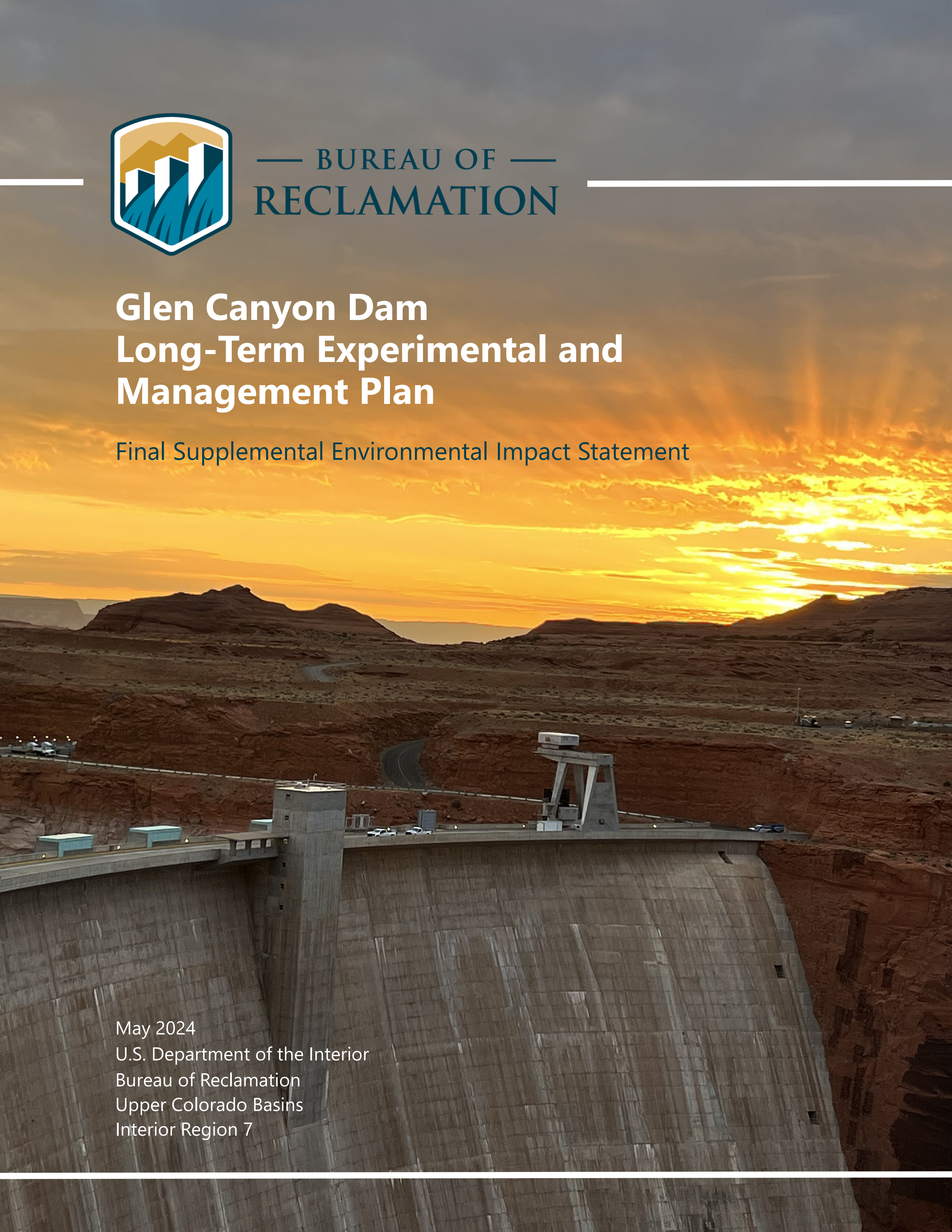
BUREAU OF RECLAMATION

# Glen Canyon Dam Long-Term Experimental and Management Plan

## Final Supplemental Environmental Impact Statement



May 2024
U.S. Department of the Interior
Bureau of Reclamation
Upper Colorado Basins
Interior Region 7

# 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 by Bureau of Reclamation, Operations Supervisor, Kato Miyagishima, June 2023, Flickr.com, Glen Canyon Dam at sunset

# Glen Canyon Dam Long-Term Experimental and Management Plan Supplemental Environmental Impact Statement

**Proposed Action:** The United States (US) Department of the Interior (Department), Bureau of Reclamation (Reclamation), is proposing to revise the 2016 Long-Term Experimental and Management Plan (LTEMP) for operations of Glen Canyon Dam to address the potential impacts from reduced high-flow experiment (HFE) release frequency and the threat of smallmouth bass below Glen Canyon Dam. Potential impacts from smallmouth bass pose an unacceptable risk to the threatened and endangered species below the dam. The reduction of water temperature and adjustments in flow velocity may serve as essential tools to disrupt the successful spawning and establishment of smallmouth bass. Reclamation has determined that a supplemental environmental impact statement (SEIS) is required to explore the implementation of additional flow options at Glen Canyon Dam. Various reservoir releases with different temperature and velocity combinations will be assessed to disrupt smallmouth bass spawning. This SEIS will also examine sediment accounting periods and implementation windows related to the HFE protocol analyzed in LTEMP.

**Lead Agency:** Bureau of Reclamation, Upper Colorado Basin Interior Region 7

**Cooperating Agencies:**

Arizona Game and Fish Department
Bureau of Indian Affairs
Colorado River Board of California
Colorado River Commission of Nevada
Havasupai Tribe
Hopi Tribe
Hualapai Tribe
Kaibab Band of Paiute Indians
National Park Service
Navajo Nation
Pueblo of Zuni
Salt River Project
Upper Colorado River Commission
US Fish and Wildlife Service
Utah Associated Municipal Power Systems
Western Area Power Administration

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# Acronyms and Abbreviations

| Acronym or Abbreviation | Full Phrase |
|---|---|
| °C | degrees Celsius |
| °F | degrees Fahrenheit |
| af | acre-feet |
| AMWG | Glen Canyon Adaptive Management Work Group |
| APE | area of potential effect |
| Argonne | Argonne National Laboratory |
| ASM | Arizona State Museum |
| AZGFD | Arizona Game and Fish Department |
| AZ-SGCN | State of Arizona species of greatest conservation need |
| Basin Fund | Upper Colorado River Basin Fund |
| BCE | before the Common Era |
| BGEPA | Bald and Golden Eagle Protection Act of 1940 |
| BIA | Bureau of Indian Affairs |
| BLM | Bureau of Land Management |
| CAA | Clean Air Act |
| CE | Common Era |
| CEQ | Council on Environmental Quality |
| CFR | Code of Federal Regulations |
| cfs | cubic feet per second |
| $CH_4$ | methane |
| CO | carbon monoxide |
| $CO_2$ | carbon dioxide |
| $CO_2e$ | carbon dioxide equivalent |
| CRSP | Colorado River Storage Project |
| CRSS | Colorado River Simulation System |
| CV | contingent valuation |
| Department | US Department of the Interior |
| DO | dissolved oxygen |
| eGRID | Emissions and Generation Resource Integrated Database |
| EMPS | Environmental Planning and Solutions |
| EPA | Environmental Protection Agency |
| ESA | Endangered Species Act |
| FEIS | final environmental impact statement |

| | |
|---|---|
| GCDAMP | Glen Canyon Dam Adaptive Management Program |
| GCMRC | Grand Canyon Monitoring and Research Center |
| GCNP | Grand Canyon National Park |
| GCNRA | Glen Canyon National Recreation Area |
| GCPA | Grand Canyon Protection Act |
| GHG | greenhouse gas |
| GTMax | Generation and Transmission Maximization Model |
| GTMax SL | Generation and Transmission Maximization Superlite Transmission |
| GWh | gigawatt-hour |
| GWP | global warming potential |
| $H_2S$ | hydrogen sulfide |
| HFE | high-flow experiment |
| Interim Guidelines | 2007 Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead |
| Interim Guidelines SEIS | 2023 Revised Supplemental Environmental Impact Statement for Near-term Colorado River Operations |
| kaf | thousand acre-feet |
| lb/MWh | pounds per megawatt-hour |
| LMNRA | Lake Mead National Recreation Area |
| LTEMP | Long-Term Experimental and Management Plan |
| maf | million acre-feet |
| mg/L | milligrams per liter |
| MOA | memorandum of agreement |
| MW | megawatts |
| MWh | megawatt-hours |
| $N_2O$ | nitrous oxide |
| NAAQS | National Ambient Air Quality Standards |
| NEPA | National Environmental Policy Act |
| NHPA | National Historic Preservation Act |
| NHWZ | new high-water zone |
| $NO_2$ | nitrogen dioxide |
| NOI | Notice of Intent |
| NOx | nitrogen oxides |
| NPS | National Park Service |
| NREL | National Renewable Energy Laboratory |
| NRHP | National Register of Historic Places |
| $O_3$ | ozone |
| OHWZ | old high-water zone |
| PA | programmatic agreement |
| Pb | lead |

| | |
|---|---|
| PM | particulate matter |
| $PM_{2.5}$ | particulate matter less than or equal to 2.5 micrometers |
| $PM_{10}$ | particulate matter less than or equal to 10 micrometers |
| PSD | Prevention of Significant Deterioration |
| Reclamation | United States Bureau of Reclamation |
| ROD | Record of Decision |
| SEIS | supplemental environmental impact statement |
| SERM | SLIP Energy Routing Model |
| Service | United States Fish and Wildlife Service |
| SGCN | species of greatest conservation need |
| SHPO | State Historic Preservation Officer |
| SLCA/IP | Salt Lake City Area Integrated Projects |
| SMB EA | Glen Canyon Dam/Smallmouth Bass Flow Options Draft Environmental Assessment |
| $SO_2$ | sulfur dioxide |
| SRM | Sand Routing Model |
| TCP | traditional cultural property |
| TDS | total dissolved solids |
| THPO | Tribal Historic Preservation Officer |
| UAMPS | Utah Associated Municipal Power Systems |
| UCRC | Upper Colorado River Commission |
| US | United States |
| USGS | United States Geological Survey |
| VOC | volatile organic compound |
| WAPA | Western Area Power Administration |
| WECC | Western Electricity Coordinating Council |
| YOY | young of year |

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# Chapter 1. Purpose and Need

## 1.1 Introduction

The Colorado River flows from Lake Powell through the Glen Canyon Dam and into the canyons below, where it meanders through sandstone cliffs, limestone, schist, and granite, traversing the Glen Canyon National Recreation Area (GCNRA) and the Grand Canyon National Park (GCNP) before emptying into Lake Mead. The river runs approximately 275 miles from the Glen Canyon Dam to the inlet of Lake Mead and includes some of the country's most unique and rich ecosystems. This stretch of river crosses through Utah, Arizona, and Nevada (**Map 1-1**).

To adaptively manage this stretch of river, Reclamation and National Park Service (NPS) developed the Long-Term Experimental and Management Plan (LTEMP) for operations of Glen Canyon Dam, the largest hydropower-generating unit of the Colorado River Storage Project (CRSP; DOI 2016a).

The National Environmental Policy Act of 1969 (NEPA; 42 US Code 4321 et seq.), the regulations of the Council on Environmental Quality' (CEQ) for implementing the procedural provisions of NEPA (40 Code of Federal Regulations [CFR] 1500–1508), and the Department NEPA regulations (43 CFR 46) require the Department to consider the potential environmental impacts of a proposed action before making a decision.

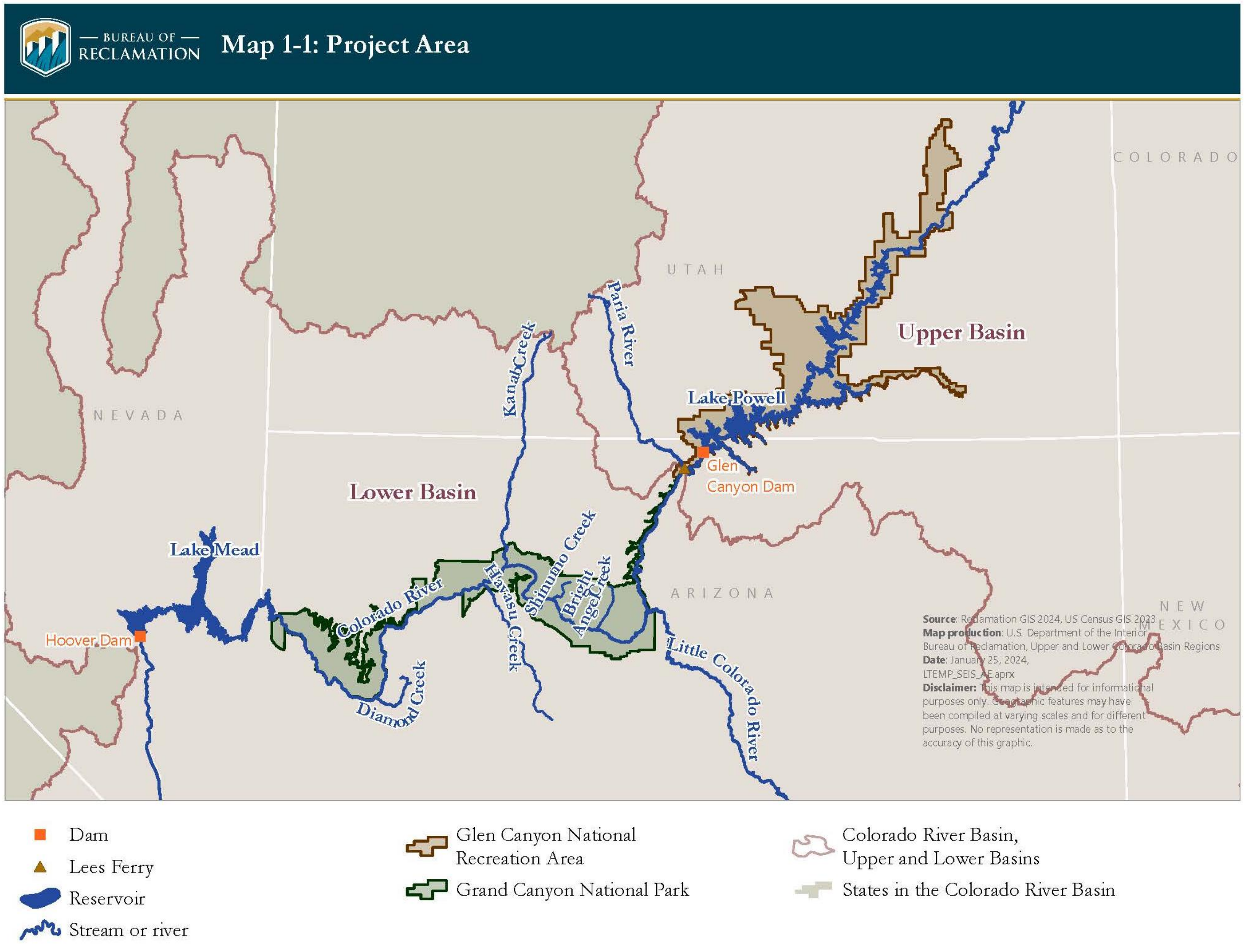
In 2016, Reclamation and NPS prepared a final environmental impact statement (FEIS) to evaluate impacts that could result from LTEMP. Since then, environmental conditions and new science have led Reclamation to pursue improvements to the 2016 LTEMP FEIS. Reclamation has prepared this SEIS to evaluate impacts that could result from the proposed updates to the 2016 LTEMP FEIS.

## 1.2 Background

The proposed updates to the 2016 LTEMP FEIS are a result of the extended period of drought, aridification, and low runoff conditions in the Colorado River Basin. Despite an above-average runoff in 2023, the period from 2000 to 2023 is considered one of the driest in over a century and among the driest in the last 1,200 years (Williams 2022). As Lake Powell's water elevation has decreased, the epilimnion,[1] where most fish reside, has drawn closer to the dam's penstocks.[2] The reduction in water elevation increases the likelihood of nonnative fish, such as smallmouth bass

[1] The upper stratum of the water column of a reservoir that is generally warm, circulating, and turbulent
[2] Dam structures that conduct water from the reservoir through the dam to the turbines of a powerplant. The Glen Canyon Dam centerline penstock elevation is 3,470 feet.

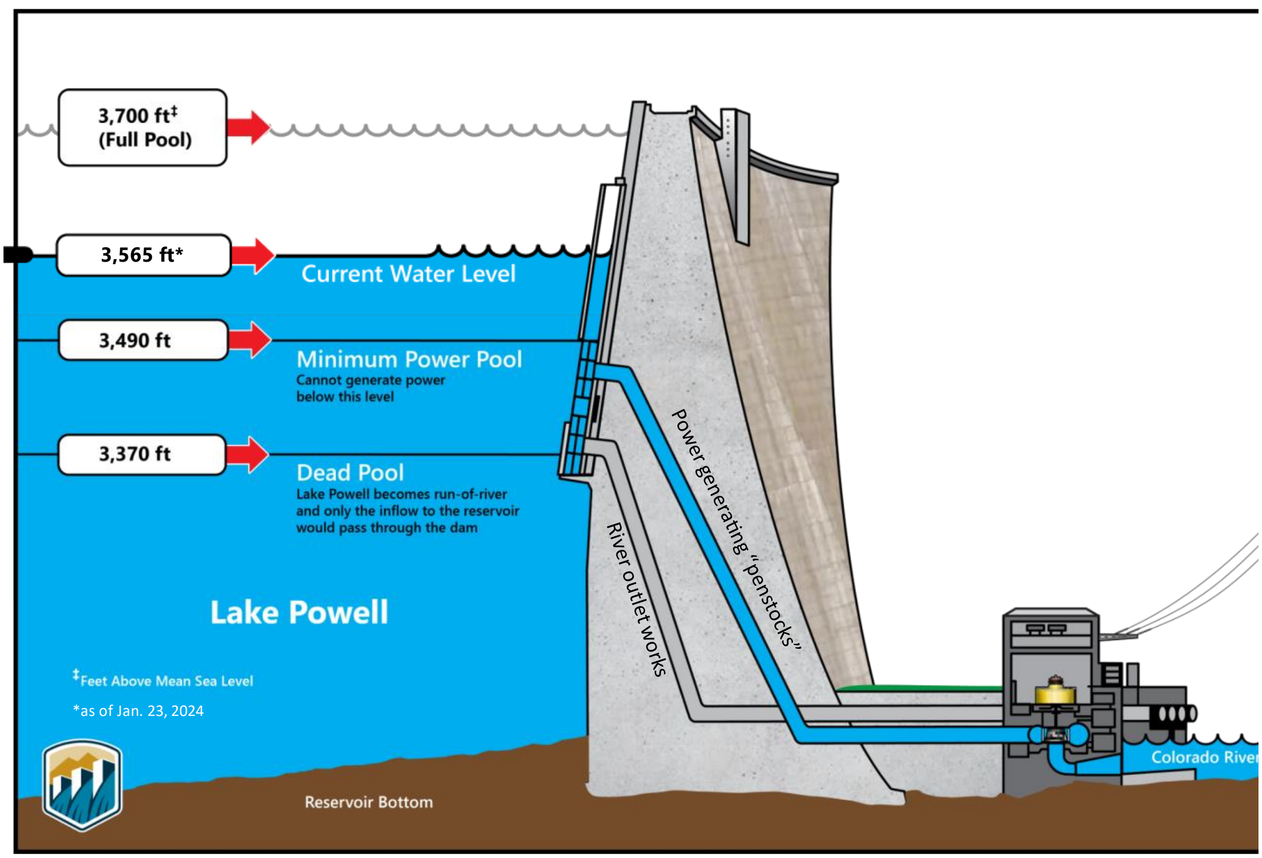
## Map 1-1
## Project Area



(*Micropterus dolomieui*), being entrained,[3] passing through the dam, and entering the Colorado River downstream.

As Lake Powell's elevations decline, warmer water from the epilimnion is released from the dam, resulting in increased water temperatures downstream. See **Figure 1-1** for a conceptual representation of Glen Canyon Dam operations. These warmer water conditions facilitate the reproduction and establishment of warmwater nonnative fish that pose a major threat to federally listed fish species and other native and sport fish living downstream of Glen Canyon Dam. If highly predaceous smallmouth bass, which specialize in eating other fish, were to establish below the dam, removal efforts would be difficult and expensive with potentially limited success. In 20 years of mechanical removal efforts of smallmouth bass in the Upper Colorado River Basin upstream of Glen Canyon Dam, there has been limited success in reducing smallmouth bass densities to benefit native fish populations (Dibble et al. 2021; Bestgen and Hill 2016a).

**Figure 1-1**
**Glen Canyon Dam Operations Guide**




Source: USGS and Reclamation 2023

In response to these changing conditions, the Secretary of the Interior's acting designee to the Glen Canyon Dam Adaptive Management Work Group (AMWG) directed Reclamation in August 2022 to identify and analyze operational alternatives at Glen Canyon Dam to disrupt the spawning of

[3] Fish entrainment is the process of fish passing from the reservoir through the dam and into the river below.

smallmouth bass and other warmwater nonnative fish that pass through the dam. As directed, Reclamation prepared the Glen Canyon Dam/Smallmouth Bass Flow Options Draft Environmental Assessment (SMB EA).

The SMB EA was released for public review and comment on February 24, 2023. Reclamation accepted public comments on the SMB EA from February 24 through March 10, 2023. Reclamation received 6,953 public comment submissions. Following the in-depth analysis of the SMB EA and upon analyzing and reviewing the comments, Reclamation determined that further analysis was necessary by expanding the SMB EA to an SEIS.

The 2016 LTEMP FEIS also includes management practices for implementing HFE releases, which were initially implemented under the Development and Implementation of a Protocol for High-Flow Experimental Releases from Glen Canyon Dam Environmental Assessment (Reclamation 2011a). An HFE is a special release from Glen Canyon Dam that involves the full powerplant capacity (30,000 cubic feet per second [cfs]) and the four by-pass valves (15,000 cfs). The duration of HFE releases range from about 2 days to 7 days. Total release may be less depending on water availability and the total of the eight penstocks and generators that are functional. The purpose of an HFE release is to create high flows and water velocities that will suspend the sediment stored on the river bottom and transport it downstream, where it can become entrained in large eddy complexes and deposit as sand beaches for riparian habitat and recreational camp sites.

Prior to the development of the protocol for HFE releases, three experiments were conducted in 1996, 2004, and 2008 (Wright and Kennedy 2011). HFE releases are triggered based on hydrologic conditions and sediment accumulation in the Colorado River from runoff in the Paria River and other tributaries. Each year, potential HFE releases are evaluated by a planning and implementation team. If conditions warrant it, the planning and implementation team recommends implementation to the Department.

The 2011 HFE protocol was carried forward into the 2016 LTEMP FEIS. Under the 2016 LTEMP FEIS, HFE releases can be scheduled when conditions permit, within two time frames: in the spring from March through April and in the fall from October through November. Six HFE releases have been conducted since the HFE protocol was initiated in 2012. Under the protocol, those HFE releases occurred in November 2012, 2013, 2014, 2016, and 2018.

The Department also conducted a 3-day spring HFE that was outside the HFE protocol but consistent with LTEMP, on April 24–27, 2023. Water releases from the dam during the 3-day 2023 experiment were as high as 39,500 cfs. The 2023 experiment's release did not meet sediment trigger requirements for the spring sediment accounting period in the HFE protocol, nor was there enough annual volume (greater than 10 million acre-feet [maf]) to initiate a proactive HFE release. However, high fall sediment loads in Marble Canyon and favorable hydrology conditions were present to support a spring experiment consistent with LTEMP. As such, Reclamation analyzed the effects of the unique situation and concluded in a supplemental information report to the 2016 LTEMP FEIS that the 2023 experiment would not substantially change the analysis or findings presented in the 2016 LTEMP FEIS with regard to other spring HFE releases (Reclamation 2023b).

Since the protocol for HFE releases was initiated in 2012, there have been years in which sediment conditions warranted a recommendation for an HFE release, but an HFE release was not implemented based on other resource conditions. The Department made the decision not to implement fall HFE releases in 2015, 2021, and 2022, despite reaching input triggers for sediment HFE releases because of increased water temperatures and the higher potential for entrainment of warmwater nonnative fish. Concurrently, analyses indicated reduced transport of fine sediments in years characterized by low release volumes. These developments prompted a comprehensive reevaluation of the scientific data underpinning the HFE protocol.

Over the last quarter century, scientific insights regarding the use and timing of HFE releases have substantially enhanced the understanding of the management of sediment supplies derived from tributaries below the dam. The review of HFE releases over the past decade, particularly in the context of lower releases, highlights the need to reassess the HFE sediment accounting period and the implementation window to more effectively improve sediment conditions in the Grand Canyon.

On June 6, 2023, the Secretary of the Interior's acting designee to the AMWG, a federal advisory committee, issued a directive to Reclamation. This directive charged Reclamation with the responsibility of preparing this SEIS. This SEIS will explore potential adjustments to the LTEMP HFE protocol to incorporate the latest scientific findings.

This SEIS supplements the December 2016 Record of Decision (ROD) for the 2016 LTEMP FEIS (DOI 2016b). The core focus of this SEIS is the evaluation of sub-annual flow options designed to prevent the establishment of smallmouth bass and other warmwater nonnative, invasive fish below Glen Canyon Dam by impeding their reproduction. Additionally, this SEIS will explore changes to the sediment accounting periods[4] associated with the LTEMP HFE protocol using the latest available science. This SEIS will not impact annual releases as described in the 2007 Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead (Interim Guidelines); see **Section 1.8** for additional details.

## 1.3 Proposed Federal Action

Recognizing the ecological threat that smallmouth bass pose on the Colorado River downstream of Glen Canyon Dam, Reclamation has concluded that immediate actions must be developed to ensure the prevention of population establishment of smallmouth bass and other warmwater nonnative, invasive fish. In addition, Reclamation has acknowledged improved ways to assess sediment inputs and sediment retention that may affect the frequency of HFE releases.

Accordingly, Reclamation is proposing to revise the 2016 LTEMP FEIS to address the potential impacts from reduced HFE release frequency and the threat of smallmouth bass below Glen Canyon Dam. Reclamation has concluded that the potential impacts from smallmouth bass pose an unacceptable risk to threatened and endangered species below the dam.

[4] Periods in which the available sediment for a potential HFE release is measured

The reduction of water temperature and adjustments in flow velocity may serve as essential tools to disrupt recruiting smallmouth bass populations from expanding. Therefore, a range of reservoir releases with varying combinations of temperature and release volumes will be analyzed to assess their effectiveness in disrupting smallmouth bass spawning and preventing recruiting populations from expanding. Reclamation will also examine the sediment accounting periods and implementation windows associated with the HFE protocol analyzed in the 2016 LTEMP FEIS.

Reclamation and its partners have already begun efforts toward additional protections for listed fish at Glen Canyon Dam. These efforts include guidance provided by the Glen Canyon Dam Adaptive Management Program (GCDAMP) stakeholders. The guidance includes, but is not limited to, fish exclusions, modification to the slough at river mile -12, and temperature control devices (GCDAMP 2023). These efforts are considered medium- and long-term solutions and will require additional development and analysis. Reclamation plans to explore these options through future NEPA actions. Ongoing removal efforts led by NPS will continue with the goal of providing a short-term response to reduce the breeding and expansion of warmwater invasive fish.

## 1.4 Purpose of and Need for Action

The purpose of the LTEMP SEIS is for Reclamation to analyze additional flow options at Glen Canyon Dam in response to nonnative, invasive smallmouth bass and other warmwater nonnative species recently detected directly below the dam. The recent detection of large numbers of young of year (YOY) smallmouth bass suggests spawning is occurring for the first time directly below the dam. The need is to disrupt the establishment of smallmouth bass below Glen Canyon Dam by limiting additional recruitment, which could threaten populations of threatened humpback chub (*Gila cypha*) below the dam.

The LTEMP SEIS purpose relative to HFE releases is to consider adjusting sediment accounting periods and HFE implementation windows. The need is to include the latest scientific information to improve Reclamation's ability to implement HFE releases as detailed in the 2016 LTEMP FEIS.

## 1.5 Lead and Cooperating Agencies

The Secretary of the Interior is responsible for the operation of Glen Canyon Dam pursuant to applicable federal law. The Secretary of the Interior is also vested with the responsibility of managing the mainstream waters of the Colorado River below Glen Canyon Dam pursuant to federal law. This responsibility is carried out in a manner consistent with the Law of the River[5] (Reclamation 2008). Reclamation, as the agency designated to act on the Secretary of the Interior's behalf with respect to these matters, is the lead federal agency for the development of this SEIS in accordance with NEPA.

[5] The numerous compacts, federal laws, court decisions and decrees, contracts, and regulatory guidelines used to administer the Colorado River are collectively referred to as the "Law of the River."

Sixteen federal, state, Tribal, and public utility agencies are cooperating for the purpose of assisting with environmental analysis and preparation of this SEIS. State, Tribal, and public utility cooperators include the Arizona Game and Fish Department (AZGFD), Colorado River Commission of Nevada, Salt River Project, Utah Associated Municipal Power Systems (UAMPS), Upper Colorado River Commission, Colorado River Board of California, Havasupai Tribe, Hopi Tribe, Hualapai Tribe, Kaibab Band of Paiute Indians, Navajo Nation, and Pueblo of Zuni. The federal cooperating agencies include the US Fish and Wildlife Service (Service), Bureau of Indian Affairs (BIA), NPS, and Western Area Power Administration (WAPA).

The BIA has responsibility for the administration and management of lands held in trust by the United States for American Indians and American Indian Tribes located within the Colorado River 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 four national wildlife refuges along the lower 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.

NPS administers areas of national significance along the Colorado River, including GCNRA, GCNP, and Lake Mead National Recreation Area (LMNRA). NPS administers visitor use (including recreation) of cultural and natural resources in these areas from offices located at Page, Arizona; GCNP, Arizona; and Boulder City, Nevada. NPS also grants and administers concessions for the operation of marinas and other recreation facilities at Lake Powell and Lake Mead, as well as concession 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. WAPA's mission is to market and transmit electricity from federal multiuse water projects. WAPA markets and transmits power generated from the various hydropower plants located within the CRSP under the CRSP Act and operated by Reclamation. WAPA customers include municipalities, cooperatives, public utility and irrigation districts, federal and state agencies, and Tribes located throughout the Colorado River Basin. The wholesale customers, in turn, provide retail electric service to millions of consumers within the seven Colorado River Basin States of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming.

# 1.6 Scope of the SEIS

## 1.6.1 Affected Region and Interests

The project area encompasses Glen Canyon Dam and the Colorado River downstream of the dam to the inlet[6] of Lake Mead. Lake Powell and Lake Mead are *not* within the project area. The analysis area may vary depending on the specific resource being considered. For instance, the cultural analysis will encompass a rim-to-rim area of potential effect (APE), while the socioeconomic and hydropower analyses will examine surrounding counties and communities.

## 1.6.2 Relevant Issues

The following relevant issues will be addressed in this SEIS:

- **Drought and Low Runoff Conditions:** Given the prolonged period of drought, aridification, and low runoff conditions in the Colorado River Basin, it is crucial to assess the impact of these conditions on water levels, water temperature, and fish populations.
- **Entrainment of Nonnative Fish:** The analysis will investigate the risk and consequences of warmwater nonnative fish, especially smallmouth bass, being entrained, passing through Glen Canyon Dam, and entering the Colorado River.
- **Effect of Water Temperature:** The discharge of warmer water downstream due to decreasing Lake Powell elevations will be explored. Warmer water creates conditions conducive to the reproduction and establishment of warmwater nonnative fish, posing a threat to native species downstream.
- **Threat to Federally Listed Fish Species:** The potential threat posed by nonnative, predatory fish, including smallmouth bass, to federally listed fish species and other native fish downstream of Glen Canyon Dam will be examined.
- **HFE Protocol Evaluation:** The evaluation of the HFE protocol will consider factors such as the absence of fall HFE releases in certain years, despite sediment triggers being met; sediment transport in low-release and low-elevation years; the use of the best available science for sediment accounting; and the need to improve the protocol to utilize the best available science.
- **Modifications to HFE Protocol:** The SEIS will explore potential modifications to the HFE protocol in light of the latest scientific findings and insights, including adjustments to sediment accounting periods and HFE implementation windows.

# 1.7 Timing Considerations for this SEIS

The NEPA analysis in this process is designed to address river conditions that typically begin to occur in the summer of each year for warmwater nonnative predation and in the spring of each year for potential HFE releases. These timing considerations are pertinent because of a need to evaluate

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[6] The inlet of Lake Mead can fluctuate from season to season and year to year. The fluctuations of the inlet do not impact the resource analysis for this SEIS.

and select, if appropriate, potential solutions to be in place and ready to deploy by the summer of 2024. Timing considerations are particularly appropriate given the potential effects of nonnative warmwater predators on native and listed fish.

The need to have tools evaluated and, if appropriate, selected to be in place as soon as summer 2024 has compressed the schedule of this NEPA process for the lead and cooperating agencies. Even with a compressed schedule, the information used in this analysis is sufficient to allow comparison among the alternatives. More information may become available to evaluate particular resources as the NEPA process develops. The use of additional information is discussed more in **Section 2.2**, Preferred Alternative.

## 1.8 Relationship of this Action to Other Colorado River Operations

The actions at issue in LTEMP, and correspondingly in this supplement to LTEMP, concern sub-annual releases from Glen Canyon Dam on hourly, daily, monthly, and experimental timescales. These sub-annual operations are a subset of broader Glen Canyon Dam operations that occur within the larger legal framework governing the Colorado River.

LTEMP does not affect other aspects of Glen Canyon Dam operations. LTEMP cannot affect the hydrology or changes to the hydrology or climate that determine how much water is stored by Glen Canyon Dam. LTEMP does not affect the operations of dams and other facilities upstream or downstream of Glen Canyon Dam. LTEMP does not control how much water is released from Glen Canyon Dam on an annual basis; such annual operation releases are currently controlled by the Interim Guidelines (Reclamation 2007), which have been supplemented by the 2024 Revised Supplemental Final Environmental Impact Statement for Near-term Colorado River Operations (Interim Guidelines SEIS; Reclamation 2024a). LTEMP instead controls the sub-annual timing of releases to improve downstream conditions, meeting the requirements of the Grand Canyon Protection Act, and minimizing—consistent with other laws—adverse impacts on downstream natural, recreational, and cultural resources.

## 1.9 Operational Considerations

Dry hydrology in recent years has resulted in low elevations at Lake Powell and Glen Canyon Dam, providing operating experience and an opportunity to assess facility performance at low elevations in Lake Powell (for example, 3,490 feet, Glen Canyon Dam's minimum power pool). Reclamation is learning from these low-elevation operations and will continue to refine the operating parameters for Glen Canyon Dam to incorporate new information and operating experience as it becomes available. Since the publication of the Draft SEIS, Reclamation has obtained additional information about enhanced risks of relying on the river outlet works at Glen Canyon Dam, particularly as the exclusive means of releasing water at low elevations for sustained periods of time. Reclamation has recently developed Interim Operating Guidance for Glen Canyon Dam during Low Reservoir Levels at Lake Powell (Reclamation 2024b) to address the potential for negative consequences associated with the long-term operation of the river outlet works at Glen Canyon Dam at low reservoir levels. This Interim Operating Guidance indicates that Reclamation should exercise the full extent of operational capabilities within the Upper Colorado Basin to attempt to maintain the reservoir level at or above an elevation of 3,490 feet, the minimum power pool, to allow redundant downstream delivery of water through the penstocks and river outlet works if needed. As explained in the Interim Operating Guidance, Reclamation will continue to evaluate these risks and any appropriate mitigation and remedial measures and will manage Glen Canyon Dam accordingly.

The Interim Operating Guidance also contains a table of reduced capacities for Glen Canyon Dam's river outlet works below a Lake Powell elevation of 3,550 feet above sea level, information pertinent to this NEPA analysis because some alternatives rely on the river outlet works for resource effects. Reclamation began to describe considerations related to the river outlet works to the AMWG's regular public meetings as early as August 26, 2023.[7]

Based on this developing information, the Draft SEIS incorporated modeling assumptions for reduced release capacity from the river outlet works while the Interim Operating Guidance was being developed. For example, the maximum unrestricted release for each of the four river outlet work tubes is 3,750 cfs, for a maximum capacity of 15,000 cfs, and Chapter 2 of the Draft SEIS modeling assumed a reduced capacity of 3,150 cfs for each of the four tubes, for a total capacity of 12,600 cfs. These reduced volumes were used in the Draft SEIS resource analysis. Additionally, the Draft SEIS described a limitation on HFE releases when Lake Powell's elevation is below 3,500 ft.

The reduced flows from the river outlet works described in the Interim Operating Guidance are consistent with the assumptions used in the Draft SEIS and carried forward in this Final SEIS, thus providing an accurate assessment of resource effects for alternatives that rely on the river outlet works with the Interim Operating Guidance in place.

## 1.10 Changes to the Final SEIS

In response to public, Tribal, and agency comments on the Draft SEIS, several additions were made to the chapters and appendixes in the Final SEIS. No changes to the alternatives were required because of comments. **Appendix A**, Response to Public Comments, notes what has been changed in the Final SEIS based on a specific comment. A summary of changes is as follows:

- The Grand Canon Monitoring and Research Center (GCMRC) published Modeling the Impacts of Glen Canyon Dam Operations on Colorado River Resources (Yackulic et al 2024). This report supersedes the LTEMP Draft SEIS, Appendix A, Evaluation of LTEMP SEIS Alternatives on Smallmouth Bass. For that reason, the original appendix was removed and replaced with references to the GCMRC report, which is hereby incorporated by reference.
- The Hydrology section was updated to better analyze dam releases.

[7] https://www.usbr.gov/uc/progact/amp/amwg/2023-08-17-amwg-meeting/20230817-AMWGMeeting-FinalMInutes-508-UCRO.pdf

- The Energy and Power section was substantially updated to include additional input from WAPA and other stakeholders. This update includes additional Plexos modeling results, as discussed in **Section 1.10.2**.
- Many resource sections now include additional analysis focused on impacts specifically during modeled traces that include experiments, along with analysis of average impacts across all modeled traces.
- The Air Quality section was updated with new analysis using the Plexos modeling results as a basis for data, as discussed in **Section 1.10.2**.
- An independent study was published by the Center for Colorado River Studies. More information about these updates is discussed below in **Section 1.10.1**.
- Minor updates were made across all sections based on public comments.

### 1.10.1 Additional Smallmouth Bass Information

Since the publication of the Draft SEIS, a report has been provided by the Center for Colorado River Studies reviewing smallmouth bass management in the Colorado River ecosystem (Smallmouth Bass Management Review Committee 2024). The study discussed the uncertainties in the risk of smallmouth bass establishment. Reclamation understands the inherent uncertainties but believes that immediate actions are supported by data based on smallmouth bass risks, considering the potential for substantial consequences to threatened and endangered species in the river and the expensive rehabilitation that could come from a lack of action. The need to act is based on empirical scientific reason outlined in GCDAMP's Invasive Fish Species below Glen Canyon Dam: A Strategic Plan to Prevent, Detect, and Respond (2023).

The Center for Colorado River Studies report identifies turbidity as a potential limiting factor for smallmouth bass establishment. While this analysis is derived from scientific studies in the Basin, Reclamation lacks the ability to directly control turbidity levels that would allow for population control. Water temperature has also been shown to limit smallmouth bass establishment and can be manipulated by dam operations. The report identifies the Cool Mix Alternative as the most likely alternative to disrupt smallmouth bass establishment based on temperature considerations.

While the degree to which turbidity affects the establishment of smallmouth bass is uncertain, it is less likely to impact warmwater species such as catfish and walleye that are more adapted to turbid conditions. Additionally, it is highly unlikely that turbidity would influence the establishment of warmwater fish in the Colorado River tributaries and the reach of the mainstem Colorado River above the Little Colorado River confluence, which is less turbid than downstream reaches.

Reclamation has considered the findings in this report, and additional information from this report has been incorporated into **Section 3.5**, Aquatic Resources. If flows related to smallmouth bass are selected, Reclamation would consider any new information concerning smallmouth bass through the planning and implementation process to adaptively manage the Colorado River ecosystem.

### 1.10.2 Plexos Modeling

Since the publication of the Draft SEIS, Reclamation has coordinated with WAPA, the US Department of Energy's Argonne National Laboratory (Argonne), and the National Renewable

Energy Laboratory (NREL) to develop Plexos modeling results to further analyze impacts on hydropower resources. This tool is widely used by NREL and other organizations to simulate the operation of the electric power system on an hourly basis. Plexos conducts an optimization to determine the least-cost unit commitment and economic dispatch of every generator in the system. Results and additional information on the model are provided in **Section 3.3**, Energy and Power, and can be found in Veselka et al. (forthcoming).

## 1.11 Summary of the Contents of this SEIS

This SEIS describes the proposed federal action, the alternatives considered, the analysis of the potential effects of these alternatives on revised 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 management strategies for Glen Canyon Dam 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 the 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, local utilities, and Tribes 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; a distribution list of agencies, organizations, and persons receiving copies of the document; and an index.

