, but the only irrigation uses that are fully reduced are those associated with contracts for Arizona fifth and sixth priority and unused¹⁹ water within CAP and CAP excess contracts.

Table D-24
Action Alternative 2 Shortage Allocation Model Irrigation Summary

Summary of Consumptive Use Impacts to Irrigation			Range of Analyzed Volumes (AF)													
Range of Analyzed Volumes of Total Shortage to Lower Division States:			400,000	1,066,000	1,234,000	1,734,000	2,083,000	2,083,000	2,083,000	2,083,000	2,250,000	2,500,000	3,000,000	3,333,000	3,667,000	4,000,000
Range of Analyzed Volumes of Total Additional Shortage to Lower Division States:			200,000	533,000	617,000	867,000	983,000	1,066,000	1,116,000	1,166,000	1,283,000	1,483,000	1,900,000	2,233,000	2,567,000	2,900,000
Percentage Reductions to Each Water User's 2021 Adjusted Consumptive Use:			2.67%	7.11%	8.23%	11.56%	13.11%	14.21%	14.88%	15.55%	17.11%	19.77%	25.33%	29.77%	34.23%	38.67%
Arizona																
Water User	% Distribution of Additional Shortage	County														
GM Gabrych Family (fka Jack Rayner Jr.)	0.03865333%	La Paz County	77	206	238	335	380	412	431	451	496	573	734	863	992	1,121
Arizona State Land Department (agricultural)	0.02018667%	Yuma County	40	108	125	175	198	215	225	235	259	299	384	451	518	585
North Baja Pipeline (TransCanada) ²	0.00262667%	La Paz County	5	14	16	23	26	28	29	31	34	39	50	59	67	76
Cibola Island ³	0.00998667%	La Paz County	20	53	62	87	98	106	111	116	128	148	190	223	256	290
JRJ Partners LLC (Bard Date Gardens)	0.00882667%	Yuma County	18	47	54	77	87	94	99	103	113	131	168	197	227	256
Cha Cha (Glen Curtis Citrus)	0.01169333%	Yuma County	23	62	72	101	115	125	130	136	150	173	222	261	300	339
Russell Youmans (Beattie Farms Southwest)	0.00780000%	Yuma County	16	42	48	68	77	83	87	91	100	116	148	174	200	226
BLM-L. Pratt ³	0.00000000%	Yuma County	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ott Family (frmly George Ogram)	0.00301333%	Yuma County	6	16	19	26	30	32	34	35	39	45	57	67	77	87
Ogram Boys' Enterprises	0.00790667%	Yuma County	16	42	49	69	78	84	88	92	101	117	150	177	203	229
BLM-Monte Lee (frmly Amigo Farms) ³	0.00246667%	Yuma County	5	13	15	21	24	26	28	29	32	37	47	55	63	72
Armon Curtis (fmrlly Curry Family Limited)	0.00216000%	Yuma County	4	12	13	19	21	23	24	25	28	32	41	48	55	63

¹⁹ 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 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 additional shortage in the Action Alternative 2 Shortage Allocation Model.

Summary of Consumptive Use Impacts to Irrigation			Range of Analyzed Volumes (AF)													
R. Griffin (outside PPR No. 7 boundary) ³	0.00041333%	Yuma County	1	2	3	4	4	4	5	5	5	6	8	9	11	12
Power (outside PPR No. 7 boundary) ³	0.00226667%	Yuma County	5	12	14	20	22	24	25	26	29	34	43	51	58	66
PPR No. 7 -Griffin Family Ltd.	0.00029333%	Yuma County	1	2	2	3	3	3	3	3	4	4	6	7	8	9
PPR No. 7 -Griffin Ranches	0.00130667%	Yuma County	3	7	8	11	13	14	15	15	17	19	25	29	34	38
PPR No. 7 -Milton Phillips	0.00060000%	Yuma County	1	3	4	5	6	6	7	7	8	9	11	13	15	17
Gary Pasquinelli	0.00226667%	Yuma County	5	12	14	20	22	24	25	26	29	34	43	51	58	66
Arizona State Land Department (agricultural)	0.08109333%	Yuma County	162	432	500	703	797	864	905	946	1,040	1,203	1,541	1,811	2,082	2,352
Mohave Valley IDD ²	0.24958667%	Mohave County	499	1,330	1,540	2,164	2,453	2,661	2,785	2,910	3,202	3,701	4,742	5,573	6,407	7,238
Mohave County Water Authority - Use by MVIDD (5-07-30-W0320)	0.00900000%	Mohave County	18	48	56	78	88	96	100	105	115	133	171	201	231	261
Arizona Game & Fish	0.03402667%	La Paz County	68	181	210	295	334	363	380	397	437	505	647	760	873	987
Cibola Valley IDD ²	0.07926667%	La Paz County	159	422	489	687	779	845	885	924	1,017	1,176	1,506	1,770	2,035	2,299
Red River Land Co.	0.00284000%	La Paz County	6	15	18	25	28	30	32	33	36	42	54	63	73	82
Western Water LLC	0.00085333%	La Paz County	2	5	5	7	8	9	10	10	11	13	16	19	22	25
GSC Farms, LLC	0.02777333%	La Paz County	56	148	171	241	273	296	310	324	356	412	528	620	713	805
Gila Monster Farms	0.05914667%	Yuma County	118	315	365	513	581	631	660	690	759	877	1,124	1,321	1,518	1,715
Wellton Mohawk IDD ¹	3.49492000%	Yuma County	6,990	18,628	21,564	30,301	34,355	37,256	39,003	40,751	44,840	51,830	66,403	78,042	89,715	101,353
University of Arizona	0.01298667%	Yuma County	26	69	80	113	128	138	145	151	167	193	247	290	333	377
North Gila Valley Irrigation District ¹	0.11838667%	Yuma County	237	631	730	1,026	1,164	1,262	1,321	1,380	1,519	1,756	2,249	2,644	3,039	3,433
Yuma Irrigation District ¹	0.50062667%	Yuma County	1,001	2,668	3,089	4,340	4,921	5,337	5,587	5,837	6,423	7,424	9,512	11,179	12,851	14,518
Yuma Mesa IDD ¹	1.67529333%	Yuma County	3,351	8,929	10,337	14,525	16,468	17,859	18,696	19,534	21,494	24,845	31,831	37,409	43,005	48,584
Unit B IDD	0.21761333%	Yuma County	435	1,160	1,343	1,887	2,139	2,320	2,429	2,537	2,792	3,227	4,135	4,859	5,586	6,311
Yuma County Water Users' Association ²	3.34032000%	Yuma County	6,681	17,804	20,610	28,961	32,835	35,608	37,278	38,948	42,856	49,537	63,466	74,589	85,746	96,869
5th and 6th Priority Contracts, and CAP Agricultural and Other Excess	All remaining	Maricopa, Pinal, and Pima Counties	236,537	329,379	329,026	333,913	331,082	328,836	330,092	331,348	337,645	332,791	337,718	332,846	338,074	343,080
		Subtotal	256,590	382,819	390,887	420,840	429,640	435,715	441,984	448,253	466,282	481,479	528,216	556,731	595,447	633,840
California																
Water User	% Distribution of Additional Shortage	County														
CA Pumpers Davis to Parker	0.00543%	San Bernardino County	11	29	33	47	53	58	61	63	70	80	103	121	139	157
Palo Verde Irrigation District	5.64652%	Riverside, Imperial	11,293	30,096	34,839	48,955	55,505	60,192	63,015	65,838	72,445	83,738	107,284	126,087	144,946	163,749
Yuma Project Reservation Division	0.57755%	Imperial County	1,155	3,078	3,563	5,007	5,677	6,157	6,445	6,734	7,410	8,565	10,973	12,897	14,826	16,749