**Table 1-1**
**Resources Considered for Detailed Analysis**

| Resource | Potentially Significant | Issue Areas |
|---|---|---|
| **Water Resources** | | |
| Hydrologic Resources | Yes | Reservoir elevations, reservoir releases, river flows |
| Water Quality | Yes | Salinity, temperature, dissolved oxygen (DO) |
| **Physical Resources** | | |
| Air Quality | Yes | Air pollutant emissions from alternative power sources |
| Visual Resources | No | Colorado River landscape character between Glen Canyon Dam and Lake Mead |
| Cultural Resources | Yes | Exposure of and increased visitation to resources (historic properties) as river levels fluctuate; sediment availability for wind-borne transport to protect resources downstream of the dam |
| Geomorphology and Sediment | Yes | Sediment transport, erosion, deposition, and beach-building conditions |
| Climate | Yes | Greenhouse gas (GHG) emissions from alternative power sources |
| **Biological Resources** | | |
| Aquatic Resources | Yes | Food base, fish |
| 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 |
| **Human Environment** | | |
| Tribal Resources | Yes | Mortality of fish, which are contributing elements to traditional cultural properties (TCPs); exposure and increased visitation to sacred sites and archaeological sites; changes in vegetation important to Tribes |
| Recreation | Yes | Whitewater boating, fishing |
| Energy and Hydropower | Yes | Generation, economic analysis, capacity |
| Socioeconomic Impacts | Yes | Net value from recreation activities, environmental nonuse value, economic impacts from electricity rate changes, and hydropower generation capacity changes |
| Environmental Justice | Yes | Disproportionate effects on minority and low-income populations |

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# Chapter 2. Description of Alternatives

## 2.1 Development of Alternatives

This chapter discusses the process used to define, develop, and analyze the range of reasonable alternatives for implementing the proposed federal action. As discussed in **Chapter 1**, Purpose and Need, Reclamation received approximately 7,000 public comments following the release of the SMB EA. Many of these comments specifically addressed the potential impacts on Tribal resources, hydropower generation, and the associated economic impacts. In response to the direction from the Secretary of the Interior's acting designee, Reclamation is now transitioning to a more comprehensive SEIS analysis.

For the LTEMP SEIS scoping process, Reclamation considered the following preliminary six alternatives:

- **(1) No Action Alternative**: This alternative represents the continuation of current operations without implementing any changes.
- **Flow Alternatives Initially Analyzed in the SMB EA (February 2023)**: These original action alternatives build on the analysis conducted in the SMB EA (Reclamation 2023a). These alternatives aim to reduce the river temperature below 15.5 degrees Celsius (°C; 60 degrees Fahrenheit [°F]) to disrupt smallmouth bass spawning. This target temperature is similar to temperatures observed from 2005 to 2021, when smallmouth bass production was not observed and the humpback chub population increased. The two flow spike alternatives include changes in dam releases to implement flows high enough to cool river temperatures in backwater areas (a known spawning location of smallmouth bass). These alternatives were analyzed to cool the river water temperature down to either 15 river miles below Lees Ferry (river mile 15) or the confluence with the Little Colorado River (river mile 61). Moving forward, alternatives 2 through 5 may be referred to as the "cold-water alternatives," "flow alternatives," or "smallmouth bass flow alternatives," due to their similarities.
    - **(2) Cool Mix Alternative**
    - **(3) Cool Mix with Flow Spike Alternative**
    - **(4) Cold Shock Alternative**
    - **(5) Cold Shock with Flow Spike Alternative**
- **(6) Non-Bypass Alternative**: This alternative explores a flow option that does not involve the use of Glen Canyon Dam's bypass system. Instead of aiming to reduce river temperatures, this alternative focuses on river stage fluctuations to disrupt smallmouth bass spawning.

These alternatives examine a range of options, addressing the concerns raised by the public and stakeholders during the SMB EA process and ensuring a more detailed evaluation of potential impacts and benefits in the upcoming SEIS. The range of alternatives considered reflects input from Reclamation, states, Tribes, cooperating agencies, stakeholders, and other interested parties, including comments submitted during the SEIS public scoping period and the public comment period on the SMB EA.

## 2.2 Preferred Alternative

Under NEPA, the "preferred alternative" is a preliminary indication of the lead agency's preference of action among the proposed alternatives. In accordance with the NEPA implementing regulations (40 CFR 1502.14[d] and 43 CFR 46.425(a)), Reclamation has identified the Cool Mix Alternative as the preferred alternative for potential flow actions to address smallmouth bass in the summer of 2024. The Cool Mix Alternative modifies dam hourly, daily, and monthly releases with the intent to disrupt the establishment of smallmouth bass below the dam to meet the purpose and need while minimizing impacts on other resources (**Section 1.4**).

While Reclamation has identified a preferred alternative in this Final SEIS, the actual decision to select an alternative for implementation will not occur until the ROD. The decision on the alternative to implement will consider public comments and the full analysis presented in **Chapter 3**. For potential flow-based actions to address smallmouth bass after the summer of 2024 (if warranted based on temperature targets), Reclamation will consider the other alternatives described in this final SEIS, including Cool Mix, and make any implementation decisions based on current conditions and information based on any 2024 flows.

For potential implementation in 2024, Reclamation would use the planning and implementation process to review the current hydrology and model projected temperatures and associated bypass quantities. As described in the LTEMP ROD, the relative effects of the experiment on the following resource areas will be evaluated and considered: (1)water quality and water delivery; (2) humpback chub; (3) sediment; (4) riparian ecosystems; (5) historic properties and TCPs; (6) Tribal concerns; (7) hydropower production, power availability, transmission and WAPA's assessment of the status of the Upper Colorado River Basin Fund (Basin Fund);[8] (8) the rainbow trout fishery; (9) recreation; and (10) other resources. These resources will be analyzed using the best available data and models.

For 2024, triggering of the cool mix would occur if the average observed daily temperatures, measured at river mile 61, exceed 15.5°C (60°F) for three consecutive days. If triggered, the cool mix experiments would be conducted until temperature releases (without bypass) fall below 15.5°C (60°F) at the target river mile 61. If real-time estimates of water temperatures at the targeted river mile are not available, the Dibble et al. (2021) model would be used to estimate downstream temperatures at the target location using live stream gages at Glen Canyon Dam or Lees Ferry. Temperature and biological monitoring would occur throughout this process to assess its effectiveness. Potential off-ramp conditions would be monitored and considered to determine if conditions warrant ending any experimental flows, as determined through the planning and implementation process. Off-ramps could include data showing that smallmouth bass population

[8] https://www.usbr.gov/uc/rm/crsp/index.html

growth has increased or showing long-term unacceptable adverse impacts on resources identified above.

The proposed modifications to the HFE protocol are included in the Preferred Alternative. Reclamation is considering adjusting sediment accounting periods and HFE implementation windows based on the findings of the 2023 Proposal to Amend the High-Flow Experiment Protocol and Other Considerations. The goal is to use the latest scientific information to improve Reclamation's ability to account for sediment inputs when considering whether to implement HFE releases, as detailed in the 2016 LTEMP FEIS.

## 2.3 Implementation

The duration of any selected alternative concerning operations for smallmouth bass is through the operating year 2027. As discussed in **Section 1.7**, this timing is designed to create strategies that can be implemented in time to prevent the establishment of smallmouth bass and other warmwater nonnative fish that were identified in the Invasive Fish Species below Glen Canyon Dam: A Strategic Plan to Prevent, Detect, and Respond (GCDAMP 2023). Additionally, the HFE-related changes to sediment accounting windows and implementation periods will last through the duration of the 2016 LTEMP FEIS. The Department may select different parts of any of the alternatives to best meet the purpose and need. The process for determining the implementation of potential actions discussed in this SEIS will be included in the ROD. In general, it is anticipated that temperature models will be used for planning purposes to estimate the timing and quantity of releases. Adjustments closer to implementation will be made based on observed temperatures. Such implementation process details will not change the assessment of alternatives provided in this SEIS.

### 2.3.1 Planning and Implementation

Planning and implementation of HFE releases will continue as outlined in the LTEMP ROD. This process includes coordination and consultation with the Department bureaus (United States Geological Survey [USGS], NPS, the Service, BIA, and Reclamation), WAPA, AZGFD, and one liaison from each Basin State and from the UCRC, as needed. Planning will include an analysis of impacts on resources, including but not limited to sediment, threatened and endangered species, hydropower (including the Basin Fund), environmental justice communities, and Tribal concerns. The implementation process will include formal stakeholder engagement, including additional consultations with the Tribes, to ensure informed decision-making. This planning and implementation process will provide advice for the Secretary of the Interior to use in the decision-making process.

Planning and implementation of smallmouth bass experimental flows will include coordination between Reclamation and the Service to prepare an analysis on current conditions and the proposed flow depending on Basin conditions, including hydrology, water quality, the Basin Fund, and fish populations. Following the preparation of a proposed flow, Reclamation will coordinate with the Department bureaus, WAPA, AZGFD, and one liaison from each Basin State and from the UCRC as needed. This will ensure all pertinent resources are analyzed prior to implementing a proposed flow.

These planning and implementation processes are designed to optimize adaptive management strategies. Reclamation has prioritized an adaptive management approach to dam operations since the 1996 Operation of Glen Canyon Dam ROD (1996 ROD, [Reclamation 1996]), which outlines the operation of Glen Canyon Dam under the Colorado River Storage Project.. The LTEMP SEIS uses an adaptive management and experimental framework to refine existing information regarding the effects of dam operations and management actions on affected resources. Information gathered through the adaptive management and experimental process may be used to adjust operations within the range of the actions analyzed for impacts in this SEIS. Planning and implementation for 2024 may require expedited communication and cooperation between Reclamation and its cooperators. If river temperatures are expected to reach 15.5°C (60°F) in the summer, Reclamation will collaborate closely with cooperators and stakeholders to ensure as much advance notice as possible prior to implementation.

## 2.4 Common to All Action Alternatives

Under all alternatives, operations would continue pursuant to the continued implementation of existing agreements that control operations of Glen Canyon Dam, unless stated otherwise. In addition, in accordance with the purpose and need (**Section 1.4**), all action alternatives incorporate changes to the HFE sediment accounting period and implementation windows to utilize the best available science. These changes consist of adjusting the semiannual sediment accounting period to an annual period with the option for a spring or fall HFE release, or both. In the event that a sediment trigger is met, but an HFE release is not implemented in the fall or spring, rollover of sediment into the next accounting period is possible.

These changes to the HFE protocol would not change the duration or magnitude of HFE releases as outlined in the 2016 LTEMP FEIS; instead, they would adjust the timing to optimize the best available science when implementing HFE protocols. Please note that short-duration HFE releases are still implementable under the original LTEMP ROD. However, they would not provide much sandbar building (Salter 2024) and, therefore, were not analyzed in this modeling effort.

The detailed changes to the HFE protocol were outlined in the 2023 Proposal to Amend the High-Flow Experiment Protocol and Other Considerations, which was developed by the Flow Ad Hoc Group through the Technical Work Group of the AMWG in partnership with the GCMRC and Reclamation; this 2023 proposal is incorporated by reference. This document provides detailed changes to both the sediment account period and implementation window.

Reclamation has analyzed a 1-year sediment accounting period starting on July 1. Under the 1-year sediment accounting period, if an HFE release were triggered but not implemented, and there were no other HFE releases in the accounting period, a positive sediment mass balance would be carried over into the next accounting period. The 1-year accounting period provides the flexibility to defer the consideration of a triggered fall HFE release to the spring, given that the projected sediment mass balance would allow for a spring HFE release. Sediment rollover scenarios were not modeled and would not result in a change in the number or magnitude of HFE releases and, therefore, are within the analysis of the original LTEMP. The planning and implementation process would include updated sand routing modeling that would analyze any impacts from rollover on a case-by-case basis. Additional assumptions are included in **Section 3.4.2**.

Dam operations would allow for the emergency exception criteria to continue as needed and as outlined in the 2016 LTEMP FEIS (DOI 2016a).

## 2.5 Alternatives Assumptions

To accurately model the alternatives described below, Reclamation, in coordination with the GCMRC and WAPA, developed a series of assumptions based on current conditions, operating criteria, system constraints, and the best available science. This section outlines the assumptions and modeling process that was conducted during the analysis.

Flow options to target smallmouth bass are flexible to address where smallmouth bass are found in the river. Recent surveys have found juvenile smallmouth bass around river mile 16, while historic surveys have found adult smallmouth bass further downstream. For the purposes of the modeling effort, cold-water alternatives were modeled to river mile 15 (approximately 15 river miles below Lees Ferry) and river mile 61 (the confluence with the Little Colorado River). Cooling to river mile 15 would allow Reclamation to target smallmouth bass in the more heavily populated areas, such as the slough. Cooling to river mile 61 would allow Reclamation to target smallmouth bass that have traveled farther downstream. Actual river mile targets for potential implementation could vary depending on where smallmouth bass are located within a given year.

**General overview of analyses for the smallmouth bass flow alternatives:**

- Hydrologic data modeled for the Interim Guidelines SEIS were used because these data represented the most up-to-date modeling data available at the time of analysis (Reclamation 2024a). A set of 30 hydrologic traces[9] representing a wide range of hydrologic conditions provided a robust range of monthly data for 4 years to match the timescale of the smallmouth bass flow options. Please refer to the Interim Guidelines SEIS for additional details on the hydrologic modeling (Reclamation 2024a).
- An initial run of the smallmouth bass model was made to determine the months in which flow spikes would be expected to be triggered under the operational alternatives that include flow spikes and under the two scenarios in which different river miles (river miles 15 and 61) were targeted. Additional information on the smallmouth bass model can be found in the GCMRC modeling report (Yackulic et al. 2024, chap. 4).
- An initial run of the sediment model was conducted to determine when high flows would be triggered under different alternatives, what the magnitude and duration of a high flow would be, and what the magnitude of a flow spike could be (under alternatives that include flow spikes). This analysis also determined whether water needed to be moved among months to allow for an HFE release. Modified monthly volumes were then reported. Further

[9] The 30 traces used in this SEIS are the 100 percent ensemble streamflow predictions from the Interim Guidelines SEIS.

information on the sediment model can be found below and in **Section 3.4**, Geomorphology/Sediment.

- For traces in which monthly volumes were modified to accommodate HFE releases or flow spikes, updates were made to Lake Powell elevations during the intervening months based on the rules embedded in the Colorado River Simulation System (CRSS) and reported in the revised elevations tab.
- The smallmouth bass model was then rerun to determine the expected smallmouth bass lambda (rate of population growth) value and, when appropriate, the monthly bypass required under a given scenario.
- To maximize the value of hydropower, an optimization algorithm was run and given a series of constraints to determine the hydropower value in each month that differed among alternatives. This algorithm required the input of monthly outflow volumes and elevations, details regarding potential HFE releases (such as duration and magnitude), potential flow spikes (number and magnitude), and any potential extra bypass for cold-water alternatives. The output was expressed as hourly releases.
- Sediment, riparian vegetation, aeolian transport, recreation economics, and water quality (CE-QUAL-W2) models were then run using the generated hourly releases.
- Smallmouth bass lambda estimates were also modified to include the effects of fine-scale variation in flow, when necessary (that is, when lambda was greater than 1 without these adjustments).
- In addition, WAPA used the modeled monthly hydrologic data to run the Generation and Transmission Maximization (GTMax) model. NREL, in coordination with WAPA, also modeled impacts on hydropower resources using the Plexos model. Additional information on both models is included in **Section 3.3**, Energy and Power.

**Glen Canyon Dam operational and regulatory constraints considered:**

- For the purposes of modeling, the initiation of the action alternatives would only begin if observed water temperatures at either river mile 15 or river mile 61 are at or above 15.5°C (60°F).
- If observed water temperatures at either river mile 15 or river mile 61 are below 15.5°C (60°F), it would not be necessary to implement the proposed actions.
- Dam operations under the emergency exception criteria will continue as needed and as outlined in the 2016 LTEMP FEIS (DOI 2016a).
- There would be a minimum release of 2,000 cfs through the penstocks at all times.
- Modeling of bypass releases that use the river outlet works[10] would seek to adhere to current guidelines, including the Interim Operating Guidance discussed in **Section 1.9**, to the extent possible, recognizing that limits to bypass use are subject to change as Reclamation learns more about the appropriate limits at different elevations.

[10] River outlet works are dam structures that conduct water from the reservoir through the dam and bypass the power-generating penstocks. The Glen Canyon Dam river outlet works elevation is approximately 3,370 feet. The river outlet works are also known as bypass tubes or jet tubes.

- For all alternatives, the assumed total release maximum ramp rates are 4,000 cfs per hour up and 2,500 cfs per hour down; these rates are consistent with the 2016 LTEMP FEIS.
- A minimum total release of 8,000 cfs during the day (7:00 a.m. to 7:00 p.m.) and 5,000 cfs at night, consistent with LTEMP, is assumed for all cold-water alternatives. A minimum total release of 2,000 cfs is assumed for the Non-Bypass Alternative.
- Per WAPA's requirements, a minimum of 40 megawatts (MW) of generation must be maintained to stabilize electrical grid requirements. The release volume to maintain 40 MW changes depending on the water surface elevations at Lake Powell. Current conversion estimates to maintain 40 MW correspond to a 1,300-cfs minimum discharge. Electrical grid stabilization releases will average minimum releases of 5,000 or 8,000 cfs,[11] according to the ROD requirements.

**General high-flow implementation modeling details:**

- The Sand Routing Model (SRM), developed by Wright et al. (2010), was used to calculate sand mass balance. The GCMRC wrote code that selects HFE magnitude and duration, selected via iteration according to the sand mass balance. The gc also redistributes monthly volumes, if necessary, and interfaces with the SRM by generating synthetic 15-minute hydrographs.
- HFE releases would be implemented in November or April, or both, depending on the alternative. Under the 1-year sediment accounting window, decision-makers can choose to implement an HFE release in the fall or spring depending on the information available at that point. For modeling purposes, it is assumed that a spring HFE release is preferred to a fall HFE release; a spring HFE release would be selected if modeling as of November 1 indicates that the release would be equal to or one duration level lower than the fall HFE release would be in that year.

  For the alternatives that include flow spikes, if a spring HFE release is selected and flow spikes are scheduled to occur in May or June, implementing the HFE release on April 15 (default) was compared with implementing it in place of the first flow spike, using sediment inputs up to April 1. For modeling purposes, if the durations are equal or within one duration level, the HFE release is implemented in place of the first flow spike.
- It is assumed that no HFE releases would be implemented below a Lake Powell elevation of 3,500 feet, as the HFE magnitude would be below 37,000 cfs, and a release could increase the risk of going below the power pool elevation of 3,490 feet. The power pool elevation is the depth below which the dam can no longer produce power. Under the 1-year window, if an HFE release were triggered but not implemented due to this constraint, and there were no other HFE releases in the accounting window, a positive sand mass balance would be carried over into the next accounting window.

[11] In addition to daily scheduled fluctuations for power generation, the instantaneous releases from Glen Canyon Dam may also fluctuate to provide 40 MW of system regulation. These instantaneous release adjustments will stabilize the electrical generation and transmission system and translate to a range of approximately 1,300 to 1,500 cfs above or below the hourly scheduled release rate. Under the system's typical conditions, fluctuations for regulation are typically short lived and generally balance out over the hour with minimal or no noticeable impacts on downstream river flow conditions.

- If HFE or flow spike implementation, plus base releases of 16 thousand acre-feet (kaf) per day (the minimum required under LTEMP), result in a monthly volume higher than the initially specified monthly release volume, volume would be borrowed from other months and added to the implementation month. For the months being borrowed from, flow would be reduced to a minimum of 16 kaf per day.

  For a fall HFE release, if the reservoir elevation at the end of the implementation month is 3,530 feet or higher, the order in which volumes would be borrowed from other months would be April, March, May, February, December, and January. If the elevation is lower than 3,530 feet, the order would be the same; however, May would be excluded. This is because borrowing from May to release water sooner could diminish the April end-of-month elevation. If, after going through all borrowing months, the implementation month still does not have sufficient volume, the adjustment process would be repeated, using LTEMP minimum flows of approximately 13.1 kaf per day. If there is still not sufficient volume, the HFE duration would be reduced to the next duration level as a last resort.

  For modeling purposes, for an April HFE implementation, the borrowing-month order would be April, March, May, June, September, August, then July. For implementation in May, June, July, August, or September, the order would be the same as above, except the implementation month would be borrowed from before any other month. Actual borrowing-month order is subject to change based on hydrologic conditions.
- Modeling of HFE releases uses modified combined river outlet works capacity at operating elevations below 3,600 feet, per current operational constraints. Actual implementation may involve slightly different magnitudes based on operational constraints.
- When monthly volumes were altered, CRSS equations for Lake Powell were rerun between the first and last modified month to create elevations that were as accurate as possible; however, for all months after the last modified month, CRSS was not rerun.

**Specific high-flow implementation modeling details:**

- The initial condition for SRM (bed thicknesses and bed grain size distribution) was based on an SRM model run from September 1, 2002, to October 1, 2023, using sediment inputs and gage discharges downloaded from the GCMRC website (GCMRC 2023a).
- For alternatives that do not include flow spikes, releases were assumed to be implemented on November 15 (the fall HFE) and April 15 (the spring HFE). However, if flow spikes occur in May or June and a spring HFE release has been triggered, the HFE release may be delayed until the first month of flow spike implementation, if the duration for the later implementation date is within one duration level of the earlier date. When selecting HFE duration, Paria River sand inputs up to the first of the implementation month are considered, and a 90 percent multiplier is used on sand inputs to reflect the "lower bound" estimate. For the 1-year accounting window, the initial decision to implement a fall versus spring HFE release is assumed to occur on November 1 based on sediment inputs to that point. If a spring HFE release is selected, the duration is revised based on inputs up to the first of the implementation month. After the appropriate HFE duration is selected, SRM is rerun with the full sediment inputs.

- Possible HFE durations are 250, 192, 144, 96, 72, 60, 48, 36, 24, and 12 hours. The possibility of HFE releases under 12 hours was not analyzed; this is because such short durations are unlikely to be sufficient for sandbar building, and they could result in adverse erosion. Please note that short-duration HFE releases are still implementable under the original LTEMP ROD. However, they would not provide much sandbar building (Salter 2024) and, therefore, were not analyzed in this modeling effort. Following LTEMP, the 250-hour option is part of the extended-duration, fall HFE releases and cannot occur until a 192-hour HFE release is conducted. If an HFE release longer than 96 hours is run in the fall, no spring HFE releases can be run. The HFE with the longest possible duration resulting in a positive sand mass balance for Marble Canyon for the accounting period is the selected HFE. Under the No Action Alternative, the accounting period runs July 1 to November 30, and December 1 to June 30. For the 1-year window, the mass balance between July 1 and the termination of the HFE is used when selecting the HFE duration, with the possibility of sediment carryover from the previous year(s) if an HFE release was triggered but not implemented (for instance, due to low reservoir elevation).
- Each of the 30 hydrologic traces is randomly assigned a trace of Paria River sediment inputs derived from the October 1996 to September 2023 record. Assuming that on October 1, 2023, the trace loops back around to October 1996, for the 30 hydrologic traces starting in 1991, the Paria trace starting years are as follows: (1) 1998, (2) 2010, (3) 2022, (4) 2001, (5) 2014, (6) 2000, (7) 2002, (8) 2015, (9) 2008, (10) 1999, (11) 2018, (12) 2003, (13) 2004, (14) 1996, (15) 2012, (16) 2006, (17) 2005, (18) 2013, (19) 2011, (20) 2007, (21) 2019, (22) 1997, (23) 2016, (24) 2020, (25) 2009, (26) 2021, (27) 2017, (28) 1997, (29) 2000, and (30) 2019. Hence, differences between traces are due to a combination of the hydrology and the specific trace of sediment inputs.
- HFE magnitude is based on the combined bypass and penstock capacities. Bypass releases are based on operational constraints, including the 2024 Technical Memo on Operating Guidelines during Low Reservoir Levels (Reclamation 2024b). Penstock capacities are taken from the CRSS model.
- SRM uses 15-minute-interval hydrographs. For simplicity, a synthetic dam release hydrograph was generated using hourly data and used within SRM as if it were the discharge at river miles 30 and 61. (SRM uses river mile 87 as well to calculate eastern Grand Canyon mass balance, but this information is not needed in the present modeling because only Marble Canyon mass balance is considered.) The synthetic hydrograph is generated by assuming the maximum discharge fluctuations under LTEMP, with a cap at 25,000 cfs or the maximum penstock release, whichever is lower. The daily pattern is assumed to be 12 hours on a steady daily minimum release, with a 4,000 cfs per hour ramp up and 2,500 cfs per hour ramp down to a steady daily maximum release. If, however, the minimum release based on the above is below 8,000 cfs, the modeling assumes 12 hours on maximum release, with again 4,000 cfs per hour ramp up and 2,500 cfs per hour ramp down to a steady daily minimum release; this is to avoid going below the LTEMP minimum daily releases, which must be at minimum 8,000 cfs for a full 12 hours. The hydrograph defined above is used in the initial modeling to determine HFE release dates and durations, but the final resource model runs will use refined hydrographs based on hydropower modeling.

**General smallmouth bass modeling details:**

- The cold-water alternatives are designed to target smallmouth bass (*Micropterus dolomieu*); however, other warmwater nonnative fish species with similar temperature requirements are likely to be reduced under the cold-water alternatives smallmouth bass flow options.
- Water temperatures of 16°C (61°F) or greater are typically required for smallmouth bass to lay eggs and for YOY to grow significantly, if hatched. Growth of smallmouth bass at temperatures of 16°C (61°F) is marginal, such that if a fish were hatched and maintained at approximately 16°C (61°F) for the length of a typical growing season, it would be very unlikely to grow large enough to survive the winter (Shuter et al. 1980; Dudley and Trial 2014). Because of uncertainty in temperature forecasts, target temperatures of 15.5°C (60°F) are used to trigger the timing and magnitude of flows. All smallmouth bass flows alternatives, including the Non-Bypass Alternative, were triggered by this target temperature. For the cold-water alternatives, impacts were analyzed under different scenarios in which the target temperature was calculated either at river mile 15 or river mile 61.
- Glen Canyon Dam release temperatures (using the penstocks, bypass, or a combination) used in the smallmouth bass population growth model are estimated for every day of the year using a model that relies on spring inflow (April–July) into Lake Powell, the day of year, and the depth as predictors. The model was fitted to 225 Lake Powell temperature profiles from 2000 through 2021 (Eppehimer et al., forthcoming).[12]
- Downriver warming of water released from Glen Canyon Dam is estimated using a model developed by Dibble et al. (2021) and adapted from a monthly to daily scale by calculating the average daily solar radiation (insolation) and daily air temperatures from the Page, Arizona, weather station. Reservoir release temperatures are most influential above river mile 88, while a combination of discharge, shortwave radiation, and air temperature becomes more important farther downstream (Mihalevich et al. 2020).
- The amount of water that needs to be released through the river outlet works and the penstocks varies based on the elevation of the lake and the distribution of water temperatures through the water column (factors that determine the temperature of the water being released), the time of year (which affects air temperature and solar radiation), and the daily discharge; all of these determine how quickly a given amount of water warms as it travels downriver (Dibble et al. 2021; Mihalevich et al. 2020).
- For modeling of the Cool Mix and Cold Shock Alternatives, it was assumed that river outlet works have a capacity of 3,150 cfs and can be operated at half-tube increments. As described in **Section 1.8**, this reduced capacity is consistent with the Interim Operating Guidance.
- The smallmouth bass population growth model is run on a 16-month time step beginning in January. An inflow, outflow, and elevation for October 2027–April 2028 were added to the model. This timeline was necessary due to the 16-month time step required by the model. It was assumed that 8 maf annual inflows follow monthly volumes determined by a log-transformed linear model fit to 2000–2021 historical inflows. The modeling assumed 7.48 maf annual outflows with monthly volumes determined by LTEMP guidelines. Elevations are calculated using the CRSS water balance equation for Lake Powell, given a starting

[12] This source is scheduled to be published before the public draft. The citation will be updated accordingly.

elevation (September 2027) and subsequent monthly inflows and outflows. Given the minimal variation in monthly inflow and outflow during the October to April intervals and the fact that this period is primarily used to calculate starvation days,[13] which are primarily a function of reservoir elevations. The above assumptions have minimal impact on overall lambda and are not expected to change the bypass required under a smallmouth bass alternative.

- For each year, trace, and scenario within an alternative, the predicted population growth, lambda, was calculated based on predicted water temperatures using the model described in Eppehimer et al. (forthcoming). For alternatives that included flows to increase velocities (e.g., the Non-Bypass Alternative or alternatives with flow spikes), the calculations were adjusted based on the calculated amount of spawning habitat available in Lees Ferry during regular operations that would be expected to be disturbed by flows designed to increase velocity. Spawning habitat was defined as habitat that remained wetted with velocities less than 0.1 meters per second during normal operations. This habitat was expected to be disturbed if disturbance flows either dried the habitat or increased velocities above 0.3 meters per second. Analyses of velocities and wet/dry status were calculated at a 5- by 5-meter resolution from a discharge water velocity model previously developed for the Lees Ferry reach (Kaplinski et al. 2022; Nelson et al. 2016).

**Hydropower modeling assumptions:**

GTMax

- GTMax is an optimization model used by CRSP to estimate power availability, forecast and schedule hourly generation, estimate energy purchases and sales, forecast marketable capacity, and assess other changes in operations. GTMax's primary objective is to meet hourly customer demand. The secondary objective is to minimize costs if purchases are necessary to meet contractual obligations or to maximize revenue if WAPA has more energy than the contractual commitments to sell to the market.
- The model is used to maximize the value of the electric system, taking into account not only its limited energy but also firm contracts, independent power producer agreements, and bulk power transaction opportunities on the spot market.
- The GTMax modeling for this SEIS estimated hourly releases at Glen Canyon Dam. For months when no bypass experiment was implemented, the model calculated hourly values for 1 week each month and then replicated those results for every week of the month.
- In months where a bypass experiment took place, every hour of the month was modeled.
- Lake Powell elevations used to estimate a water-to-power conversion factor were calculated by averaging the end-of-month elevation of the current month with the previous month's end-of-month elevation.
- Peak and off-peak pricing data were estimated using Argus Forward Mid-Market power curves for the Palo Verde hub.

[13] Days that are less than 10°C (50°F)

GCMRC

- This model was developed based on standard constrained optimization methods (Harpman 1999). Modeling efforts included a constrained optimization model, which optimizes Glen Canyon Dam operations based on the observed load following from November 2020 through November 2023. This model used observed operations as a proxy for the scheduling of energy at Glen Canyon Dam by WAPA customers. Energy production was constrained by water availability and operating constraints.
- Elevations were calculated using end-of-month elevations.
- The estimated costs of changes in energy generation at Glen Canyon Dam were developed using the results of the constrained optimization model.
- Hourly pricing parameters were derived by using historical Argus Forward Mid-Market projections for the Palo Verde hub and actual prices from February 2000 through November 2023. Future monthly energy prices were estimated using Argus Forward Mid-Market power curves, adjusted using the estimated parameters, for October 2023 through November 2027.

Model Comparison

- Both models used the same 30 hydrologic traces described above.
- Modeling data were analyzed from January 2024 through September 2027 for both models.
- When implementing high-flow or other experiments, GTMax and the GCMRC model may slightly differ in ramp rates or other hydrograph details.

Plexos

- This model is used to simulate the operation of the electric power system on an hourly basis. Additional information on the Plexos model can be found in **Section 3.3**, and the Plexos modeling report prepared by Argonne (Veselka et al., forthcoming).

## 2.6 No Action Alternative

Reclamation analyzed the No Action Alternative, as it provides an appropriate basis against which to compare the effects of the proposed action. Under the No Action Alternative, there will be no changes to operations at Glen Canyon Dam, as analyzed in the LTEMP ROD. Sediment accounting and HFE implementation will continue as described in the LTEMP ROD (DOI 2016b).

If low reservoir elevations at Lake Powell persist, the No Action Alternative will result in continued warming of water and the spread of smallmouth bass and other warmwater nonnative species in the Colorado River below Glen Canyon Dam. Warmer water temperatures will likely encourage smallmouth bass spawning and will likely result in further population establishment downstream of Glen Canyon Dam. Smallmouth bass are predatory and will likely prey upon native species, including the federally protected humpback chub, potentially impacting the threatened species status of the humpback chub population. Moreover, there is strong evidence from the Upper Basin indicating that smallmouth bass could also have adverse effects on other native fish populations below the dam (Bestgen and Hill 2016b). This includes the small number of federally listed razorback sucker currently in the canyon, along with bluehead suckers, flannelmouth suckers, and speckled dace.

If drought and aridification conditions continue, the No Action Alternative could also result in the continued trend of fewer and smaller HFE releases. The reduced number and magnitude of HFE releases will not optimize the best available science for sediment accounting. The No Action Alternative will not meet the project's purpose or need.

## 2.7 Cool Mix Alternative

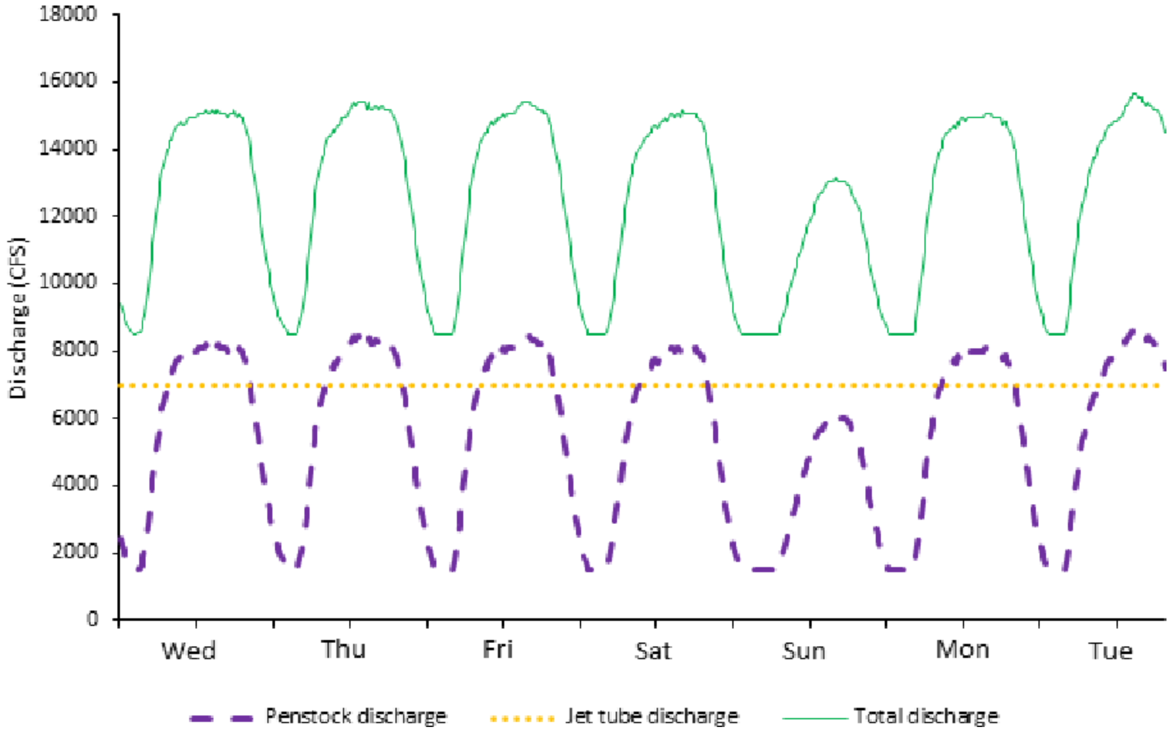
The Cool Mix Alternative would involve strategic water releases from both the penstocks and river outlet works to maintain a daily average water temperature below 15.5°C (60°F) from below the dam to either below Lees Ferry (river mile 15) or the Little Colorado River (river mile 61) (USGS 2022). The quantity of water released through the river outlet works would be determined by predicted temperatures at the river outlet works and penstocks during the flow, ensuring the minimum necessary release to meet the water temperature goal. These temperatures would be monitored using observed data and modeled results as necessary. The release quantity would vary throughout the year, influenced by monthly water volumes and temperature conditions (**Figure 2-1**; USGS 2022).

Within the smallmouth bass model, flows would be triggered when temperatures at the target river mile are predicted to rise above 15.5°C (60°F). This target accounts for variations in water temperature releases and warming rates, increasing the likelihood of maintaining temperatures near or below 15.5°C (60°F) at the target river mile (Dibble et al. 2021; Mihalevich et al. 2020; USGS 2022).

Differences among weeks in a month are most pronounced during June and early July when the temperature profile in Lake Powell is developing. Daily bypass estimates were post-processed to closer align with actual implementation practices. Modeled flows were simulated to occur all month, if they were triggered before the month's halfway mark, and start in the subsequent month, if they were triggered after the halfway mark. Additionally, all days within a month would have bypass equal to the median of the month, with minimal changes observed in overall bypass across traces (USGS 2022). Actual implementation could vary, with the possibility of weekly and daily fluctuations of bypass.

Upon triggering, water would be released from both penstocks and river outlet works to maintain a daily average water temperature below 15.5°C (60°F) at the targeted river mile. Closer to the dam, temperatures are cooler in the main river. The amount of water released through the river outlets would be based on predicted temperatures at the river outlet works and penstocks during the flow, representing the minimum amount of bypass required to meet the water temperature goal (USGS 2022).

**Figure 2-1**
**Conceptual Hydrograph for Cool Mix Alternative**




Source: USGS 2022
Note: This conceptual hydrograph for the Cool Mix Alternative assumes that a monthly volume of about 740,000 acre-feet (af) is being released. Similar hydrographic shapes would be expected at different monthly volumes. The hydrograph begins at midnight between Tuesday and Wednesday and illustrates a full week of operations.

The target temperature of 15.5°C (60°F) below river mile 15 or river mile 61 is highly achievable when all four river outlet works are available and the average daily discharge exceeds 8,500 cfs (USGS 2022). Challenges may arise under specific conditions, such as average daily discharge below 8,000 cfs and penstock temperatures exceeding 23°C (73.4°F). In these cases, maintaining daily average water temperatures below 15.5°C (60°F) may be limited to below the dam through river mile 45 in Marble Canyon. Smaller volumes of water warm more quickly, posing difficulties in releasing sufficient cold water to counteract warming.

This alternative has been modeled to show cooling down to river miles 15 and 61. These two scenarios have been analyzed to show the impacts if smallmouth bass were identified in upper reaches (below Lees Ferry) or farther downstream (Little Colorado River).

## 2.8 Cool Mix with Flow Spike Alternative

For the Cool Mix with Flow Spike Alternative, water would be released through the penstocks and river outlet works to maintain a daily average water temperature below 15.5°C (60°F) from below the dam to Lees Ferry or the Little Colorado River. In this alternative, up to three 8-hour flow spikes could be implemented if sufficient water is available. The flow spike is anticipated to disrupt spawning in margin habitats that may be warmer than the mainstream river. During a flow spike, as much water as possible (up to 45,000 cfs) would be released through the penstocks and river outlet works. Additionally, an HFE release could replace a flow spike if doing so would maximize benefits to sediment and is timed appropriately to affect smallmouth bass spawning (USGS 2022). In practice, flow spikes and HFE releases are essentially the same action: releasing large volumes of water. Flow spikes are initiated based on temperatures, while HFE releases are initiated based on sediment. When temperatures and sediment input are both triggered, a flow spike and an HFE release could serve the same purpose. However, the duration, goals and objectives, and planning and implementation process would vary between the two actions.

The amount of water released during the cool mix phase of the hydrograph would depend on predicted temperatures at the river outlet works and penstocks. The minimum necessary amount would be released through the river outlet works, varying throughout the year based on monthly volumes. Refer to **Figure 2-2** for a conceptual hydrograph of this flow option.

The required release through the river outlet works and penstocks would vary based on the Lake Powell elevation and the distribution of water temperatures through the water column. The water's temperature upon release and the time of year (which affects air temperature and solar radiation) dictate how quickly the water warms downstream (Dibble et al. 2021; Mihalevich et al. 2020).