Summary of Consumptive Use Impacts to Irrigation			Range of Analyzed Volumes (AF)													
Yuma Island Pumpers ³	0.02153%	Imperial County	43	115	133	187	212	230	240	251	276	319	409	481	553	624
Imperial Irrigation District	34.47317%	Imperial County	68,946	183,742	212,699	298,882	338,871	367,484	384,721	401,957	442,291	511,237	654,990	769,786	884,926	999,722
Coachella Valley Water District	4.89205%	Riverside County	9,784	26,075	30,184	42,414	48,089	52,149	54,595	57,041	62,765	72,549	92,949	109,240	125,579	141,870
		Subtotal	91,233	243,135	281,452	395,493	448,408	486,269	509,077	531,886	585,257	676,489	866,709	1,018,611	1,170,969	1,322,871
Nevada																
Water User	% Distribution of Additional Shortage	County														
None		None	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Subtotal	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Total	347,822	625,953	672,340	816,333	878,048	921,984	951,062	980,139	1,051,538	1,157,968	1,394,925	1,575,342	1,766,416	1,956,711
Summary by County																
Arizona	-	# of entitlement holders/county														
Coconino County		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
La Paz County		8	392	1,045	1,209	1,700	1,927	2,090	2,188	2,286	2,515	2,907	3,725	4,377	5,032	5,685
Mohave County		2	517	1,378	1,595	2,242	2,542	2,757	2,886	3,015	3,318	3,835	4,913	5,774	6,638	7,499
Yuma County		24	19,143	51,017	59,057	82,986	94,089	102,033	106,819	111,605	122,803	141,947	181,860	213,734	245,703	277,576
Pima County		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinal County		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maricopa County		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal Arizona Irrigation		34	20,052	53,440	61,862	86,927	98,558	106,879	111,892	116,905	128,636	148,689	190,498	223,885	257,373	290,760
California																
San Bernardino County	-	1	11	29	33	47	53	58	61	63	70	80	103	121	139	157
Riverside County		1	9,784	26,075	30,184	42,414	48,089	52,149	54,595	57,041	62,765	72,549	92,949	109,240	125,579	141,870
Imperial County		3	70,145	186,935	216,396	304,076	344,760	373,870	391,406	408,942	449,977	520,122	666,373	783,163	900,305	1,017,095
Subtotal California Irrigation		4	79,939	213,039	246,613	346,538	392,902	426,077	446,062	466,047	512,812	592,751	759,425	892,524	1,026,023	1,159,122
Nevada																
None		None	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Reductions and contributions were administered in 2022 and 2023 as shared between the CAP and other Arizona Fourth Priority water users, but the burden of wet water reductions was borne solely by CAP. This Alternative 2, as currently modeled, does not incorporate the shortage sharing recommendation or other priority system-based modeling for non-CAP Fourth Priority water users and assumes the burden of the existing wet water reductions continues to be borne by CAP.

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

¹Combined irrigation and domestic entitlement where domestic use is contractually subordinated to irrigation.

²Combined 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.

³User that does not appear in Action Alternative 1 analysis, which is based on entitlements.

Disclaimer: These modeling results (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 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 D-25 below summarizes the shortage impacts to domestic uses according to the Action Alternative 2 Shortage Allocation Model. Within the CAP, NIA priority contractors and subcontractors are potentially fully reduced according to the modeling assumptions for the CAP priority system, but the Indian and M&I Priorities receive a partial supply even at the deepest modeled shortage level and Arizona priority three water delivered through the CAP is not reduced.

Table D-25
Action Alternative 2 Shortage Allocation Model Domestic Summary

Summary of Consumptive Use Impacts to Domestic Uses			Range of Analyzed Volumes (AF)													
Range of Analyzed Volumes of Total Shortage to Lower Division States:			400,000	1,066,000	1,234,000	1,734,000	2,083,000	2,083,000	2,083,000	2,083,000	2,250,000	2,500,000	3,000,000	3,333,000	3,667,000	4,000,000
Range of Analyzed Volumes of Total Additional Shortage to Lower Division States:			200,000	533,000	617,000	867,000	983,000	1,066,000	1,116,000	1,166,000	1,283,000	1,483,000	1,900,000	2,233,000	2,567,000	2,900,000
Percentage Reductions to Each Water User's 2021 Adjusted Consumptive Use:			2.67%	7.11%	8.23%	11.56%	13.11%	14.21%	14.88%	15.55%	17.11%	19.77%	25.33%	29.77%	34.23%	38.67%
Arizona																
Water User	% Distribution of Additional Shortage	County														
Marble Canyon Company	0.00012%	Coconino County	0	1	1	1	1	1	1	1	2	2	2	3	3	3
McAlister Family Trust	0.00009%	Mohave County	0	0	1	1	1	1	1	1	1	1	2	2	2	3
Crystal Beach Water Conservation District	0.00097%	Mohave County	2	5	6	8	10	10	11	11	12	14	18	22	25	28
EPCOR CSA No. 1 (formerly Arizona-American Water Company)	0.00768%	Mohave County	15	41	47	67	75	82	86	90	99	114	146	171	197	223
Arizona State Parks (Windsor Beach)	0.00012%	Mohave County	0	1	1	1	1	1	1	1	2	2	2	3	3	3
Hillcrest Water Company	0.00024%	La Paz County	0	1	1	2	2	3	3	3	3	4	5	5	6	7
Springs Del Sol	0.00003%	La Paz County	0	0	0	0	0	0	0	0	0	0	1	1	1	1
Arizona State Land Department (domestic)	0.00068%	Yuma County	1	4	4	6	7	7	8	8	9	10	13	15	17	20
B&F Investment	0.00005%	La Paz County	0	0	0	0	1	1	1	1	1	1	1	1	1	2
BLM Permittees (LHFO & YFO)	0.00860%	La Paz County	17	46	53	75	85	92	96	100	110	128	163	192	221	249
Fisher's Landing	0.00009%	Yuma County	0	0	1	1	1	1	1	1	1	1	2	2	2	3
Shepard Water Company	0.00024%	Yuma County	0	1	1	2	2	3	3	3	3	4	5	5	6	7

Summary of Consumptive Use Impacts to Domestic Uses			Range of Analyzed Volumes (AF)													
BLM Permittees (YFO)	0.00083%	Yuma County	2	4	5	7	8	9	9	10	11	12	16	18	21	24
Arizona Public Service Company, (Yucca Power Plant)	0.00000%	Yuma County	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lake Mead National Recreation Area, AZ Temple Bar	0.00107%	Mohave County	2	6	7	9	10	11	12	12	14	16	20	24	27	31
Lake Mead National Recreation Area, AZ Lake Mohave	0.00301%	Mohave County	6	16	19	26	30	32	34	35	39	45	57	67	77	87
Bureau of Reclamation - Davis Dam	0.00001%	Mohave County	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bullhead City	0.11533%	Mohave County	231	615	712	1,000	1,134	1,229	1,287	1,345	1,480	1,710	2,191	2,575	2,961	3,345
Mohave Water Conservation District	0.01079%	Mohave County	22	57	67	94	106	115	120	126	138	160	205	241	277	313
EPCOR CSA No. 2 (frmly Brooke Water LLC)	0.00436%	La Paz County	9	23	27	38	43	46	49	51	56	65	83	97	112	126
Mohave County Water - Use by AZGFC (04-XX-30-W0431)	0.00000%	Mohave County	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Golden Shores Water Conservation District	0.00387%	Mohave County	8	21	24	34	38	41	43	45	50	57	73	86	99	112
Havasu National Wildlife Refuge	0.05161%	Mohave County	103	275	318	447	507	550	576	602	662	765	981	1,153	1,325	1,497
Lake Havasu City	0.10679%	Mohave County	214	569	659	926	1,050	1,138	1,192	1,245	1,370	1,584	2,029	2,385	2,741	3,097
Town of Parker	0.00497%	La Paz County	10	27	31	43	49	53	56	58	64	74	94	111	128	144
Ehrenberg Improvement District	0.00309%	La Paz County	6	16	19	27	30	33	35	36	40	46	59	69	79	90
Cibola National Wildlife Refuge	0.13979%	La Paz County	280	745	862	1,212	1,374	1,490	1,560	1,630	1,793	2,073	2,656	3,121	3,588	4,054
Imperial National Wildlife Refuge	0.03125%	La Paz County	63	167	193	271	307	333	349	364	401	463	594	698	802	906
US Army - Yuma Proving Grounds	0.00513%	Yuma County	10	27	32	45	50	55	57	60	66	76	98	115	132	149
City of Yuma	0.18015%	Yuma County	360	960	1,112	1,562	1,771	1,920	2,010	2,101	2,311	2,672	3,423	4,023	4,624	5,224
US Marine Corps Air Station Yuma	0.01652%	Yuma County	33	88	102	143	162	176	184	193	212	245	314	369	424	479
Union Pacific Railroad	0.00039%	Yuma County	1	2	2	3	4	4	4	5	5	6	7	9	10	11
Yuma Union High School District	0.00156%	Yuma County	3	8	10	14	15	17	17	18	20	23	30	35	40	45