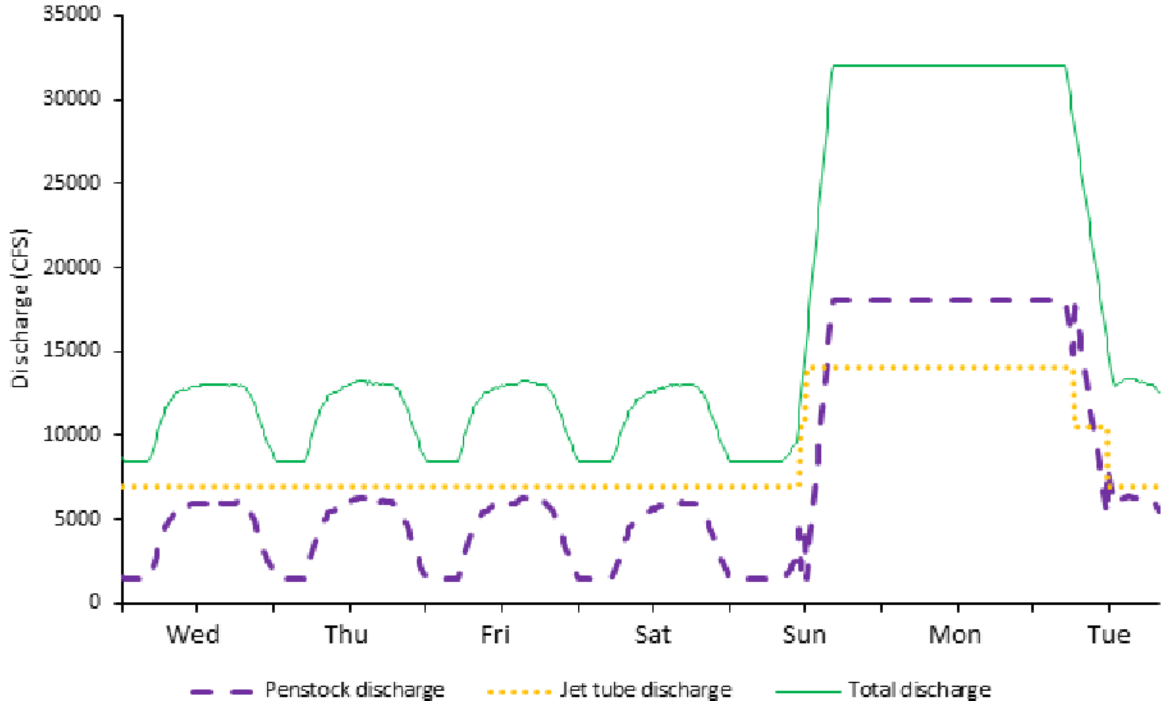
The effectiveness of this alternative at achieving temperature goals, given certain river outlet works availability, would be similar to those outlined in the Cool Mix Alternative.

Flow spikes would likely be implemented in spring/early summer due to the available monthly release volumes and the higher potential to disrupt spawning. Modeling assumes two flow spikes in the first month that smallmouth bass flows are triggered in a given year and one flow spike in the following month (if smallmouth bass flows are still triggered in that month).

The assumed peak discharge during the flow spike is up to 32,000 cfs, based on constraints from the current maintenance schedule. A 32,000-cfs flow spike moves approximately 133,000 af of water over 3 days; this is approximately 94,000 af more than the minimum base operations. Consequently, the minimum monthly volume required for two flow spikes would be approximately 590,000 af (USGS 2022). If additional water were available for the flow spike, the volume would need to be recalculated.

This alternative has been modeled to show cooling down to river mile 15 and river mile 61. These two scenarios have been analyzed as sub-alternatives to show what the impacts would be if smallmouth bass were identified in upper reaches (below Lees Ferry) or farther downstream (Little Colorado River).

**Figure 2-2**
**Conceptual Hydrograph for Cool Mix with Flow Spike Alternative**



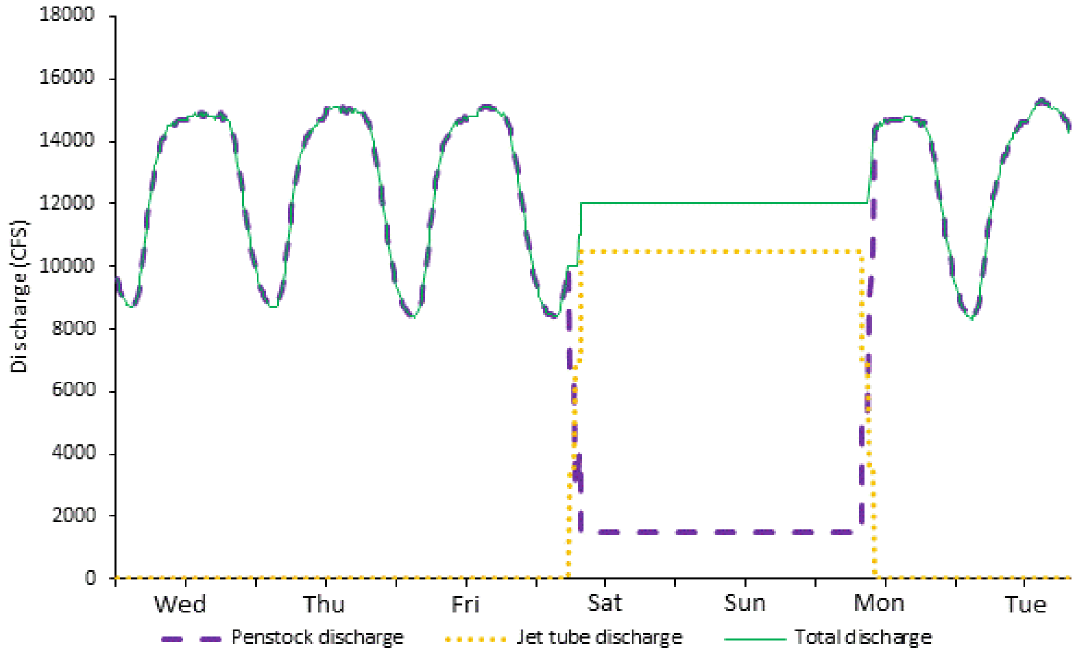

Source: USGS 2022
Note: This conceptual hydrograph for the Cool Mix with Flow Spike Alternative assumes a monthly release volume of approximately 740,000 af. Similar hydrographic shapes would be expected at different monthly volumes. The hydrograph begins at midnight between Tuesday and Wednesday and illustrates a full week of operations. During the other 3 weeks of the month, daily releases would be similar to the first 4 days shown on the above hydrograph. If a second flow spike were added per month while maintaining operations, an additional 68,000 af of water would be required. Alternatively, the average daily discharge on nonflow spike days could be lowered from approximately 10,920 cfs to approximately 9,550 cfs to allow two flow spikes while maintaining a monthly release of approximately 740,000 af. While days of the week are depicted in this conceptual hydrograph, they are not fixed and would be determined by the implementation team. Please note that the above figure shows a 36-hour flow spike, which was initially included in the SMB EA; this SEIS proposes 8-hour flow spikes. The concept and shape of the hydrograph remain the same.

## 2.9 Cold Shock Alternative

For the Cold Shock Alternative, the release of water through the river outlet works is designed to induce a short-duration cold shock, targeting temperatures of 13°C (55.4°F) or below at Lees Ferry or the Little Colorado River to disrupt smallmouth bass spawning and rearing (Henderson and Foster 1957; Rawson 1945; Latta 1963).

In the smallmouth bass model, flows would be activated when temperatures at the targeted river mile are forecasted to rise above 15.5°C (60°F). Flows would aim to disrupt spawning behavior through a rapid and sustained cooling of the river. Refer to **Figure 2-3** for a conceptual hydrograph of this alternative.

**Figure 2-3**
**Conceptual Hydrograph for Cold Shock Alternative**




Source: USGS 2022
Note: This conceptual hydrograph for the Cold Shock Alternative assumes that approximately 740,000 af and at least three river work outlets are available in June. Similar hydrographic shapes would be expected at different monthly volumes. The hydrograph begins on the midnight between Tuesday and Wednesday and illustrates a full week of operations. Operations would be the same for all weeks in the month.

Cold shocks were simulated to occur throughout the entire month if smallmouth bass flows were triggered before the halfway mark of a month. If triggered after the halfway mark, simulations began in the subsequent month.

Upon triggering, cold shocks could be executed every weekend for up to a total of 12 weekends, each lasting 48 hours. The transition to normal flows would occur outside these implementing weekends. In the simulation of the cold-shock alternatives, up to 12,600 cfs was assumed to be released as bypass, recognizing that the actual capacity for long-term releases could vary slightly based on operational constraints. Within a month, the calculated bypass for cold shocks is the minimum required, tested in half-tube increments, to lower the temperature below 13°C (55.4°F) at the targeted river mile on all weekends or 12,600 cfs if a lesser volume fails to meet this condition. Hydropower releases during the cold shock are consistently assumed to be 2,000 cfs.

Under certain extreme high-temperature scenarios (for example, greater than 23°C [73.4°F]), it may not be possible to reach the desired target temperatures based on release temperatures and the availability of river outlet works (USGS 2022).

This alternative has been modeled to show cooling at both river mile 15 and river mile 61. These two scenarios have been analyzed as sub-alternatives to demonstrate the impacts if smallmouth bass were identified in upper reaches (below Lees Ferry) or farther downstream (Little Colorado River).

## 2.10 Cold Shock with Flow Spike Alternative

For the Cold Shock with Flow Spike Alternative, water would be released through the river outlet works for a minimum of 48 hours to induce a cold shock downstream to either Lees Ferry or the Little Colorado River. In addition, up to three 8-hour flow spikes could be implemented if sufficient water is available. The flow spikes aim to disrupt spawning in margin habitats, which are potentially warmer than the mainstem river. As much water as possible, up to 45,000 cfs, would be released through penstocks and river outlet works during flow spikes. This flow spike could be replaced by an HFE release if it maximizes benefits to sediment and is appropriately timed to impact smallmouth bass spawning. A conceptual hydrograph is provided for this alternative in **Figure 2-4**.

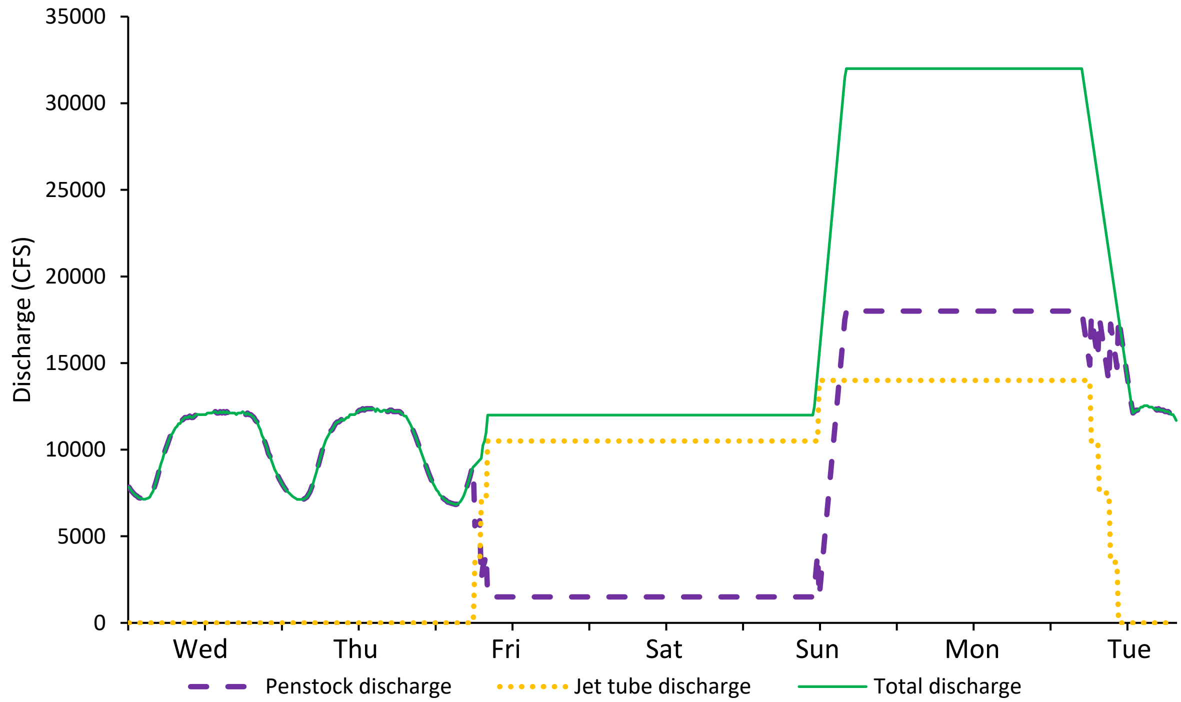
This option would commence when daily water temperatures at the Little Colorado River reach 15.5°C (60°F), providing weekly 48-hour cold-shock releases and at least one 8-hour spike flow, lasting up to 12 weeks. The cold shock, transitioning into the flow spike for that given week, is integral to this alternative.

The quantity of water released through the river outlet works during the cold-shock phase would be based on predicted temperatures at the river outlet works and penstocks during the flow. The minimum water required to meet the temperature goal would be released through the river outlet works, considering constraints due to operations and maintenance. The release amount could vary throughout the year based on water temperatures at river outlet works and penstock depths. Releases on other days would primarily align with the monthly volume. The water release needed to meet the temperature goal varies based on lake elevation and water temperature distribution through the water column. The released water's temperature and the time of year (which affects air temperature and solar radiation) influence how quickly it warms downstream (Dibble et al. 2021; Mihalevich et al. 2020).

The effectiveness of this alternative at achieving temperature goals, given certain river outlet works availability, would be similar to those outlined in the Cool Mix Alternative.

Under alternatives with flow spikes, these spikes are expected to be most effective if timed earlier in the potential reproductive cycle of smallmouth bass. For modeling purposes, it was assumed that there would be two flow spikes in the first month that smallmouth bass flows were triggered in a given year, and one flow spike in the following month if smallmouth bass flows were still triggered. Flow spikes would only occur during the months of May, June, July, August, and September, as during this period the margin habitat is typically warmer than the mainstream river. These considerations ensure a comprehensive understanding of the flow option's impact on smallmouth bass spawning (USGS 2022).

**Figure 2-4**
**Conceptual Hydrograph for Cold Shock with Flow Spike Alternative**




Source: USGS 2022
Note: This conceptual hydrograph for the Cold Shock with Flow Spike Alternative assumes approximately 740,000 af are available in June, all four river outlet works are available, and there is one flow spike per month. Similar hydrographic shapes would be expected at different monthly volumes. The hydrograph begins on midnight between Tuesday and Wednesday and illustrates a full week of operations. For the other 3 weeks of the month (without flow spikes), the first part of the hydrograph would be the same as the first 4 days of the week (baseline plus cold shock) but would include 3 additional days of baseline releases in place of the flow spike. Please note that the above figure shows a 36-hour flow spike, which was initially included in the SMB EA; this SEIS proposes 8-hour flow spikes. The concept and shape of the hydrograph remain the same.

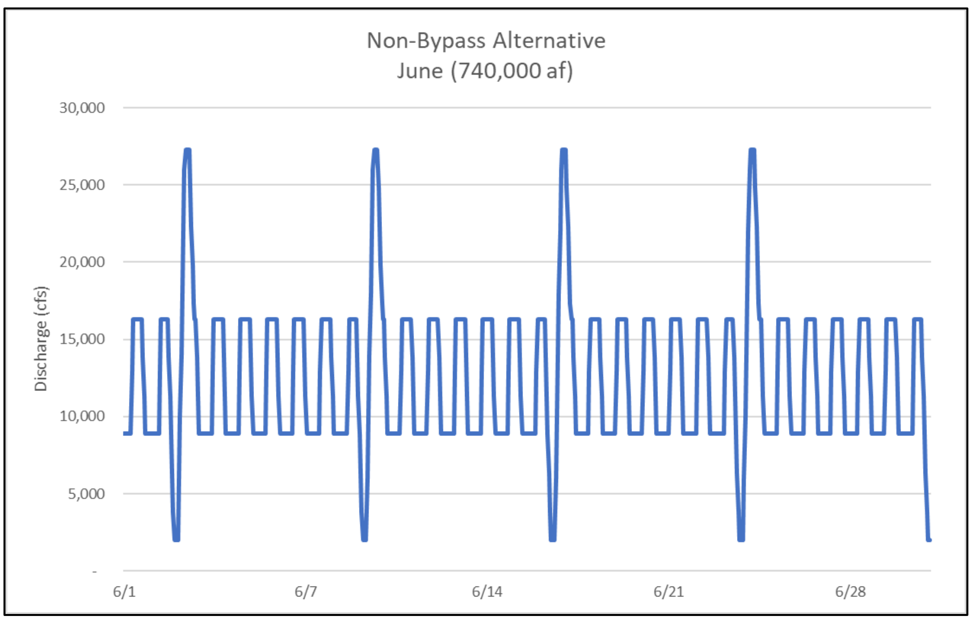
This alternative has been modeled to show cooling down to both river mile 15 and river mile 61. These two scenarios have been analyzed as sub-alternatives to demonstrate the impacts if smallmouth bass were identified in upper reaches (below Lees Ferry) or farther downstream (Little Colorado River).

## 2.11 Non-Bypass Alternative

The Non-Bypass Alternative proposes a hydrograph centered on strategically employing substantial river stage changes that are targeted along the Lees Ferry reach to disrupt smallmouth bass nests and spawning activities below Glen Canyon Dam. This alternative consists of a once-weekly, short-duration, low-flow release immediately followed by a short-duration high flow. The low-flow release is meant to dewater shallow nesting areas along shorelines or in backwaters and sloughs. The high-flow release is meant to increase water velocities in nesting areas in deeper habitats that are not dewatered during the low flow. The design of this alternative is such that the short-duration, low-flow, and high-flow releases are largely attenuated by the time the flow wave reaches the confluence with the Little Colorado River. This alternative is predicated on the flow fluctuations that reduced rainbow trout reproduction during the pre-ROD period (1965–1991) to the point where the fishery could only be maintained through stocking (McKinney et al. 1999a).

The low-flow release would begin on Sunday nights at 9:00 p.m. local time and last until 1:00 a.m. Beginning Monday morning at 1:00 a.m., releases would begin ramping up and reach a maximum powerplant release (that is, approximately 27,300 cfs) by 7:00 a.m. Releases would remain at a maximum powerplant release until 11:00 a.m. when releases would begin to down-ramp back into normal operations for the rest of the week. The treatment would be repeated weekly once water temperatures are forecasted to rise above 15.5°C (60°F) in areas where smallmouth bass are observed spawning (for example, the -12 mile slough) to disrupt renesting. Potential off-ramp conditions would be monitored and considered to determine if conditions warrant ending any experimental flows, as determined through the planning and implementation process. Off-ramps could include data showing that smallmouth bass population growth has increased or showing long-term unacceptable adverse impacts on resources identified above. **Figure 2-5** shows a conceptual hydrograph of the Non-Bypass Alternative.

**Figure 2-5**
**Conceptual Hydrograph of the Non-Bypass Alternative**

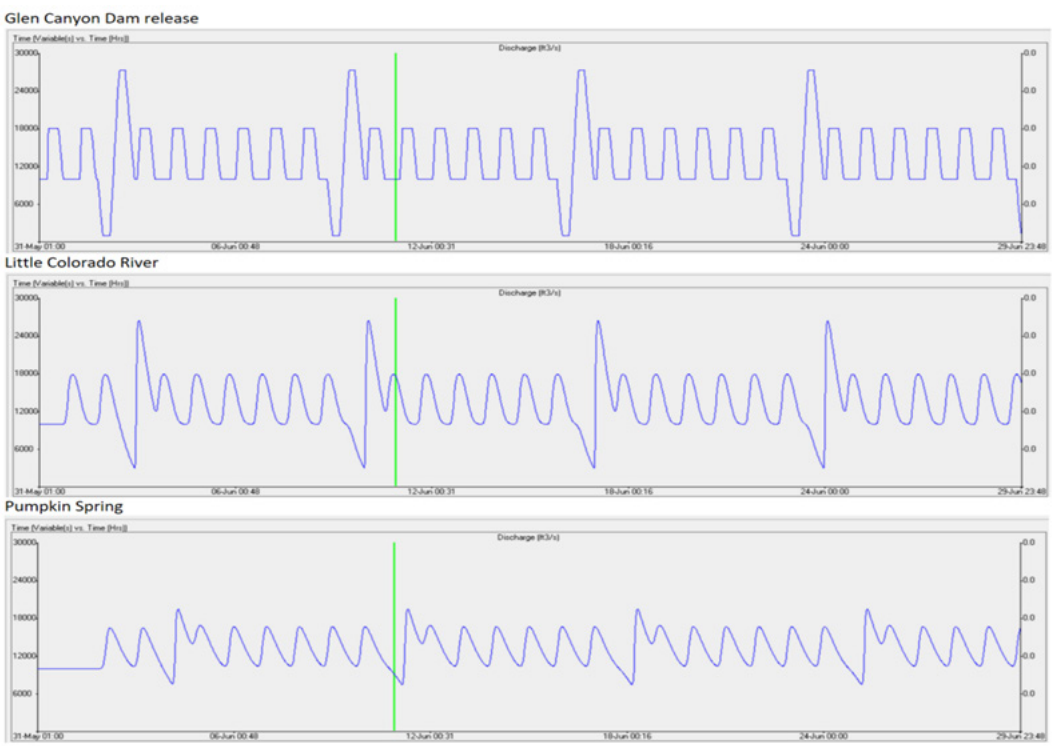



Source: WAPA 2023
Note: This conceptual hydrograph for the Non-Bypass Alternative assumes approximately 740,000 af are available in June. Similar hydrographic shapes would be expected at different annual volumes. This graph shows the repeated low- and high-flow release combinations at the start of each week, beginning Sunday night and ending Monday afternoon. The magnitude of the trough and spike would diminish as the releases travel downstream.

Under the Non-Bypass Alternative, flows could drop as low as 2,000 cfs and rise as high as approximately 27,300 cfs. The minimum flows proposed under this alternative fall below those developed in the LTEMP ROD (5,000 cfs at night and 8,000 cfs during the day). This alternative would exceed the maximum daily range of 8,000 cfs analyzed in the LTEMP ROD. Modeled ramp rates were slightly outside the LTEMP requirements. Actual ramp rates would be within the operating range of the LTEMP ROD.

The fluctuations shown in **Figure 2-5** were designed to disrupt the smallmouth bass spawning at river mile 61. This alternative could be adjusted during the planning and implementation process to target different river miles. As the water from the low-flow and high-flow releases travels downstream, the magnitude of both would diminish due to additional river inputs and the progression of low flow to high flow, which would aid in "collapsing" the trough or minimizing downstream changes to river stage. This diminishing of the flow magnitude is depicted in **Figure 2-6**. Under this scenario, the trough is almost entirely collapsed by river mile 213.

**Figure 2-6**
**Non-Bypass Alternative Flow Modeling of "Collapsing" Trough**




Source: WAPA 2023 using a flow routing model based on Wiele and Smith 1996
Note: Flow modeling using the Colorado River Flow, Stage, and Sediment model showing the release wave created by the Non-Bypass Alternative treatment at Glen Canyon Dam (top panel), at river mile 61 at the Little Colorado River (middle panel), and at river mile 213 at Pumpkin Spring (bottom panel).

# 2.12 Alternatives Considered but Eliminated from Detailed Analysis

## 2.12.1 HFE Only Alternative

The HFE Only Alternative describes a set of actions aimed at better implementation of HFE releases, as outlined by the LTEMP ROD, utilizing the best available science for sediment accounting. This alternative would change both the sediment accounting windows and HFE implementation periods with the goal of utilizing improved ways to assess sediment inputs and sediment retention that may affect the frequency of HFE releases. This alternative did not meet the purpose and need because it did not address the issue of smallmouth bass.

# 2.13 Summary Comparison of Alternatives

**Table 2-1**
**Summary Comparison of Alternatives**

| Alternative | Description |
|---|---|
| **No Action Alternative** | This alternative will maintain existing water release operations at Glen Canyon Dam. This could lead to continued warming of the Colorado River below Glen Canyon Dam. If drought and aridification conditions continue, it could potentially foster smallmouth bass and other warmwater invasive fish species spawning. These warmwater invasive species could negatively impact the federally protected humpback chub through predation or competition for resources. This alternative will not meet the project's purpose or need. |
| **Cool Mix Alternative** | The Cool Mix Alternative would strategically release water mixed from the penstocks and river outlet works to maintain a daily average water temperature below 15.5°C (60°F) from Glen Canyon Dam to either Lees Ferry or the Little Colorado River. The release quantity would vary based on predicted temperatures and monthly water volumes. Implementation would occur weekly when river temperatures exceed 15.5°C (60°F) until the river temperatures drop below 15.5°C (60°F). The goal is to interrupt smallmouth bass spawning by reducing water temperature below the level when smallmouth bass initiate spawning. |
| **Cool Mix with Flow Spike Alternative** | This alternative would operate in a manner similar to the Cool Mix Alternative, by disrupting smallmouth bass spawning. It would include up to three 8-hour flow spikes to disrupt spawning through a change in water velocity near smallmouth bass nests, in addition to those under the Cool Mix Alternative. If implemented, flow spikes would release water through penstocks and river outlet works to maintain the target temperature in margin habitats, such as the -12 mile slough. Implementation would occur weekly when river temperatures exceed 15.5°C (60°F) until the river temperatures drop below 15.5°C (60°F). |

| Alternative | Description |
|---|---|
| **Cold Shock Alternative** | The Cold Shock Alternative would induce a cold shock, targeting temperatures of 13°C (55.4°F) or below at either Lees Ferry or the Little Colorado River to disrupt smallmouth bass spawning. Flows would be triggered when temperatures rise above 15.5°C (60°F) and would occur on a weekly schedule for 12 weekends. The release amount would vary based on temperature conditions and capacity considerations. Implementation would occur weekly when river temperatures exceed 15.5°C (60°F) until the river temperatures drop below 15.5°C (60°F). |
| **Cold Shock with Flow Spike Alternative** | Combining cold shocks and flow spikes, this alternative would be initiated when daily water temperatures at either Lees Ferry or the Little Colorado River reach 15.5°C (60°F). It would include weekly 48-hour cold-shock releases and up to three 8-hour flow spikes. The release quantity would be based on predicted temperatures, with flow spikes aiming to disrupt spawning in margin habitats. Implementation would occur weekly when river temperatures exceed 15.5°C (60°F) until the river temperatures drop below 15.5°C (60°F). |
| **Non-Bypass Alternative** | Focusing on smallmouth bass nesting habits, the Non-Bypass Alternative would propose a hydrograph with substantial stage changes to disrupt smallmouth bass spawning. It would suggest a weekly treatment schedule, combining low and high flows to desiccate nests in shallow water and scour nests in deeper areas. Implementation would occur when river temperatures exceed 15.5°C (60°F) until the river temperatures drop below 15.5°C (60°F). |

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## 2.14 Summary of Potential Effects

**Table 2-2**
**Summary of Potential Effects**

| Resource | No Action Alternative | Cool Mix Alternative | Cool Mix with Flow Spike Alternative | Cold Shock Alternative | Cold Shock with Flow Spike Alternative | Non-Bypass Alternative |
|---|---|---|---|---|---|---|
| Hydrologic Resources | Operations at Glen Canyon Dam will not change; this means there will be no changes to the hydrology. Reservoir elevations and release volumes will follow current trends. | Impacts on system hydrology under the Cool Mix Alternative would be temporary and would not exceed the cumulative impacts on water resources as identified in the 2016 LTEMP FEIS. | Increased flow rates from the flow spikes would temporarily decrease water surface elevations in Lake Powell; however, the elevations would be restored to previous elevations depending on inflows. No long-term impacts on hydrology are anticipated. | Impacts on system hydrology under the Cold Shock Alternative would be temporary and would not exceed the cumulative impacts on water resources as identified in the 2016 LTEMP FEIS. | Increased flow rates from the flow spikes would temporarily decrease water surface elevations in Lake Powell; however, elevations would be restored to previous elevations, dependent on inflows. No long-term impacts on hydrology are anticipated. | The minimum and maximum proposed flows would exceed the maximum daily range, as developed in the LTEMP ROD. However, monthly and annual release volumes would be the same as those under the cold-water alternatives. |
| Water Quality | Operations at Glen Canyon Dam will remain unchanged. Therefore, the water released from the penstocks will remain warm, with a lower DO concentration. The increase in temperature and salinity will continue to follow current trends. | Cool mix operations would result in decreased total release temperature during summer periods when bypass would be utilized, and temperatures would remain cooler over a longer duration compared with cold shock operations. Cool mix operations would lead to an increase in salinity compared with the No Action Alternative but would remain lower than the early spring concentration peaks, so the increase would be minimal. In years under which an experiment would be implemented, low DO events would be less probable than under the No Action Alternative and the cold-shock operations. | Impacts on temperature, salinity, and DO would be similar to those under the Cool Mix Alternative. The flow spike would further reduce release temperature, but this change would be minimal. The flow spike would also lead to a further increase in salinity, but salinity would remain lower than the early spring salinity concentration peaks so the increase would be minimal. | Cold-shock operations would result in decreased total release temperature during summer periods when bypass would be utilized. The duration of cold releases would be more effective at reducing the total release temperature than under the cool mix operations. Cold-shock operations would lead to an increase in salinity compared with the No Action Alternative and cool mix operations but would remain lower than the early spring concentration peaks, so the increase would be minimal. In years under which an experiment would be implemented, low DO events would be similar to the No Action Alternative. | Impacts on temperature, salinity, and DO would be similar to those under the Cold Shock Alternative. The flow spike would further reduce release temperature, but this change would be minimal. The flow spike would also lead to a further increase in salinity, but salinity would remain lower than the early spring salinity concentration peaks so the increase would be minimal. | Impacts on temperature, salinity, and DO would be similar to those under the No Action Alternative since the Non-Bypass Alternative would not involve the use of Glen Canyon Dam's bypass system and would instead focus on changes in release volumes. |
| Air Quality | Operations at Glen Canyon Dam will not change; this means hydropower generation from the facility will remain consistent with historical levels. No changes in air quality will occur from replacing any portion of the electric generation from the facility with sources that create emissions of air pollutants. | Due to the changes proposed under this alternative, the amount of hydropower generated at the Glen Canyon Dam Powerplant would be reduced. The reduction in generation would need to be replaced by other sources of generation on the grid in the impact analysis area, which is the 11-state Western Interconnection region. This region consists of Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. These replacement sources could create increased emissions of air pollutants, compared with the generation at | Due to the changes proposed under this alternative, the amount of hydropower generated at the Glen Canyon Dam Powerplant would be reduced. The reduction in generation would need to be replaced by other sources of generation on the grid. These replacement sources could create increased emissions of air pollutants, compared with the generation at Glen Canyon Dam. Compared with the total 2020 emissions within the 11-state impact analysis area, the increased emissions would represent 0.022 percent and 0.015 percent of $SO_2$ and 0.004 | Due to the changes proposed under this alternative, the amount of hydropower generated at the Glen Canyon Dam Powerplant would be reduced. The reduction in generation would need to be replaced by other sources of generation on the grid. These replacement sources could create increased emissions of air pollutants, compared with the generation at Glen Canyon Dam. Compared with the total 2020 emissions within the 11-state impact analysis area, the increased emissions would represent 0.011 percent and 0.008 percent of $SO_2$ and 0.002 | Due to the changes proposed under this alternative, the amount of hydropower generated at the Glen Canyon Dam Powerplant would be reduced. The reduction in generation would need to be replaced by other sources of generation on the grid. These replacement sources could create increased emissions of air pollutants, compared with the generation at Glen Canyon Dam. Compared with the total 2020 emissions within the 11-state impact analysis area, the increased emissions would represent 0.009 percent and 0.007 percent of $SO_2$ and 0.002 | Due to the changes proposed under this alternative, the amount of hydropower generated at the Glen Canyon Dam Powerplant would be slightly increased. This increase in zero-emission hydropower could result in a small reduction in air emissions from other power generation sources in the air quality analysis area, potentially resulting in a negligible improvement in air quality and visibility in the area. |

| Resource | No Action Alternative | Cool Mix Alternative | Cool Mix with Flow Spike Alternative | Cold Shock Alternative | Cold Shock with Flow Spike Alternative | Non-Bypass Alternative |
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| Air Quality *(cont.)* | *(See above.)* | Glen Canyon Dam. Compared with the total 2020 emissions within the 11-state impact analysis area, the increased emissions would represent 0.025 percent and 0.016 percent of sulfur dioxide ($SO_2$) and 0.005 percent and 0.003 percent of nitrogen oxides ($NO_x$) at the Little Colorado River and river mile 15 modeling points, respectively, under the existing grid replacement scenario. The Cool Mix Alternative would result in the largest increase in emissions compared with the No Action Alternative. In the highest emission year under the highest-case emissions scenario, the emissions resulting from the implementation at the Little Colorado River modeling point of this alternative would make up approximately 0.006 percent of emissions of $NO_x$, 0.022 percent of emissions of lead (Pb) components, 0.001 percent of emissions of particulate matter less than or equal to 2.5 microns ($PM_{2.5}$), 0.052 percent of emissions of $SO_2$, and less than 0.001 percent of emissions of carbon monoxide (CO), volatile organic compounds (VOCs), and particulate matter less than or equal to 10 microns ($PM_{10}$) in the 11-state impact analysis area. The additional emissions resulting from the changes proposed under this alternative are not expected to result in any new violation or significant increase in the level of existing violation of any National Ambient Air Quality Standards (NAAQS) or state ambient air quality standards. The changes are not expected to result in any noticeable increase in the levels of visibility impairment at any Class I or Class II areas, including GCNP, GCNRA, and LMNRA. | percent and 0.003 percent of $NO_x$ at the Little Colorado River and river mile 15 modeling points, respectively, under the existing grid replacement scenario. The additional emissions resulting from the changes proposed under this alternative are not expected to result in any new violation or significant increase in the level of existing violation of any NAAQS or state ambient air quality standards. The changes are not expected to result in any noticeable increase in the levels of visibility impairment at any Class I or Class II areas, including GCNP, GCNRA, and LMNRA. | percent and 0.001 percent of $NO_x$ at the Little Colorado River and river mile 15 modeling points, respectively, under the existing grid replacement scenario. The additional emissions resulting from the changes proposed under this alternative are not expected to result in any new violation or significant increase in the level of existing violation of any NAAQS or state ambient air quality standards. The changes are not expected to result in any noticeable increase in the levels of visibility impairment at any Class I or Class II areas, including GCNP, GCNRA, and LMNRA. | percent and 0.001 percent of $NO_x$ at the Little Colorado River and river mile 15 modeling points, respectively, under the existing grid replacement scenario. The additional emissions resulting from the changes proposed under this alternative are not expected to result in any new violation or significant increase in the level of existing violation of any NAAQS or state ambient air quality standards. The changes are not expected to result in any noticeable increase in the levels of visibility impairment at any Class I or Class II areas, including GCNP, GCNRA, and LMNRA. | *(See above.)* |

| Resource | No Action Alternative | Cool Mix Alternative | Cool Mix with Flow Spike Alternative | Cold Shock Alternative | Cold Shock with Flow Spike Alternative | Non-Bypass Alternative |
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| Visual Resources | The existing trends of increasing bank armoring and a narrowing lower riparian zone will continue to affect the area's landscape character; beneficial effects will occur on sandbar building and sediment export when HFE releases are conducted. | Impacts on landscape character would be similar to those described under the No Action Alternative. The HFE releases would continue to contribute to sandbar building and sediment export in the Colorado River, positively affecting the adjacent landscape character, with spring HFE releases resulting in smaller sandbars than under the No Action Alternative. | Increased flow events during flow spikes would be similar to HFE releases, but based on modeling associated with spring HFE releases, these flow spikes would have negligible effects on riparian vegetation and would result in smaller sandbars than under the No Acton Alternative. Overall, landscape character along the Colorado River under this alternative would be similar to that under the No Action Alternative except for smaller anticipated sandbars. | Impacts on landscape character would be similar to those described under the No Action Alternative. The HFE releases would continue to contribute to sandbar building and sediment export in the Colorado River, positively affecting the adjacent landscape character, with spring HFE releases resulting smaller sandbars than under the No Action Alternative. | Increased flow events during flow spikes would be similar to HFE releases, but based on modeling associated with spring HFE releases, these flow spikes would have negligible effects on riparian vegetation and would result in smaller sand bars than under the No Acton Alternative. Overall, landscape character along the Colorado River under this alternative would be similar to that under the No Action Alternative except for smaller anticipated sandbars. | The high- and low-volume flows under this alternative would allow for an increase in native riparian vegetation compared with the No Action Alternative, especially in western Grand Canyon. Based on modeling associated with sandbar building, this alternative would result in smaller sandbars than under the No Action Alternative but larger sandbars than those anticipated under alternatives without flow spikes. Overall, landscape character along the Colorado River under this alternative would be similar to that under the No Action Alternative except for smaller anticipated sandbars and marginally increased native riparian vegetation, including in the western Grand Canyon area. |
| Cultural Resources | No additional positive or negative impacts beyond those analyzed in the 2016 LTEMP FEIS are expected for archaeological sites, HFE releases, and sandbar building. There will be no changes to daily available sediment for aeolian deposits on archaeological sites. | No additional impacts beyond those analyzed in the 2016 LTEMP FEIS are expected for archaeological sites. The daily available sediment would be similar to that under the No Action Alternative. Fewer and shorter HFE releases in the fall and more and longer HFE releases in the spring would result in less sandbar growth than under the No Action Alternative. | No additional impacts beyond those analyzed in the 2016 LTEMP FEIS are expected for archaeological sites. The daily available sediment would be similar to that under the No Action Alternative. HFE releases would be similar to those under the Cool Mix Alternative, but flow spikes may contribute to sandbar growth. | No additional impacts beyond those analyzed in the 2016 LTEMP FEIS are expected for archaeological sites. The daily available sediment would be similar to that under the No Action Alternative. Fewer and shorter HFE releases in the fall and more and longer HFE releases in the spring would result in less sandbar growth than under the No Action Alternative. | No additional impacts beyond those analyzed in the 2016 LTEMP FEIS are expected for archaeological sites. The daily available sediment would be similar to that under the No Action Alternative. HFE releases would be similar to those under the Cold Shock Alternative, but flow spikes may contribute to sandbar growth. | Low flows may expose previously inundated historic properties. The daily available sediment would be similar to that under the No Action Alternative, and HFE probability would fall between that of the cold-water alternatives and that of the cold-water alternatives with flow spikes; however, the non-bypass fluctuations would eventually result in lower sandbar volume. |