Summary of Consumptive Use Impacts to Domestic Uses			Range of Analyzed Volumes (AF)													
Desert Lawn Memorial Park	0.00031%	Yuma County	1	2	2	3	3	3	3	4	4	5	6	7	8	9
Bureau of Reclamation - Yuma Area Office	0.00127%	Yuma County	3	7	8	11	12	14	14	15	16	19	24	28	33	37
Scottsdale (Yavapai Prescott Indian Tribe Allocation)	N/A: CAP Indian	Maricopa County	0	0	7	70	138	101	107	113	126	157	263	313	357	400
ASARCO	N/A: CAP M&I	Pima County	0	1,126	3,484	5,701	8,140	6,810	7,031	7,253	7,696	8,805	12,574	14,348	15,900	17,452
Avondale	N/A: CAP M&I	Maricopa County	0	290	898	1,470	2,099	1,756	1,813	1,871	1,985	2,271	3,243	3,700	4,101	4,501
Arizona State Land Department (AZSLD)	N/A: CAP M&I	Maricopa County	0	279	863	1,412	2,016	1,686	1,741	1,796	1,906	2,180	3,114	3,553	3,937	4,322
Arizona Water Company, Casa Grande	N/A: CAP M&I	Pinal County	0	476	1,474	2,412	3,444	2,881	2,975	3,068	3,256	3,725	5,320	6,070	6,727	7,383
Arizona Water Company, Coolidge	N/A: CAP M&I	Pinal County	0	107	332	543	775	649	670	691	733	839	1,198	1,366	1,514	1,662
Arizona Water Company, Superstition	N/A: CAP M&I	Pinal County	0	337	1,043	1,706	2,436	2,038	2,104	2,171	2,303	2,635	3,763	4,294	4,759	5,223
Arizona Water Company, White Tank	N/A: CAP M&I	Maricopa County	0	52	161	263	375	314	324	334	355	406	580	661	733	804
Buckeye	N/A: CAP M&I	Maricopa County	0	12	37	61	86	72	75	77	82	94	134	152	169	185
Central Arizona Groundwater Replenishment District (CAGRDR)	N/A: CAP M&I	Maricopa County	0	344	1,066	1,744	2,491	2,084	2,152	2,219	2,355	2,694	3,848	4,391	4,865	5,340
Carefree Water Company	N/A: CAP M&I	Maricopa County	0	47	147	241	343	287	297	306	325	371	531	605	671	736
Cave Creek	N/A: CAP M&I	Maricopa County	0	140	432	707	1,010	845	873	900	955	1,093	1,560	1,781	1,973	2,166
Chandler	N/A: CAP M&I	Maricopa County	0	464	1,436	2,349	3,354	2,806	2,898	2,989	3,172	3,629	5,182	5,913	6,552	7,192
Chaparral City Water Company	N/A: CAP M&I	Maricopa County	0	478	1,478	2,419	3,453	2,889	2,983	3,077	3,265	3,735	5,335	6,087	6,746	7,404
Circle City	N/A: CAP M&I	Maricopa County	0	0	0	0	0	0	0	0	0	0	0	0	0	0
El Mirage	N/A: CAP M&I	Maricopa County	0	27	84	138	197	165	170	175	186	213	304	347	385	422
Eloy	N/A: CAP M&I	Pinal County	0	116	360	589	842	704	727	750	796	910	1,300	1,483	1,644	1,804
EPCOR, Agua Fria	N/A: CAP M&I	Maricopa County	0	595	1,840	3,011	4,300	3,597	3,714	3,831	4,066	4,651	6,642	7,579	8,399	9,219
EPCOR, Paradise Valley	N/A: CAP M&I	Maricopa County	0	173	536	877	1,252	1,048	1,082	1,116	1,184	1,355	1,935	2,208	2,446	2,685
EPCOR, Sun City	N/A: CAP M&I	Maricopa County	0	225	695	1,137	1,624	1,358	1,403	1,447	1,535	1,756	2,508	2,862	3,172	3,481

Summary of Consumptive Use Impacts to Domestic Uses			Range of Analyzed Volumes (AF)													
EPCOR, Sun City West	N/A: CAP M&I	Maricopa County	0	127	393	644	919	769	794	819	869	995	1,420	1,621	1,796	1,971
Florence	N/A: CAP M&I	Pinal County	0	110	340	556	794	664	686	707	751	859	1,226	1,399	1,551	1,702
Freeport-Miami	N/A: CAP M&I	Gila County	0	156	482	789	1,126	942	973	1,004	1,065	1,218	1,740	1,986	2,200	2,415
Flowing Wells Irrigation District (FWID)	N/A: CAP M&I	Pima County	0	153	473	775	1,106	925	956	986	1,046	1,197	1,709	1,950	2,161	2,372
Gilbert	N/A: CAP M&I	Maricopa County	0	388	1,200	1,964	2,804	2,346	2,422	2,499	2,652	3,034	4,332	4,943	5,478	6,013
Glendale	N/A: CAP M&I	Maricopa County	0	924	2,859	4,679	6,681	5,589	5,771	5,953	6,317	7,227	10,321	11,776	13,050	14,324
Goodyear	N/A: CAP M&I	Maricopa County	0	576	1,782	2,916	4,164	3,483	3,597	3,710	3,937	4,504	6,432	7,339	8,133	8,927
Greater Tonopah, Water Utility	N/A: CAP M&I	Maricopa County	0	3	11	17	25	21	21	22	23	27	38	44	48	53
Green Valley Community Water Company	N/A: CAP M&I	Pima County	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Green Valley Domestic Water Improvement District	N/A: CAP M&I	Pima County	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Marana	N/A: CAP M&I	Pima County	0	125	388	634	905	757	782	807	856	979	1,399	1,596	1,769	1,941
Maricopa County Parks & Recreation	N/A: CAP M&I	Maricopa County	0	36	110	181	258	216	223	230	244	279	398	454	504	553
Mesa	N/A: CAP M&I	Maricopa County	0	2,332	7,217	11,810	16,862	14,106	14,566	15,025	15,944	18,240	26,049	29,723	32,939	36,154
Metropolitan Domestic Water Improvement District (Includes ICS Creation)	N/A: CAP M&I	Pima County	0	722	2,233	3,654	5,217	4,365	4,507	4,649	4,933	5,644	8,060	9,197	10,191	11,186
Oro Valley	N/A: CAP M&I	Pima County	0	552	1,709	2,798	3,994	3,342	3,450	3,559	3,777	4,321	6,170	7,041	7,803	8,564
Peoria	N/A: CAP M&I	Maricopa County	0	1,454	4,499	7,363	10,513	8,794	9,081	9,367	9,940	11,372	16,240	18,530	20,535	22,539
Phoenix	N/A: CAP M&I	Maricopa County	0	6,551	20,272	33,175	47,368	39,626	40,917	42,207	44,788	51,239	73,174	83,496	92,528	101,560
Pine	N/A: CAP M&I	Gila County	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Queen Creek	N/A: CAP M&I	Maricopa County	0	27	82	134	192	161	166	171	181	208	296	338	375	411
Rio Verde Utilities	N/A: CAP M&I	Maricopa County	0	44	135	220	315	263	272	280	298	340	486	555	615	675
San Tan Irrigation District	N/A: CAP M&I	Maricopa County	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scottsdale	N/A: CAP M&I	Maricopa County	0	2,831	8,761	14,336	20,470	17,124	17,682	18,240	19,355	22,143	31,622	36,082	39,985	43,889
Spanish Trail Water Company	N/A: CAP M&I	Pima County	0	163	504	824	1,177	985	1,017	1,049	1,113	1,273	1,819	2,075	2,299	2,524
Surprise	N/A: CAP M&I	Maricopa County	0	549	1,700	2,782	3,973	3,323	3,432	3,540	3,756	4,297	6,137	7,003	7,760	8,518

Summary of Consumptive Use Impacts to Domestic Uses			Range of Analyzed Volumes (AF)													
Tempe	N/A: CAP M&I	Maricopa County	0	231	716	1,171	1,673	1,399	1,445	1,490	1,581	1,809	2,584	2,948	3,267	3,586
Tonopah	N/A: CAP M&I	Maricopa County	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tonto Hills Domestic Water Improvement District	N/A: CAP M&I	Maricopa County	0	4	12	19	28	23	24	25	26	30	43	49	54	59
Tucson	N/A: CAP M&I	Pima County	0	7,729	23,920	39,144	55,891	46,756	48,278	49,801	52,846	60,458	86,339	98,518	109,175	119,832
Vail Water Company	N/A: CAP M&I	Pima County	0	100	308	504	720	602	622	641	681	779	1,112	1,269	1,406	1,543
Water Utilities Community Facilities District, Apache Junction	N/A: CAP M&I	Pinal County	0	156	484	792	1,131	947	977	1,008	1,070	1,224	1,748	1,994	2,210	2,426
Phoenix	N/A: CAP NIA-A	Maricopa County	0	37,280	37,280	37,280	37,280	37,280	37,280	37,280	37,280	37,280	37,280	37,280	37,280	37,280
Chandler	N/A: CAP NIA-A	Maricopa County	0	3,924	3,924	3,924	3,924	3,924	3,924	3,924	3,924	3,924	3,924	3,924	3,924	3,924
Gilbert	N/A: CAP NIA-A	Maricopa County	0	1,537	1,537	1,537	1,537	1,537	1,537	1,537	1,537	1,537	1,537	1,537	1,537	1,537
Glendale	N/A: CAP NIA-A	Maricopa County	0	682	682	682	682	682	682	682	682	682	682	682	682	682
Mesa	N/A: CAP NIA-A	Maricopa County	0	5,551	5,551	5,551	5,551	5,551	5,551	5,551	5,551	5,551	5,551	5,551	5,551	5,551
Scottsdale	N/A: CAP NIA-A	Maricopa County	0	3,306	3,306	3,306	3,306	3,306	3,306	3,306	3,306	3,306	3,306	3,306	3,306	3,306
Tempe	N/A: CAP NIA-A	Maricopa County	0	23	23	23	23	23	23	23	23	23	23	23	23	23
Buckeye	N/A: CAP NIA-B	Maricopa County	0	2,786	2,786	2,786	2,786	2,786	2,786	2,786	2,786	2,786	2,786	2,786	2,786	2,786
Central Arizona Groundwater Replenishment District (CAGRDR)	N/A: CAP NIA-B	Maricopa County	0	18,185	18,185	18,185	18,185	18,185	18,185	18,185	18,185	18,185	18,185	18,185	18,185	18,185
Carefree Water Company	N/A: CAP NIA-B	Maricopa County	0	112	112	112	112	112	112	112	112	112	112	112	112	112
Cave Creek	N/A: CAP NIA-B	Maricopa County	0	386	386	386	386	386	386	386	386	386	386	386	386	386
El Mirage	N/A: CAP NIA-B	Maricopa County	0	1,318	1,318	1,318	1,318	1,318	1,318	1,318	1,318	1,318	1,318	1,318	1,318	1,318
EPCOR, San Tan (ST)	N/A: CAP NIA-B	Pinal County	0	3,217	3,217	3,217	3,217	3,217	3,217	3,217	3,217	3,217	3,217	3,217	3,217	3,217
Freeport	N/A: CAP NIA-B	Pima County	0	5,678	5,678	5,678	5,678	5,678	5,678	5,678	5,678	5,678	5,678	5,678	5,678	5,678
Gilbert	N/A: CAP NIA-B	Maricopa County	0	1,832	1,832	1,832	1,832	1,832	1,832	1,832	1,832	1,832	1,832	1,832	1,832	1,832
Marana	N/A: CAP NIA-B	Pima County	0	515	515	515	515	515	515	515	515	515	515	515	515	515
Queen Creek	N/A: CAP NIA-B	Maricopa County	0	4,162	4,162	4,162	4,162	4,162	4,162	4,162	4,162	4,162	4,162	4,162	4,162	4,162
Resolution Copper	N/A: CAP NIA-B	Maricopa County	0	2,238	2,238	2,238	2,238	2,238	2,238	2,238	2,238	2,238	2,238	2,238	2,238	2,238