| Resource | No Action Alternative | Cool Mix Alternative | Cool Mix with Flow Spike Alternative | Cold Shock Alternative | Cold Shock with Flow Spike Alternative | Non-Bypass Alternative |
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| Geomorphology and Sediment | No additional impacts beyond those analyzed in the 2016 LTEMP FEIS are expected for HFE releases, mass balance, and sandbar building. | Under the 1-year sediment accounting period, fall and spring HFE releases would be equally likely, with the decision to defer fall HFE releases to spring at the discretion of decision makers. Under this alternative, HFE releases deferred to spring would last approximately 60 percent longer than if they were implemented in the fall. Mass balance at Marble Canyon would decline more slowly than under the No Action Alternative, and this would be reflected in relatively gradual sandbar growth and smaller sandbars. | Under the 1-year sediment accounting period, HFE releases would typically be triggered and implemented in the spring. Fall HFE releases would likely be rare. Mass balance at Marble Canyon would decline more slowly than under the No Action Alternative. This would be reflected in relatively gradual sandbar growth and overall smaller sandbars. In some years, flow spikes would cause sand export in the lead-up to HFE implementation, which would reduce the resulting HFE release duration. Flow spikes would decrease mass balance at Marble Canyon by 169 percent for a river mile 15 target and 222 percent for a river mile 61 target. Flow spikes would possibly contribute slightly more volume to sandbars. | Under the 1-year sediment accounting period, fall and spring HFE releases would be equally likely, with the decision to defer fall HFE releases to spring at the discretion of decision makers. Under this alternative, HFE releases deferred to spring would last approximately 60 percent longer than if they were implemented in the fall. Mass balance at Marble Canyon would decline more slowly than under the No Action Alternative. This would be reflected in relatively gradual sandbar growth and smaller sandbars. | Under the 1-year sediment accounting period, HFE releases would typically be triggered and implemented in the spring. Fall HFE releases would likely be rare. Mass balance at Marble Canyon would decline more slowly than under the No Action Alternative. This would be reflected in relatively gradual sandbar growth and overall smaller sandbars. In some years, flow spikes would cause sand export in the lead-up to HFE implementation, which would reduce the resulting HFE release duration. Flow spikes would decrease mass balance at Marble Canyon by 169 percent for a river mile 15 target and 222 percent for a river mile 61 target. Flow spikes would possibly contribute slightly more volume to sandbars. | Under the 1-year sediment accounting period, HFE releases would typically be triggered and implemented in the spring. Fall HFE releases would likely be rare. Mass balance at Marble Canyon would decline more slowly than under the No Action Alternative, but it would decrease more quickly relative to alternatives that would have a 1-year accounting period without large fluctuations. Compared with the No Action Alternative, non-bypass fluctuations would result in relatively gradual sandbar growth and smaller sandbars. Overall, the Non-Bypass Alternative would erode more sand, removing 196 percent more mass balance relative to the No Action Alternative. This alternative would produce less sandbar building relative those modeled under the smallmouth bass flow alternatives with flow spikes. |
| Climate Change | Operations at Glen Canyon Dam will not change hydropower generation from the facility. There will be no change in climate change trends as a result of GHG emissions that would occur from replacing any portion of electric generation with power generated from sources that emit GHGs (for example, coal, oil, and natural gas). | Due to the changes proposed under this alternative, the amount of hydropower generated at the Glen Canyon Dam Powerplant would be reduced. In years under which an experiment would be implemented, the reduction in generation would need to be replaced by other sources of generation within the 11-state Western Interconnection region. Replacement sources, which could include higher-cost sources such as coal, natural gas, and oil, would result in increased GHG emissions compared with the generation at Glen Canyon Dam. At the Little Colorado River and river mile 15 modeling points, increased emissions would represent 0.0039 and 0.0024 percent of total emissions, respectively, under a composite grid scenario, and up to 0.0122 and 0.0077 percent, respectively, under a coal-powered generation scenario. The Cool Mix Alternative would result in the largest increase in emissions compared with the No Action Alternative. | Due to the changes proposed under this alternative, the amount of hydropower generated at the Glen Canyon Dam Powerplant would be reduced. In years under which an experiment would be implemented, the reduction in generation would need to be replaced by other sources of generation within the 11-state Western Interconnection region. Replacement sources, which could include higher-cost sources such as coal, natural gas, and oil, would result in increased GHG emissions compared with the generation at Glen Canyon Dam. At the Little Colorado River and river mile 15 modeling points, increased emissions would represent 0.0034 and 0.0023 percent of total emissions, respectively, under a composite grid scenario, and up to 0.0109 and 0.0075 percent, respectively, under a coal-powered generation scenario. | Due to the changes proposed under this alternative, the amount of hydropower generated at the Glen Canyon Dam Powerplant would be reduced. In years under which an experiment would be implemented, the reduction in generation would need to be replaced by other sources of generation within the 11-state Western Interconnection region. Replacement sources, which could include higher-cost sources such as coal, natural gas, and oil, would result in increased GHG emissions compared with the generation at Glen Canyon Dam. At the Little Colorado River and river mile 15 modeling points, increased emissions would represent 0.0017 and 0.0012 percent of total emissions, respectively, under a composite grid scenario, and up to 0.0055 and 0.0037 percent, respectively, under a coal-powered generation scenario. | Due to the changes proposed under this alternative, the amount of hydropower generated at the Glen Canyon Dam Powerplant would be reduced. In years under which an experiment would be implemented, the reduction in generation would need to be replaced by other sources of generation within the 11-state Western Interconnection region. Replacement sources, which could include higher-cost sources such as coal, natural gas, and oil, would result in increased GHG emissions compared with the generation at Glen Canyon Dam. At the Little Colorado River and river mile 15 modeling points, increased emissions would represent 0.0014 and 0.0011 percent of total emissions, respectively, under a composite grid scenario, and up to 0.0044 and 0.0035 percent, respectively, under a coal-powered generation scenario. | Under the Non-Bypass Alternative, the implementation of high release volumes routed through the generation facility would result in an increase in hydropower generation, compared with the No Action Alternative. In years under which an experiment would be implemented, the increase in generation could replace other sources of generation within the 11-state Western Interconnection region, which would result in reduced emissions. Reduced emissions would represent 0.0007 percent of total 11-state analysis area emissions, assuming power generated would replace a composite of sources, and up to 0.0022 percent of emissions, assuming the power generated would replace coal-powered generation sources. |

| Resource | No Action Alternative | Cool Mix Alternative | Cool Mix with Flow Spike Alternative | Cold Shock Alternative | Cold Shock with Flow Spike Alternative | Non-Bypass Alternative |
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| Aquatic Resources | Smallmouth bass will likely continue to pass through the dam and expand their range and numbers from Glen Canyon Dam to Lake Mead, with an increased risk of predation on native fish. Smallmouth bass model lambda values >1 indicate population growth of smallmouth bass likely below Lees Ferry and near the Little Colorado River. Continued high flows could displace young rainbow trout from shoreline habitats, increase downstream displacement, and reduce food availability. Warm releases could increase incidence of fish parasites. All other resources will be as described in the 2016 LTEMP FEIS but with lower Lake Powell elevations and warmer releases. | Cool temperatures could delay or disrupt maturation and spawning by smallmouth bass, but shoreline pockets of warm water could still provide suitable spawning conditions. Smallmouth bass model lambda values of < 1 indicate population growth of smallmouth bass would be unlikely near Lees Ferry and the Little Colorado River. Other fish species, including rainbow trout, and the aquatic food base have experienced cool releases; therefore, they are not expected to be negatively affected. Cooler temperatures could support higher nutrient concentrations, which could stimulate food base production. | Cool temperatures could delay or disrupt maturation and spawning by smallmouth bass, and flow spikes would potentially displace adults, eggs, and fry, lowering survival. Smallmouth bass model lambda values of < 1 indicate population growth of smallmouth bass would be unlikely near Lees Ferry and the Little Colorado River. Spike flows in May–July could displace juvenile rainbow trout and lead to lower recruitment. These spike flows would not likely affect spawning by rainbow trout. Native fish species may also be affected, but they exist mostly downstream of Glen Canyon. Short-term spike flows would potentially limit food base production; however, cooler temperatures may stimulate food production. | Cold shocks could disrupt and possibly delay maturation and spawning by smallmouth bass, as well as displace eggs and fry; however, the cold shocks may not affect warm pockets along shorelines. Given the short duration of cold shocks, smallmouth bass could still successfully spawn and recruit under this alternative. Thus, smallmouth bass model lambda values of > 1 indicate population growth of smallmouth bass would be likely near Lees Ferry and the Little Colorado River. Cold shock treatments may negatively affect rainbow trout physiology and behavior but are not expected to substantially affect the population in the Lees Ferry reach. Native fish species may also be affected, but they exist mostly downstream of Glen Canyon where cold shocks would be ameliorated. Cold-shock releases would likely negatively affect the aquatic food base. | Cold shocks could disrupt and possibly delay maturation and spawning by smallmouth bass, as well as displace eggs and fry. Flow spikes could displace adults, eggs, and fry in areas where a velocity change results in lower survival. Given the short duration of cold shocks and flow spikes, smallmouth bass could still successfully spawn and recruit under this alternative. Thus, smallmouth bass model lambda values of > 1 indicate population growth of smallmouth bass would be likely near Lees Ferry and the Little Colorado River. Cold shock treatments may negatively affect rainbow trout physiology and behavior but are not expected to substantially affect the population in the Lees Ferry reach. Native fish species may also be affected, but they exist mostly downstream of Glen Canyon where cold shocks and spikes would be ameliorated. Cold-shock releases would likely negatively affect the aquatic food base. | The Non-Bypass Alternative could disrupt smallmouth bass spawning by changing the water velocity. This could lead to nest abandonment and mortality of smallmouth bass eggs and larvae. Smallmouth bass model lambda values of > 1 indicate population growth of smallmouth bass would be likely near Lees Ferry and the Little Colorado River. The population could possibly double in some years (lambda > 2). Potential effects of lambda > 2 from the Non-Bypass Alternative could mean a dramatic increase in smallmouth bass abundance at river mile 15. Native fish species, including flannelmouth sucker, bluehead sucker, and speckled dace, may be affected in the Glen Canyon reach. Continued warm releases could increase the incidence of fish parasites. The low flow (2,000 cfs) element of the Non-Bypass Alternative would dewater margins and shallow habitats, negatively affecting young trout and the aquatic food base. |
| Vegetation | Water volumes in the Colorado River will continue to decrease in response to regional aridification and drought conditions. Frequent, extended high flows will result in an overall decrease in native plant communities and decrease in wetland habitat. Upper riparian zones will likely transition to desert ecosystems. | Total vegetation cover would increase slightly compared with the No Action Alternative in Marble Canyon and eastern Grand Canyon. In western Grand Canyon, the proportion of native vegetation cover would decrease slightly, and species richness and total vegetation cover would increase slightly compared with the No Action Alternative. | Impacts on riparian vegetation in Marble Canyon would be negligible. Total vegetation cover would increase slightly in eastern Grand Canyon, and the proportion of native vegetation cover would decrease slightly in western Grand Canyon (depending on the flow spike scenario). | Impacts on riparian vegetation would be similar to those described for the Cool Mix with Flow Spike Alternative. | Impacts on riparian vegetation would be the same as those listed for the Cool Mix with Flow Spike Alternative | In Marble Canyon, this alternative would result in a small increase in the proportion of native versus nonnative species cover, a small increase in species richness, and a small decrease in total vegetation cover, compared with the No Action Alternative. In eastern Grand Canyon, this alternative would result in a small increase in the proportion of native versus nonnative species cover, a small increase in species richness, and a small decrease in total vegetation cover, compared with the No Action Alternative. In western Grand Canyon, the effects of this alternative would be most pronounced and would result in a moderate increase in the proportion of native versus nonnative species cover, a small increase in species richness, and a small decrease in total vegetation cover, compared with the No Action Alternative. |

| Resource | No Action Alternative | Cool Mix Alternative | Cool Mix with Flow Spike Alternative | Cold Shock Alternative | Cold Shock with Flow Spike Alternative | Non-Bypass Alternative |
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| Wildlife | This alternative will continue to allow nonnative, invasive fish species passage through the dam and therefore may reduce abundance and diversity of native species of invertebrates, small mammals, small birds, reptiles, and amphibians due to predation by nonnative invasives. | Compared with the No Action Alternative, predation of native wildlife species by invasive fish species would be halted, but smallbouth bass would not be completely extirpated from the river system, leading to reduced—but not entirely eliminated—predation of native wildlife species (invertebrates, small birds, mammals, and amphibians). Impacts on wildlife from fluctuations in flows associated with HFE releases are expected to be minimal and temporary (i.e., displacement of individuals during higher flows and the potential disruption of breeding and foraging habitat). | Impacts would be the same as described for the Cool Mix Alternative. In addition, under this alternative wetland-obligate species could benefit due to periods of elevated, steady flows, and flow spikes could provide water resources to species at higher elevations during summer months. | This alternative is expected to decrease the smallmouth bass population compared with the No Action alternative but not halt population growth entirely, as in the Cool Mix Alternative; thus, impacts on wildlife would include decreased predation from invasive fish as compared with the No Action Alternative, but some level of predation of native wildlife species would persist. Impacts on amphibians may also include the potential spread of pathogens introduced by invasive species. Impacts on wildlife from fluctuations in flows associated with HFE releases are expected to be minimal and temporary, as described for the Cool Mix Alternative. | Impacts on wildlife would be similar to those described for the Cold Shock Alternative. In addition, under this alternative wetland-obligate species could benefit due to periods of elevated, steady flows, and flow spikes could provide water resources to species at higher elevations during summer months. | High fluctuations in flows would reductions total vegetation cover and thus reduce riparian habitat, which may have minor impacts on species that utilize riparian habitat for foraging or nesting. Impacts on wildlife under the Non-Bypass Alternative would be similar to those listed for the cold-shock alternatives (i.e., predatation of native wildlife by invasive fish and the potential spread of pathogens). Impacts on wildlife from fluctuations in flows associated with HFE releases are expected to be minimal and temporary (i.e., displacement of individuals during higher flows and the potential disruption of breeding and foraging habitat). |
| Special Status Species and Threatened and Endangered Species | The risk of smallmouth bass predation on special status fish species (that is, humpback chub, razorback sucker, flannelmouth sucker, and bluehead sucker) is expected to increase if smallmouth bass become established in areas occupied by native fish, potentially negatively affecting populations.<br><br>Growth of smallmouth bass populations and other nonnative fish may result in increased predation of native special status amphibians, including both lowland and northern leopard frogs. | If the alternative reduces smallmouth bass populations, the risk of smallmouth bass negatively impacting special status fish species would be reduced compared with the No Action Alternative. The cool temperature is not expected to negatively affect special status fish.<br><br>The risk of predation of native special status amphibians would be reduced compared with the No Action Alternative. | If the alternative reduces smallmouth bass populations, the risk of smallmouth bass negatively impacting special status fish species would be reduced compared with the No Action Alternative. The cool temperature and spikes would be ameliorated downstream where most of these species exist.<br><br>The risk of predation of native special status amphibians would be reduced compared with the No Action Alternative. Increased shoreline instability associated with flow spikes could impact the lowland and northern leopard frogs. | If the alternative reduces smallmouth bass populations, the risk of smallmouth bass negatively impacting special status fish species would be reduced compared with the No Action Alternative. The cold shock would be ameliorated downstream where most of these species exist.<br><br>Continued population growth of smallmouth bass and other nonnative fish may result in increased predation of native special status amphibians, including both lowland and northern leopard frogs. | If the alternative reduces smallmouth bass populations, the risk of smallmouth bass negatively impacting special status fish species would be reduced compared with the No Action Alternative. The cold shock and spikes would be ameliorated downstream where most of these species exist.<br><br>Continued growth of smallmouth bass populations and other nonnative fish may result in increased predation of native special status amphibians, including both lowland and northern leopard frogs. Increased shoreline instability associated with flow spikes could impact the lowland and northern leopard frogs. | Increased shoreline instability could impact the endangered northern leopard frog. Growth of smallmouth bass populations and other nonnative fish may result in increased predation of native special status amphibians, including both lowland and northern leopard frogs. |
| Tribal Resources | Operations at Glen Canyon Dam will not change, and there will be no change in fish mortality from what is analyzed in the 2016 LTEMP FEIS, which does include management activities to prevent the spread of nonnative fish. There will be no additional impacts on archaeological or sacred sites than those analyzed in the 2016 LTEMP FEIS. Riparian vegetation will follow current trends. | The Cool Mix Alternative would not result in fish mortality. There would be no additional impacts on archaeological or sacred sites beyond those analyzed in the 2016 LTEMP FEIS. Differences in vegetation communities would be minor. | The Cool Mix with Flow Spike Alternative may result in fish mortality. There would be no additional impacts on archaeological or sacred sites beyond those analyzed in the 2016 LTEMP FEIS. Differences in vegetation communities would be minor. | The Cold Shock Alternative may result in egg or larval fish mortality. There would be no additional impacts on archaeological or sacred sites beyond those analyzed in the 2016 LTEMP FEIS. Differences in vegetation communities would be minor. | The Cold Shock with Flow Spike Alternative may result in egg or larval fish mortality. There would be no additional impacts on archaeological or sacred sites beyond those analyzed in the 2016 LTEMP FEIS. Differences in vegetation communities would be minor. | The Non-Bypass Alternative would result in the loss of life of eggs and fry. Low flows could result in the exposure of archaeological sites or sacred sites. Differences in vegetation communities would be minor. |

| Resource | No Action Alternative | Cool Mix Alternative | Cool Mix with Flow Spike Alternative | Cold Shock Alternative | Cold Shock with Flow Spike Alternative | Non-Bypass Alternative |
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| Recreation | Under the No Action Alternative, Glen Canyon Dam operations will remain unchanged, following the guidelines set in the 2016 LTEMP FEIS. In the Glen Canyon reach, implementation of HFE releases will continue to result in reduced short-term angler satisfaction, lost opportunities for the concessionaire from visitors rafting, and increased erosion of campsites on terraces. In the Grand Canyon, daytime flows will continue to be above the safe whitewater minimum of 8,000 cfs, with good river conditions (between 20,000 and 26,000 cfs) occurring most of the time. Sediment-triggered HFE releases will result in a potential increase in camping areas in the Grand Canyon. Exact impacts on recreation will continue to depend on water availability for releases. | Under the Cool Mix Alternative, reduced water temperatures would improve water quality for rainbow trout, which would likely increase angler satisfaction in the short and long terms. Since total discharge volumes would be approximately the same as under the No Action Alternative, impacts on boating, the rafting concessionaire, and camping in the Glen Canyon reach and whitewater boating and camping in the Grand Canyon would be similar to those described under the No Action Alternative. | Under the Cool Mix with Flow Spike Alternative, benefits to the rainbow trout fishery resulting from reduced water temperatures would be similar to those described under the Cool Mix Alternative. Flow spikes would reduce catchability during the peak fishing months, thereby reducing angler satisfaction in the short term. Flow spikes would also temporarily disrupt boating in the Glen Canyon reach and the ability of the rafting concessionaire to operate. The spikes also would contribute to increased erosion of campsites in both the Glen Canyon reach and the Grand Canyon, compared with the No Action Alternative. Flow spikes would likely improve whitewater boating navigabililty in the Grand Canyon, but they could temporarily limit beach usability for camping during implementation. | Under the Cold Shock Alternative, cold shocks would likely have adverse impacts on fry and early juveniles, which could decrease angler satisfaction in the short term; however, cooler water temperatures would likely improve the water quality for rainbow trout in the long term, thereby increasing angler satisfaction in the long term. Impacts on boating, the rafting concessionaire, and camping in the Glen Canyon reach and whitewater boating and camping in the Grand Canyon would be similar to those described under the No Action Alternative. | Under the Cold Shock with Flow Spike Alternative, short-term reduced angler satisfaction could occur; it would be similar to that described under the Cold Shock Alternative. Flow spikes would reduce catchability during the peak fishing months, thereby reducing angler satisfaction in the short term. Flow spikes would also temporarily disrupt boating in the Glen Canyon reach and the ability of the rafting concessionaire to operate. They also would contribute to increased erosion of campsites in both the Glen Canyon reach and the Grand Canyon, compared with the No Action Alternative. Flow spikes would likely improve whitewater boating navigability in the Grand Canyon, but they could temporarily limit beach usability for camping during implementation. | Under the Non-Bypass Alternative, fry and juveniles would be negatively affected by both the high and low flows. The rapid fluctuations in water levels could also disrupt fishing during the flows' implementation. The Non-Bypass Alternative would also be less likely to benefit the rainbow trout fishery by reducing water temperatures, and it could result in long-term impacts on the rainbow trout fishery from increased predation from warmwater predators compared with the cold-water alternatives. The low flows under the Non-Bypass Alternative could limit the ability of boats to freely navigate in the Glen Canyon reach, which would adversely impact boating and the rafting concessionaire in the short term, compared with all other alternatives. The Non-Bypass Alternative would substantially erode sand that has accumulated in the channel and could preclude the opportunity to conduct an HFE release, which would further reduce sandbar size, reducing camping opportunities in the Glen Canyon reach and the Grand Canyon to the greatest extent of all alternatives. In the Grand Canyon, minimum flows would be below the safe whitewater minimum, which would adversely affect whitewater boating navigability and trip management because of a greater risk of boating incidents. |

| Resource | No Action Alternative | Cool Mix Alternative | Cool Mix with Flow Spike Alternative | Cold Shock Alternative | Cold Shock with Flow Spike Alternative | Non-Bypass Alternative |
|---|---|---|---|---|---|---|
| Energy and Hydropower | Under the No Action Alternative, no changes will be made to Glen Canyon Dam operations. The power generation and economic value of electric energy will continue, similar to historical levels; there will be slight variations, depending on water availability and the constraints outlined in the 2016 LTEMP FEIS. | The Cool Mix Alternative would result in a total loss of approximately 130–145 gigawatt hours (GWh) from 2024 to 2027 when modeled to river mile 15 and a loss of approximately 215–230 GWh when modeled to river mile 61. Relative to the No Action Alternative, this is equivalent to a 0.9 to 1.0 percent loss and a 1.5 to 1.6 percent loss, respectively. The loss in economic value of electric energy would be approximately $12.8–15.9 million for river mile 15 and $19.4–26.9 million for the Little Colorado River. These are equivalent to a 1.2 to 1.4 percent loss and a 1.8 to 2.4 percent loss, respectively, relative to the No Action Alternative.<br><br>During months with experiments, the Cool Mix Alternative would result in the loss of approximately 20–23 GWh when modeled to river mile 15 and a loss of approximately 35–37 GWh when modeled to river mile 61. Relative to the No Action Alternative, this is equivalent to an 8.0 to 9.2 percent loss for river mile 15 and a 13.5 to 14.7 percent loss for river mile 61. The loss in economic value of electric energy during these months would be approximately $2.3–3.6 million for river mile 15 and $3.3–5.4 million for the Little Colorado River. These are equivalent to a 14.0 to 18.4 percent loss and a 23.6 to 24.7 percent loss, respectively, relative to the No Action Alternative. | The Cool Mix with Flow Spike Alternative would result in a total loss of approximately 132–140 GWh from 2024 to 2027 when modeled to river mile 15 and a loss of approximately 200–212 GWh when modeled to river mile 61. Relative to the No Action Alternative, these are equivalent to a 0.9 to 1.0 percent loss and a 1.4 to 1.6 percent loss, respectively. The loss in economic value of electric energy would be approximately $12.5–15.5 million for river mile 15 and $17.8–26.4 million for the Little Colorado River. These are equivalent to a 1.1 to 1.4 percent loss and a 1.6 to 2.4 percent loss, respectively, relative to the No Action Alternative.<br><br>During months with experiments, the Cool Mix with Flow Spike Alternative would result in loss of approximately 19–21 GWh when modeled to river mile 15 and a loss of approximately 31–37 GWh when modeled to river mile 61. Relative to the No Action Alternative, this is equivalent to a 7.7 to 8.2 percent loss for river mile 15 and a 12.3 to 14.5 percent loss for river mile 61. The loss in economic value of electric energy during these months would be approximately $2.0–3.7 million for river mile 15 and $2.9–5.3 million for the Little Colorado River. These are equivalent to a 12.6 to 18.1 percent loss and a 17.2 to 24.1 percent loss, respectively, relative to the No Action Alternative. | The Cold Shock Alternative would result in a total loss of approximately 66–70 GWh from 2024 to 2027 when modeled to river mile 15 and a loss of approximately 102–109 GWh when modeled to river mile 61. Relative to the No Action Alternative, these would be equivalent to a 0.5 percent loss and a 0.7 to 0.8 percent loss, respectively. The loss in economic value of electric energy would be approximately $6.5–8.8 million for river mile 15 and $8.4–13.8 million for the Little Colorado River. These are equivalent to a 0.6 to 0.8 percent loss and a 0.8 to 1.2 percent loss, respectively, relative to the No Action Alternative.<br><br>During months with experiments, the Cold Shock Alternative would result in loss of approximately 1.3–2.2 GWh when modeled to river mile 15 and a loss of approximately 9.2–12.6 GWh when modeled to river mile 61. Relative to the No Action Alternative, this is equivalent to a 0.5 to 0.9 percent loss for river mile 15 and a 3.6 to 4.9 percent loss for river mile 61. The loss in economic value of electric energy during these months would be approximately $0.6–1.9 million for river mile 15 and $1.0–2.8 million for the Little Colorado River. These are equivalent to a 3.9 to 9.1 percent loss and a 6.0 to 12.6 percent loss, respectively, relative to the No Action Alternative. | The Cold Shock with Flow Spike Alternative would result in a total loss of approximately 65–66 GWh from 2023 to 2027 when modeled to river mile 15 and a loss of approximately 83–109 GWh when modeled to river mile 61. Relative to the No Action Alternative, these would be equivalent to a 0.5 percent loss and a 0.6 to 0.8 percent loss, respectively. The loss in economic value of electric energy would be approximately $6.1–9.2 million for river mile 15 and $7.3–15.0 million for the Little Colorado River. These are equivalent to a 0.6 to 0.8 percent loss and a 0.7 to 1.4 percent loss, respectively, relative to the No Action Alternative.<br><br>During months with experiments, the Cold Shock with Flow Spike Alternative would result in loss of approximately 1.7–2.4 GWh when modeled to river mile 15 and a loss of approximately 3.8–15.2 GWh when modeled to river mile 61. Relative to the No Action Alternative, this is equivalent to a 0.7 to 1.0 percent loss for river mile 15 and a 1.5 to 5.9 percent loss for river mile 61. The loss in economic value of electric energy during these months would be approximately $0.4–2.0 million for river mile 15 and $0.6–3.2 million for the Little Colorado River. These are equivalent to a 2.3 to 9.9 percent loss and a 3.6 to 14.2 percent loss, respectively, relative to the No Action Alternative. | The Non-Bypass Alternative would result in a total gain of approximately 9 GWh from 2024 to 2027 when modeled to river mile 15 and a gain of approximately 20–42 GWh when modeled to river mile 61. Relative to the No Action Alternative, these would be equivalent to a 0.1 percent gain and a 0.1 to 0.3 percent gain, respectively. The gain in economic value of electric energy would be approximately $1 million for river mile 15 and $0.2–0.7 million for the Little Colorado River. These are equivalent to a 0.1 percent gain and a 0.0 to 0.1 percent gain, respectively, relative to the No Action Alternative. |

| Resource | No Action Alternative | Cool Mix Alternative | Cool Mix with Flow Spike Alternative | Cold Shock Alternative | Cold Shock with Flow Spike Alternative | Non-Bypass Alternative |
|---|---|---|---|---|---|---|
| Socioeconomic Impacts | Under the No Action Alternative, the estimated net value for the 50-month analysis period was calculated at $366.76 million for whitewater boaters and $19.03 million for anglers. Nonmarket values associated with the humpback chub may decrease in the long term. Other nonmarket values may also be impacted in the long term. HFE releases could continue to impact sandbar development and the associated values. It should also be noted that nonmarket values may differ for different groups. Respondents who are supportive of hydropower, concerned about the health effects of air pollution, and concerned about ways of life for American Indian Tribes and rural western communities are more likely to support the continuation of current patterns of dam operations and assign a higher value to this operation. Additionally, individuals owning property in the region around Glen Canyon Dam are considerably more likely to support continuation of dam operations. | As compared with the No Action Alternative, this alternative would result in minimal changes to the net value for anglers and whitewater boaters for all reaches. Nonmarket values associated with humpback chub are not likely to be negatively affected. In terms of sandbars and the associated values, this alternative would result in the potential for slight increases in the associated nonmarket value. For values associated with climate change, nonmarket values would be impacted by an increase in carbon emissions. This alternative represents the greatest level of increased emissions. Similarly, this alternative represents the greatest potential for impacts on other values associated with rural ranching and farmers, or other power customers who may value continued current operations of the dam. | Estimates of the net value for anglers include a 17 percent increase in value in the Glen Canyon reach and a 1.5 percent increase in the lower Grand Canyon reach, compared with the No Action Alternative. A minimal change would occur for the whitewater boating value. Impacts on the values associated with the humpback chub from the Cool Mix with Flow Spike Alternative would be the same as described under the Cool Mix Alternative. Values associated with sandbars would be increased compared with the No Action Alternative. Values associated with continued current operations of the dam could be impacted under this alternative. | Under the Cold Shock Alternative, some long-term increases in angler satisfaction would likely occur. Compared with the No Action Alternative, boating would have minimal changes in terms of satisfaction and value. Under the Cold Shock Alternative, potential impacts on values associated with the humpback chub would occur. Sandbar increases would support increased values compared with the No Action Alternative. Compared with the No Action Alternative, increased carbon emissions would occur, resulting in impacts on climate change–associated values; however, these increases under the Cold Shock Alternative would be lower than those increases described for the Cool Mix Alternative. Impacts on the people who value continued dam operations would occur, but at a lower level than under the Cool Mix Alternative. | Impacts on angler and boating net economic values would be the same as those described for the Cold Shock Alternative. Under the Cold Shock with Flow Spike Alternative, impacts on humpback chub values would be similar to those under the No Action Alternative. Values associated with sandbars would be increased compared with the No Action Alternative. Values associated with continued current operations of the dam could be impacted under this alternative. | Some short-term impacts on angler satisfaction could occur. The high and low fluctuations of water could impact the boater experience in both the Glen Canyon and Grand Canyon reaches. This could adversely impact the associated value. Under the Non-Bypass Alternative, there is the potential for short-term impacts on humpback chub juveniles from flow changes; however, the effect of these high flows is expected to be minimal and no long-term changes to the associated value are expected.<br>No change is anticipated to carbon emissions or values associated with continued dam operations under this alternative. |

| Resource | No Action Alternative | Cool Mix Alternative | Cool Mix with Flow Spike Alternative | Cold Shock Alternative | Cold Shock with Flow Spike Alternative | Non-Bypass Alternative |
|---|---|---|---|---|---|---|
| Environmental Justice | Under the No Action Alternative, operations at Glen Canyon Dam will not change, and hydropower generation will continue at historical levels. There will be no impacts on environmental justice communities because of changes to power generation. | Reduced energy generation and increased replacement energy would result in financial impacts, changes to air quality emissions from replacement power, changes to Tribal resources, changes to regional economic activity related to recreation, and changes to use and nonuse values. The Cool Mix Alternative would result in the most impacts on power generation, the most financial impacts, and the most impacts on air quality. These impacts could disproportionately impact environmental justice communities. Because the bypass is treated as experiment, WAPA would purchase replacement power on the market to ensure that customers, including Tribes, are kept whole. As a result, it is anticipated that in 2024 customers, including Tribes with benefit crediting contracts, would receive their power as if no bypass had occurred. This alternative could accelerate the potential for direct financial impacts on customers in future years, should the Basin Fund reach a critically low level. However, adaptive management would minimize the potential for direct impacts on consumers and Reclamation would consider environmental justice communities at the planning and implementation phases. | Impacts on environmental justice communities would be similar to those described for the Cool Mix Alternative; however, the Cool Mix with Flow Spike Alternative would result in the second-most impacts on power generation and the second-most financial impacts. As under the Cool Mix Alternative, financial impacts would be to the Basin Fund. It is anticipated that in 2024 customers, including environmental justice communties and Tribes with benefit crediting contracts, would receive their power as if no bypass had occurred. Potential for direct financial impacts on environmental justice communities would be the second-most accelerated under this alternative. The quality of the angling experience in terms of angling access would result in potential impacts on environmental justice communities. | The Cold Shock Alternative would result in the third-most potential financial impacts on environmental justice communities. As under the other cold-water alternatives, financial impacts would be to the Basin Fund. It is anticipated that in 2024 customers, including environmental justice communities and Tribes with benefit crediting contracts, would receive their power as if no bypass had occurred. Potential for direct financial impacts on environmental justice communities would be the third-most accelerated under this alternative, compared with the other cold-water alternatives. | The Cold Shock with Flow Spike Alternative would result in the least potential financial impacts on environmental justice communities. Impacts on environmental justice communities because of changes to angling access would be the same as those described under the Cool Mix with Flow Spike Alternative. As under the other cold-water alternatives, financial impacts would be to the Basin Fund . It is anticipated that in 2024 customers, including environmental justice communities and Tribes with benefit crediting contracts, would receive their power as if no bypass had occurred. The potential for direct financial impacts on environmental justice communities would be the least accelerated under this alternative, compared with the other cold-water alternatives. | The Non-Bypass Alternative would result in the least impacts on hydropower generation and the least financial impacts. Under this alternative, there would be a gain in economic value of electric power. This could benefit communities, including environmental justice communities. However, this alternative would result in the most potential impacts on recreation and Tribal resources (through fish mortalities). These impacts would result in potentially disproportionate adverse impacts for environmental justice communities. |

# 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 2016. The environmental consequences sections provide an analysis of the No Action and Action Alternatives, as described in **Chapter 2**. The analysis is issue-based, addressing the specific relevant concerns identified during scoping for a particular resource. For brevity and to avoid redundancy, the 2016 LTEMP FEIS (DOI 2016a) is incorporated by reference. To supplement the 2016 LTEMP FEIS (DOI 2016a), these sections provide a summary of the affected environment from the original 2016 document, modified as necessary to include changes that have occurred since 2016.

### 3.1.1 HFE Protocol Changes

The following analysis focuses on the combined impacts of implementing smallmouth bass experimental flows and changes to the HFE protocol from 2024 through 2027. Following the life of the smallmouth bass experimental flows in 2027, the changes to the HFE protocol will continue through the life of the original LTEMP. The impacts from only the changes to the HFE protocol are within the range of impacts analyzed in the 2016 LTEMP FEIS.

## 3.2 Hydrology

### 3.2.1 Affected Environment

The Colorado River headwaters begin in the Rocky Mountains of Colorado. The river flows southwesterly until its terminus in the Gulf of California. It benefits approximately 40 million users in seven western states and the Republic of Mexico. Peak inflow at Glen Canyon Dam occurs in late spring to early summer, although flows in late summer through autumn sometimes can increase following monsoonal rain events (Reclamation 2007). Snowmelt during spring and early summer is the main contributor to the river's flow, but inflow is also driven by precipitation within the basin and controlled by upstream dams and diversion structures.

The Upper Colorado River Basin, defined as the area above Lee Ferry, is mainly classified as semiarid, and the Lower Basin, located below Lee Ferry, is classified as arid. The climate, however, can vary from cold and dry in alpine environments at high elevations to dry-temperate west of the mountains and arid to the southwest. Average annual precipitation in the alpine regions of the

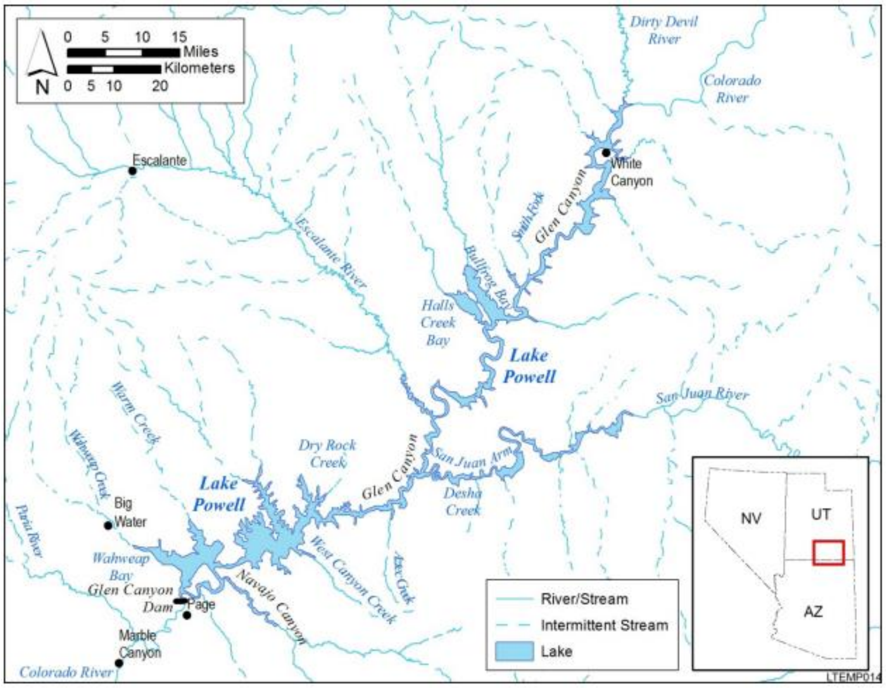
Upper Colorado River Basin ranges from 30 to 60 inches. Near Glen Canyon Dam, rainfall averages between 6 and 8 inches, mostly in the form of cloudburst storms during late summer and early fall. The arid climate of the region around Lake Powell leads to significant evaporation rates, especially during summer months.

In 2021, Reclamation updated climate and hydrology projections across the western United States to better align with new techniques, data, and analyses (Reclamation 2021a). Under all GHG scenarios, average temperatures are projected to continue increasing overall across the West; over the past 40 years, the climate of the Colorado River Basin has become increasingly warmer, mainly due to anthropomorphic changes to the atmosphere. In addition, lower total annual precipitation is projected, with greater fluctuation in the timing, frequency, and magnitude of storm events (Zhang et al. 2021). The continued warming and subsequent aridification of the Upper Basin results in reduced snowpack; this warming has been shown to disproportionately impact snowmelt-dominated regions, causing runoff to decline at double the rate compared with regions without snowpack (Bass et al. 2023). Studies have also found that a hotter climate has led to a reduction in runoff efficiency in both wet and dry years. Therefore, future flows will be less than anticipated from both precipitation and snowmelt (Woodhouse and Pederson 2018), yielding reduced inflow and lower resulting elevations in Lake Powell. Climate experts and scientists suggest that droughts of this severity occurred in the past and are likely to continue occurring.

The Upper Colorado River Basin experiences significant year-to-year hydrologic variability. Unregulated inflow into Lake Powell, which is a good measure of hydrologic conditions in the Colorado River Basin, has ranged between approximately 5.4 and 25.4 maf over the 105-year full record of flow (1906–2010) (Reclamation 2007, 2013). The period of 2000–2022 is the driest 23-year period since the closure of Glen Canyon Dam in 1963, with average unregulated inflow of 8.29 maf, or 93 percent of the 30-year period of record (1991–2021) average inflow of 9.6 maf. Additionally, the period of 2000–2011 was the driest 11-year period in recorded history, and the period of 1999–2010 was the second driest 11-year period (Holdren et al. 2012; GCMRC 2015).

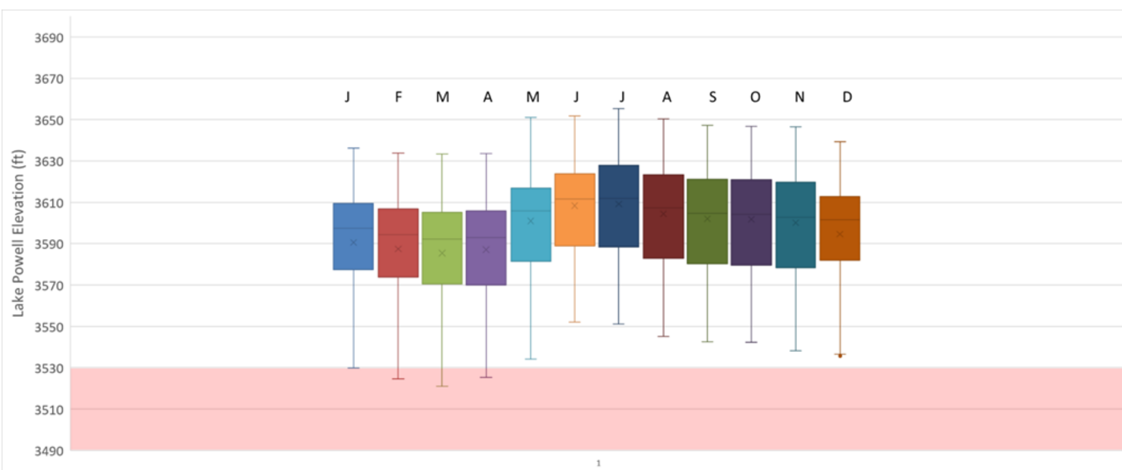
Lake Powell is the second-largest reservoir in the Colorado River system. It was created following the construction of Glen Canyon Dam in 1963 through the Colorado River Storage Project. Overall, approximately 95 percent of the reservoir's inflow originates from the Colorado River and two of its major tributaries: the San Juan River and the Green River (Stanford and Ward 1991; Reclamation 1995, 2007; Wildman et al. 2011). Lake Powell has a maximum storage capacity of 25.3 maf as of October 2023. When storage is full, it has an average depth of 165 feet and a depth of 560 feet near the dam. Water levels in Lake Powell can fluctuate based on seasonal variations in inflow as well as operations of the dam. Releases from Glen Canyon Dam are pursuant to the 2007 Interim Guidelines ROD and the 2016 LTEMP ROD. Lake Powell storage assists the Upper Colorado River Basin States in meeting Colorado River Compact obligations, generates hydroelectric power through the Glen Canyon Dam powerplant, and provides recreational benefits. **Figure 3-1** shows Lake Powell and its major tributaries. **Figure 3-2** shows annual average modeled monthly elevations at Lake Powell under existing operations.

## Figure 3-1
## Map of Lake Powell and Associated Major Tributaries




Source: DOI 2016a

## Figure 3-2
## Average Monthly Modeled Lake Powell Elevations




Source: Yackulic et al. 2024

Note: The red zone below elevation 3,530 feet indicates where the warmer thermocline zone begins as opposed to the cooler hypolimnion zone above. The figure presented is based on estimates from 30 modeled traces.

The outflow from Lake Powell is regulated by the Glen Canyon Dam. Monthly release volumes are based on the monthly pattern determined by the 2016 LTEMP ROD, which takes into account GCPA resource concerns, anticipated power demands, forecasted inflows, and other factors such as storage equalization between Lake Powell and Lake Mead. High release rates do not always coincide with peaks in reservoir inflow; instead, they typically occur during times of increased power demands or during HFE releases. Colorado River flows at the Lees Ferry gaging station, or river mile 0 (located approximately 15.5 miles downstream of Glen Canyon Dam and approximately 1 mile upstream of the Paria River mouth), have been monitored since May 1921, prior to the dam's construction (DOI 2016a). This record provides an outlook comparing pre- and post-dam conditions. The average pre-dam annual peak flow was approximately 92,000 cfs throughout the period of record.

Additionally, paleoflood research has determined that during the last 4,500 years, 15 floods at Lees Ferry had peak discharges greater than 120,000 cfs. Of these floods, 10 had peak discharges greater than 140,000–150,000 cfs during the last 2,100–2,300 years, and one flood that occurred 1,200–1,600 years ago had a peak discharge exceeding about 300,000 cfs (Topping et al. 2003). Since the installation of the dam, both peak flows and the frequency of very low flows have been reduced (DOI 2016a). Long-term and annual release volumes from Lake Powell are detailed in the Interim Guidelines (Reclamation 2007) and supplemented by the Interim Guidelines SEIS (Reclamation 2024a). Releases can also fluctuate beyond those scheduled under certain allowed circumstances in accordance with 2016 LTEMP ROD section 1.2B (DOI 2016b).

### 3.2.2 Environmental Consequences

#### *Methodology*

The analysis presented in this section is informed by hydrologic modeling showing the impacts of monthly flow alterations at Glen Canyon Dam on Lake Powell and the Colorado River between Glen Canyon Dam and Lake Mead. As described in **Section 1.8**, these actions only concern sub-annual releases from Glen Canyon Dam on hourly, daily, monthly, and experimental timescales. For the cold-water alternatives, scenarios were created analyzing cooling to either river mile 15, 15 miles downstream of Lees Ferry, or river mile 61, at the confluence with the Little Colorado River.

These two scenarios were modeled to demonstrate impacts if smallmouth bass were identified in upper reaches or farther downstream. The action alternatives would only be triggered if water temperatures at the target river mile are at or above 15.5°C (60°F), as described in the planning and implementation process in **Section 2.3.1**. Releases under the cold-water alternatives were modeled to stay within the range of those analyzed in the 2016 LTEMP FEIS (DOI 2016a); however, the Non-Bypass Alternative included flows outside of those analyzed in the 2016 LTEMP FEIS. Detailed assumptions for the alternatives can be found in **Section 2.5**.

Alternatives were modeled using a set of 30 hydrologic traces on a monthly timestep, each lasting 4 years, to capture a wide range of hydrologic conditions. The traces were developed as part of the Interim Guidelines SEIS (Reclamation 2024a), based on the June 2023 ensemble streamflow predictions forecast,[14] which represents hydrological conditions over the past 30 years. An initial run of the smallmouth bass model was made to determine the months in which flow spikes would be expected to be triggered under operational alternatives that include flow spikes. Additional

[14] The 100 percent ensemble streamflow prediction in this analysis as it provided a wide range of hydrologic conditions that included many years without any bypass needed.

information on the smallmouth bass model can be found in the GCMRC report (Yackulic et al. 2024, chap. 4).

Subsequently, a sediment model was run to identify the timing, magnitude, and duration of an HFE release. If an HFE release or flow spike event were marked to occur in a given month, monthly release volumes from Glen Canyon Dam and Lake Powell elevations were reallocated and adjusted between months, such that the annual release volume from Lake Powell remained unchanged from the No Action Alternative. The smallmouth bass model was then run to determine the monthly bypass required under a given scenario based on the expected rate of smallmouth bass population growth.

### Impact Analysis Area

The impact analysis area is the Colorado River at Glen Canyon Dam to Lake Mead, with targets of river mile 15 and river mile 61 (Little Colorado River) for cold-water alternatives.

### Assumptions

- Inflow into Lake Powell would follow existing trends; action alternatives would not influence inflows.
- Total annual release volumes from Lake Powell would remain consistent with the 2007 Interim Guidelines (Reclamation 2007) and subsequent Interim Guidelines SEIS (Reclamation 2024a).

### Impact Indicators

For all alternatives considered, the primary indicators for analysis include: (1) release hydrographs for water released from Glen Canyon Dam based on USGS conceptual hydrographs and (2) release volumes from Glen Canyon Dam evaluated using modeling results from CRSS (Reclamation 2024a).

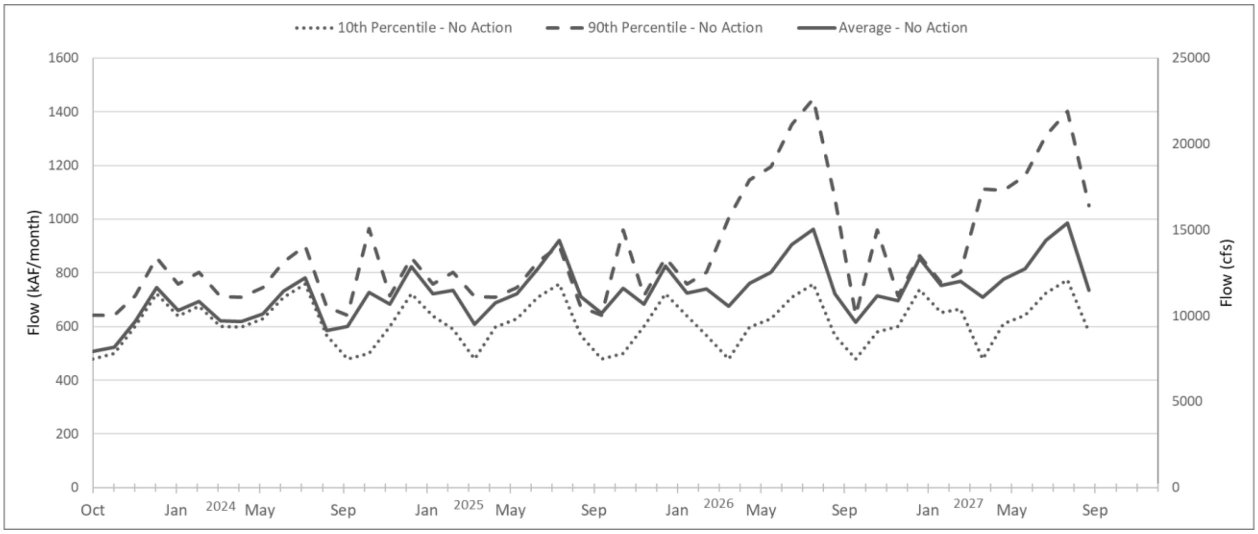
## *Issue 1: How would flow alterations at Glen Canyon Dam affect the hydrology at Lake Powell and the Colorado River downstream?*

### No Action Alternative

Under this alternative, operations at Glen Canyon Dam will remain unchanged. The flow regime will continue to be implemented as determined by the LTEMP ROD (DOI 2016b). Specifically, water will continue to be discharged primarily through the penstocks, and HFE releases will most likely occur in the fall, with a low likelihood of HFE releases being implemented in the spring. If drought and aridification continue, the No Action Alternative could result in the continued trend of fewer and smaller HFE releases. The hydrograph downstream of Glen Canyon Dam will remain the same, with spikes in flows occurring during HFE releases.

**Figure 3-3** shows modeled projected monthly Glen Canyon Dam release volumes under the No Action Alternative for the period of analysis.

**Figure 3-3**
**Monthly Glen Canyon Dam Release Volumes for the No Action Alternative**




Source: Yackulic et al. 2024
Note: The flows presented are based on estimates from 30 modeled traces.

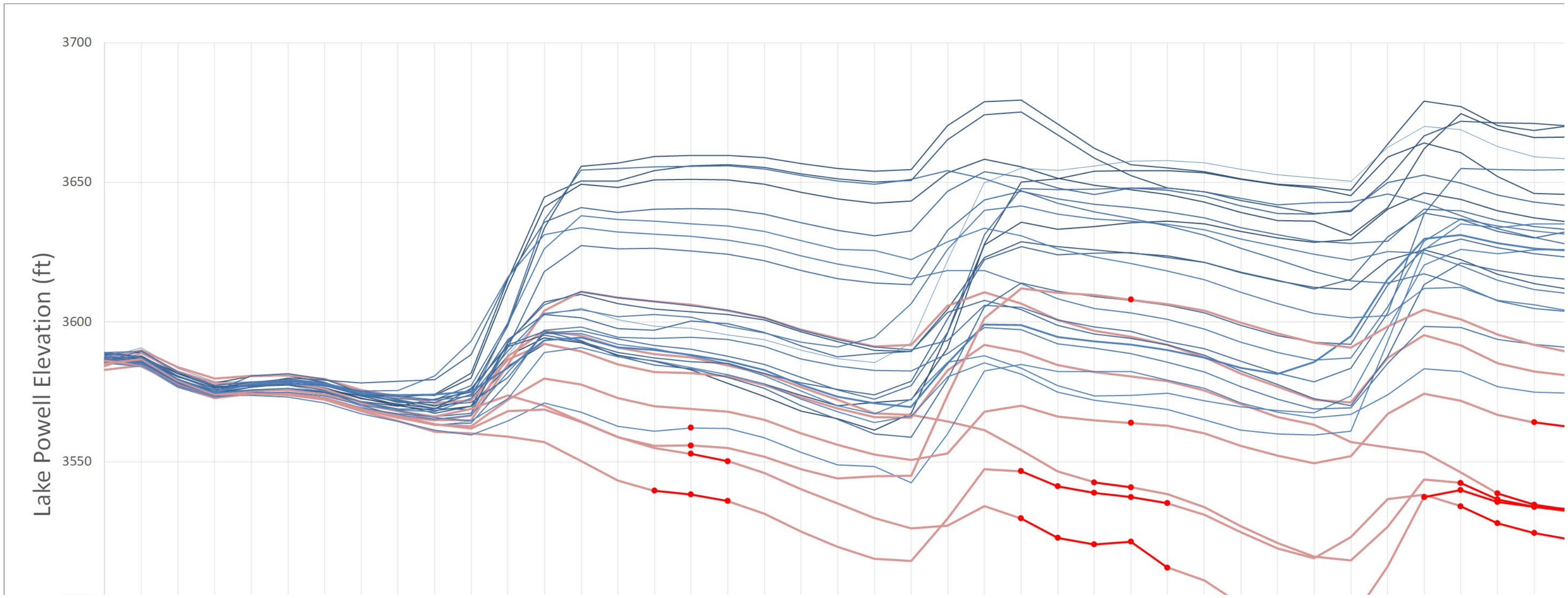
**Cool Mix Alternative**

Under the Cool Mix Alternative, strategic releases from the penstocks and river outlet works are intended to maintain a daily average water temperature below 15.5 °C (60°F) on the Colorado River from below the dam to the target locations at river mile 15 or river mile 61 (USGS 2022). The volume of water released through the river outlet works and penstocks would vary based on the elevation of Lake Powell, monthly water releases, and water temperatures in the reservoir. Flows would be triggered when temperatures are observed to be greater than 15.5 °C (60°F) at the target river mile, and releases from the penstocks and river outlet works would be made to ensure the minimum necessary release from the river outlet works required to maintain the temperature goal.

A detailed description of the Cool Mix Alternative can be found in **Section 2.7**. **Figure 3-4** shows an example of possible traces and months in which the temperature threshold exceeds 15.5°C (60°F) at river mile 15 and river mile 61, and in which flows could be triggered under the Cool Mix Alternative. Traces reaching these thresholds under the other cold-water alternatives would look similar. Note that while 8 of the traces at river mile 15 and 13 of the traces at river mile 61 resulted in bypass when temperature exceeded the 15.5°C (60°F) threshold, the smallmouth bass model only indicated a population growth for 5 of the traces at river mile 15 and 7 of the traces at river mile 61 (see **Section 3.5.2**).

The conceptual hydrograph for the Cool Mix Alternative, shown in **Figure 2-1**, shows 1 week of a hydrograph under this alternative. The hydrograph would follow the same hydrographic pattern as the No Action Alternative and would repeat throughout the duration of the triggered flows. The only change would be the release point of flows from the dam, whether from the penstocks or the river outlet works.

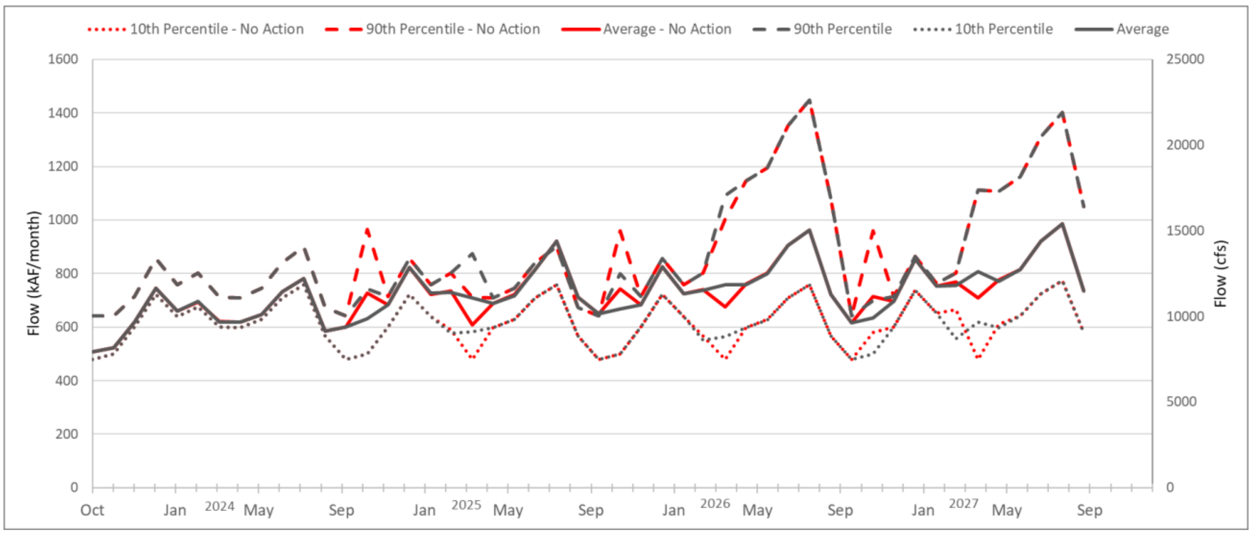
**Figure 3-4**
**Example Traces Exceeding 15.5°C at River Mile 15 and River Mile 61 Under Cold-Water Alternatives**




Source: Yackulic et al. 2024
Note: Traces in red have temperatures exceeding 15.5°C (60°F) at river mile 15 and river mile 61 in the months shown with red dots. Actual implementation under any of the cold-water alternatives may look different from what is shown.

Under this alternative, releases from the dam would continue to be within the range of existing flows described in the 2016 LTEMP FEIS; therefore, hydrologic conditions downstream of the dam would remain within the range described in the 2016 LTEMP FEIS (DOI 2016a). As such, monthly releases and reservoir elevations would be the same as those under the No Action Alternative. **Figure 3-5** shows modeled projected monthly Glen Canyon Dam release volumes under the Cool Mix Alternative relative to the No Action Alternative for the period of analysis. There were no discernible differences in monthly release volumes from Glen Canyon Dam between the river mile 15 and river mile 61 sub-alternatives.

**Figure 3-5**
**Monthly Glen Canyon Dam Release Volumes for the Cool Mix Alternative**




Source: Yackulic et al. 2024
Note: The flows presented are based on estimates from 30 modeled traces. Differences in results between sub-alternatives at river mile 15 and river mile 61 are not discernible.

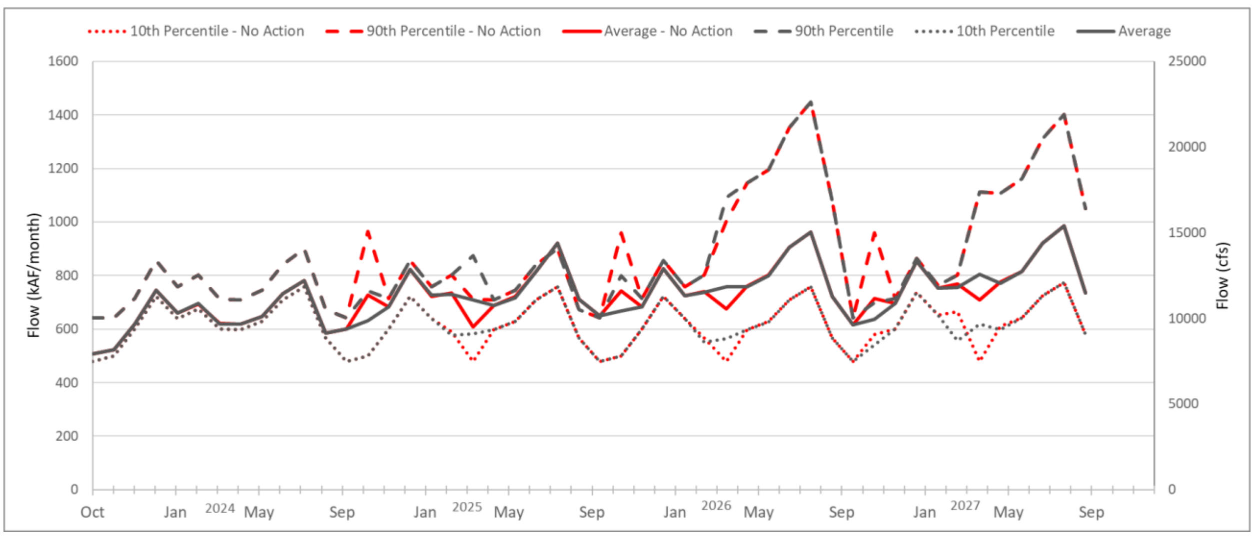
## Cool Mix with Flow Spike Alternative

The Cool Mix with Flow Spike Alternative is similar to the Cool Mix Alternative but also includes the implementation of up to three 8-hour flow spikes intended to increase flows and decrease temperatures in backwater areas. As much water as possible, up to a maximum of 45,000 cfs, would be released through the penstocks and river outlet works. These flow spikes would likely be implemented in spring or early summer if sufficient water is available in Lake Powell. Under this alternative, increased flow events during flow spikes would be similar to HFE releases and could be replaced by HFE releases if sufficient benefits to sediment and impacts on smallmouth bass spawning were anticipated (USGS 2022). A detailed description of the Cool Mix with Flow Spike Alternative can be found in **Section 2.8**. **Figure 3-4** shows an example of possible traces and months in which the temperature threshold exceeds 15.5°C (60°F) at river miles 15 and river mile 61, triggering flows under the Cool Mix with Flow Spike Alternative.

The conceptual hydrograph for the Cool Mix with Flow Spike Alternative, shown in **Figure 2-2**, shows 1 week of a hydrograph under this alternative. This hydrograph would have a period of flows like those under the Cool Mix Alternative, followed by a flow spike. The hydrograph would then return to the Cool Mix Alternative hydrograph for the duration of the triggered flows unless up to two more flow spikes were implemented, in which case the hydrograph would look like the Cool Mix with Flow Spike hydrograph during those spikes. Like the Cool Mix Alternative hydrograph, the hydrograph would mimic the same pattern as the No Action Alternative when spikes are not occurring.

Under this alternative, the volume of water released during flow spikes would be greater than during typical operations; however, release volumes would still be within the range analyzed in the 2016 LTEMP FEIS and not affect annual releases. Therefore, hydrologic conditions downstream of the dam would remain within the range described in the 2016 LTEMP FEIS (DOI 2016a), and monthly releases and reservoir elevations would be the same as those under the No Action Alternative apart from monthly changes where flow spikes occur. **Figure 3-6** shows modeled projected monthly Glen Canyon Dam release volumes under the Cool Mix with Flow Spike Alternative relative to the No Action Alternative for the period of analysis. There were no discernible differences in monthly reservoir elevations or Glen Canyon Dam release volumes between the river mile 15 and river mile 61 sub-alternatives.

**Figure 3-6**
**Monthly Glen Canyon Dam Release Volumes for the Cool Mix with Flow Spike Alternative**




Source: Yackulic et al. 2024
Note: The flows presented are based on estimates from 30 modeled traces. Differences in results between sub-alternatives at river mile 15 and river mile 61 are not discernible.

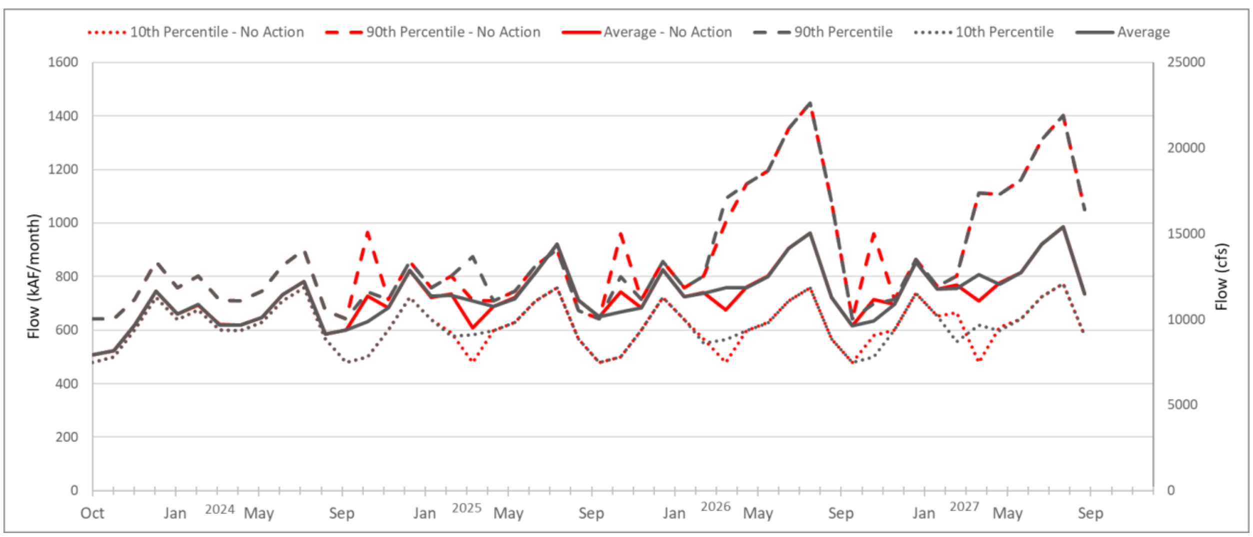
### Cold Shock Alternative

Under the Cold Shock Alternative, a large, 48-hour weekly release from the river outlet works is intended to reduce water temperatures in the river to 13°C (55.4°F) at the target locations of river mile 15 or 61. Cold shocks could occur for up to 12 consecutive weekends. A detailed description of the Cold Shock Alternative can be found in **Section 2.9**. **Figure 3-4** shows an example of possible traces and months in which the temperature threshold exceeds 15.5°C (60°F) at river mile 15 and river mile 61, triggering flows under the Cold Shock Alternative.

The conceptual hydrograph for the Cold Shock Alternative, shown in **Figure 2-3**, shows 1 week of a hydrograph under this alternative. This hydrograph would follow normal operations and would mimic the No Action Alternative apart from the 48-hour cold shocks and associated transitions in and out of each cold shock. This hydrograph would repeat for the duration of the triggered flows.

Under this alternative, discharges from the dam would continue to be within the range of existing flows described in the 2016 LTEMP FEIS; therefore, hydrologic conditions downstream of the dam would remain within the range described in the 2016 LTEMP FEIS (DOI 2016a). As such, monthly releases and reservoir elevations would be the same as those under the No Action Alternative. **Figure 3-7** shows modeled projected monthly Glen Canyon Dam release volumes under the Cold Shock Alternative relative to the No Action Alternative for the period of analysis. There were no discernible differences in monthly release volumes from Glen Canyon Dam between the river mile 15 and river mile 61 sub-alternatives.

**Figure 3-7**
**Monthly Glen Canyon Dam Release Volumes for the Cold Shock Alternative**




Source: Yackulic et al. 2024
Note: The flows presented are based on estimates from 30 modeled traces. Differences in results between sub-alternatives at river mile 15 and river mile 61 are not discernible.

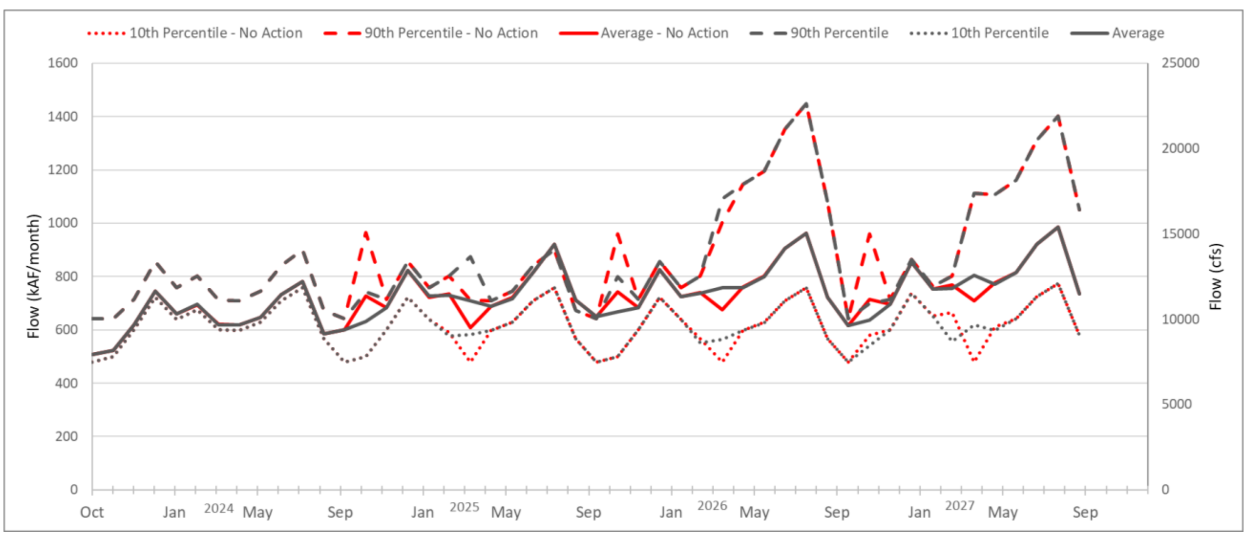
### Cold Shock with Flow Spike Alternative

The Cold Shock with Flow Spike Alternative is similar to the Cold Shock Alternative but also includes the implementation of up to three 8-hour flow spikes intended to increase flows and decrease temperatures in backwater areas. As much water as possible, up to 45,000 cfs, would be released through the penstocks and river outlet works during these spikes. These flow spikes would only occur between May and September and only if sufficient water is available in Lake Powell. Under this alternative, increased flow events during flow spikes would be similar to HFE releases and could be replaced by HFE releases if sufficient benefits to sediment and impacts on smallmouth bass spawning are anticipated (USGS 2022). A detailed description of the Cold Shock with Flow Spike Alternative can be found in **Section 2.10**. **Figure 3-4** shows an example of possible traces and months in which the temperature threshold exceeds 15.5°C (60°F) at river mile 15 and river mile 61, triggering flows under the Cold Shock with Flow Spike Alternative.

The conceptual hydrograph for the Cold Shock with Flow Spike Alternative, shown in **Figure 2-4**, shows 1 week of a hydrograph under this alternative. This hydrograph would follow the same flow pattern as the Cold Shock Alternative but with a flow spike following the cold shock up to three times throughout the duration of the triggered flows.

Under this alternative, the volume of water released during flow spikes would be greater than during typical operations but still be within the range analyzed in the 2016 LTEMP FEIS (DOI 2016a). Therefore, hydrologic conditions downstream of the dam would remain within the range described in the 2016 LTEMP FEIS, and monthly releases and reservoir elevations would be the same as those under the No Action Alternative, apart from monthly changes from flow spikes. **Figure 3-8** shows modeled projected monthly Glen Canyon Dam release volumes under the Cold Shock with Flow Spike Alternative relative to the No Action Alternative for the period of analysis. There were no discernible differences in monthly reservoir elevations or Glen Canyon Dam release volumes between the river mile 15 and river mile 61 sub-alternatives.

**Figure 3-8**
**Monthly Glen Canyon Dam Release Volumes for the Cold Shock with Flow Spike Alternative**




Source: Yackulic et al. 2024

Note: The flows presented are based on estimates from 30 modeled traces. Differences in results between sub-alternatives at river mile 15 and river mile 61 are not discernible.

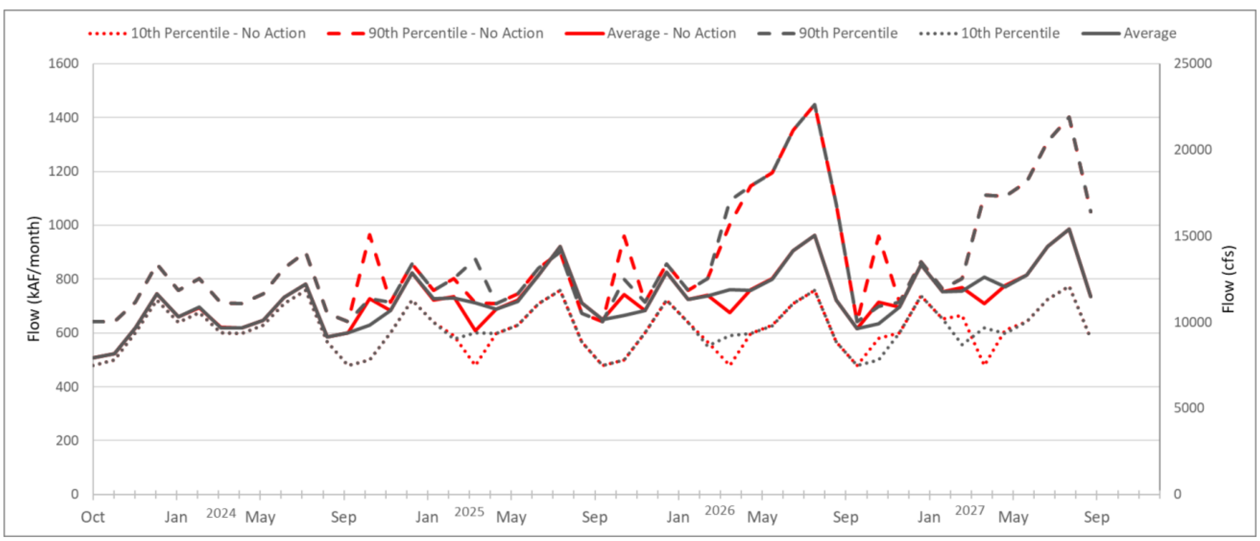
## Non-Bypass Alternative

The Non-Bypass Alternative proposes a hydrograph centered on employing river stage changes to disrupt existing nests and spawning activities below Glen Canyon Dam. This approach involves a detailed analysis of timing, duration, magnitude, and frequency, capitalizing on the susceptibility of male bass to changes in their environment that cause the males to abandon their nests. On a weekly basis, flows from Glen Canyon Dam would drop to a minimum of 2,000 cfs for 4 hours, followed by a rapid increase to approximately 27,300 cfs over a period of about 6 hours, where it would remain for about 4 hours before ramping down to normal operations for the rest of the week. A detailed description of the Non-Bypass Alternative can be found in **Section 2.11**.

A conceptual hydrograph for the Non-Bypass Alternative, shown in **Figure 2-5**, shows 1 week of a hydrograph under this alternative. The graph shows repeated high- and low-flow release combinations on Sunday night through Monday afternoon. Water from the high-flow and low-flow releases would move downstream with decreasing magnitude. The effects on water levels within the Colorado River under this alternative would be most intense near Glen Canyon Dam, with impacts of the high- and low- volume releases on river water levels diminishing further downstream. As shown in **Figure 2-6,** by the time water reaches Pumpkin Spring at river mile 213, the trough would be almost entirely collapsed.

The LTEMP ROD defines maximum ramp rates as 4,000 cfs per hour up and 2,500 cfs per hour down. The modeled ramp up between the low flow (2,000 cfs) and the high flow (approximately 27,300 cfs) over the 6-hour window slightly exceeds ramp rates. However, actual ramp rates would be within the operating range of the LTEMP ROD. The minimum flows and the maximum daily range under this alternative would fall outside of the limits proposed in the LTEMP ROD (DOI 2016b). **Figure 3-9** shows modeled projected monthly Glen Canyon Dam release volumes under the Non-Bypass Alternative relative to the No Action Alternative for the period of analysis.

**Figure 3-9**
**Monthly Glen Canyon Dam Release Volumes for the Non-Bypass Alternative**




Source: Yackulic et al. 2024
Note: The flows presented are based on estimates from 30 modeled traces.

### Cumulative Effects

Direct impacts on the Colorado River downstream of Glen Canyon Dam and at Lake Powell stemming from alternate monthly water releases are likely to be temporary and are not anticipated to have major impacts on the local hydrology. On an annual basis, release volumes to the Lower Basin would remain unchanged. All proposed flow options, except for the Non-Bypass Alternative, would operate within the spatial and temporal bounds and under the assumptions of the existing analysis in the 2016 LTEMP FEIS (DOI 2016a). Management of annual release volumes and reservoir elevations are anticipated to be updated in the Colorado River Post-2026 Operations NEPA effort.

## 3.3 Energy and Power

Hydropower effects are modeled for several parameters below using two different methods and using potential bypass volumes to cool different points in the river (river miles 15 and 61). The methodology, assumptions, strengths, weaknesses, and results of each method are described below in *Methodologies*. The *Summary of Hydropower Impacts* subsection summarizes the results of each method and provides a basis for comparing the alternatives.

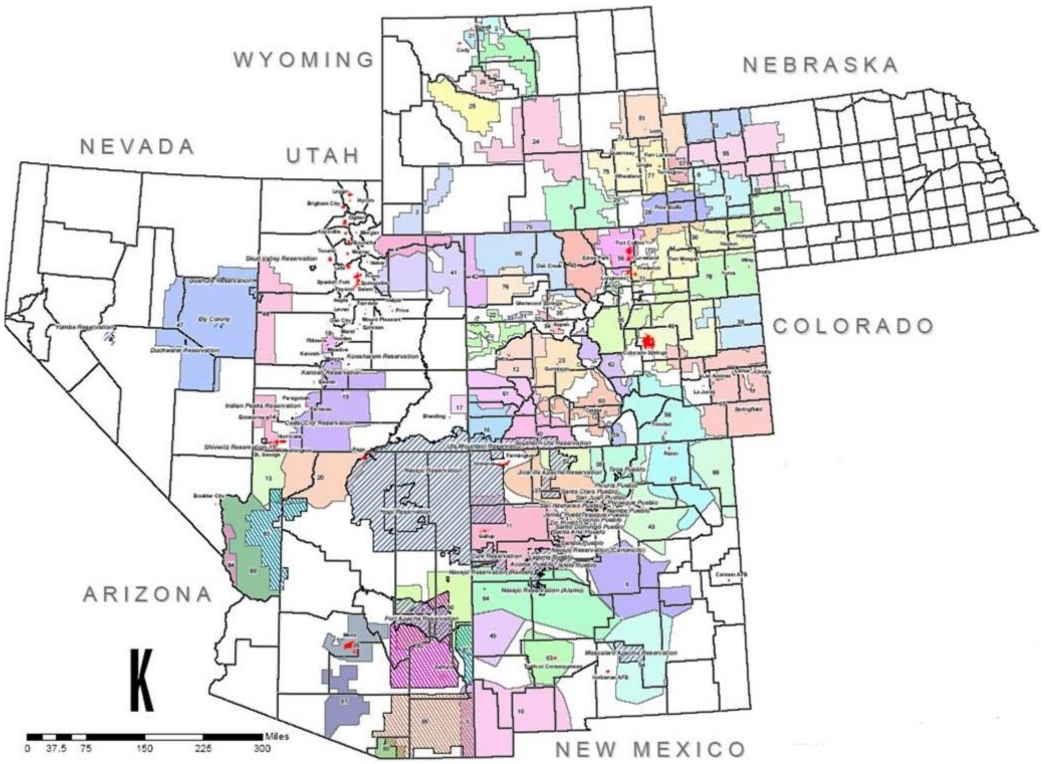
### 3.3.1 Affected Environment

This section describes Glen Canyon Dam and the Glen Canyon Powerplant's power operations and power marketing. Additional information on the socioeconomic environment relating to hydropower and additional resources, including baseline economic conditions for the seven-state CRSP hydropower customer area, can be found in **Section 3.15**, Socioeconomics, and **Section 3.16**, Environmental Justice.

The powerplant is connected to the Western Power Grid via a regional transmission system. Power generated at Glen Canyon Dam provides electricity for the US Department of Energy's WAPA customers. WAPA is responsible for providing electricity to a 15-state region of the western United States. Glen Canyon Dam is a major contributor to the CRSP transmission system and typically provides electricity to parts of Wyoming, Utah, Colorado, New Mexico, Arizona, Nevada, and Nebraska (DOI 2016a, p. 3.221). Glen Canyon Dam also provided emergency power supplies to California in 2000, 2001, 2020, and 2022. **Figure 3-14** shows a map of CRSP hydroelectric power customers.

Operations at Glen Canyon Dam affect the Basin Fund, consumers, and government agencies. Revenues from power generation are deposited into the Basin Fund, which funds authorized activities under the CRSP Act of 1956 and other federal laws.

**Figure 3-10**
**CRSP Hydroelectric Power Customers Map**

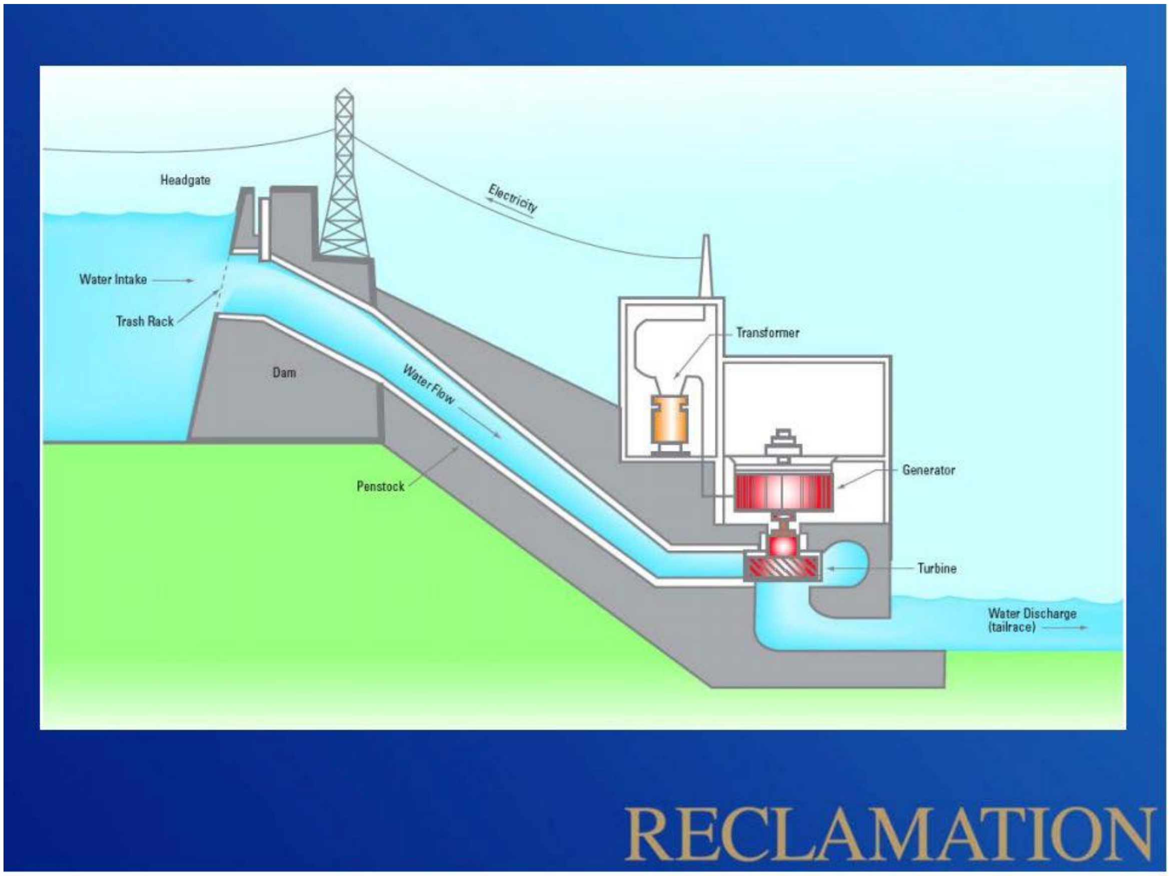



### *Power Operations*

Power operations are the physical operations of an electric power system, including hydropower generation and control, operational flexibility, scheduling, power generation load following[15], regulation, reserves, transmission, and emergency operations. These are discussed in the sections below. Glen Canyon Dam operations directly impact power generation. The amount of water discharged through the generator units and the elevation of the reservoir dictate the amount of electricity generated. Typical operations at Glen Canyon Dam result in power generation at the powerplant, with electricity moving from the plant and along the transmission system to the customers. **Figure 3-11** provides a simplified diagram of the powerplant's operations.

[15] Load following - adjustments to power output as demand for electricity fluctuates throughout the day.

**Figure 3-11**
**Powerplant Operations Diagram**




### Hydropower Generation

Glen Canyon Dam has eight generators with a maximum combined capacity of 1,320 MW when the reservoir elevation is 3,700 feet (DOI 2016a). The powerplant requires a minimum Lake Powell elevation of 3,490 feet to operate. The 2016 LTEMP FEIS provides additional historical power generation data, such as annual net generation, and is incorporated by reference (DOI 2016a, pp. 3.199–3.200). Power generation varies on daily, seasonal, and yearly scales as a result of contract obligations, water release schedules, power needs, reservoir levels, and operational requirements. Releases through the river outlet works do not generate power and, therefore, have no power system economic value (DOI 2016a).