Summary of Consumptive Use Impacts to Domestic Uses			Range of Analyzed Volumes (AF)													
Rosemont Copper	N/A: CAP NIA-B	Pima County	0	1,124	1,124	1,124	1,124	1,124	1,124	1,124	1,124	1,124	1,124	1,124	1,124	1,124
SRP	N/A: CAP NIA-B	Maricopa County	0	2,160	2,160	2,160	2,160	2,160	2,160	2,160	2,160	2,160	2,160	2,160	2,160	2,160
Water Utilities Community Facilities District, Apache Junction	N/A: CAP NIA-B	Pinal County	0	817	817	817	817	817	817	817	817	817	817	817	817	817
Chandler (Salt River Pima-Maricopa Exchange)	N/A: Arizona P3 in CAP	Maricopa County	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gilbert (Salt River Pima-Maricopa Exchange)	N/A: Arizona P3 in CAP	Maricopa County	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glendale (Salt River Pima-Maricopa Exchange)	N/A: Arizona P3 in CAP	Maricopa County	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mesa (Salt River Pima-Maricopa Exchange)	N/A: Arizona P3 in CAP	Maricopa County	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix (Salt River Pima-Maricopa Exchange)	N/A: Arizona P3 in CAP	Maricopa County	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scottsdale (Salt River Pima-Maricopa Exchange)	N/A: Arizona P3 in CAP	Maricopa County	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tempe (Salt River Pima-Maricopa Exchange)	N/A: Arizona P3 in CAP	Maricopa County	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Subtotal	1,402	131,899	198,120	261,644	330,406	293,925	300,453	306,980	320,155	352,442	460,377	512,128	557,710	603,284
California																
Water User	% Distribution of Additional Shortage	County														
The Metropolitan Water District of Southern California	12.89337%	Los Angeles, Orange, San Diego, Riverside, and San Bernardino	25,787	68,722	79,552	111,786	126,742	137,443	143,890	150,337	165,422	191,209	244,974	287,909	330,973	373,908
Interim Guidelines Reductions and DCP Contributions	N/A	Los Angeles, Orange, San Diego, Riverside, and San Bernardino	0	0	0	200,000	350,000	350,000	300,000	250,000	300,000	350,000	350,000	350,000	350,000	350,000
City of Needles (includes LCWSP use)	0.01753%	San Bernardino County	35	93	108	152	172	187	196	204	225	260	333	392	450	508
City of Winterhaven	0.00065%	Imperial County	1	3	4	6	6	7	7	8	8	10	12	15	17	19

Summary of Consumptive Use Impacts to Domestic Uses			Range of Analyzed Volumes (AF)													
CA Pumpers Parker to Imperial Above Imperial Dam	0.00191%	San Bernardino, Riverside, and Imperial	4	10	12	17	19	20	21	22	24	28	36	43	49	55
		Subtotal	25,827	68,829	79,676	311,960	476,939	487,658	444,114	400,571	465,680	541,507	595,356	638,358	681,489	724,491
Nevada																
Water User	% Distribution of Additional Shortage	County														
Robert B. Griffith Water Project (SNWS)	3.68200%	Clark	7,364	19,625	22,718	31,923	36,194	39,250	41,091	42,932	47,240	54,604	69,958	82,219	94,517	106,778
Interim Guidelines Reductions and DCP Contributions	N/A	Clark	8,000	21,000	25,000	27,000	30,000	27,000	27,000	27,000	27,000	27,000	30,000	30,000	30,000	30,000
Lake Mead NRA, NV - Diversions from Lake Mead	0.00451%	Clark	9	24	28	39	44	48	50	53	58	67	86	101	116	131
Lake Mead NRA, NV - Diversions from Lake Mohave	0.00256%	Clark	5	14	16	22	25	27	29	30	33	38	49	57	66	74
Basic Management Inc.	0.06099%	Clark	122	325	376	529	599	650	681	711	782	904	1,159	1,362	1,566	1,769
City of Henderson (BMI Delivery)	0.17677%	Clark	354	942	1,091	1,533	1,738	1,884	1,973	2,061	2,268	2,622	3,359	3,947	4,538	5,126
Nevada Department of Wildlife	0.00016%	Clark	0	1	1	1	2	2	2	2	2	2	3	4	4	5
Pacific Coast Building Products Inc.	0.01236%	Clark	25	66	76	107	121	132	138	144	159	183	235	276	317	358
Boulder Canyon Project	0.00031%	Clark	1	2	2	3	3	3	3	4	4	5	6	7	8	9
Big Bend Water District	0.01983%	Clark	40	106	122	172	195	211	221	231	254	294	377	443	509	575
		Subtotal	15,919	42,104	49,430	61,329	68,922	69,208	71,188	73,168	77,800	85,719	105,230	118,415	131,640	144,825
		Total	43,148	242,832	327,226	634,933	876,267	850,791	815,755	780,719	863,635	979,668	1,160,963	1,268,901	1,370,838	1,472,600
Summary by County		# of Entitlement Holders/County														
Arizona																
Coconino County	1	0	1	1	1	1	1	1	1	1	2	2	2	3	3	3
Gila County	0	0	156	482	789	1,126	942	973	1,004	1,065	1,218	1,740	1,986	2,200	2,415	
La Paz County	9	385	1,025	1,187	1,668	1,891	2,051	2,147	2,243	2,468	2,853	3,655	4,296	4,939	5,579	
Maricopa County	0	0	104,683	144,911	182,794	224,465	201,735	205,524	209,312	216,888	235,830	300,231	330,537	357,055	383,573	
Mohave County	13	603	1,606	1,859	2,613	2,962	3,212	3,363	3,514	3,866	4,469	5,726	6,729	7,736	8,739	

Summary of Consumptive Use Impacts to Domestic Uses		Range of Analyzed Volumes (AF)													
Pima County	0	0	17,986	40,336	61,351	84,468	71,859	73,960	76,062	80,265	90,772	126,499	143,311	158,022	172,732
Pinal County	0	0	5,337	8,066	10,633	13,456	11,916	12,173	12,429	12,942	14,226	18,589	20,642	22,438	24,235
Yuma County	12	414	1,104	1,278	1,796	2,036	2,208	2,312	2,415	2,658	3,072	3,936	4,626	5,318	6,008
Subtotal Arizona Domestic	35	1,402	131,899	198,120	261,644	330,406	293,925	300,453	306,980	320,155	352,442	460,377	512,128	557,710	603,284
California															
MWD Service Area (Los Angeles, Orange, San Diego, Riverside, and San Bernardino)	1	25,787	68,722	79,552	311,786	476,742	487,443	443,890	400,337	465,422	541,209	594,974	637,909	680,973	723,908
San Bernardino County	1	35	93	108	152	172	187	196	204	225	260	333	392	450	508
Riverside County	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Imperial County	1	1	3	4	6	6	7	7	8	8	10	12	15	17	19
Subtotal California Domestic	4	25,823	68,819	79,664	311,943	476,921	487,637	444,093	400,549	465,655	541,478	595,320	638,315	681,440	724,435
Nevada															
Clark	10	15,919	42,104	49,430	61,329	68,922	69,208	71,188	73,168	77,800	85,719	105,230	118,415	131,640	144,825
Subtotal Nevada Domestic	10	15,919	42,104	49,430	61,329	68,922	69,208	71,188	73,168	77,800	85,719	105,230	118,415	131,640	144,825

Note: Reductions and contributions were administered in 2022 and 2023 as shared between the CAP and other Arizona Fourth Priority water users, but the burden of wet water reductions was borne solely by CAP. This Action Alternative 2 as currently modeled does not incorporate the shortage sharing recommendation or other priority system-based modeling for non-CAP Fourth Priority water users, and it assumes the burden of the existing wet water reductions continues to be borne by CAP.