### Basin Fund

The CRSP Act of 1956 established the Basin Fund (43 US Code 620d), which remains available until the funds are expended to carry out the purposes and operations. Maintaining a sufficient Basin Fund balance is critical to operating and maintaining the reliability of CRSP facilities in delivering water to water users and generating and transmitting power to power customers. Reclamation and WAPA use this fund to repay the federal CRSP investment (with interest), operate CRSP facilities and maintain CRSP facilities' expenses, provide power for WAPA customers, provide funding under a Basin States' memorandum of agreement (MOA), support environmental and salinity programs, and provide irrigation assistance. The Basin Fund also has historically funded environmental programs like the GCDAMP and the San Juan River Basin Endangered Fish Recovery Programs (and other related experiments). In recent years, however, appropriations—instead of the Basin Fund—have funded environmental programs like the GCDAMP and the Upper Colorado and San Juan River Basin Endangered Fish Recovery Programs (and other related experiments).

WAPA provides wholesale power to preference customers, including public utilities, municipalities, and Tribes, which fold this power into the rest of their portfolio to fulfill their load requirements. More information on Tribal power can be found in **Section 3.16**, Environmental Justice. Under WAPA's current rate structure, WAPA provides its long-term firm power customers with a set amount of power on a quarterly basis. The amount of power is based on the amount of water Reclamation forecasts to release from the CRSP units during that quarter. If the CRSP units do not generate enough power to fulfill these contractual and rate obligations based on the quarterly set amount, WAPA and its customers purchase power and transmission on the energy market to make up the difference. WAPA uses cash from the Basin Fund to make those purchases.

Under the Grand Canyon Protection Act of 1992 (Public Law 102-575), WAPA records the financial costs of environmental experiments at Glen Canyon Dam as a nonreimbursable expense by accounting for such costs as a constructive return to the US Treasury rather than an operations and maintenance expense to be recovered through WAPA's cost-based power rates. Experimental releases that bypass the electrical generators at Glen Canyon Dam reduce hydropower generation. Accordingly, WAPA purchases replacement power to fulfill contractual delivery obligations. The Basin Fund is not a nonreimbursable funding source. WAPA does not have a nonreimbursable funding source that can be used to mitigate the potential costs of the proposed alternatives in this SEIS.

**Operational Flexibility**

The operational flexibility of hydroelectric power generation allows WAPA to quickly and efficiently increase or decrease generation in response to customer demand, generating unit or transmission line outages (contingency reserves), unscheduled customer deviations from internally scheduled contracted power usage (regulation and load/generation following) within a specific metered load area known as a balancing authority, integrated power system requirements, and requests for emergency assistance from interconnected utilities. Under the water release parameters instituted on an interim basis in 1991 and permanently under the 1996 ROD following the completion of the Glen Canyon Environmental Impact Statement (Reclamation 1995), WAPA currently restricts the scheduling of customer contract allocations to 2-day-ahead prescheduling only. Customer demand schedules frequently exceed the availability of Glen Canyon generation based on water availability and operating constraints. Operational conditions are complicated by the frequency, season, and time of day any of these events may occur; physical and environmental operating restrictions at other CRSP generating facilities and within the interconnected electric system; and the availability and price of alternative power resources (DOI 2016a).

The Glen Canyon Dam Powerplant operating regime was modified with the 2016 LTEMP ROD, which continued with a minimum water release rate of 8,000 cfs or more between 7:00 a.m. and 7:00 p.m., and at least 5,000 cfs between 7:00 p.m. and 7:00 a.m.; the maximum hourly increase (that is, the up-ramp rate) of 4,000 cfs per hour; a daily fluctuation limit of 8,000 cfs per 24-hour period; and a maximum release rate for power generation of 25,000 cfs. The LTEMP ROD modified the daily fluctuation limit, so it is calculated as a function of the monthly volume; it also increased the down-ramp rate to 2,500 cfs per hour (DOI 2016a).

**Scheduling**

Power scheduling occurs by matching available power generation to seasonal, daily, and hourly system energy and capacity needs. At Glen Canyon Dam, power scheduling is affected by the temporal distribution of monthly water release volumes, restrictions in water release patterns, availability of generator units (due to maintenance), availability of other CRSP hydropower units, power allocations, and peak and off-peak power demand periods. Scheduling to meet power requirements typically results in higher water releases via the powerplant in the peak power demand months of December, January, July, and August.

**Load Following, Generation, and Regulation**

Hydropower generation can change instantaneously in response to changes in the load (demand) or unanticipated changes in the power generation resources within the operating region. This ability to respond to rapidly changing load conditions is called load or generation following, or both (DOI 2016a, p. 3.203).

Typically, power demand—or power load—increases during daylight hours and decreases during nighttime hours. The load is similar from Monday through Saturday, but the load drops considerably on Sunday. This type of operation (load following) creates large fluctuations in water releases, which can have negative impacts on some downstream environmental resources (DOI 2016a, p. 3.204). The 1996 ROD (Reclamation 1996) narrowed the range of operation for Grand Canyon Protection Act (GCPA) and CRSP Act purposes, thereby reducing the ability of power generation at Glen Canyon Dam to respond to customer load.

Changes in WAPA's scheduling guidelines typically occur over a period of months, not only because of the operational constraints originally imposed by the 1996 ROD (Reclamation 1996) but also due to changing market conditions. The 2016 LTEMP FEIS also further reduced the load-following capability, despite increasing down-regulation rates, reducing operational flexibility. Operational flexibility has been affected by extended experimental releases that reduce daily flow-rate fluctuations (DOI 2016a, p. 3.204). Operational conditions are further affected by the frequency, season, and time-of-day limitations that may be in effect; physical and environmental operating restrictions at other CRSP generating facilities and within the interconnected electric system; and the availability and price of replacement power (DOI 2016a, p. 3.201).

**Capacity Reserves**

WAPA operates a balancing authority for the region and is required to maintain sufficient generating capacity to continue serving its customer load. This is to ensure reliable power availability and uninterrupted service. Total available capacity, in turn, is determined by the minimum and maximum allowable releases from other unit powerplants and is particularly important for emergency situations (DOI 2016a).

### Disturbances, Emergencies, and Outage Assistance

During experimental releases, including the ones described in this SEIS, Reclamation will continue to operate Glen Canyon Dam with emergency exception criteria, as described in the 2016 LTEMP ROD, the 2018 Operating Criteria for Glen Canyon Dam, and the 2021 Interagency Agreement (19-SLC-1021) between Reclamation and WAPA. Emergency operations are typically of short duration (usually less than 4 hours) and would be the result of emergencies at the dam or within the interconnected electric system.

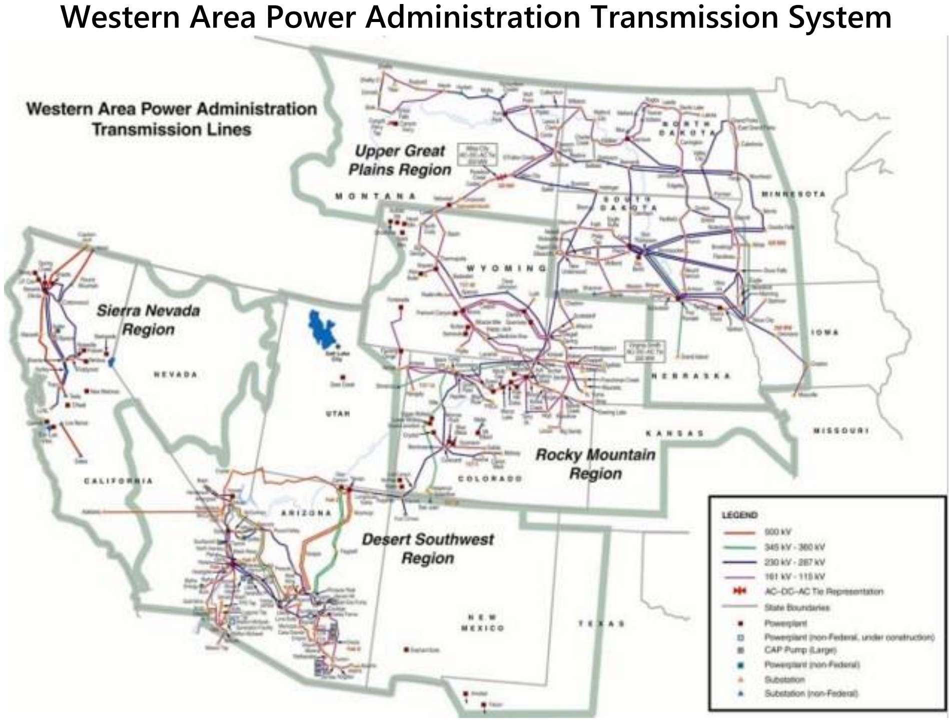
The emergency exception criteria specify that operations at Glen Canyon Dam will be altered temporarily to respond to emergencies, including:

- Insufficient generating capacity
- Transmission system overload, voltage control, and frequency
- System restoration
- Humanitarian situations (search and rescue)

### Transmission System

Glen Canyon Dam is connected to a transmission system that allows for power to serve users such as municipal, residential, Tribal, agricultural, and commercial consumers (**Figure 3-12**). Glen Canyon Dam's generation can affect transmission limitations if lines do not have enough capacity to transmit electricity from the point of generation to the point of demand. Actual transmission refers to the measured flow of power on the line. The North American Electric Reliability Corporation requires monitoring of the actual and scheduled power flow for system operation (DOI 2016a).

**Figure 3-12**
**Western Area Power Administration Transmission System**



#### *Power Marketing*

WAPA markets wholesale CRSP power to preference entities (WAPA, n.d.), serving approximately 5.8 million retail customers in the operating region (DOI 2016a, p. 3.206). Additional information about power marketing, including wholesale and retail rates, is included in the 2016 LTEMP FEIS. This information is incorporated by reference (DOI 2016a, pp. 3.206–3.209).

WAPA modified firm power rates for fiscal year 2022 in response to continued drought conditions and aridification, Lake Powell's reservoir level, associated reductions in power production caused by lower Glen Canyon Dam water releases, and increasing market prices for firming power. Under these new rates, the burden of replacing generation not provided by the CRSP facilities was largely shifted to CRSP customers.

### 3.3.2 Environmental Consequences

The Glen Canyon Dam Powerplant is connected to the Western Power Grid through a regional transmission system. It provides electricity to utilities in a 15-state region of the western United States. The objective of modeling energy costs of Glen Canyon Dam releases is to produce hourly flows, generation, and economic value estimates over the planning horizon for each alternative and hydrologic trace in the LTEMP SEIS. The results are used to quantitatively analyze the economic impacts of each alternative. The models are based on standard energy economic analysis methods (Harpman 1999).

The proposed alternatives include a new sediment accounting window and managing Colorado River water temperature downstream of Glen Canyon Dam from May through October. Therefore, altered flows would not be implemented during the winter months, and there would be little effect on energy generation during this time frame. The following analysis focuses on warm-weather months when flows could be implemented.

Compared with current conditions, the cold-water alternatives would include passing more water through the river outlet works where energy is not generated. Energy generation effects would vary depending on the alternative implemented.

This section provides an evaluation of the impacts on hydropower and CRSP operations by the alternatives. The 2016 LTEMP FEIS found no impacts on the Hoover Dam Powerplant; therefore, the Hoover Dam Powerplant is not included in this analysis. Evaluation should include consideration of all the following components that were analyzed in the 2016 LTEMP FEIS (DOI 2016a, p. 4-322):

- Changes in the amount (megawatt-hours [MWh]) and dollar value of hydropower generation at Glen Canyon Dam
- Impacts on the Basin Fund and CRSP operations
- Changes in marketable capacity
- Impacts on the transmission system
- Availability of replacement power and source
- Changes in emissions

- Effects on regional energy prices
- Impacts on responding to emergencies and disturbances
- Effects on the WAPA wholesale rate
- Effects on retail rates
- Nonuse value

### *Methodologies*

**GTMax Modeling**

The Generation and Transmission Maximization Superlite Transmission (GTMax SL) model was developed by Argonne to simulate the operation of the dams and powerplants in the CRSP system. The GTMax SL model is well suited for this application because it uses a systemic modeling approach to represent all system components while recognizing interactions among supply, demand, and water resources over time. GTMax SL represents other CRSP facilities in the same manner they are operated and marketed by WAPA. It optimizes the system on an hourly time step using a large set of mathematical equations that are solved using a linear programming software. All operations are within component limitations and system dispatch goals that are formulated as a set of linear constraints and bounds. The model considers reservoir information (releases and elevation), environmental constraints, electricity market prices, scheduling objectives, and operational constraints. The flow of energy between connected grid points and river flows is represented in the model by links that connect node objects. All hours are solved simultaneously, allowing the model to recognize that the dispatch of supply resources in any one hour affects the dispatch during all other times in a simulated week.

A version of the GTMax model that includes the CRSP transmission topology called the SLIP Energy Routing Model (SERM) was used to estimate potential impacts on the transmission of CRSP energy and to estimate the cost to replace lost Glen Canyon Dam generation. SERM determines optimal pathways that "contractually" transport CRSP energy from supply sources (generation and purchases) to sinks (Firm Electric Service customer loads) and energy market sales. SERM optimizes hourly energy market purchases and sales and measures implications of the action alternatives on CRSP office finances. SERM also simulates Salt River Project exchange agreements with the CRSP office in which generation from Salt River Project's Craig, Hayden, and Four Corners thermal powerplants serve CRSP Firm Electric Service customers' loads in the northern and Four Corners area.

**GTMax Modeling Inputs and Assumptions**

*Study period*—Modeling from GTMax SL was conducted for the planning horizon, which was October 2023 through September 2027. Model results produced the energy generation (MWh) and economic value of electric energy from operational differences at Glen Canyon Dam for each alternative. For computational efficiency, in months when no experiments take place, GTMax was run for only a 7-day representation each month. Hourly values from the 7-day representation were then extracted out to monthly values. In months where an experiment would take place, every hour of the month was modeled.

*Energy prices*—Future average peak and off-peak energy prices were from the forward mid-market power curves at the Palo Verde Hub on December 6, 2023.

*Reservoir releases and elevations*—A subset of 30 traces from Reclamation's CRSS were used in the Interim Guidelines SEIS (Reclamation 2024b).

*Electric load*—Estimated hourly generation, assuming no experiments occurred, was used as the estimated hourly load. Generation with no experiments was estimated using the GTMax SL model.

**Plexos Modeling**

To assess the impact of varying operational patterns at the Glen Canyon Powerplant, NREL, in collaboration with Argonne and WAPA, used a commercially available production cost modeling tool, Plexos,[16] to provide additional analysis for this LTEMP SEIS (Veselka et al., forthcoming). The Plexos tool is widely used by NREL and other organizations to simulate the operation of the electric power system on an hourly basis. Plexos does an optimization to determine the least-cost unit commitment and economic dispatch of every generator in the system, given the physical constraints of the system itself. These physical constraints include the hourly electricity demand, the operating parameters of individual generators, the transmission system topology, and the availability of wind, solar, and water for electricity generation. It also ensures the sufficient provision of operating reserves.

The outputs of Plexos include the hour-by-hour optimal dispatch of the generation fleet, locational marginal prices, and total generation cost (including fuel costs, variable operating and maintenance costs, and start and shutdown costs). Plexos can also identify transmission lines or paths that exhibit congestion and any reliability concerns, such as unserved load or reserves.

The analysis focused on the Colorado River Basin, which includes parts of several balancing authorities or load-serving entities in the southwestern United States: Western Area Lower Colorado, Western Area Colorado Missouri, Arizona Public Service, Nevada Power, parts of the PacificCorp footprint, Public Service of Colorado, Public Service of New Mexico, Tucson Electric Power, and Salt River Project. NREL worked with study participants (WAPA, Argonne, and Salt River Project) to improve the representation of this focus area by adjusting generator retirement dates, updating transmission line wheeling rates, and increasing the reserve requirement in the region. The largest portion of electricity generation in 2024 is still coal, but by 2027, wind and coal generation will be present in roughly equal amounts driven by growth in wind generation and retirements of coal generation. Solar generation also continues to grow through the 4 years, and the other sources of generation (nuclear, natural gas, and hydropower) remain relatively stable. Note that the total generation in the region exceeds the total annual load; this indicates that the region is a net exporter to other regions of the Western Interconnection.

Plexos modeling was not available at the time of the 2016 LTEMP FEIS. This modeling is part of the best available science and has, therefore, been included in this analysis. A detailed description of

[16] A product of Energy Exemplar (https://www.energyexemplar.com/plexos)

methods and scenarios considered can be found in the NREL 2024 report (Veselka et al., forthcoming).

**GCMRC**

In addition to GTMax and Plexos modeling, this analysis also contains modeling results by GCMRC. In this model, the estimated costs of changes in energy generation at Glen Canyon Dam were developed using a standard constrained optimization model. The constrained optimization model optimizes electricity production based on a specified objective, water availability, and operating constraints. Modeling was conducted for the planning horizon, which was October 2023 through November 2027.

Monthly operating priorities are based on average historical hourly releases at Glen Canyon Dam from September 2020 through August 2023. The assumption is made that the recent operation at Glen Canyon Dam is a reasonable representation of WAPA's attempt to meet near-term scheduling requests by utilities.

Operation at Glen Canyon Dam was optimized using these release data (Reclamation 2024c) to prioritize hourly operation within a representative week, constrained by the operational constraints in the LTEMP ROD (DOI 2016b).

The hydropower optimization model closely follows Harpman (1999). The hydropower objective is to identify the load-following path that maximizes the opportunity to meet scheduling of hydropower generation. A detailed explanation of the optimization model can be found in Yackulic et al. 2024 (chapter 2).

GCMRC post processes the optimal hydrograph based on flow specifications in the LTEMP SEIS alternatives. For example, if flow spikes are implemented for a month under an alternative and hydrologic trace, those flow constraints are imposed on the baseline hydrograph, staying true to the constraints specified in the LTEMP ROD (DOI 2016b).

To forecast the economic value of energy generated at Glen Canyon Dam, GCMRC developed models that predict marginal prices given industry forecasts of price (that is, Argus Forward Mid-Market Power Curves [Argus Media 2024]). While these industry forecasts include important information on changing energy markets, they also include a risk premium that leads to systematic overestimation of future marginal prices (Benth et al. 2008; OMB 2023); therefore, the use of these raw forecasts is likely to lead to systematic overestimation of differences among alternatives. GCMRC treated the observed hourly historical, locational, marginal price at the Palo Verde Hub from February 2020 to August 2023 (California Independent System Operator 2024) as data since many (but not all) users of power from Glen Canyon Dam trade at this hub. GCMRC assumed that the relationship between Argus Forward Mid-Market Power curves (forecasts) and observed data would vary by month, day of the week, and hour of the day such that each month of the year should have 168 independent models (one for each hour in each day of the week).

Each of these models was a linear regression of the form $Y = a + b*X$, where X was the forecasted off-peak power price; Y was the observed locational, marginal price; and a and b were estimated coefficients. GCMRC also tested using on-peak forecasts as a predictor, but GCMRC found that on-peak forecasts did a poorer job of predicting relative changes in observed prices than off-peak forecasts (based on a comparison of competing models via Akaike Information Criterion). While X was off peak, forecasts of the value of b varied dramatically based on the hour and day of the week, allowing for accurate predictions. Values of a and b for each month, day, and hour were then combined with Argus Forward Mid-Market Power Curves for October 2023 through November 2027 (Argus Media 2024) to predict prices over the LTEMP SEIS's period.

The economic cost of foregone energy generation from implementing an alternative is the difference between hydroelectricity economic value under the optimal load-following path (No Action Alternative) and hydroelectricity economic value under an action alternative.

### *Alternatives*

#### No Action Alternative

Under the No Action Alternative, no changes would be made to Glen Canyon Dam operations. Therefore, water would continue to be released primarily through the penstocks, as described in the 2016 LTEMP FEIS. Power generation would continue, similar to historical levels, with slight variations depending on water availability and the constraints outlined in the 2016 LTEMP FEIS. The economic value of electric energy from energy sales would also continue to be generated, similar to historical levels, with slight variations, depending on consumer demands, generation levels, and the constraints outlined in the 2016 LTEMP FEIS.

#### Action Alternatives

*HFE Action Common to All Alternatives*

The HFE changes to the implementation window are common to all action alternatives, and they modify the actions in the same manner. All results in this section include the effects of proposed HFE adjustments. Impacts from changes to the HFE protocol are within those analyzed with the 2016 LTEMP FEIS. Instances where bypass occurs through 2027 because of HFE releases are included in the bypass analysis related to smallmouth bass flows.

*WAPA Methodology*

The WAPA methodology is to assess costs per flow event rather than an average. This method is designed to better estimate the cost of experimental flows as compared to the use of average values, including time frames, when no experimental flows occur. WAPA's historical cost estimates relative to the actual cost incurred for past HFE releases and macroinvertebrate flow experiments are described in **Table 3-1**. This methodology focuses on only considering traces with bypass. The modeling to river mile 15 resulted in 8 traces that required bypass. The modeling to river mile 61 resulted in 13 traces that required bypass. Only considering traces with bypass can accurately estimate average impacts if experiments are required in all 4 years. Other methodologies below include averages using all 30 hydrologic traces, which provides a range of impacts incorporating the potential for years without bypass. **Table 3-2** compares these two methodologies and shows the higher averages if bypass is required all 4 years (average using only bypass traces).

**Table 3-1**
**Comparison of WAPA's Pre-experiment Cost Estimate with the Post-experiment Cost Determination for HFE Releases (2012–2023) and Macroinvertebrate Flows (2018 to 2022)**

| Experiment | Estimated Cost per Occurrence ($M) | Actual Cost per Occurrence ($M) | Difference between Estimated and Actual ($M) | Difference between Estimated and Actual (%) |
|---|---|---|---|---|
| High-Flow Experiments (HFE Releases) | | | | |
| LTEMP EIS | 1.640 | | | |
| 2012 | — | 1.918* | | |
| 2013 | 1.740 | 2.593 | -0.844 | -49 |
| 2014 | 1.749 | 2.100 | -0.351 | -20 |
| 2016 | 1.400 | 1.150 | +0.250 | +18 |
| 2018 | 0.920 | 1.300 | -0.376 | -41 |
| 2023 | 1.480 | —** | | |
| Macroinvertebrate Flows | | | | |
| LTEMP EIS | (1.620) | | | |
| 2018 | 0.336 | 0.166 | +0.170 | +51 |
| 2019 | 0.332 | 0.327 | -0.005 | -2 |
| 2020 | 0.408 | 0.941 | -0.533 | -131 |
| 2021 | 0.729 | 1.021*** | -0.292 | -40 |
| 2022 | 1.401 | 1.154 | -0.247 | +18 |

Sources: GCDAMP 2024a, 2024b, 2024c
*Included the cost of the fall steady flow
**Financial assessment has not been completed.
***Macroinvertebrate flows were not implemented in 2021, but Argonne calculated a cost for discussion purposes at the time to see what the cost would have been if one had been implemented.

**Table 3-2**
**Cost Estimates of Action Alternatives Using All Traces and Only Traces where Bypass Flows May Be Considered**

| Alternative (River Mile) | Average Using All 30 Traces ($M) | Average Using Only Bypass Traces ($M) | Difference between All Traces and Bypass Traces ($M) | Difference between All Traces and Bypass Traces (%) |
|---|---|---|---|---|
| Cool Mix (river mile 15) | 15.26 | 60.72 | -45.46 | -298 |
| Cool Mix (river mile 61) | 26.20 | 62.53 | -36.33 | -139 |
| Cool Mix with Flow Spike (river mile 15) | 15.48 | 59.00 | -43.52 | -281 |
| Cool Mix with Flow Spike (river mile 61) | 25.75 | 61.14 | -35.39 | -137 |
| Cold Shock (river mile 15) | 8.76 | 33.08 | -24.32 | -278 |
| Cold Shock (river mile 61) | 13.05 | 31.36 | -18.31 | -131 |
| Cold Shock with Flow Spike (river mile 15) | 9.21 | 34.69 | -25.48 | -277 |
| Cold Shock with Flow Spike (river mile 61) | 15.04 | 34.40 | -19.36 | -129 |
| Non-Bypass (river mile 15) | 0.97 | 4.00 | -3.03 | -312 |
| Non-Bypass (river mile 61) | 0.67 | 2.81 | -2.14 | -319 |

Source: GTMax model (Veselka et al., forthcoming)

*Impacts on Power Generation*

These Action Alternatives may impact WAPA's ability to meet its customers' energy needs, and a reduction in generation could result in energy emergencies when supply is insufficient to meet demand. Additional information about replacement power availability can be found below in *Availability of Replacement Power and Source*. The cold-water alternatives would increase the risk that WAPA would be unable to meet its contractual obligations to provide customers with power unless it is able to procure sufficient replacement energy and associated transmission. This replacement energy and transmission may not be available without significant added expense, and WAPA has been notified by some of its trading partners that they may not have sufficient replacement power and transmission available for purchase during periods of peak power demand available at any price. In addition, replacement power from nonrenewable sources may result in the loss of existing renewable energy credits, potentially impacting achievement of corporate goals, meeting stakeholder commitments, and advancing decarbonization of the region.

**Table 3-3** shows the effect, including traces where an Action Alternative is not triggered in the analysis. The table shows the impacts over 45 months to match the duration of the Plexos and GTMax SL modeling; actual implementation may vary. In the columns showing average lost power production for all 30 traces (including when an Action Alternative is not implemented), the potential effect on power generation is reduced when compared to the average values for traces where an Action Alternative is implemented (the 8 traces for river mile 15 and 13 traces for river mile 61). Note that while 8 and 13 traces were modeled based on when the temperature exceeded the 15.5°C (60°F) threshold, the smallmouth bass model only indicated a population growth for 5 of the traces at river mile 15 and 7 of the traces at river mile 61 (see **Section 3.5.2**). Actual costs would likely be lower than the modeled results due to this reduced frequency in bypass.

## Table 3-3
## Potential 45-Month Flow Impacts on Power Generation, All 30 Traces versus Only Traces with Bypass

| Alternative | 4-Year Average Lost Production – River Mile 15 | | 4-Year Average Lost Production – River Mile 61 | |
|---|---|---|---|---|
| | (GWh) 30 Traces, including Zeros | (GWh) 8 Bypass Traces | (GWh) 30 Traces, including Zeros | (GWh) 13 Bypass Traces |
| Cool Mix Alternative | 146.88 | 584.16 | 234.09 | 552.83 |
| Cool Mix with Flow Spike Alternative | 136.73 | 545.60 | 254.56 | 545.51 |
| Cold Shock Alternative | 68.11 | 284.60 | 108.89 | 273.05 |
| Cold Shock with Flow Spike Alternative | 68.37 | 283.58 | 125.65 | 288.98 |
| Non-Bypass Alternative | (9.01) | 10.70 | (8.43) | 4.68 |

Source: GTMax model (Veselka et al., forthcoming)
Model results are for the operating period from January 2024 to September 2027. The figures presented are the average power generation estimates out of all 30 traces compared with just the 8 and 13 modeled traces where an Action Alternative was triggered.

Another important consideration when assessing hydropower impacts is the time of year an Action Alternative is expected to be implemented. The number of months when an Action Alternative is triggered is shown below in **Figure 3-13**. The months with the most occurrences of Action Alternative flows are August through October. This is somewhat different from the typical release temperature data because, depending on the elevation of the reservoir, the warmest releases typically occur in October or November. Less bypass is needed in October and November because the river stops warming as water continues downstream during this time of year (**Figure 3-14**). Thus, the peak occurrence of an Action Alternative's releases happens earlier in the year than when the warmest release temperatures are typically observed.

Peak hydropower needs and values occur over these same months, with capacity generally being limited in August (see *Impacts on Capacity* below). These data also show the serial correlation that occurs within a year. If an Action Alternative is triggered in the early season, it is much more likely to continue to be triggered in subsequent months due to factors that triggered the Action Alternative, like low reservoir elevations, which are likely to continue for the rest of the summer. Therefore, using averages will underestimate the impact of an event because the likelihood of having bypass in a month following a month with bypass is high, and not independent. The economic value of energy section below further describes the impacts of the various bypass traces and the impact that those events could have on hydropower value.

In summary, when looking at the likelihood of implementation over the 30 traces, implementation is more likely with the river mile 61 trigger than the river mile 15 trigger. Overall implementation, according to the smallmouth bass model, is shown to only occur in 8 of the 30 traces at river mile 15 and 13 of the 30 traces at river mile 61. This is in part because the data are serially correlated, meaning that once the reservoir is high enough to avoid triggering a warm-water release, then

**Figure 3-13**
**The Number of Times Each Alternative Is Triggered, by Month, for All 30 Traces**

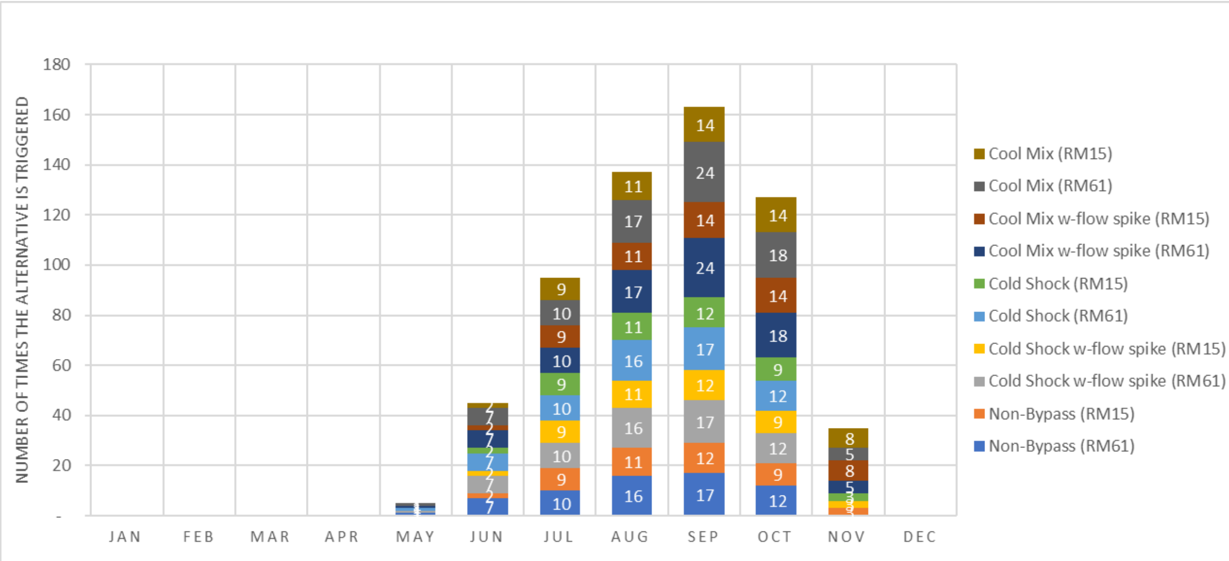
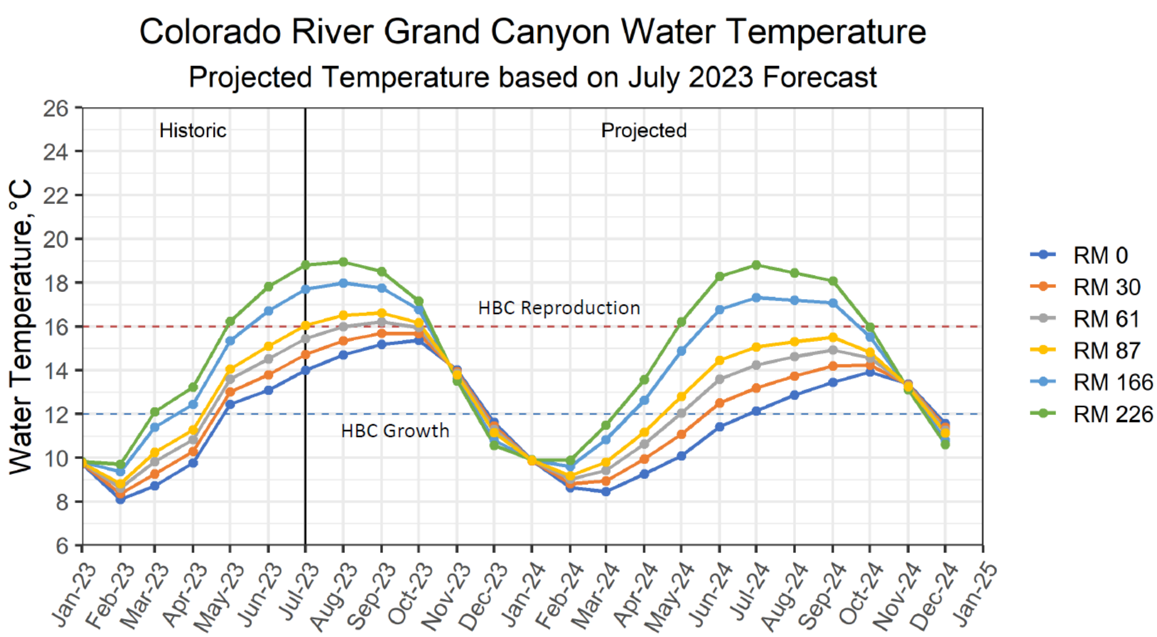



**Figure 3-14**
**Projected Water Temperatures in the Colorado River Downstream of Lees Ferry (River Mile 0) in 2023 and 2024**



reservoir elevations in the months and years following are likely to be high as well, especially over a short 4-year time period like this one. Thus, the rest of the risk assessment is to determine the consequence of an event occurring and how to mitigate that event.

*Impacts on Power Generation*

All four bypass alternatives would include bypassing more water through the river outlet works where energy is not generated. Each bypass alternative would reduce the energy generation and increase the amount of replacement energy required to meet demand in the interconnected transmission and distribution system. The Non-Bypass Alternative would provide modest increases in energy production; however, it would be impacted by the effects of the new HFE window at similar levels of impact.

**Table 3-4** compares generation results between USGS and WAPA modeling for only the months when an Action Alternative would occur. The ordering from these results mirrors the previous sections; however, the average differences here show a greater magnitude because these effects are only for the particular months when an Action Alternative would occur. The Cool Mix Alternative and the Cool Mix with Flow Spike Alternative would result in the most impacts on power generation, with an average monthly river mile 15 loss of approximately 75-80 GWh for months when those Action Alternatives would occur, and a river mile 61 loss of approximately 85-90 GWh. The Cool Mix with Flow Spike Alternative would result in a higher loss than the Cool Mix Alternative because water would be consistently released through the river outlet works, with large amounts released during the flow spikes.

**Table 3-4**
**Potential Flow Impacts on Power Generation for Months when an Action Alternative Occurs, USGS and WAPA Comparison**

| Alternative | Average Monthly Lost Production – River Mile 15 | | Average Monthly Production – River Mile 61 | |
|---|---|---|---|---|
| | (GWh) USGS | (GWh) WAPA | (GWh) USGS | (GWh) WAPA |
| Cool Mix Alternative | 80.17 | 80.57 | 87.50 | 87.64 |
| Cool Mix with Flow Spike Alternative | 75.34 | 75.97 | 85.34 | 90.49 |
| Cold Shock Alternative | 49.52 | 49.50 | 51.53 | 56.34 |
| Cold Shock with Flow Spike Alternative | 42.69 | 50.38 | 37.53 | 59.67 |

Sources: USGS and Reclamation 2024; GTMax model (Veselka et al., forthcoming)
Model results are for the operating period from January 2024 to September 2027. The figures presented are the average power generation estimates out of 30 modeled traces only for the months when and Action Alternative would run.

The Cold Shock Alternative and the Cold Shock with Flow Spike Alternative would have the next highest impact on modeled power generation. The Cold Shock Alternative would have an average monthly river mile 15 loss of approximately 50 GWh; this is because water would be released periodically during weekends with an average monthly river mile 61 loss of approximately 51–56 GWh. The Cold Shock with Flow Spike Alternative would have a river mile 15 loss of approximately 43–50 GWh and a river mile 61 loss of approximately 38–60 GWh. It would mirror the Cold Shock

Alternative, but it would include flow spikes, which would result in large releases of water through the river outlet works during those events.

As above, in 22 traces for river mile 15 and 17 traces for river mile 61, no incidents of bypass occur for the Action Alternatives; thus, the only impacts for those traces are changes due to the new HFE window. For river mile 15, **Table 3-5** and **Table 3-6** describe the impacts on generation of the 8 traces with bypass events from USGS and WAPA modeling, respectively. For river mile 61, **Table 3-7** and **Table 3-8** describe the impacts on generation of the 13 traces with bypass events from the USGS and WAPA modeling, respectively.

**Table 3-5**
**Potential 45-Month Flow Impacts on Power Generation for Action Alternative Traces, River Mile 15 (Loss in GWh) – USGS**

| Alternative | Average | Median | Min | 10th % | 90th % | Max |
|---|---|---|---|---|---|---|
| Cool Mix Alternative | 536.89 | 350.46 | 3.29 | 6.14 | 1,315.78 | 1,371.70 |
| Cool Mix with Flow Spike Alternative | 502.45 | 325.52 | 3.29 | 6.14 | 1,249.43 | 1,347.60 |
| Cold Shock Alternative | 255.57 | 209.12 | 3.29 | 6.14 | 592.59 | 612.12 |
| Cold Shock with Flow Spike Alternative | 222.32 | 174.03 | 3.29 | 6.14 | 530.18 | 532.66 |
| Non-Bypass Alternative | — | — | — | — | — | — |

Source: USGS and Reclamation 2024
Model results are for the operating period from January 2024 to September 2027. The figures presented are the power generation estimates out of 8 modeled traces where an Action Alternative is triggered at river mile 15.

**Table 3-6**
**Potential 45-Month Flow Impacts on Power Generation for Action Alternative Traces, River Mile 15 (Loss in GWh) – WAPA**

| Alternative | Average | Median | Min | 10th % | 90th % | Max |
|---|---|---|---|---|---|---|
| Cool Mix Alternative | 564.27 | 368.63 | 69.71 | 70.35 | 1,300.49 | 1,345.78 |
| Cool Mix with Flow Spike Alternative | 527.46 | 356.49 | 69.71 | 70.35 | 1,192.11 | 1,242.89 |
| Cold Shock Alternative | 278.72 | 233.65 | 51.37 | 58.74 | 563.06 | 587.43 |
| Cold Shock with Flow Spike Alternative | 279.67 | 219.11 | 51.37 | 58.74 | 570.35 | 601.19 |
| Non-Bypass Alternative | 3.22 | 2.90 | (29.89) | (17.03) | 24.50 | 28.35 |

Source: GTMax model (Veselka et al., forthcoming)
Model results are for the operating period from January 2024 to September 2027. The figures presented are the power generation estimates out of 8 modeled traces where an Action Alternative is triggered at river mile 15.

Effects on energy generation for an Action Alternative's bypass, using the river mile 15 trigger, could range from a loss of 3.29 GWh up to a loss of 1,371.70 GWh over the 4 years of the SEIS, depending on the bypass alternative implemented (**Table 3-5** and **Table 3-6**). The Cool Mix Alternative would have the most impact. Effects on energy generation for an Action Alternative's bypass, using the river mile 61 trigger, could range from a gain of 28.79 to a loss of 1,906.06 GWh, depending on the bypass from the Action Alternative implemented (**Table 3-7** and **Table 3-8**). The Cool Mix Alternative would again have the most impact.

**Table 3-7**
**Potential 45-Month Flow Impacts on Power Generation for Action Alternative Traces, River Mile 61 (Loss in GWh) – USGS**

| Alternative | Average | Median | Min | 10th % | 90th % | Max |
|---|---|---|---|---|---|---|
| Cool Mix Alternative | 548.51 | 211.41 | 44.97 | 53.40 | 1,751.53 | 1,906.06 |
| Cool Mix with Flow Spike Alternative | 481.91 | 143.63 | (28.79) | (5.34) | 1,628.15 | 1,871.25 |
| Cold Shock Alternative | 255.52 | 246.75 | 58.25 | 65.00 | 569.69 | 648.57 |
| Cold Shock with Flow Spike Alternative | 200.59 | 177.26 | (15.85) | 5.19 | 516.39 | 564.60 |
| Non-Bypass Alternative | (78.18) | (52.74) | (212.64) | (170.21) | (6.60) | (0.30) |

Source: USGS and Reclamation 2024
Model results are for the operating period from January 2024 to September 2027. The figures presented are the power generation estimates out of 13 modeled traces where an Action Alternative is triggered at river mile 61.

**Table 3-8**
**Potential 45-Month Flow Impacts on Power Generation for Action Alternative Traces, River Mile 61 (Loss in GWh) – WAPA**

| Alternative | Average | Median | Min | 10th % | 90th % | Max |
|---|---|---|---|---|---|---|
| Cool Mix Alternative | 542.20 | 227.35 | 39.80 | 48.28 | 1,742.31 | 1,884.40 |
| Cool Mix with Flow Spike Alternative | 526.20 | 178.97 | 47.68 | 51.80 | 1,691.75 | 1,851.72 |
| Cold Shock Alternative | 271.04 | 239.30 | 42.71 | 49.01 | 649.68 | 733.33 |
| Cold Shock with Flow Spike Alternative | 278.28 | 146.76 | 47.29 | 60.31 | 669.64 | 783.85 |
| Non-Bypass Alternative | 1.20 | 0.05 | (35.53) | (19.39) | 29.73 | 34.55 |

Source: GTMax model (Veselka et al., forthcoming)
Model results are for the operating period from January 2024 to September 2027. The figures presented are the power generation estimates out of 13 modeled traces where an Action Alternative is triggered at river mile 61.

**Table 3-9** through **Table 3-12** show the potential impacts on power generation when all 30 traces are considered. Based on the average energy generation estimates over the 30 modeled traces, and similar to the trends above, the Cool Mix Alternative and the Cool Mix with Flow Spike Alternative could result in the most impacts on power generation. Using the river mile 15 trigger, the average loss for the Cool Mix Alternative and the Cool Mix with Flow Spike Alternative would range from 132.17 to 145.12 GWh over the 4 years of the SEIS (**Table 3-9** and **Table 3-10**). The average loss for the Cold Shock Alternative and the Cold Shock with Flow Spike Alternative would range from 65.05 to 70.05 GWh over the 4 years of the SEIS (**Table 3-9** and **Table 3-10**).

**Table 3-9**
**Potential 45-Month Flow Impacts on Power Generation for 30 Traces, River Mile 15 (Loss in GWh) – USGS**

| Alternative | Average | Median | Min | 10th % | 90th % | Max |
|---|---|---|---|---|---|---|
| Cool Mix Alternative | 145.12 | 4.94 | (46.22) | (38.91) | 621.20 | 1,371.70 |
| Cool Mix with Flow Spike Alternative | 139.90 | 5.33 | (26.68) | (15.96) | 558.99 | 1,347.60 |
| Cold Shock Alternative | 70.05 | 4.94 | (46.22) | (38.91) | 324.36 | 612.12 |
| Cold Shock with Flow Spike Alternative | 65.05 | 5.33 | (26.68) | (15.96) | 273.42 | 532.67 |
| Non-Bypass Alternative | — | — | — | — | — | — |

Source: USGS and Reclamation 2024
Model results are for the operating period from January 2024 to September 2027. The figures presented are the power generation estimates out of all 30 modeled traces where an Action Alternative is triggered at river mile 15.

**Table 3-10**
**Potential 45-Month Flow Impacts on Power Generation for 30 Traces, River Mile 15 (Loss in GWh) – WAPA**

| Alternative | Average | Median | Min | 10th % | 90th % | Max |
|---|---|---|---|---|---|---|
| Cool Mix Alternative | 141.99 | 0 | (157.88) | (55.67) | 622.07 | 1,345.78 |
| Cool Mix with Flow Spike Alternative | 132.17 | 0 | (157.88) | (55.67) | 624.35 | 1,242.89 |
| Cold Shock Alternative | 65.84 | 0 | (157.88) | (55.67) | 326.13 | 587.43 |
| Cold Shock with Flow Spike Alternative | 66.09 | 0 | (157.88) | (55.67) | 347.44 | 601.19 |
| Non-Bypass Alternative | (8.71) | 0 | (157.88) | (55.67) | 29.74 | 79.18 |

Sources: Data from the GTMax model (Veselka et al., forthcoming); calculations from Environmental Planning and Management Solutions (EMPS) 2024
Model results are for the operating period from January 2024 to September 2027. The figures presented are the power generation estimates out of all 30 modeled traces where an Action Alternative is triggered at river mile 15.

Using the river mile 61 trigger, the average loss for the Cool Mix Alternative and the Cool Mix with Flow Spike Alternative would range from 205.01 to 229.82 GWh over the 4 years of the SEIS (**Table 3-11** and **Table 3-12**). The average loss for the Cold Shock Alternative and the Cold Shock with Flow Spike Alternative would range from 83.10 to 108.89 GWh over the 4 years of the SEIS (**Table 3-9** and **Table 3-10**). The Non-Bypass Alternative would have the fewest impacts, with a river mile 61 gain of approximately 8.15 to 41.75 GWh. This is because the bypass system would not be used; instead, there would be changes in release volumes.

**Table 3-11**
**Potential 45-Month Flow Impacts on Power Generation for 30 Traces, River Mile 61 (Loss in GWh) – USGS**

| Alternative | Average | Median | Min | 10th % | 90th % | Max |
|---|---|---|---|---|---|---|
| Cool Mix Alternative | 229.82 | 7.75 | (46.22) | (38.91) | 857.40 | 1,906.06 |
| Cool Mix with Flow Spike Alternative | 205.01 | 0.56 | (28.79) | (17.89) | 794.61 | 1,871.25 |
| Cold Shock Alternative | 102.86 | 7.75 | (46.22) | (38.91) | 337.44 | 648.57 |
| Cold Shock with Flow Spike Alternative | 83.10 | 0.56 | (26.68) | (16.02) | 292.45 | 564.60 |
| Non-Bypass Alternative | (41.75) | (22.62) | (212.64) | (121.12) | 2.99 | 24.56 |

Source: USGS and Reclamation 2024
Model results are for the operating period from January 2024 to September 2027. The figures presented are the power generation estimates out of all 30 modeled traces where an Action Alternative is triggered at river mile 61.

**Table 3-12**
**Potential 45-Month Flow Impacts on Power Generation for 30 Traces, River Mile 61 (Loss in GWh) – WAPA**

| Alternative | Average | Median | Min | 10th % | 90th % | Max |
|---|---|---|---|---|---|---|
| Cool Mix Alternative | 226.29 | 41.06 | (157.88) | (55.67) | 856.64 | 1,884.40 |
| Cool Mix with Flow Spike Alternative | 212.14 | 45.00 | (271.11) | (65.91) | 848.95 | 1,851.72 |
| Cold Shock Alternative | 108.89 | 42.27 | (156.88) | (54.70) | 403.02 | 733.33 |
| Cold Shock with Flow Spike Alternative | 104.71 | 44.80 | (271.11) | (65.91) | 430.08 | 783.85 |
| Non-Bypass Alternative | (8.15) | 0 | (157.88) | (55.67) | 35.32 | 79.18 |

Sources: Data from GTMax model (Veselka et al., forthcoming); calculations from EMPS 2024
Model results are for the operating period from January 2024 to September 2027. The figures presented are the power generation estimates out of all 30 modeled traces where an Action Alternative is triggered at river mile 61.

*Impacts on the Economic Value of Electric Energy*

The cold-water alternatives would have financial impacts that vary to a large extent based on market prices for energy, reservoir elevations, temperature conditions, and which river mile is targeted for cooling (that is, river mile 15 or river mile 61), which will be based on the distribution of smallmouth bass found in the river. Bypassing water around the generators results in a reduction in power generation and in expenses to the Basin Fund because WAPA purchases replacement power to cover the lost generation to firm energy contracts during experimental releases.

Economic value impacts are directly correlated to impacts from reduced power generation. Therefore, the Cool Mix Alternative and the Cool Mix with Flow Spike Alternative would have the most financial impacts. **Table 3-13** compares the economic value impact estimates between USGS and WAPA modeling for only the months when an Action Alternative would occur. The ordering from these results mirrors the previous sections. The Cool Mix Alternative and the Cool Mix with Flow Spike Alternative would result in the most impact on economic value. The Cool Mix Alternative modeling shows an average monthly river mile 15 loss of approximately $6.06 to $8.38

**Table 3-13**
**Potential Flow Impacts on the Economic Value of Electric Energy for Months when Action Alternative Occurs, USGS and WAPA Comparison**

| Alternative | Average Monthly Lost Production – River Mile 15 | | Average Monthly Lost Production – River Mile 61 | |
|---|---|---|---|---|
| | ($ million) USGS | ($ million) WAPA | ($ million) USGS | ($ million) WAPA |
| Cool Mix Alternative | $6.06 | $8.38 | $6.67 | $9.91 |
| Cool Mix with Flow Spike Alternative | $5.67 | $8.21 | $6.59 | $10.19 |
| Cold Shock Alternative | $3.32 | $5.75 | $3.31 | $6.47 |
| Cold Shock with Flow Spike Alternative | $2.77 | $6.16 | $2.41 | $7.16 |

Sources: USGS and Reclamation 2024; GTMax model (Veselka et al., forthcoming)
Model results are for the operating period from January 2024 to September 2027. The figures presented are the average economic value of electric energy estimates out of 30 modeled traces only for the months when an Action Alternative would run.

million and a river mile 61 loss of approximately $6.67 to $9.91 million for months when the Action Alternative would occur. The Cool Mix with Flow Spike Alternative modeling shows an average monthly river mile 15 loss of approximately $5.67 to $8.21 million and a river mile 61 loss of approximately $6.59 to $10.19 million for months when the Action Alternative would occur.

The Cold Shock Alternative and the Cold Shock with Flow Spike Alternative would have the next highest impact on modeled economic value. The Cold Shock Alternative modeling shows an average monthly river mile 15 loss of approximately $3.32 to $5.75 million and a river mile 61 loss of approximately $3.31 to $6.47 million for months when the Action Alternative would occur. The Cold Shock with Flow Spike Alternative modeling shows an average monthly river mile 15 loss of approximately $2.77 to $6.16 million and a river mile 61 loss of approximately $2.41 to $7.16 million for months when the Action Alternative would occur.

The bypass alternatives would have financial impacts that vary to a large extent based on market prices for energy, reservoir elevations, temperature conditions, and which river mile is targeted for cooling (that is, river mile 15 or river mile 61), which will be based on the distribution of smallmouth bass found in the river. Bypassing water around the generators results in a reduction in power generation and in expenses to the Basin Fund because WAPA purchases replacement power to cover the lost generation to firm energy contracts during experimental releases. In **Table 3-15** through **Table 3-17**, below, only the traces that result in an Action Alternative's bypass are used; these are the same 8 traces for the river mile 15 triggers and the same 13 traces for the river mile 61 triggers as used above. Adding traces with no bypass decreases the estimate of the potential impact; however, it is important to include these traces because they represent real possibilities that bypass will not be necessary.

When an Action Alternative is not implemented, the impact would be zero; again, this relates to the risk of occurrence, not to the effect of the action. If the January 1 reservoir elevation remains above about 3,570 feet, the risk of being in one of the traces with bypass is very low (Eppehimer et. al. 2024). Thus, if future hydrology shows it is likely that the reservoir will increase in elevation, then the likelihood of implementation and impacts decreases toward zero. During possible bypass months from August to November, reservoir elevations are almost always declining. This means there is a high risk of triggering an Action Alternative's bypass release the following year due to the serial correlation of the data and the nature of reservoir operations.

Effects on the value of electric energy for the cold-water alternatives using the river mile 15 trigger could range from a loss of $0.29 million to a loss of $142.99 million over the next 4 years, depending on the bypass alternative implemented (**Table 3-14** and **Table 3-15**). The Cool Mix Alternative would have the most financial impacts, with an average estimated economic value of electric energy loss of around $42.04 to $59.04 million for river mile 15 triggered traces over the period from January 2024 to September 2027. The Cool Mix with Flow Spike Alternative would have the second-most financial impacts, with an estimated economic value loss of $39.48 to $57.38 million for river mile 15. The Cold Shock Alternative would have the third-most financial impacts, with an estimated economic value loss of $18.62 to $32.16 million for river mile 15. The Cold Shock with Flow Spike Alternative would have an estimated economic value loss of $15.91 to $33.86 million for river mile 15. The Non-Bypass Alternative is modeled to have a loss of about $3.14 million at river mile 15.

**Table 3-14**
**Potential 45-Month Flow Impacts on the Economic Value of Electric Energy for Action Alternative Traces, River Mile 15 (Loss in $ Million) – USGS**

| Alternative | Average | Median | Min | 10th % | 90th % | Max |
|---|---|---|---|---|---|---|
| Cool Mix Alternative | $42.04 | $29.20 | $0.29 | $0.55 | $101.44 | $105.12 |
| Cool Mix with Flow Spike Alternative | $39.48 | $27.64 | $0.40 | $0.61 | $96.20 | $103.17 |
| Cold Shock Alternative | $18.62 | $15.79 | $0.29 | $0.55 | $42.68 | $44.55 |
| Cold Shock with Flow Spike Alternative | $15.91 | $13.09 | $0.29 | $0.55 | $37.56 | $37.94 |
| Non-Bypass Alternative | — | — | — | — | — | — |

Source: USGS and Reclamation 2024
Model results are for the operating period from January 2024 to September 2027. The figures presented are the economic value of electric energy estimates out of 8 modeled traces where an Action Alternative is triggered at river mile 15. Note that the USGS did not model the Non-Bypass Alternative.

**Table 3-15**
**Potential 45-Month Flow Impacts on the Economic Value of Electric Energy for Action Alternative Traces, River Mile 15 (Loss in $ Million) – WAPA**

| Alternative | Average | Median | Min | 10th % | 90th % | Max |
|---|---|---|---|---|---|---|
| Cool Mix Alternative | $59.04 | $39.74 | $2.71 | $3.27 | $139.34 | $142.99 |
| Cool Mix with Flow Spike Alternative | $57.38 | $40.65 | $2.71 | $3.27 | $134.44 | $137.76 |
| Cold Shock Alternative | $32.16 | $24.09 | $1.62 | $2.63 | $70.58 | $76.21 |

| Alternative | Average | Median | Min | 10th % | 90th % | Max |
|---|---|---|---|---|---|---|
| Cold Shock with Flow Spike Alternative | $33.86 | $25.99 | $1.62 | $2.15 | $75.02 | $82.32 |
| Non-Bypass Alternative | $3.14 | $3.25 | ($1.22) | ($1.15) | $7.15 | $8.78 |

Source: GTMax model (Veselka et al., forthcoming)
Model results are for the operating period from January 2024 to September 2027. The figures presented are the economic value of electric energy estimates out of 8 modeled traces where an Action Alternative is triggered at river mile 15.

Effects on the value of electric energy for an Action Alternative's bypass, using the river mile 61 trigger, could range from a gain of $1.00 million to a loss of $216.31 million over the next 4 years, depending on the bypass alternative implemented (**Table 3-16** and **Table 3-17**). The Cool Mix Alternative would have the most financial impacts, with an average estimated economic value of electric energy loss of around $43.24 to $61.73 million for river mile 61 triggered traces over the period from January 2024 to September 2027. The Cool Mix with Flow Spike Alternative would have the second-most financial impacts, with an estimated economic value loss of $38.75 to $61.24 million for river mile 61. The Cold Shock Alternative would have the third-most financial impacts, with an estimated economic value loss of $17.86 to $31.03 million for river mile 61. The Cold Shock with Flow Spike Alternative would have an estimated economic value loss of $14.35 to $34.99 million for river mile 61. The impact for the Non-Bypass Alternative ranges from a gain of about $1.83 million to a loss of about $2.87 million at river mile 61.

### Table 3-16
### Potential 45-Month Flow Impacts on the Economic Value of Electric Energy for Action Alternative Traces, River Mile 61 (Loss in $ Million) – USGS

| Alternative | Average | Median | Min | 10th % | 90th % | Max |
|---|---|---|---|---|---|---|
| Cool Mix Alternative | $43.24 | $17.73 | $3.29 | $3.74 | $137.29 | $145.96 |
| Cool Mix with Flow Spike Alternative | $38.75 | $13.65 | ($1.86) | ($0.07) | $129.45 | $144.25 |
| Cold Shock Alternative | $17.86 | $17.25 | $3.76 | $4.14 | $36.99 | $47.06 |
| Cold Shock with Flow Spike Alternative | $14.35 | $10.14 | ($1.00) | $0.80 | $34.22 | $41.88 |
| Non-Bypass Alternative | ($1.83) | ($0.64) | ($7.41) | ($5.93) | $1.00 | $3.45 |

Source: USGS and Reclamation 2024
Model results are for the operating period from January 2024 to September 2027. The figures presented are the economic value of electric energy estimates out of 13 modeled traces where an Action Alternative is triggered at river mile 61.

### Table 3-17
### Potential 45-Month Flow Impacts on the Economic Value of Electric Energy for Action Alternative Traces, River Mile 61 (Loss in $ Million) – WAPA

| Alternative | Average | Median | Min | 10th % | 90th % | Max |
|---|---|---|---|---|---|---|
| Cool Mix Alternative | $61.73 | $22.88 | $2.37 | $4.77 | $198.27 | $216.31 |
| Cool Mix with Flow Spike Alternative | $61.24 | $23.25 | $3.67 | $6.06 | $196.80 | $210.21 |

| Alternative | Average | Median | Min | 10th % | 90th % | Max |
|---|---|---|---|---|---|---|
| Cold Shock Alternative | $31.03 | $24.33 | $1.86 | $4.69 | $68.33 | $97.07 |
| Cold Shock with Flow Spike Alternative | $34.99 | $21.30 | $3.05 | $7.45 | $72.45 | $108.22 |
| Non-Bypass Alternative | $2.87 | $1.47 | ($1.12) | ($0.62) | $8.34 | $10.35 |

Source: GTMax model (Veselka et al., forthcoming)
Model results are for the operating period from January 2024 to September 2027. The figures presented are the economic value of electric energy estimates out of 13 modeled traces where an Action Alternative is triggered at river mile 61.

Impacts to the value of energy in the more severe scenarios could have substantial impacts to the Basin Fund over the next 4 years, as described below. These scenarios would have substantial effects on the Basin Fund, as described below. Typical costs for experiments historically under LTEMP have been about $1–$3 million for HFE releases and about $0.3–$1 million for the macroinvertebrate flows. These figures are in contrast, however, to the relatively large cost of the 2000 Low Summer Steady Flow, which was about $26.4 million (Ralston 2011). If an Action Alternative is implemented, and the Cool Mix Alternative is chosen, even the average costs are estimated to be about $60 million over the 4-year time period of this SEIS with the possibility of much higher costs if poor hydrologic conditions continue. However, it is also possible that the costs will be lower than the average because there are many zero bypass traces. If the Cool Mix Alternative is triggered in year 1 (for example, summer of 2024), which remains possible based on the current hydrology, then the expectation based on these traces and the serial correlation of the time series is that the costs would continue over the 4 years and tend to track the $60 million value identified above. However, all traces start with the same initial conditions, and most would result in no bypass.

**Table 3-18** through **Table 3-21** show the potential impacts on economic value when all 30 traces are considered. Based on average energy generation estimates over the 30 modeled traces, and similar to the trends above, the Cool Mix Alternative and the Cool Mix with Flow Spike Alternative could result in the most impacts on economic value. Using the river mile 15 trigger, the average loss for the Cool Mix Alternative and the Cool Mix with Flow Spike Alternative would range from $12.52 to $15.93 million over the 4 years of the LTEMP SEIS (**Table 3-18** and **Table 3-19**). The average loss for the Cold Shock Alternative and the Cold Shock with Flow Spike Alternative would range from $6.08 to $9.22 million over the 4 years of the LTEMP SEIS.

Using the river mile 61 trigger, the average loss for the Cool Mix Alternative and the Cool Mix with Flow Spike Alternative would range from $17.78 to $26.87 million over the 4 years of the LTEMP SEIS (**Table 3-20** and **Table 3-21**). The average loss for the Cold Shock Alternative and the Cold Shock with Flow Spike Alternative would range from $7.25 to $15.05 million over the 4 years of the LTEMP SEIS. The Non-Bypass Alternative would have the fewest impacts, with an average impact at river mile 61 of approximately a loss of $1.37 to a gain of $0.15 million because the bypass system would not be used.

## Table 3-18
## Potential 45-Month Flow Impacts on the Economic Value of Electric Energy for 30 Traces, River Mile 15 (Loss in $ Million) – USGS

| Alternative | Average | Median | Min | 10th % | 90th % | Max |
|---|---|---|---|---|---|---|
| Cool Mix Alternative | $12.82 | $1.45 | ($0.45) | $0.22 | $50.02 | $105.12 |
| Cool Mix with Flow Spike Alternative | $12.52 | $2.69 | ($0.38) | $0.12 | $45.72 | $103.17 |
| Cold Shock Alternative | $6.48 | $1.45 | ($0.45) | $0.22 | $23.31 | $44.55 |
| Cold Shock with Flow Spike Alternative | $6.08 | $2.58 | ($0.45) | $0.06 | $19.45 | $37.94 |
| Non-Bypass Alternative | — | — | — | — | — | — |

Source: USGS and Reclamation 2024
Model results are for the operating period from January 2024 to September 2027. The figures presented are the economic value of electric energy estimates out of all 30 modeled traces where an Action Alternative is triggered at river mile 15.

## Table 3-19
## Potential 45-Month Flow Impacts on the Economic Value of Electric Energy for 30 Traces, River Mile 15 (Loss in $ Million) – WAPA

| Alternative | Average | Median | Min | 10th % | 90th % | Max |
|---|---|---|---|---|---|---|
| Cool Mix Alternative | $15.93 | $0.62 | ($5.32) | ($1.35) | $69.54 | $142.99 |
| Cool Mix with Flow Spike Alternative | $15.49 | $0.62 | ($5.32) | ($1.35) | $70.28 | $137.76 |
| Cold Shock Alternative | $8.76 | $0.62 | ($5.32) | ($1.35) | $37.62 | $76.21 |
| Cold Shock with Flow Spike Alternative | $9.22 | $0.62 | ($5.32) | ($1.35) | $40.50 | $82.32 |
| Non-Bypass Alternative | $0.97 | $0.17 | ($5.32) | ($1.35) | $5.04 | $8.78 |

Sources: Data from GTMax model (Veselka et al., forthcoming); calculations from EMPS 2024
Model results are for the operating period from January 2024 to September 2027. The figures presented are the economic value of electric energy estimates out of all 30 modeled traces where an Action Alternative is triggered at river mile 15.

## Table 3-20
## Potential 45-Month Flow Impacts on the Economic Value of Electric Energy for 30 Traces, River Mile 61 (Loss in $ Million) – USGS

| Alternative | Average | Median | Min | 10th % | 90th % | Max |
|---|---|---|---|---|---|---|
| Cool Mix Alternative | $19.38 | $2.61 | ($0.45) | $0.22 | $68.82 | $145.96 |
| Cool Mix with Flow Spike Alternative | $17.78 | $3.30 | ($1.86) | ($0.45) | $64.59 | $144.25 |
| Cold Shock Alternative | $8.38 | $2.61 | ($0.45) | $0.22 | $24.07 | $47.06 |
| Cold Shock with Flow Spike Alternative | $7.25 | $3.39 | ($1.00) | ($0.04) | $20.96 | $41.88 |
| Non-Bypass Alternative | ($0.15) | $0.69 | ($7.41) | ($4.52) | $2.27 | $3.49 |

Source: USGS and Reclamation 2024
Model results are for the operating period from January 2024 to September 2027. The figures presented are the economic value of electric energy estimates out of all 30 modeled traces where an Action Alternative is triggered at river mile 61.

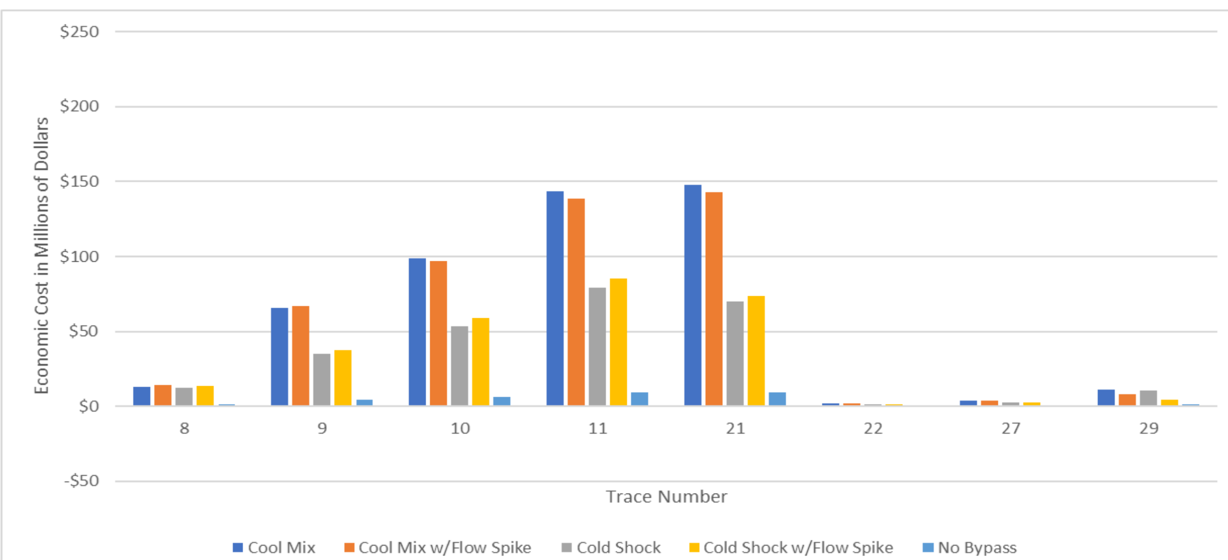
**Table 3-21**
**Potential 45-Month Flow Impacts on the Economic Value of Electric Energy for 30 Traces, River Mile 61 (Loss in $ Million) – WAPA**

| Alternative | Average | Median | Min | 10th % | 90th % | Max |
|---|---|---|---|---|---|---|
| Cool Mix Alternative | $26.87 | $2.60 | ($5.32) | ($1.35) | $100.75 | $216.31 |
| Cool Mix with Flow Spike Alternative | $26.43 | $3.42 | ($11.59) | ($1.16) | $99.65 | $210.21 |
| Cold Shock Alternative | $13.58 | $2.62 | ($5.24) | ($1.16) | $47.39 | $97.07 |
| Cold Shock with Flow Spike Alternative | $15.05 | $3.11 | ($11.59) | ($1.16) | $52.19 | $108.22 |
| Non-Bypass Alternative | $1.37 | $0.37 | ($5.32) | ($1.35) | $5.63 | $10.35 |

Sources: Data from GTMax model (Veselka et al., forthcoming); calculations from EMPS 2024
Model results are for the operating period from January 2024 to September 2027. The figures presented are the economic value of electric energy estimates out of all 30 modeled traces where an Action Alternative is triggered at river mile 61.

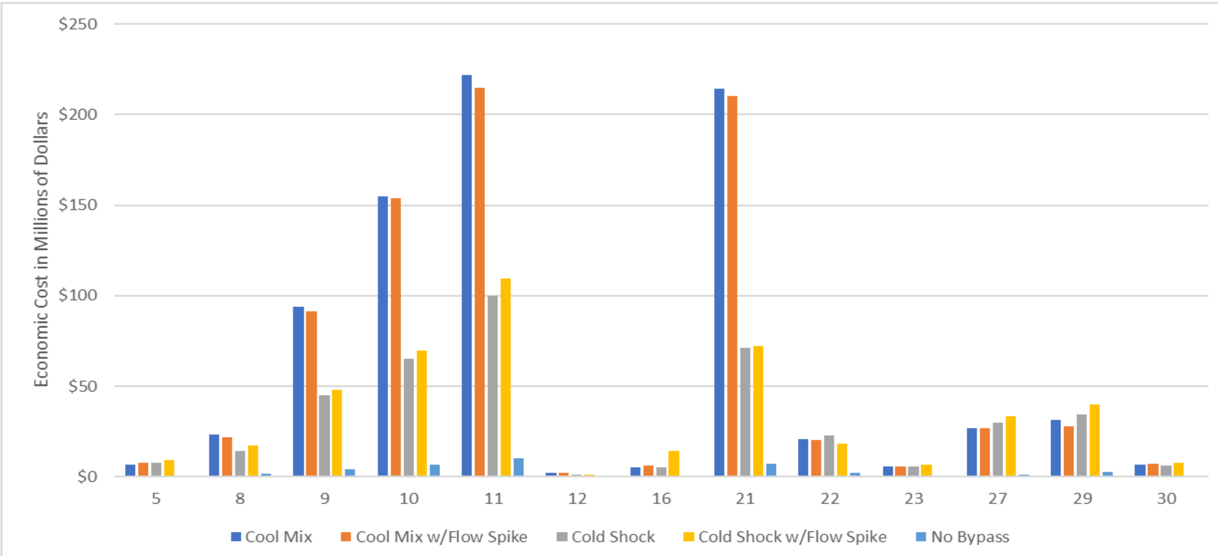
The smallmouth bass modeling at river mile 15 resulted in the 8 driest hydrologic traces requiring bypass. When looking at the 8 traces in **Figure 3-15**, the impacts are concentrated in roughly 5 of the traces (trace numbers 8, 9, 10, 11, 21) and with minimal impacts from trace numbers 22, 27, and 29 using the river mile 15 trigger. For river mile 61, **Figure 3-16** shows similar effects for the 15 driest hydrologic traces (trace numbers 8, 9, 10, 11, 21), and adds trace numbers 5, 12, 16, 23, and 30 to trace numbers 22, 27, and 29 with the smaller energy loss values. Given the relationship in the hydrologic traces to the original time series, Reclamation would expect similar levels of impact from adjacent traces because they overlap in their years of origin.

**Figure 3-15**
**Cost to Economic Value (in millions)—by Alternative—for the 8 Traces where They Were Triggered at River Mile 15**




Source: GTMax model (Veselka et al., forthcoming)

**Figure 3-16**
**Cost to Economic Value (in millions)—by Alternative—for the 13 Traces where They Were Triggered at River Mile 61**

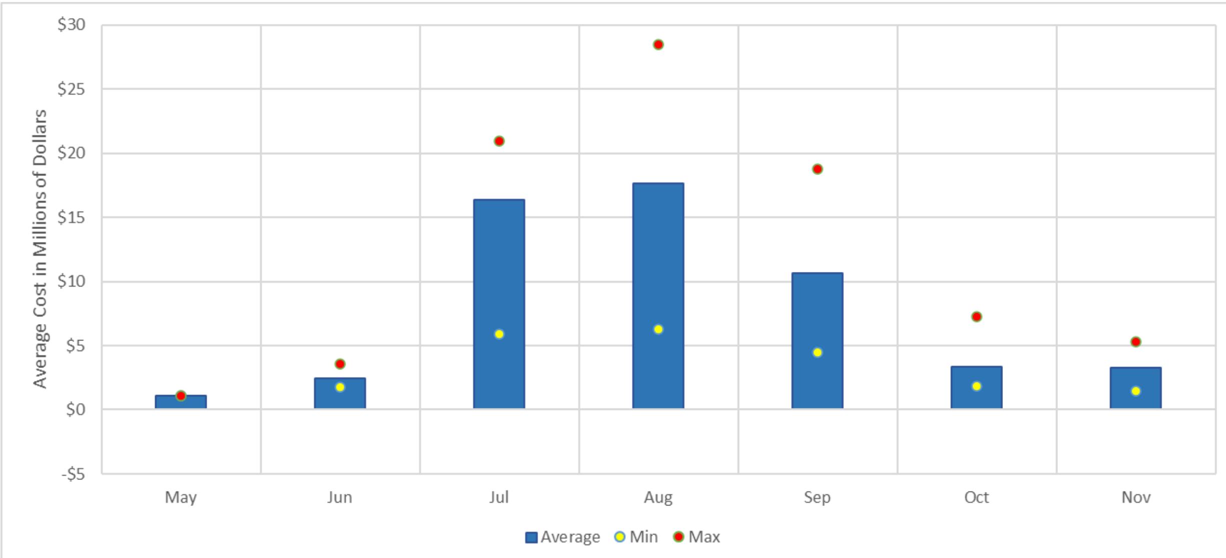



Source: GTMax model (Veselka et al., forthcoming)

Most of the Action Alternatives' effects occur in a few months of the year during peak demand times for power in the Southwest. **Figure 3-17** is an example for illustration purposes using one of the likely scenarios for bypass, the Cool Mix Alternative at river mile 61, and shows the average difference in hydropower value by month when the Cool Mix Alternative is implemented. In **Figure 3-13**, above, the instances of bypass events occur most in September, followed by August and then October. However, due to energy prices, the highest economic loss occurs in August, followed by July and then September (**Figure 3-17** and **Figure 3-18**). Average values for the peak months are about $10–$17 million per month for the Cool Mix Alternative; if implemented in all the possible months during a single year, the Cool Mix Alternative would equal about $62.53 million, on average, using the river mile 61 trigger. The Cold Shock Alternative would follow the same trend by month, with values ranging from about $5 to $11 million per month in the peak months.

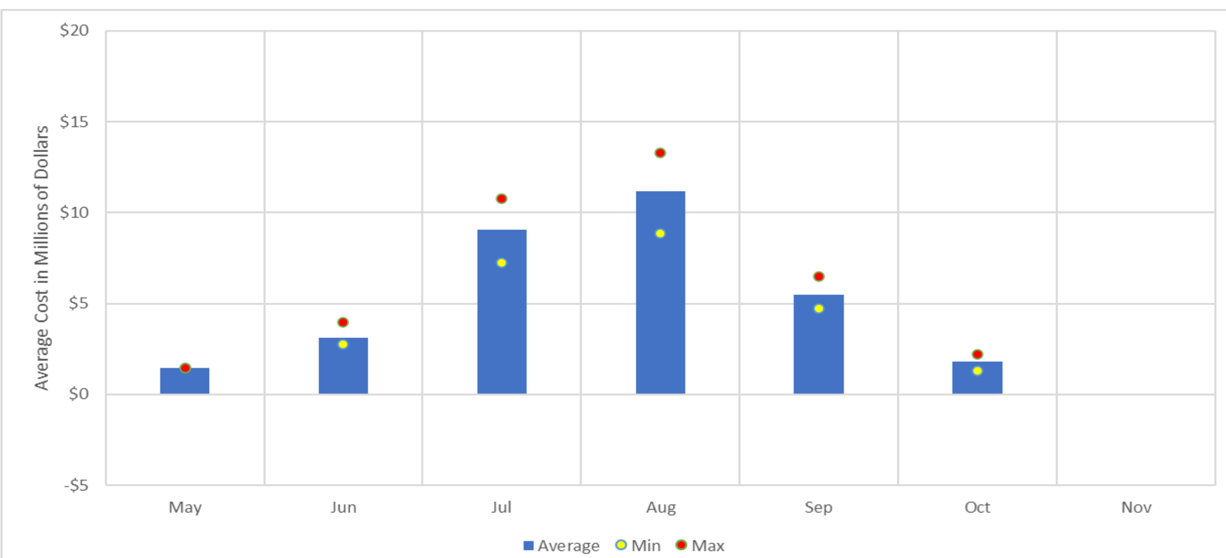
To summarize, based on the modeled generation and economic value due to electric energy loss under each alternative, the Cool Mix Alternative and the Cool Mix with Flow Spike Alternative would likely result in the most significant loss of energy value. Relative to the No Action Alternative, the Cool Mix Alternative is modeled to have an average loss of energy value over the 4-year period of $43.24 to $67.13 million (for the 13 traces with bypass at river mile 61). The Cold Shock Alternative would result in the second-most modeled loss, averaging $17.86 to $34.99 million. The Non-Bypass Alternative would result in the lowest modeled loss in energy value.

**Figure 3-17**
**The Average Difference in Energy Value by Month for those Months when Bypass Is Triggered, for the Cool Mix Alternative Using the River Mile 61 Trigger**




Source: GTMax model (Veselka et al., forthcoming)
Average (blue bar), minimum (yellow dot), and maximum (red dot) values for the monthly difference in energy value in the months when the Cool Mix Alternative's bypass occurs

**Figure 3-18**
**The Average Difference in Energy Value by Month for those Months when Bypass Is Triggered, for the Cold Shock Alternative Using the River Mile 61 Trigger**




Source: GTMax model (Veselka et al., forthcoming)
Average (blue bar), minimum (yellow dot), and maximum (red dot) values for the monthly difference in energy value in the months when the Cold Shock Alternative's bypass occurs

*Impacts on the Basin Fund*

Because WAPA accounts for financial impacts of experimental releases as nonreimbursable, WAPA has not included those expenses for recovery in its power rates. Thus, without other funding sources, the cost of this experimental action would directly reduce the Basin Fund balance (see **Table 3-13** through **Table 3-21** for the estimated cost). Impacts to the value of energy in the more severe scenarios could have substantial impacts to the Basin Fund over the next 4 years, as described below.

Implementation of the proposed Action Alternatives would have a wide range of impacts, from scenarios with no impact to scenarios with substantial economic impact. On average, the economic impact would range from $13.5 to $26.9 million (at river mile 61; **Table 3-24**) for the flow options that include bypass, though impacts could exceed $200 million in the worst-case scenario. If mitigating funds are not obtained, the Basin Fund would bear the costs of the impacts. At the average economic impact level, WAPA and Reclamation would need to consider funding impacts on some projects for the operation and maintenance of the CRSP system. At the maximum economic impact level, many projects and programs that are currently supported by the Basin Fund may have to be deferred or reduced. Reclamation and WAPA would need to consider impacts on funding for operation and maintenance of the CRSP system, use of revenues under the MOA, and other program obligations. This could include substantial impacts on capital funding for Reclamation and WAPA, which may include deferring projects like generator rewinds, butterfly valve replacements, station service transformer replacement, aging transmission line replacement, power transformer replacement, high-voltage breaker replacement, and more. Extended delays or deferrals of these types of projects may reduce system reliability and could lead to N-1 or N-2 system outage risks.[17] System outages can cause major economic impacts and security risks to society.

Revenues in the Basin Fund in excess of operating needs are to be paid annually to the general fund of the Treasury. This criterion has not been met for several years, and the Basin Fund has not returned cash to the Treasury since 2012. Due to ongoing drought and the increasing need to replace infrastructure, WAPA does not project the Basin Fund will have revenues in excess of operating needs for at least the next 10 years.

*Impacts on Capacity*

Although the Glen Canyon Powerplant is rated at 1,320 MW, it has been limited by elevation to a lower capacity since 2000. Additionally, it is limited by the 2016 LTEMP ROD, as described in the *Affected Environment* section. However, it can produce at rated capacity during extremely high hydropower conditions and during high peak HFE releases when the reservoir is relatively high, with elevation above 3,675 feet (approximately 84 percent full; Lake Powell is approximately 31 percent full as of April 2024).

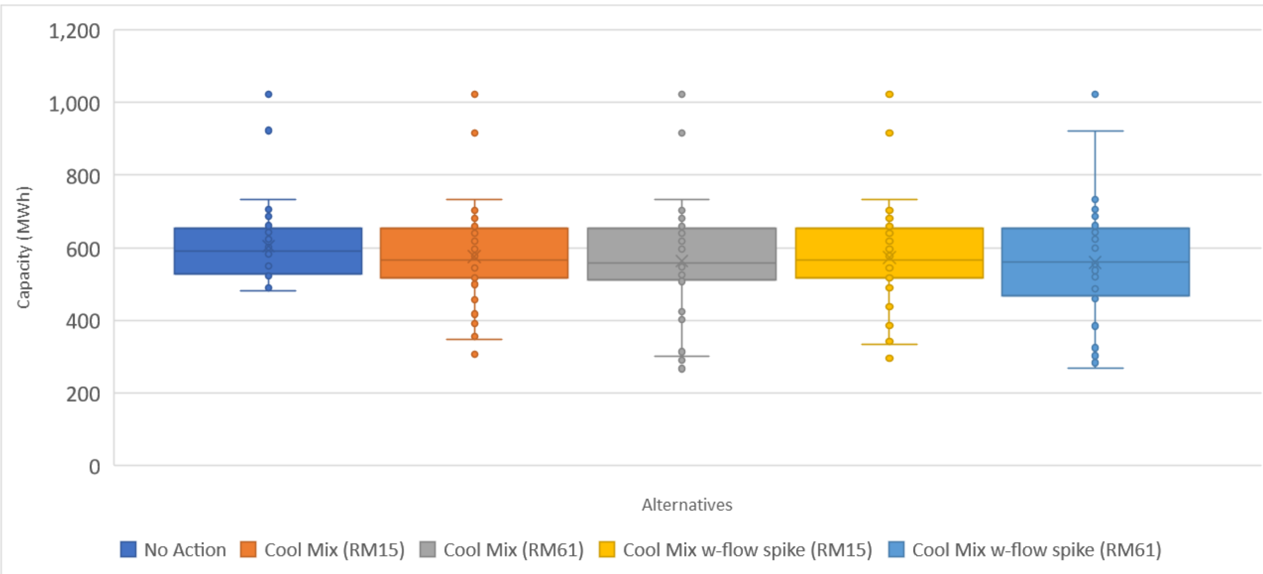
Under expected conditions, the No Action Alternative would provide about 604 MW of firm capacity, whereas the Cool Mix with Flow Spike Alternative at river mile 61 would reduce this to about 560 MW, or a loss of 44 MW of firm capacity. The Cool Mix with Flow Spike Alternative would reduce capacity by about 31 MW if triggered at river mile 15 and 44 MW if triggered at river

[17] N-1 and N-2 system outages describe a situation where power is compromised to the grid if a single component (n=1) or two components (n=2) of generation or the transmission system are out of service (either planned or unplanned).

mile 61. The Cool Mix Alternative would reduce capacity by about 28 MW if triggered at river mile 15 and 40 MW if triggered at river mile 61. However, it might be possible to mitigate this impact for critical hours of the day by shifting water from bypass to generation and then back as long as the mean daily temperatures meet desired temperature targets at desired locations.