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

Disclaimer: These modeling results (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 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.

D.4.3 Relationship between CRMMS and Action Alternative 2 Shortage Allocation Model

(See **Section D.3.4** for a discussion on the relationship between CRMMS and the Action Alternative 1 Shortage Allocation Model.) That discussion is largely applicable to differences between CRMMS and the Action Alternative 2 Shortage Allocation Model, except where noted below.

CRMMS modeling and the Action Alternative 2 Shortage Allocation Model are based on the same set of water users – those identified in the Water Accounting Report.

The same percentages calculated for distribution of additional shortage to each water user in the Action Alternative 2 Shortage Allocation Model were used in CRMMS modeling.

CRMMS lumps certain water users into groups by geography, and only some of those groups (including the CAP) were further itemized for the Action Alternative 2 Shortage Allocation Model.

There is no distinction between Stage 1 and Stage 2 shortages for Action Alternative 2 in CRMMS or the Shortage Allocation Model.

D.5 No Action Alternative Shortage Allocation Model

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 the 2019 DCP. The Shortage Allocation Model for the No Action Alternative 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.

The discrete volumes of total shortage to the Lower Division States considered in the No Action Alternative 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 | • 917,000 |
| • 533,000 | • 967,000 |
| • 617,000 | • 1,017,000 |
| • 867,000 | • 1,100,000 |

D.5.1 Distribution Among States

The Shortage Allocation Model for the No Action Alternative distributes shortages among states based on state reductions specified in the 2007 Interim Guidelines. As in the 2007 Shortage Allocation Model and the Action Alternative 1 Shortage Allocation Model, shortages to the Lower Division States are characterized by two stages, Stage 1 and Stage 2. In Stage 1, shortages are imposed only upon Arizona (96 percent) and Nevada (4 percent) and continue until the deliveries to

the post–1968 water entitlement holders in Arizona (including the CAP) are reduced to zero. (See **Section D.3.1.1** for additional details on the Stage 1 calculations, but note that the output from the No Action Shortage Allocation Model calculations for Arizona and Nevada are rounded to the nearest thousand acre-feet so that the volumes align with the 2007 ROD.) The maximum shortage volume simulated in the No Action Shortage Allocation Model does not exceed Stage 1 shortage amounts (deliveries to the post-1968 water entitlement holders in Arizona were not reduced to zero).

The Shortage Allocation Model for the No Action Alternative also simulated water savings contributions that were distributed among states as agreed to in the 2019 DCP. For the purpose of comparing 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.

At some Lake Mead elevation tiers, the 2019 DCP contributions for California exceed the 2024 shortage volume assigned to California in the Action Alternative 1 Shortage Allocation Model, which represents an interpretation of the priority system. In these instances, the No Action Alternative Shortage Allocation Model will show greater volumes of shortage to California than the Action Alternative 1 Shortage Allocation Model. **Table D-26** below displays the No Action Alternative Shortage Allocation Model’s state distribution, which comprises shortages in accordance with the 2007 Interim Guidelines and contributions in accordance with the 2019 DCP.

Table D-26
State Distribution from the No Action Alternative Shortage Allocation Model

"Stage 1" Shortage Distribution	Arizona	California	Nevada	Total
Ratio of Apportionment to Total	=2,800,000/9,000,000 or 37.33%	=4,400,000/7,500,000 or 58.67%	=300,000/7,500,000 or 4%	
Percentage Assignment of Shortage	96.00%	0.00%	4.00%	

Distribution of Available Water Until Arizona Fourth Priority is Eliminated (Threshold Approximated)

Lower Division States Supply (AF)	Lower Division States Shortage Volume (including DCP) (AF)	AZ Shortage Volume (AF)	Water Available to AZ (AF)	CA Shortage Volume (AF)	Water Available to CA (AF)	NV Shortage Volume (AF)	Water Available to NV (AF)	Lower Division States Shortage Volume (AF)
7,300,000	(200,000)	(192,000)	2,608,000	-	4,400,000	(8,000)	292,000	(200,000)
6,967,000	(533,000)	(512,000)	2,288,000	-	4,400,000	(21,000)	279,000	(533,000)
6,883,000	(617,000)	(592,000)	2,208,000	-	4,400,000	(25,000)	275,000	(617,000)
6,633,000	(867,000)	(640,000)	2,160,000	(200,000)	4,200,000	(27,000)	273,000	(867,000)
6,583,000	(917,000)	(640,000)	2,160,000	(250,000)	4,150,000	(27,000)	273,000	(917,000)
6,533,000	(967,000)	(640,000)	2,160,000	(300,000)	4,100,000	(27,000)	273,000	(967,000)
6,483,000	(1,017,000)	(640,000)	2,160,000	(350,000)	4,050,000	(27,000)	273,000	(1,017,000)
6,400,000	(1,100,000)	(720,000)	2,080,000	(350,000)	4,050,000	(30,000)	270,000	(1,100,000)

Note: No "Stage 2" needed in No Action Alternative Analysis, since Arizona Fourth Priority is not eliminated at these shortage levels.

The results of these assumptions are summarized in **Table D-27** below, showing a distribution of shortage among the Lower Division States (which consists of both 2007 Interim Guidelines reductions and 2019 DCP water savings contributions) and corresponding volumes of water available to each Lower Division State.

Table D-27
Summary of Shortage Volumes by Lower Division State Under the No Action Alternative 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

D.5.2 Distribution Within States

The No Action Alternative Shortage Allocation Model distributes shortages within states using the same assumptions about intra-state priority systems that are described in detail for the Action Alternative 1 Shortage Allocation Model, with the difference being the magnitude of shortages that are distributed. (See **Section D.3.2** for a description of the assumptions for distributing shortage within states in the Action Alternative 1 Shortage Allocation Model, which also apply to the No Action Alternative Shortage Allocation Model.²⁰)

D.5.3 Shortage Allocation Model Results

The tables in this section summarize the results of the No Action Alternative 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 D-28 below summarizes the shortage attributed to each priority within the Lower Division States in the No Action Alternative Shortage Allocation Model. Contracts for Arizona fifth and sixth priority and unused water within CAP, and CAP excess contracts, are immediately impacted and potentially fully reduced. The only other priority group potentially fully reduced under the No Action Alternative Shortage Allocation Model is CAP NIA Priority, although other priorities are impacted to some degree. These results do not reflect the increased risk of Lake Mead's elevation falling to dead pool under the No Action Alternative in comparison to either of the action alternatives.

²⁰ As the Action Alternative 1 Shortage Allocation Model distributed total volumes of shortage according to priority without distinguishing between shortages and DCP contributions, this attributes California DCP contributions to MWD, notwithstanding Coachella Valley Water District's 7 percent contribution pursuant to May 20, 2019 DCP Implementation Agreement Between Metropolitan Water District of Southern California and Coachella Valley Water District.

Table D-28
No Action Alternative 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	200,000	250,000	300,000	350,000	350,000
	3rd Priority (IID, CVWD, PVID, QSA Diversions by MWD)	0	0	0	0	0	0	0	0
	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.

¹Agricultural and other CAP excess contracts do not confer a Colorado River water entitlement, and it 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, 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 D-29 below summarizes the shortage impacts to Tribes according to the No Action Alternative Shortage Allocation Model. Tribal entitlements within the Arizona fourth priority are potentially impacted, and CAP NIA Priority entitlements are potentially fully reduced.

Table D-29
No Action Alternative Shortage Allocation Model Tribal Summary

Summary of Consumptive Use Impacts to 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 to 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										
	Arizona	# 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 to 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 impacted 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.

¹Denotes full or substantial use in Tribal agricultural operations, which may or may not be impacted according to the terms of related agreements.

²This user also holds a PPR entitlement, which is not impacted at these levels of shortages.

Table D-30 below summarizes the shortage impacts to irrigation according to the No Action Alternative Shortage Allocation Model. Contracts for Arizona fifth and sixth priority and unused²¹ water within CAP, and CAP excess contracts, are immediately impacted and potentially fully reduced, but other irrigation entitlements are only potentially impacted at the deepest levels of shortage.

Table D-30
No Action Alternative Shortage Allocation Model Irrigation Summary

Summary of Consumptive Use Impacts to 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	793
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

²¹ 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 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 No Action Shortage Allocation Model.

Summary of Consumptive Use Impacts to 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	344,722
	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	0	0	0	0	0
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	0	0	0	0	0

Summary of Consumptive Use Impacts to 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	338,687	338,687	338,687	338,687	344,722
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	4,813
	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	344,722
	California									
	Riverside County	2.5	0	0	0	0	0	0	0	0
	Imperial County	2.5	0	0	0	0	0	0	0	0
	Subtotal California Irrigation	5	0	0	0	0	0	0	0	0
	Nevada									
	None	None	0	0	0	0	0	0	0	0

¹Combined irrigation and domestic entitlement where domestic use is contractually subordinated to irrigation.

²Combined 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.

³This user also holds a PPR entitlement, which is not impacted at these levels of shortages and it was not included here.

Note: PPR entitlements are not impacted 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 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, 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 D-31 below summarizes the shortage impacts to domestic use according to the No Action Alternative Shortage Allocation Model. Within the Arizona P4(i), certain domestic users may be impacted at the deepest level of modeled shortage. CAP M&I Priority uses are potentially impacted, and CAP NIA Priority uses are potentially fully reduced. Domestic impacts within California and Nevada are limited to MWD and SNWA, respectively.

Table D-31
No Action Alternative Shortage Allocation Model Domestic Summary

Summary of Consumptive Use Impacts to Domestic Uses			Range of Analyzed Volumes of Total Shortage to Lower Division States for the No Action Alternative (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, LLC.	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

Summary of Consumptive Use Impacts to Domestic Uses			Range of Analyzed Volumes of Total Shortage to Lower Division States for the No Action Alternative (AF)							
4(i)	Hillcrest Water Company	La Paz County	0	0	0	0	0	0	0	0
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)	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

Summary of Consumptive Use Impacts to Domestic Uses			Range of Analyzed Volumes of Total Shortage to Lower Division States for the No Action Alternative (AF)							
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
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

Summary of Consumptive Use Impacts to Domestic Uses			Range of Analyzed Volumes of Total Shortage to Lower Division States for the No Action Alternative (AF)							
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
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

Summary of Consumptive Use Impacts to Domestic Uses			Range of Analyzed Volumes of Total Shortage to Lower Division States for the No Action Alternative (AF)							
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
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

Summary of Consumptive Use Impacts to Domestic Uses			Range of Analyzed Volumes of Total Shortage to Lower Division States for the No Action Alternative (AF)							
2	Imperial National Wildlife Refuge	La Paz County	0	0	0	0	0	0	0	0
2	Havasupai 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	178,590
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	200,000	250,000	300,000	350,000	350,000
3	MWD Diversions from QSA (3a from IID and CVWD)		0	0	0	0	0	0	0	0
		Subtotal	0	0	0	200,000	250,000	300,000	350,000	350,000
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

Summary of Consumptive Use Impacts to Domestic Uses			Range of Analyzed Volumes of Total Shortage to Lower Division States for the No Action Alternative (AF)							
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 Area ⁴ , 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	355,162	405,162	455,162	505,162	558,590
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	55	0	78,174	85,482	104,683	104,683	104,683	104,683	133,558
	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	124	0	89,525	96,833	128,162	128,162	128,162	128,162	178,590
	California									
	Los Angeles, Orange, San Diego, Riverside, San Bernardino	6	0	0	0	200,000	250,000	300,000	350,000	350,000
	Subtotal California Domestic	6	0	0	0	200,000	250,000	300,000	350,000	350,000
	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

¹This user also holds a PPR entitlement, which is not impacted at these levels of shortages and it was not included here.

Note: PPRs are not impacted 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 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, 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.

D.5.4 Relationship between CRMMS and No Action Alternative Shortage Allocation Model

(See **Section D.3.4** for a discussion on the relationship between CRMMS and the Action Alternative 1 Shortage Allocation Model.) That discussion is largely applicable to differences between CRMMS and the No Action Alternative Shortage Allocation Model, except that the distinction between Stage 1 and Stage 2 is mooted by the limited volumes of shortage under consideration in the No Action Alternative and the fact that participation by California in shortages analyzed under the No Action Alternative is volumetrically defined only by the 2019 DCP. Accordingly, the results of CRMMS and the No Action Alternative Shortage Allocation Model are expected to be more consistent.

While CRMMS is able to model system shortages as a Lower Basin volume, the shortage allocations models do not attempt to represent the effect of potential system shortages and how these shortages might be distributed should such conditions occur. This is of particular importance in the No Action Alternative where system shortages may be more likely under low flow hydrologic scenarios.

Attachment D-1

Reclamation's September 14, 2022 letter notifying interested parties of a Tier 2 Shortage Condition and required DCP contributions in calendar 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 Contingency 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:

¹The 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.

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 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 D-2

Reclamation's September 28, 2022 letter to the
Central Arizona Water Conservation District
announcing the calendar 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 -0700

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

Attachment D-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.

Appendix E

Table of Sensitive Species

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Appendix E. 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	
Fish							
Bluehead sucker	<i>Catostomus discobolus</i>	BLM AZ BLM UT		X	X	X	Yes
Bonytail	<i>Gila elegans</i>	Endangered BLM NV	X (rare, stocked)			X (stocked)	Yes
Colorado pikeminnow	<i>Ptychocheilus lucius</i>	Endangered	X				Yes
Desert pupfish	<i>Cyprinodon macularis</i>	Endangered					No
Desert sucker	<i>Catostomus clarkii</i>	BLM AZ				X	Found only in tributaries—not in the project area
Flannelmouth sucker	<i>Catostomus latipinnis</i>	BLM AZ BLM UT	X	X	X	X	Yes
Gila longfin dace	<i>Agosia chrysogaster chrysogaster</i>	BLM AZ				X	No; found in tributaries, not in the project area
Humpback chub	<i>Gila cypha</i>	Threatened		X	X		Yes; present in inflow to Lake Mead
Pahrump poolfish	<i>Empetrichthys latos</i>	BLM NV					Not present in the project area
Razorback sucker	<i>Xyrauchen texanus</i>	Endangered BLM NV	X	X	X	X	Yes
Roundtail chub	<i>Gila robusta</i>	BLM AZ BLM UT	X	X	X	X	Not in the project area; does not occur downstream of Mesquite, Nevada
Sonora sucker	<i>Catostomus insignis</i>					X	No; found in tributaries, not in the project area

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	
Speckled dace	<i>Rhinichthys osculus</i>	BLM AZ	X	X	X	X	No; found in tributaries
Virgin spinedace	<i>Lepidomeda mollispinis</i>	BLM Sensitive			X		Not in the project area; this species does not occur downstream of Mesquite, Nevada
Woundfin	<i>Plagopterus argentissimus</i>				X		Not present in the project area; does not occur downstream of Mesquite, Nevada
Birds							
American peregrine falcon	<i>Falco peregrinus</i>	BLM AZ BLM NV		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	<i>Pelicanus erythrorhynchos</i>	BLM UT	X			X	Yes
Arizona Bell's vireo	<i>Vireo bellii arizonae</i>	BLM CA				X	Yes
Arizona grasshopper sparrow	<i>Ammodramus savannarum ammoregus</i>	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.
Bald eagle	<i>Haliaeetus leucocephalus</i>	BLM AZ BLM NV BLM UT	X	X	X	X	Yes
Bank swallow	<i>Riparia riparia</i>	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.

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	
Bendire's thrasher	<i>Toxostoma bendirei</i>	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	<i>Cypseloides niger</i>	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	<i>Athene cunicularia</i>	BLM UT BLM NV	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	<i>Glaucidium brasilianum cactorum</i>	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	<i>Laterallus jamaicensis coturniculus</i>	BLM AZ BLM CA				X	Yes
California brown pelican	<i>Pelecanus occidentalis californicus</i>	BLM CA				X	No. This species is rarely detected.
California condor	<i>Gymnogyps californianus</i>	BLM AZ	X	X			Yes
Crissal thrasher	<i>Toxostoma crissale</i>	BLM CA				X	Yes
Elf owl	<i>Micrathene whitneyi</i>	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	
Ferruginous hawk	<i>Buteo regalis</i>	BLM UT	X				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	<i>Melanerpes uropygialis</i>	BLM CA				X	Yes
Gilded flicker	<i>Colaptes chrysoides</i>	BLM AZ BLM CA				X	Yes
Golden eagle	<i>Aquila chrysaetos</i>	BLM UT BLM AZ	X	X	X	X	Yes
Least bittern	<i>Ixobrychus exilis</i>	BLM NV			X	X	No. This species is not found in habitat that would be impacted by any alternatives.
LeConte's thrasher	<i>Toxostoma lecontei</i>	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	<i>Vermivora luciae</i>	BLM CA				X	Yes
Mountain plover	<i>Charadrius montanus</i>	BLM CA				X	Yes
Northern goshawk	<i>Accipiter gentilis</i>	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	<i>Phainopepla nitens</i>	BLM NV			X	X	No. This species utilizes habitat that would 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	
Southwestern willow flycatcher	<i>Empidonax traillii extimus</i>	Endangered BLM AZ BLM CA BLM NV	X		X	X	Yes
Swainson's hawk	<i>Buteo swainsoni</i>	BLM CA				X	No. This species forages over diverse habitat types, which will not be impacted by any alternative.
Tricolored blackbird	<i>Agelaius tricolor</i>	BLM CA				X	Yes
Western snowy plover	<i>Charadrius nivosus nivosus</i>	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	<i>Coccyzus americanus</i>	Threatened BLM AZ BLM CA BLM NV	X	X	X	X	Yes
White-tailed kite	<i>Elanus leucurus</i>	BLM CA				X	Yes
Yuma Ridgeway's rail	<i>Rallus obsoletus yumaniensis</i>	Endangered BLM AZ BLM CA BLM NV		X	X	X	Yes
Mammals							
Allen's big-eared bat	<i>Idionycteris phyllotis</i>	BLM AZ BLM NV BLM UT	X		X		Yes
Allen's lappet-browed bat	<i>Idionycteris phyllotis</i>	BLM AZ		X			Yes
Arizona myotis	<i>Myotis occultus</i>	BLM AZ		X	X	X	Yes
Big brown bat	<i>Eptesicus fuscus</i>	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	
Big free-tailed bat	<i>Nyctinomops macrotis</i>	BLM NV			X	X	Yes
California leaf-nosed bat	<i>Macrotus californicus</i>	BLM AZ BLM NV			X	X	Yes
California myotis	<i>Myotis californicus</i>	BLM NV	X	X	X	X	Yes
Canyon bat	<i>Parastrellus hesperus</i>	BLM NV	X	X	X	X	Yes
Cave myotis	<i>Myotis velifer</i>	BLM AZ BLM NV	X	X	X	X	Yes
Desert bighorn sheep	<i>Ovis canadensis nelsoni</i>	BLM CA	X	X	X	X	Yes
Fringed myotis	<i>Myotis thysanodes</i>	BLM UT BLM NV	X		X		Yes
Hoary bat	<i>Lasiurus cinereus</i>	BLM NV			X	X	Yes
Houserock Valley chisel-toothed kangaroo rat	<i>Dipodomys microps leucotis</i>	BLM AZ		X			No. This species utilizes dry and desert habitat types for foraging; these will not be impacted by any alternative.
Kit fox	<i>Vulpes macrotis</i>	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	<i>Myotis evotis</i>	BLM CA				X	Yes
Mexican free-tailed bat	<i>Tadarida brasiliensis</i>	BLM NV	X	X	X	X	Yes
Mexican long-tongued bat	<i>Choeronycteris mexicana</i>	BLM AZ		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	
Pale Townsend's big-eared bat	<i>Corynorhinus townsendii pallescens</i>	BLM AZ	X	X	X	X	Yes
Pallid bat	<i>Antrozous pallidus</i>	BLM NV	X	X	X	X	Yes
Palm Springs pocket mouse	<i>Perognathus longimembris bangsi</i>	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	<i>Xerospermophilus tereticaudus chlorus</i>	BLM CA				X	No. Not in the project area.
Silver-haired bat	<i>Lasionycteris noctivagans</i>	BLM NV	X	X	X	X	Yes
Spotted bat	<i>Euderma maculatum</i>	BLM AZ BLM NV BLM UT		X		X	Yes
Townsend's big-eared bat	<i>Corynorhinus townsendii</i>	BLM AZ BLM CA BLM NV BLM UT	X		X	X	Yes
Western mastiff bat	<i>Eumops perotis</i>	BLM NV		X	X	X	Yes
Western red bat	<i>Lasiurus blossevillii</i>	BLM NV BLM UT			X	X	Yes
Western small-footed myotis	<i>Myotis ciliolabrum</i>	BLM CA BLM NV			X	X	Yes
Yuma myotis	<i>Myotis yumanensis</i>	BLM CA 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	
Reptiles and Amphibians							
Arizona striped whiptail	<i>Aspidoscelis arizonae</i>	BLM AZ		X	X	X	No. This species utilizes upland habitat, which will not be impacted by any alternative.
Arizona toad	<i>Anaxyrus microscaphus</i>	BLM UT BLM NV	X			X	Yes
Banded Gila monster	<i>Heloderma suspectum cinctum</i>	BLM NV			X	X	No. This species utilizes upland habitat, which will not be impacted by any alternative.
Coast horned lizard	<i>Phrynosoma blainvillii</i>	BLM CA				X	No. This species utilizes upland habitat, which will not be impacted by any alternative.
Coronado skink	<i>Plestiodon skiltonianus interparietalis</i>	BLM CA				X	No. This specie’s range is outside of areas impacted by any alternatives.
Couch’s spadefoot	<i>Scaphiopus couchii</i>	BLM CA				X	Yes
Desert box turtle	<i>Terrapene ornata luteola</i>	BLM AZ		X	X	X	No. This species does not occur in habitat that would be impacted by any alternative.
Desert tortoise	<i>Gopherus agassizii</i>	BLM NV		X	X	X	No. This species utilizes upland habitat, which will not be impacted by any alternative.
Flat-tailed horned lizard	<i>Phrynosoma mcallii</i>	BLM AZ				X	No. This species utilizes upland habitat, which will not be impacted by any alternative.
Foothill yellow-legged frog (south coast DPS)	<i>Rana boylei</i>	BLM CA				X	No. This specie’s 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	
Lowland burrowing treefrog	<i>Smilisca fodiens</i>	BLM AZ		X	X	X	No. This specie's range is outside of areas impacted by any alternatives.
Lowland leopard frog	<i>Rana yavapaiensis</i>	BLM AZ BLM CA			X	X	Yes
Mohave fringe-toed lizard	<i>Uma scoparia</i>	BLM AZ		X	X	X	No. This species utilizes upland habitat, which will not be impacted by any alternative.
Northern leopard frog	<i>Lithobates [=Rana] pipens</i>	BLM AZ	X	X			No. This species utilizes upland habitat, which will not be impacted by any alternative.
Northern Mexican gartersnake	<i>Thamnophis eques megalops</i>	Threatened				X	Yes
Relict leopard frog	<i>Rana onca</i>	BLM AZ BLM NV			X	X	Yes
Sinaloan narrow-mouthed toad	<i>Gastrophryne mazatlanensis</i>	BLM AZ		X	X	X	No. This species does not occur in habitat that would be impacted by any alternative.
Sonoran green toad	<i>Bufo retiformis</i>	BLM AZ		X	X	X	No. This species does not occur in habitat that would be impacted by any alternative.
Two-striped Gartersnake	<i>Thamnophis hammondi</i>	BLM CA				X	No. This species does not occur in habitat that would be impacted by any alternative.
Western pond turtle	<i>Emys marmorata</i>	BLM CA				X	No. This species does not occur in habitat that would be impacted by any alternative.
Western spadefoot	<i>Spea hammondi</i>	BLM CA				X	No. This species does not occur in habitat that would 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	
Yuman desert fringe-toed lizard	<i>Uma rufopunctata</i>	BLM AZ		X	X	X	No. This species utilizes upland habitat, which will not be impacted by any alternative.
Invertebrates							
Apache springsnail	<i>Pyrgulopsis arizonae</i>	BLM AZ		X	X	X	No. This species is only known from a few locations that will not be influenced by project operations.
Gila tyronia	<i>Tryonia gilae</i>	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	<i>Pyrgulopsis bacchus</i>	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	<i>Pyrgulopsis conica</i>	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	<i>Hesperopsis gracieae</i>	BLM NV			X	X	No. This species utilizes upland habitat, which will not be impacted by any alternative.
Mojave gypsum bee	<i>Andrena balsamorhizae</i>	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	<i>Perdita meconis</i>	BLM NV			X		Yes
Monarch butterfly	<i>Danaus plexippus plexippus</i>	BLM NV		X	X	X	Yes
Sonoran talussnail	<i>Sonorella magdalenensis</i>	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	
Thorne's hairstreak	<i>Callophrys thornei</i>	BLM CA				X	No. This species relies on tecate cypress, which will not be impacted by any alternative.
Plants							
Alkali mariposa lily	<i>Calochortus striatus</i>	BLM NV			X		No. This species' range is outside of areas impacted by any alternatives.
Aravaipa sage	<i>Salvia amissa</i>	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	<i>Thelypteris puberula</i> var. <i>sonorensis</i>	BLM AZ		X			No. This species is only known from locations that will not be impacted by any alternatives.
Arizona eryngo	<i>Eryngium sparganophyllum</i>	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	<i>Vauquelinia californica</i> ssp. <i>sonorensis</i>	BLM AZ		X	X	X	No. This species grows in upland desert habitat, which will not be impacted by any alternative.
Bartram stonecrop	<i>Graptopetalum bartramii</i>	BLM AZ		X	X	X	No. This species is only known from a few locations that will not be influenced by project operations.
Beaver dam breadroot	<i>Pediomelum castoreum</i>	BLM NV			X		No. This species grows in upland desert habitat, which will not be impacted by any alternative.
Blue diamond cholla	<i>Cylindropuntia X multigeniculata</i>	BLM NV			X		No. This species grows in dry gypsiferous limestone, 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	
Blue sand lily	<i>Triteleopsis palmeri</i>	BLM AZ		X	X	X	No. This species grows on sand dunes, which will not be impacted by any alternative.
California flannelbush	<i>Fremontodendron californicum</i>	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	<i>Tortula californica</i>	BLM CA				X	No. This species' range is outside of areas impacted by any alternatives.
Chaparral sand-verbena	<i>Abronia villosa</i> var. <i>aurita</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Cochise sedge	<i>Carex ultra</i>	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	<i>Lasthenia glabrata</i> ssp. <i>coulteri</i>	BLM CA				X	No. This species' range is outside of areas impacted by any alternatives
Deane's milkvetch	<i>Astragalus deanei</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Decumbent goldenbush	<i>Isocoma menziesii</i> var. <i>decumbens</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Delicate clarkia	<i>Clarkia delicata</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Dunn's mariposa lily	<i>Calochortus dunnii</i>	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	
Fish creek fleabane	<i>Erigeron piscaticus</i>	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	<i>Monardella hypoleuca</i> ssp. <i>lanata</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Gander's pitcher sage	<i>Lepechinia ganderi</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Gander's ragwort	<i>Packera ganderi</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Gold butte moss	<i>Ceratodon purpureus</i>	BLM NV			X		Yes
Grand Canyon rose	<i>Rosa stellata</i> var. <i>abyssa</i>	BLM AZ		X			No. This species grows in upland habitat, which will not be impacted by any alternative.
Harrison's barberry	<i>Berberis harrisoniana</i>	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	<i>Eriastrum harwoodii</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Hohokam agave	<i>Agave murpheyi</i>	BLM AZ		X	X	X	No. This species grows in upland desert, which will not be impacted by any alternative.
Horn's milk-vetch	<i>Astragalus hornii</i> var. <i>hornii</i>	BLM CA				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	
Huachuca golden aster	<i>Heterotheca rutteri</i>	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	<i>Perityle ambrosiifolia</i>	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	<i>Ceanothus cyaneus</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Las Vegas bearpoppy	<i>Arctomecon californica</i>	BLM NV			X		No. This species grows in upland desert in gypsum soils, which will not be impacted by any alternative
Las Vegas buckwheat	<i>Eriogonum corymbosum</i> var. <i>nilesii</i>	BLM NV			X		No. This species grows in upland gypsum soils, which will not be impacted by any alternative.
Latimer's woodland-gilia	<i>Saltugilia latimeri</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Lincoln rockcress	<i>Boechera lincolnensis</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Little San Bernardino Mtns. linanthus	<i>Linanthus maculatus</i> ssp. <i>maculatus</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Long-spined spineflower	<i>Chorizanthe polygonoides</i> var. <i>longispina</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Marble Canyon milkvetch	<i>Astragalus cremnophylax</i> var. <i>hevronii</i>	BLM AZ		X			No. This species grows along canyon edges, 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	
Mecca-aster	<i>Xylorhiza cognata</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Mojave indigo bush	<i>Psoralea arborescens</i>	BLM AZ		X			No. This species grows in upland desert, which will not be impacted by any alternative.
Mojave tarplant	<i>Deinandra mohavensis</i>	BLM CA				X	Yes
Mokiak milkvetch	<i>Astragalus mokiensis</i>	BLM NV			X		Yes
Mount Trumbull beardtongue	<i>Penstemon distans</i>	BLM AZ		X			No. This species grows in upland forest/woodland habitat, which will not be impacted by any alternative.
Nuttall's scrub oak	<i>Quercus dumosa</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Oil neststraw	<i>Stylocline citroleum</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Orcutt's brodiaea	<i>Brodiaea orcuttii</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Orocopia Mountains spurge	<i>Euphorbia jaegeri</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Otay manzanita	<i>Arctostaphylos otayensis</i>	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	
Otay Mountain ceanothus	<i>Ceanothus otayensis</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Parish's meadowfern	<i>Limnanthus alba ssp. parishii</i>	BLM CA				X	Yes
Parish's phacelia	<i>Phacelia parryi</i>	BLM NV			X		No. This species' range is outside of areas impacted by any alternatives.
Parry's spineflower	<i>Chorizanthe parryi var. parryi</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Parry's tetradococcus	<i>Tetradococcus dioicus</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Pima Indian mallow	<i>Abutilon parishii</i>	BLM AZ		X	X	X	No. This species grows in upland desert, which will not be impacted by any alternative.
Pinto beardtongue	<i>Penstemon bicolor ssp. roseus</i>	BLM AZ				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Polished blazing star	<i>Mentzelia laevicaulis</i>	BLM NV			X		No. This species grows in upland sandy and rocky habitat, which will not be impacted by any alternative.
Rainbow manzanita	<i>Arctostaphylos rainbowensis</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Ramona horkelia	<i>Horkelia truncata</i>	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	
Reveal's buckwheat	<i>Eriogonum contiguum</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Robinson's monardella	<i>Monardella robisonii</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Rosy twotone beardtongue	<i>Penstemon bicolor</i> ssp. <i>roseus</i>	BLM NV			X		No. This species grows in upland habitat, which will not be impacted by any alternative.
Salt marsh bird's-beak	<i>Chloropyron maritimum</i> ssp. <i>maritimum</i>	BLM CA				X	No. This species grows in coastal salt marsh habitat, which will not be impacted by any alternative.
San Bernadino milk-vetch	<i>San Bernardino milk-vetch</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
San Diego goldenstar	<i>Bloomeria clevelandii</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
San Diego gumplant	<i>Grindelia hallii</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
San Diego milk-vetch	<i>Astragalus oocarpus</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Sandfood	<i>Pholisma sonora</i>	BLM AZ		X	X	X	No. This species grows in upland desert, which will not be impacted by any alternative.
San Jacinto mariposa-lily	<i>Calochortus palmeri</i> var. <i>munzii</i>	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	
San Luis Obispo sedge	<i>Carex obispoensis</i>	BLM CA				X	No. This species' range is outside of areas impacted by any alternatives.
San Miguel savory	<i>Clinopodium chandleri</i>	BLM CA				X	No. This species' range is outside of areas impacted by any alternatives.
Sanford's arrowhead	<i>Sagittaria sanfordii</i>	BLM CA				X	No. This species' range is outside of areas impacted by any alternatives.
Santa Lucia dwarf rush	<i>Juncus luciensis</i>	BLM CA				X	No. This species' range is outside of areas impacted by any alternatives.
Scaly sandplant	<i>Pholisma arenarium</i>	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	<i>Mielichhoferia shevockii</i>	BLM CA				X	No. This species' range is outside of areas impacted by any alternatives.
Siler fishhook cactus	<i>Sclerocactus sileri</i>	BLM AZ		X			No. This species grows in upland desert, which will not be impacted by any alternative.
Silverleaf sunray	<i>Enceliopsis argophylla</i>	BLM AZ BLM NV		X	X	X	No. This species grows in upland desert, which will not be impacted by any alternative.
Small wirelettuce	<i>Stephanomeria exigua</i> ssp. <i>exigua</i>	BLM AZ		X	X	X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Snake cholla	<i>Cylindropuntia californica</i> var. <i>californica</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Spring Mountain milkvetch	<i>Astragalus remotus</i>	BLM NV			X		No. This species grows in upland talus and rocky slopes, which will not be impacted by any alternative.
Sticky buckwheat	<i>Eriogonum viscidulum</i>	BLM AZ BLM NV			X		Yes

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			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	
Sticky dudleya	<i>Dudleya viscida</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Sticky ringstem	<i>Anulocaulis leiosolenus</i>	BLM NV			X		No. This species grows in upland habitat, which will not be impacted by any alternative.
Summer holly	<i>Comarostaphylis diversifolia</i> ssp. <i>diversifolia</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Tecate cypress	<i>Hesperocyparis forbesii</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Tecate tarplant	<i>Deinandra floribunda</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Threecorner milkvetch	<i>Astragalus geyeri</i> var. <i>triquetrus</i>	BLM NV			X		No. This species grows in upland sand and dune habitat, which will not be impacted by any alternative.
Tumamoc globeberry	<i>Tumamoca macdougalii</i>	BLM AZ		X	X	X	No. This species grows in upland desert, which will not be impacted by any alternative.
Variegated dudleya	<i>Dudleya variegata</i>	BLM CA				X	Yes
White bearpoppy	<i>Arctomecon merriamii</i>	BLM NV			X		No. This species grows in upland desert, which will not be impacted by any alternative.
Whitemargined beardtongue	<i>Penstemon albomarginatus</i>	BLM NV			X		No. This species grows in upland sand and dune 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	
White-bracted spineflower	<i>Chorizanthe xanti</i> <i>var. leucotheca</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.
Wiggins' croton	<i>Croton wigginsii</i>	BLM CA				X	No. This species grows in upland sand and dune habitat, which will not be impacted by any alternative.
Yellow twotone beardtongue	<i>Penstemon bicolor</i> <i>ssp. bicolor</i>	BLM NV			X		No. This species grows in upland habitat, which will not be impacted by any alternative.
Yucaipa onion	<i>Allium marvinii</i>	BLM CA				X	No. This species grows in upland habitat, which will not be impacted by any alternative.