Thus, firm capacity would be reduced by an additional 4.6 to 7.2 percent across that range of alternatives. Other alternatives would not have an impact on capacity. The Non-Bypass Alternative would not affect capacity because flows would not be modified during weekdays in August. The cold shock alternatives would also not affect capacity for the same reasons as the Non-Bypass Alternative.

**Figure 3-19**
**Estimates of Firm Capacity in August for the Alternatives that Would Affect Capacity Calculated from those Traces with Bypass Events Triggered at River Miles 15 and 61**




Source: GTMax model (Veselka et al., forthcoming)
Note: This figure is for the 8 traces triggered at river mile 15 and the 13 traces triggered at river mile 61 that have bypass events.

*Impacts of Scheduling Cold Water Experiments*
WAPA purchases energy to "firm" to the levels established in its Firm Electric Service contracts during experimental releases at Glen Canyon Dam. To sustain this approach under each of the bypass alternatives, WAPA would be required to purchase power, and possibly transmission.

- WAPA requires a minimum of 5 days' notice in order meet industry requirements in scheduling energy deliveries.
- The period of notice has a notable effect on the cost of replacement energy. WAPA therefore requests 6 weeks to arrange the purchases necessary for implementation of any bypass alternative. The closer to the five-day minimum as referenced in first bullet, the more likely WAPA would experience an increase in cost to replace energy bypassed.

- The period of notice has a notable effect on WAPA's ability to locate replacement energy. The more notice provided increases the likelihood of WAPA locating replacement energy.

*Impacts on Transmission (Plexos)*

Loss of generation from Glen Canyon Dam can also impact the transmission congestion in the surrounding region. Removing generation from Glen Canyon Dam can increase transmission congestion along certain paths and alleviate congestion in other paths. Of particular concern are the paths nearest Glen Canyon Dam. In cases with reduced generation from Glen Canyon Dam, increased congestion would be observed in the Kayenta to Shiprock path and the Kayenta to Longhouse path.

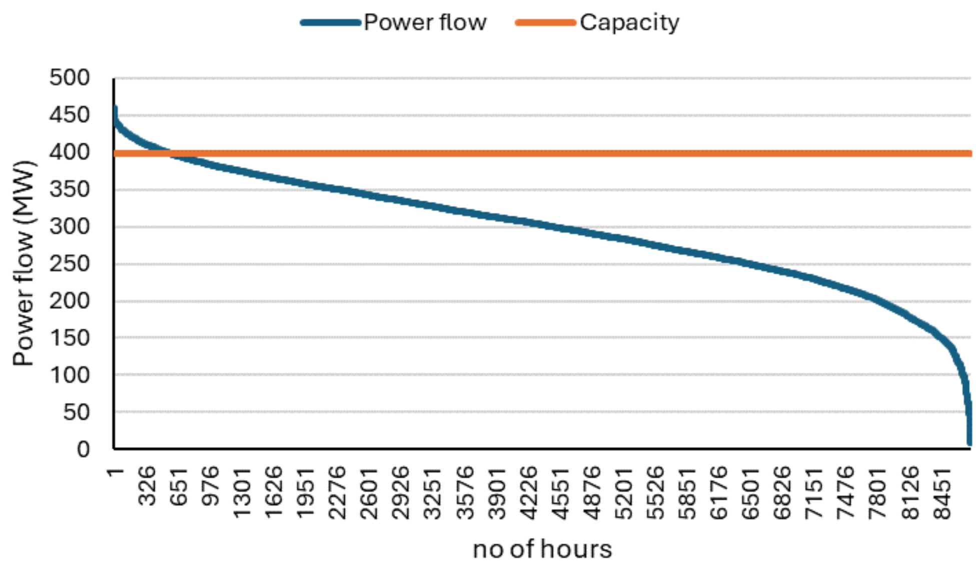
Under the No Action Alternative, WAPA anticipates around 200 hours and 20 hours of congestion along each of these two paths per year, respectively (Veselka et al., forthcoming). In the case of reduced Glen Canyon Dam generation, the number of hours showing congestion would increase to over 2,000 hours per year along both paths as other generation flows into the area to serve the load previously met by Glen Canyon Dam (Veselka et al., forthcoming). **Figure 3-20** shows the hourly flow duration (sorted high to low) and illustrates that the transmission line exceeds its rated capacity about 600 hours of the year under reduced output from Glen Canyon Dam; exceeding the rated capacity of the line could lead to excessive thermal heating of the transmission line, damaged substation equipment, and the transmission line breakers opening to prevent damage to the transmission lines and interconnected facilities. Other paths throughout the area would see reduced congestion as flows are rerouted, but the impact would be distributed among a greater number of available paths.

*SRP Exchange Discussion*

WAPA and Salt River Project exchange hydropower for coal-generated thermal power. This arrangement creates operational efficiencies and was agreed to when the first transmission lines were constructed under the CRSP Act of 1956. Under this agreement, hydropower generated at Glen Canyon Dam (up to about 533 MW) is delivered to Salt River Project in Phoenix. The remaining power is exchanged from power-generating stations at Craig and Hayden, in northwest Colorado, as well as from Four Corners generation in northwest New Mexico. The amount exchanged depends on both hydropower and thermal power being available in equal quantities. Thus, a reduction in generation at Glen Canyon Dam significantly affects the transportation of generated energy to both Four Corners and northern loads.

If hydropower is not available to facilitate a full exchange, or in the case when no hydropower is available, Salt River Project may wheel up to 250 MW of its thermal generation over WAPA's transmission lines to Salt River Project's load centers in Phoenix. This option, at least partially, prevents the stranding of Salt River Project's 533 MW of generation when the exchange cannot be facilitated. Consequently, when Glen Canyon Dam experiences generation loss due to experiments, the energy exchange stops. This scenario underscores the critical role of wheeling, as it becomes the only method for transporting energy from Craig and Hayden, as well as Four Corners generation, to the Salt River Project exchange.

**Figure 3-20**
**The Hourly Flow Duration (Sorted High to Low) Showing the Number of Hours Showing Transmission Congestion with a Reduction of Generation at Glen Canyon Dam**




Source: Veselka et al., forthcoming

Each MWh decrease in the Salt River Project exchange—a direct consequence of lost generation at Glen Canyon Dam—correlates with an increase in Salt River Project wheeling, but such wheeling may be constrained by competing power deliveries to replace the lost Glen Canyon Dam power. As generation at Glen Canyon Dam decreases, there is an expected increase in southern replacement power purchases. Overall, the Salt River Project exchange would be more sensitive to the Cool Mix Alternative than the Cold Shock Alternative; this is because the Cool Mix Alternative would be conducted throughout the week, whereas the Cold Shock Alternative would restrict the Action Alternative to weekends only.

*WAPA Power Flow Study*

WAPA staff conducted a study to assess the impact of reduced Glen Canyon Dam hydroelectric generation on transmission reliability (WAPA 2024). The study solely focused on the reliability of the transmission system from Shiprock to Pinnacle Peak on a 3-month operational horizon of summer 2024. For the purposes of this study, WAPA transmission planning engineers used two scenario cases: a 2024 heavy summer Western Electricity Coordinating Council (WECC) base case for high loading conditions, which was further coordinated by the Southwest Study Area Group for operational studies, and a 2024 light summer WECC base case for light loading conditions. The study assumed replacement power would be purchased to replace lost Glen Canyon Dam generation. There was no consideration for the cost of replacement power, only an assumption that power could be purchased.

Power flow and transient stability studies were performed, and results were analyzed based on the Northern American Electric Reliability Corporation/WECC System Performance Criteria for transmission system planning. The results are as follows:

- The reduced Glen Canyon Dam generation in the 2024 heavy summer case does not result in any thermal or voltage power flow violations in the study area.
- The reduced Glen Canyon Dam generation in the 2024 heavy summer case does not result in any WECC WR1.3–1.5 or oscillation damping dynamic stability criteria violations in the study area.
- The reduced Glen Canyon Dam generation in the 2024 light summer case does not result in any thermal or voltage power flow violations in the study area.
- The reduced Glen Canyon Dam generation in the 2024 light summer case does not result in any WECC WR1.3–1.5 or oscillation damping dynamic stability criteria violations in the study area.

With certain exceptions, the study did not find any reliability concerns for transmission systems across Shiprock to Pinnacle Peak for low Glen Canyon Dam generation. In general, none of the alternatives would likely cause a system failure, although purchases may have to be made at less desirable locations to maintain power flow, and those could be expensive to operate. Those additional costs or effects are not analyzed here.

*Impacts on Load and Generation Following and Regulation (Plexos)*

Overall, the Plexos model's runs do not indicate any inability to serve load (the unserved load in all cases is zero; Veselka et al., forthcoming). The Plexos runs also generally do not show any unserved reserves. However, in discussions with the project team, NREL assumed that other WAPA hydropower assets would be able to cover the current reserves provided by Glen Canyon Dam. Therefore, any reserve shortages identified by Plexos would result from general scarcity conditions. In all 4 years of Plexos runs, reserve shortages were only observed in two months in the year 2027 (August and September). In a run with the "No Action" Glen Canyon generation profile, there were just 2 hours with a total of 42 MWh dropped reserves. In a case with minimum Glen Canyon Dam generation, that number increases to 600 MWh over a dozen hours. The rest of the months with unserved reserves (August 2026, August 2025, June 2027, and June 2026) have less than 100 MWh over just a few hours.

*Availability of Replacement Power and Source*

Argonne and NREL, using the Plexos model, projected that replacement power would generally be available for this experiment (Veselka et al., forthcoming). However, the Plexos model assumes free exchange of power within the WECC footprint. Thus, if additional generation exists in the model and a transmission path is available, the model will dispatch the energy to meet demand without regard to generator ownership or contractual obligations. The Plexos model also assumes all utilities in the market have situational awareness and perfect foreknowledge. This model is an approximation and does not reflect the reality of WAPA's transactions to secure replacement power.

WAPA purchases replacement power through bilateral contracts with trading partners, where the sellers of electrical power must recognize market uncertainties and may not be fully aware of the positions of their trading partners. Additionally, many sellers of electrical power may be less willing to sell available power in times of scarcity and uncertainty to ensure they can fulfill their own power needs. WAPA has typically purchased power from a relatively small set of utilities, in relatively small amounts, and for short durations. Typical purchases are on the order of 10s of MW per hour and only for a few hours at a time. It may not be possible for WAPA to find enough willing utilities to trade or purchase the amount of power needed (100s of MW per hour for months at a time) to offset the impact of implementing a bypass alternative. WAPA's established trading partners have indicated they may be unable or unwilling to offer excess power during projected scarcity events during the summer periods of the SEIS.

Accordingly, the implementation of an Action Alternative could impact the federal government's ability to fulfill its contractual obligations to the customers that fund its power system if WAPA cannot secure power to firm its contractual obligations. It could also increase the likelihood of scarcity events on the power.

*Impacts on Responding to Disturbances, Emergencies, and Outages*

None of the Action Alternatives would impinge on WAPA's ability to respond to electrical disturbances, emergencies, or outages. The Action Alternatives' releases would follow LTEMP requirements for emergency situations, which require the Action Alternatives' releases to be adjusted or suspended in the event of an electrical disturbance, emergency, or outage. In the event of an electrical emergency, Reclamation would terminate the implementation of an Action Alternative for the duration of the emergency.

*Displaced Generation and Emissions*

Using the "warm start" methodology, the Plexos model can identify which of the generation sources may be called upon to provide additional generation (Veselka et al., forthcoming). The "warm start" method starts with one base case run of the full Western Interconnection, with the No Action Alternative or base case Glen Canyon Dam generation profile. This base case run determines the generation levels of all generating units outside the focus area. In this case, the annual replacement generation is from mostly gas-combined cycle generation, with a large portion also coming from coal-fired generation. In the spring months, when load is low, and hydropower, solar, and wind are all available, more of the replacement generation comes from coal generators, which have been turned down to accommodate the influx of available low-marginal-cost generation from those resources. In some cases, curtailed solar is also, to a small degree, being used to replace the generation from Glen Canyon Dam, but only in small amounts during spring months.

During the late summer months, the generation fleet is more constrained, with even more expensive units being called upon to provide replacement power, such as the most expensive marginal source of generation, gas combustion turbines. Some winter months exhibit less wind generation due to the loss of Glen Canyon Dam generation. These results are likely due to requiring more inflexible coal generation, which often has low ramp rates and high minimum generation levels, leading to slightly more economic wind curtailment as the increased rates of coal are accommodated by the system.

It is important to note that hydropower is a zero marginal source of electricity and a zero marginal emissions source as well. Therefore, most power used to replace Glen Canyon Dam would have both higher costs and higher emissions on a marginal basis. Therefore, corresponding to the increase in generation from the coal and natural gas fleet, the bypass alternatives would likely result in an increase to both total generation costs (in terms of fuel and start and shutdown costs) and to emissions.

*Summary of Hydropower Effects*
The action alternatives would result in impacts on power generation at Glen Canyon Dam during the peak summer power months. Changes in operations at Glen Canyon Dam would reduce available generating capacity at Glen Canyon Dam under all four cold-water alternatives. This reduction in capacity would need to be replaced by purchases and generation from other sources.

The action alternatives would also result in economic impacts. The estimated financial impacts for the 4-year operating time frame from the proposed alternatives would range from a net gain of $140,000 to a cost of $222.03 million, depending on the reduction in the amount of power generated and the cost to purchase power from replacement sources. The average financial impact under the Cool Mix Alternative for 2024 is estimated at around $15 million.

Power consumers could experience additional impacts throughout the Western Electrical Grid. The generation from Glen Canyon Dam is both zero marginal cost and zero marginal emissions, meaning that replacement generation would certainly increase both total generation costs as well as total emissions from the power sector. This is because the makeup generation would come from mostly natural gas plants and also from coal.

Impacts on power generation and the need to purchase replacement power, the potential impacts on the Basin Fund and consumers, and the potential impacts on the transmission system would be greatest under the Cool Mix Alternative and the Cool Mix with Flow Spike Alternative. The Cold Shock with Flow Spike Alternative would have the third-most impacts. The Cold Shock Alternative would have the second-least impacts, and the Non-Bypass Alternative would have the least impacts.

Without another source of funding to mitigate the financial impacts on the Basin Fund, impacts from the implementation of the proposed Action Alternatives could include:

- Deferred or reduced funding for projects and programs supported by the Basin Fund
- Impacts on operations and maintenance activities for both power and multipurpose facilities of the CRSP
- Reduced power being provided to WAPA customers
- Deferring critical projects, which could reduce system reliability and potentially lead to N-1 or N-2 system outage risks (in the worst-case scenarios)

Reclamation would work closely with WAPA and other stakeholders during the planning and implementation process to analyze and consider these impacts.

**Cumulative Impacts**
The Colorado River Basin has multiple energy projects currently underway and in the reasonably foreseeable future. The energy projects include the decommissioning of existing fossil fuel plants

and the development and implementation of sustainable power generation plants, such as solar fields, hydropower plants, and wind farms. These projects may not occur in the limited time frame of the smallmouth bass Action Alternatives. If they occur, the decommissioning of existing plants could decrease the stability of the grid because less power would be available. This could also increase the difficulty WAPA might have in finding replacement power. New sustainable energy projects would have the opposite impact and could provide additional grid stability and provide additional sources of replacement power. These new sustainable energy sources would also help reduce any increases in emissions impacts.

# 3.4 Geomorphology/Sediment

## 3.4.1 Affected Environment

Historically, the Colorado River conveyed high suspended sediment concentrations throughout most seasons with larger flood flows and lower base flows (USGS 2011). The placement of Glen Canyon Dam effectively cut off approximately 95 percent of the historical sediment supply from the upper watershed (Topping et al. 2000). Post-dam water releases have resulted in net erosion of sand from Marble and Grand Canyons. From 1964 to 2017, net erosion occurred for approximately 69 percent of all years in Marble Canyon and for approximately 52 percent of all years in Grand Canyon (Topping et al. 2021).

Maximum releases from the dam are substantially less than the historical annual peak flows, and the high-water zone has been lowered compared with the historical level. Pre-dam discharges below approximately 9,000 cfs occurred frequently enough to allow for seasonal sand accumulation and storage between river miles 0 and 87 (Topping et al. 2000). Current dam operations do not allow for sustained discharges lower than 5,000 cfs at night and 8,000 cfs during the day (DOI 2016a). In conjunction with reduced sand supply compared with historical conditions, post-dam discharges have reduced the height of annual deposition, reduced the period of sand accumulation, increased the rate of sediment erosion, and contributed to the loss of beaches and sandbars (USGS 2011).

The Paria and Little Colorado Rivers, tributaries to the Colorado River, are the major sources of sediment replenishment downstream of the dam. These tributaries affect the mechanisms that control sandbars in Glen, Marble, and Grand Canyons. No major sediment source exists upstream of the Paria River, making sediment a nonrenewable resource in modern-day Glen Canyon (Grams et al. 2007).

### *Sediment*

Sediment mass balance regulates the erosional and depositional processes in the Colorado River. The influx and efflux of sediment result in spatial and temporal variations in sandbars and channel-margin deposits throughout the Colorado River (Grams et al. 2013). Sediments are typically classified by particle size and include the following classes:

- Silt and clay (less than 0.06 millimeters)
- Sand (0.06 to 2.0 millimeters)

- Gravel and cobbles (2.0 to 200 millimeters)
- Boulders (greater than 200 millimeters)

In general, the term "fine sediment" refers to sediments that are sand-sized or smaller. This group makes up most of the transported sediment in the river and is carried in suspension by most dam releases. Finer sand contributes the most to sediment storage, deposition rates, and downstream sand export (Topping et al. 2021). The quantity of silt and clay transported depends mainly on the tributary supply. Sandbars contain some silt and clay, but their existence primarily depends on the transport of sand. Sand sediments in the Colorado River are delivered by tributary streams and ephemeral washes.[18] As described above, the Paria and Little Colorado Rivers are the dominant sources. The lesser tributaries in Marble Canyon upstream from river mile 30 together contribute roughly 10 percent of the sand annually supplied by the Paria River (Griffiths and Topping 2017). Downstream from river mile 30, the Marble Canyon lesser tributaries supply negligible amounts of sand (Griffiths and Topping 2017; Topping et al. 2021).

The amount of sand stored within the riverbed each year depends on the tributary and supply (which is highly variable), the frequency and duration of water released from the dam, and the amount of sand already deposited on the riverbed at the beginning of the year. Sand stored on the riverbed is the principal source for building sandbars during periods of high flow releases. Sediment transport is a function of, and increases with, the volume of water flowing in the river. It also depends on changes in the sediment size associated with tributary floods and dam operations.

The turbulence of flowing water can increase the amount of sediment in suspension and the amount that is available for transport. Sediment deposition occurs wherever there is more sediment influx than efflux (Grams et al. 2013). The greater the river's flow, the greater its velocity, turbulence, and sediment load. Finer sediment is carried in suspension by nearly all dam releases. Flows in the river are often large enough to carry sand grains in suspension or roll them along the riverbed. Higher flows and velocities are needed to move gravel and cobbles. The largest boulders remain in place for decades or more, awaiting a flood large enough to move them even short distances along the riverbed (DOI 2016a). The river stage defines the water level associated with a given discharge, which may be a result of both dam release and tributary inflow. Fluctuations in river stage are particularly important to cycles of deposition and erosion within sandbars. While fine sediments are readily transported by the Colorado River, the height of their deposition depends on river stage.

Seepage-induced erosion is also affected by fluctuations in river stage because groundwater levels within exposed sandbars rise and fall with increases and decreases in river stage. When the river stage declines faster than groundwater can drain from the sandbar, the exposed bar face becomes saturated, forming rills[19] that move sand particles toward the river (Alvarez and Schmeeckle 2012). Sediment storage on the riverbed depends on the spatial variability of the riverbed (such as variations of boulders, cobbles, and bedrock), the depth to the riverbed, and the tributary sediment supply (Rubin et al. 2020). This sediment storage, in addition to storage within sandbars and along

[18] A wash that flows part of the time, usually after a rainstorm, during wet weather, or for only part of the year.
[19] Small grooves, furrows, or channels in soil made by water flowing down over its surface; small streams

channel margins on the Colorado River, results from coupled flow, sediment transport, and storage within fan-eddy complexes[20] that lead to deposition of sediments.

Sediment storage does not mean there is no water or sediment movement. There is a mass balance between sediment deposition, erosion, and storage at a point of interest over a specified period. Thus, 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 supplied by tributaries remains in storage for only a few months before most of it is transported downstream unless flows are below approximately 9,000 cfs (Topping et al. 2000; Rubin et al. 2002; USGS 2011b).

Since 1996, Reclamation has conducted HFE releases to manage limited sediment resources to maintain or increase sandbar size. HFE releases are designed to improve sediment deposition, and these water releases from Glen Canyon Dam are much larger than the base flow that is typically released. HFE releases are the only existing mechanism for producing river stages high enough to contribute to significant sandbar building. Under LTEMP, Reclamation uses two 6-month sediment accounting 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 release implementation.[21] Sediment accounting periods are independent, meaning that accumulated sand from the prior accounting period is not used to trigger a potential HFE release during the following implementation window. HFE releases may be as low as 31,500 cfs, though releases of 34,000 cfs or greater are necessary for sandbar deposition (increased sandbar size).

Generally, sandbars erode between HFE releases (Hazel et al. 2022). Erosion rates tend to be highest immediately after a flood (when bars have the most sediment available for erosion), then decrease with time (Grams et al. 2010). Steadier flows erode bars at a lower rate than fluctuating flows (Wright et al. 2008). As discussed in LTEMP, long-term rehabilitation of eddy sandbars can occur only if the increases in sand volume caused by high flows exceed the erosion that occurs during the intervening periods. Alternatively, if there are only small amounts of deposition during high flows and large volumes of erosion during intervening periods, a long-term decrease in sandbar size will result. More frequent HFE releases may result in net increases of sandbar size given sufficiently great sand enrichment (DOI 2016).

A 72-hour HFE release conducted in April 2023 consisted of an approximately 40,000 cfs release. It was designed to resuspend and store sand that had accumulated in Marble Canyon from July 1, 2022, through October 2022 and remained during the low winter 2022/2023 releases. Preliminary findings determined that sand concentrations were higher in mid-Marble Canyon during the April 2023 HFE release than during any of the 2004–2018 HFE releases but that the sand grain size was

[20] Areas along the river where a tributary's debris fan—a sloping deposit of poorly sorted sediment ranging in size from clays and silts to larger boulders—partially blocks the river flow, causing the formation of rapids and eddies (Schmidt and Rubin 1995). Fan-eddy complexes are the controlling geomorphic feature in the Colorado River for sediment deposition.

[21] Sediment accounting periods are periods over which sand inputs and exports are measured to evaluate whether conditions have been met to trigger an HFE release during an HFE implementation window. HFE implementation windows occur (1) from October 1 to November 30, during the fall sediment accounting period, and (2) from March 2 to April 30 during the spring sediment accounting period.

slightly coarser than during most of these earlier HFE releases (Grams 2023). This result is consistent with Topping and others (JGR 2021); there was substantial sand accumulation in upper Marble Canyon before this HFE release but a generally longer interval between the Paria River sand inputs and the HFE release. Sand concentrations were higher in the central Grand Canyon (at National Canyon) than during most of the 1996 and 2008–2018 HFE releases. Roughly 200,000–400,000 metric tons of sand had been eroded from Marble Canyon since July 1, 2023, owing to high summer "balancing" releases and the decision not to conduct a fall 2023 HFE release for a lack of sufficient sediment.

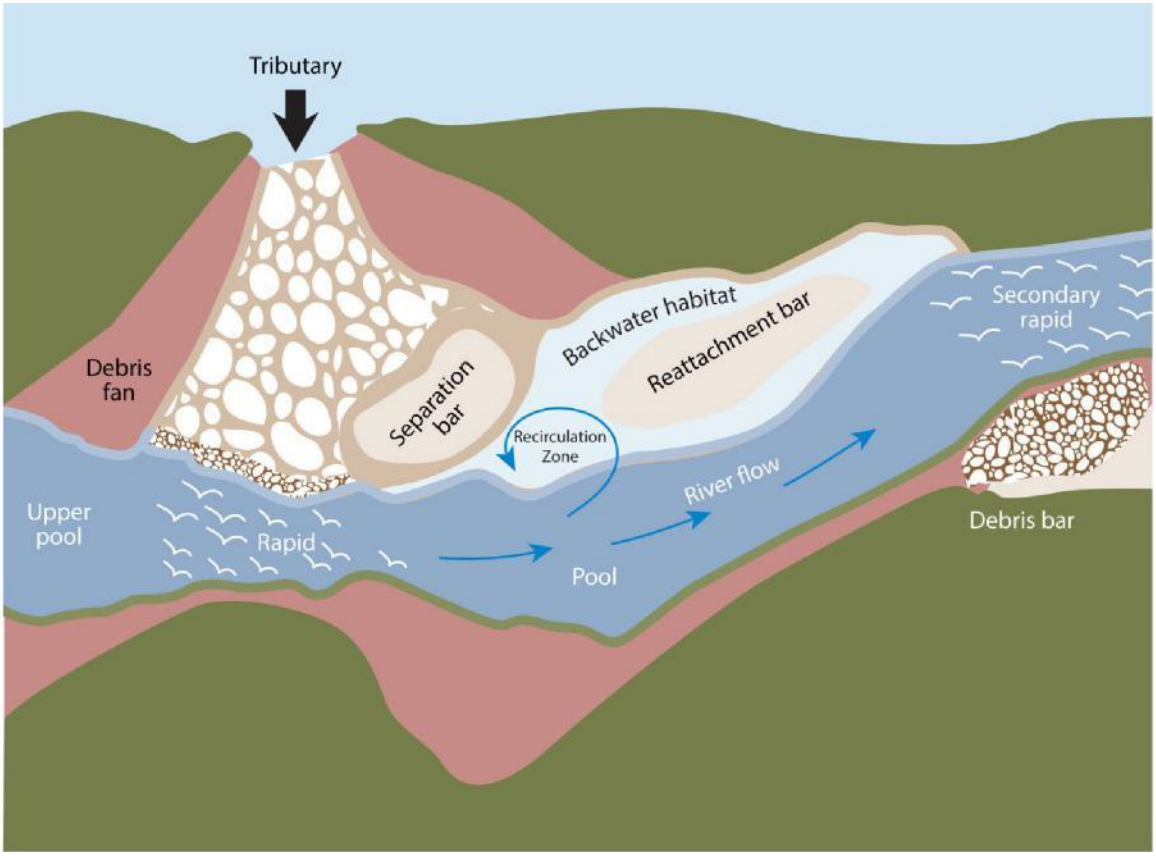
### *Geomorphic Features*

The longitudinal profile of the Colorado River consists of long, flat pool reaches with intermixed short, steep rapids. The rapids are typically associated with debris-fan deposits formed by tributary debris flows,[22] such as fan-eddy complexes. Debris fans continue to be replenished and enlarged by debris flows triggered by slope failures into tributaries. The geologic conditions favorable for debris flows from side canyons vary greatly. Debris flows tend to be high-magnitude, short-duration events. Debris flows create and maintain the rapids, control the size and location of eddies, and serve as potential sources of sand to replenish Colorado River sandbars in Marble and Grand Canyons.

The coarse sediments associated with debris-fan deposits can only be mobilized during elevated flows and do not constitute a significant contribution to sediment loads transported by the river. However, their dynamics are important with respect to their retention of fine sediments and the development of fan-eddy complexes (DOI 2016a). Debris fans extending into the Colorado River obstruct the channel, making it narrower and raising the bed elevation, which forms rapids through the point of constriction and causes the downstream-directed current to become separated from the riverbank (Webb and Griffiths 2001; see **Figure 3-21**). Downstream of the constriction, the channel is typically wider, the main current reattaches to the riverbank, and some of the water is redirected upstream. This change in flow direction forms a zone of low-velocity recirculating water (an eddy) between the points of separation and reattachment and between the main channel and riverbank (Rubin et al. 1998). These conditions allow for sediment to become entrained within the recirculation zone, where lower-velocity flows enhance the potential for sediment deposition (Schmidt and Rubin 1995).

[22] A large deposit of sediment into a tributary caused by slope failures on tributary canyons

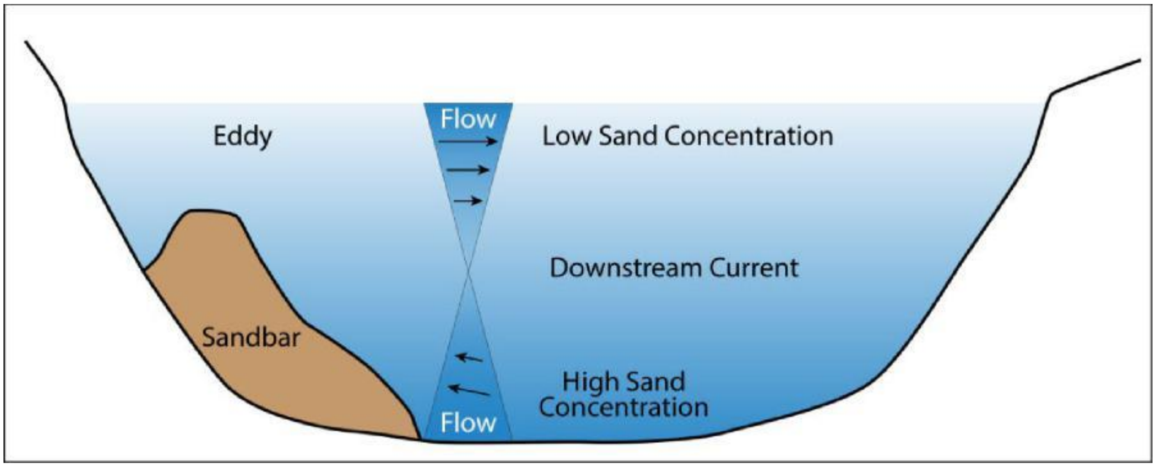
**Figure 3-21**
**Diagram of the Fan-Eddy Complex on the Colorado River**




Source: Webb and Griffiths 2001

The deep pools that form upstream of rapids (**Figure 3-21**) provide space for the temporary storage of substantial amounts of riverbed sediment (such as sand and gravel). For a given flow, the constriction width and riverbed elevation at a rapid control the velocity and water surface elevation of the upstream pool, which in turn control the amount of sand and gravel that can be deposited in the pool. Aggraded debris fans allow the channel to store more sand in the associated pools and eddies. Separation bars form along the downstream face of a debris fan, and reattachment bars form outward from the downstream point where the recirculation zone meets the channel bank (Webb and Griffiths 2001). **Figure 3-22** presents a cross-sectional diagram demonstrating how these complexes can trap sediment and work to build sandbars. In this instance, water with a relatively high sand concentration (near the streambed) moves toward the eddy and builds a sandbar; water with a relatively low sand concentration (near the surface) moves from the eddy back to the main channel (Reclamation 1995).

**Figure 3-22**
**Sediment Entrapment and Sandbar Building at a River Cross Section**




Source: Reclamation 1995

Sand is deposited throughout Glen, Marble, and Grand Canyons in bars (or patches) on the riverbed, in eddies, and on terrace sandbars. Nearly all sandbars in the Grand Canyon are associated with fan-eddy complexes. In general, these complexes generate consistent sandbar features, which include separation bars and reattachment bars, based on their specific locations within the recirculation zone (USGS 2011). They continuously exchange sand with the river. Thus, the sandbars commonly found along the banks of the Colorado River are generally dynamic and unstable. HFE releases have been shown to increase the sandbar size, and sandbars erode between these events (Hazel et al. 2022).

The magnitude of deposition varies by site, depending on geomorphic conditions and vegetative cover; some sandbars are stabilized by vegetation (Mueller et al. 2018; Hazel et al. 2022). Sandbars form a fundamental element of the river landscape and are important for vegetation, riparian habitat for fish and wildlife, cultural resources, and recreation (Reclamation 1995). They form the substrate for limited riparian vegetation in this arid environment. Low-elevation sandbars create zones of low-velocity aquatic habitat (that is, backwaters) that may be utilized by juvenile native fishes. These low-elevation sandbars are also a source of sand for wind transport that may help protect archaeological resources. In addition, beaches provide camping areas for river and backcountry users.

### 3.4.2 Environmental Consequences

#### *Methodology*

Action alternatives were modeled based on the change to the sediment accounting period that is common to all action alternatives. As described in the SMB EA (Reclamation 2023a), impacts on sediment transport are determined primarily by the rate at which water is released from the dam, as opposed to the location from where it is released. Therefore, the action alternatives analysis was split between those alternatives that incorporate flow spikes and those alternatives that do not, in addition to the Non-Bypass Alternative.

Predictions for sand mass balance were generated using the Wright et al. (2010) sand routing model. HFE release magnitude and duration were selected via iteration according to the sand mass balance. The model redistributed monthly volumes if necessary and interfaced with the sand routing model by generating synthetic 15-minute hydrographs. A set of 30 ensemble streamflow predictions, with monthly 4-year traces, was used to characterize the range of potential hydrologic conditions. These 30 traces are a subset of the 90 traces analyzed in the Interim Guidelines SEIS (Reclamation 2024a).

An initial run of the smallmouth bass model was completed to determine the months in which flow spikes would be expected to be triggered under the alternatives that include flow spikes. Two scenarios were considered in which different river miles, river mile 15 (Glen Canyon Dam) and river mile 61 (confluence with the Little Colorado River), were targeted. For the Non-Bypass Alternative, it was assumed that non-bypass fluctuations would be triggered in any month for which bypass flows were required under the Cool Mix Alternative with a river mile 61 target. For each trace of each alternative, the sand routing model was initially run to determine when HFE releases would be triggered under different alternatives, what the magnitude and duration of HFE releases would be, and what the magnitude of a flow spike could be (under alternatives that include flow spikes). Modeling of HFE releases used the combined river outlet works capacity for short-duration flows regardless of the length of an HFE release. Actual implementation may involve slightly different magnitudes.

The initial condition (bed thicknesses and bed grain-size distribution) for the sand routing model is based on a sand routing model run from September 1, 2002, to October 1, 2023, using sediment inputs and gage discharges downloaded from the GCMRC website in November 2023 (GCMRC 2023a). Each of the 30 hydrology traces were randomly assigned a trace of Paria River sediment inputs derived from the October 1996 to September 2023 record.

To generate final sand routing and sandbar volume simulations, the sand routing model was run again for each trace, with new hourly hydrographs generated by a hydropower optimization model and the same Paria River traces as in the previous round of modeling. Changes to the sediment mass balance were minimal, and HFE release durations were not modified.

In addition to discharge inputs, the output from this run of the sand routing model provided the concentration and suspended sand median grain-size inputs for the Mueller and Grams (2021) sandbar model. The sandbar model was recalibrated to the 2015–2023 period, including data from October 2023. The model was initialized using the resulting October 1, 2023, volume and was run for each of the 30 traces.

Modeling assumed that a fall HFE release would be deferred to spring if doing so would result in an equal duration or one duration tier[23] lower. Following LTEMP, an HFE release of 250 hours was not allowed to occur until a 192- or 144-hour HFE release had been run previously. If an HFE release of longer than 96 hours was run in the fall, no spring HFE releases could be run. The HFE release with the longest possible duration, resulting in a positive sand mass balance for Marble Canyon for the accounting period, was the selected HFE release. Under the No Action Alternative,

[23] Duration tiers are the possible HFE release durations determined in modeling, measured in increments of 12 hours. Duration tiers include 12, 24, 36, 48, 60, 72, 96, 144, 192, and 250 hours.

the accounting periods run July 1 to November 30 and December 1 to June 30. For the 1-year sediment accounting window, the mass balance between July 1 and the termination of the HFE release was used when selecting HFE release duration, with the possibility of sediment carryover from the previous year(s) if an HFE release was triggered but not implemented (for example, due to low reservoir elevation).

Ultimately, the decision to defer a fall HFE release would be at the discretion of decision-makers as described in the LTEMP ROD (2016; see **Section 2.3.1**). Additional modeling conducted to test how modifying this assumption would affect HFE releases is discussed in Chapter 3 of Yackulic et al. (2024).

**Methodology Caveats**

Given that dam operations may substantially exceed the LTEMP-specific 8,000 cfs minimum threshold, sandbar volumes do not necessarily represent usable sand (e.g., for recreational purposes). This caveat is particularly important when considering some traces that result in elevated discharges. Sandbar fluvial deposition can only occur at and below river stage. Under some scenarios, modeling predicted sandbar building above the 8,000 cfs stage associated with these elevated discharges, but a considerable proportion of the predicted sandbar volume would likely be unusable.

The Mueller and Grams (2021) sandbar model results for these elevated sustained discharges are not included in the calibration dataset. The sandbar model assumed a constant exponential erosion rate, where erosion rate is proportional to sandbar size and independent of discharge. It is, therefore, unable to capture enhanced erosion rates that would likely result from elevated flows.

Additionally, the sandbar model did not include any short-duration, high-magnitude discharge fluctuations, such as flow spikes and non-bypass fluctuations, over the calibration period. Although it is possible that these types of fluctuations could produce some sandbar building, particularly if they occur under sediment-enriched conditions, previous studies have also shown that repeated flow cycles with fluctuations of any magnitude cause sandbar erosion (Alvarez and Schmeeckle 2013).

Lastly, although the analysis considered the results of all 30 traces used in modeling, not all traces contain fluctuations that would be implemented under the alternatives. Specifically, 6 of 30 traces contain flow spikes for the river mile 15 target; 12 of 30 traces contain flow spikes for the river mile 61 target; and 13 of 30 traces contain non-bypass fluctuations. There may be differences between results for individual traces, which would appear reduced when all 30 traces are averaged.

Analysis of the average of 30 traces may be helpful when considering the long-term implications of alternatives on sediment balance in the impact analysis area. However, averaging all traces across several years may result in the masking of short-term impacts that may occur throughout and following high-discharge events. The six traces containing flow spikes for the river mile 15 target also contain flow spikes for the river mile 61 target as well as non-bypass fluctuations. For clarity, the modeling results for these six traces are discussed separately in the impact analysis.

### Impact Analysis Area

The impact analysis area is the Colorado River at Glen Canyon Dam to Lake Mead, including sediment inputs from the Paria River and Little Colorado River tributaries. This analysis included targets of river mile 15 and river mile 61 (confluence with the Little Colorado River).

### Assumptions and Regulatory Constraints

This analysis was performed under the following assumptions for all alternatives:

- Total discharge maximum ramp rates of 4,000 cfs per hour up and 2,500 cfs per hour down are consistent with LTEMP.
- For analysis of impacts under the cold-water alternatives, modeling assumed a minimum total discharge of 8,000 cfs during the day (7:00 a.m. to 7:00 p.m.) and a minimum total discharge of 5,000 cfs at night, consistent with LTEMP. Modeling under the Non-Bypass Alternative assumed a flow pattern consisting of a 4-hour flow with a discharge rate of 2,000 cfs (minimum powerplant capacity), followed by a 4-hour flow at a discharge rate of approximately 27,300 cfs (full powerplant capacity). This flow pattern was assumed to repeat weekly beginning on Sunday evenings. Triggered flows under the Non-Bypass Alternative targeted only river mile 61 (confluence with the Little Colorado River).
- No HFE releases would be implemented below a Lake Powell elevation of 3,500 feet, as HFE release magnitude would be below 37,000 cfs. Implementing an HFE release below 3,500 feet could increase the risk of going below the power pool elevation of 3,490 feet, the depth below which the dam can no longer produce power. Hazel et al. (2022) concluded that discharges of 37,000 cfs or greater were required to result in significant deposition at separation and undifferentiated sandbar types (with a 34,000-cfs threshold for reattachment and upper-pool bar types). Under the 1-year sediment accounting period, if an HFE release were triggered but not implemented due to this constraint, and there were no other HFE releases in the accounting period, a positive sediment mass balance would be carried over into the next accounting period.
- The 1-year accounting period provides the flexibility to defer the consideration of a triggered fall HFE release to the spring, given that the projected sediment mass balance would allow for a spring HFE release. Modeling assumes that under the 1-year accounting period, decision-makers would defer the consideration of an HFE release from fall to spring depending on year-to-year circumstances and best-available information.
- For alternatives that do not include flow spikes, fall HFE releases are assumed to be implemented on November 15, and spring HFE releases are assumed to be implemented on April 15. However, if flow spikes occur in May or June and a spring HFE release has been triggered, the HFE release may be delayed from April until the first month of flow-spike implementation, if the duration for the later implementation date is within one tier of the earlier date.

### Impact Indicators

For all alternatives evaluated, the primary indicators used in this analysis are the following: (1) the sediment mass balance; (2) the volume of sediment accumulated in sandbars and channel margin deposits; and (3) the probability, frequency, and duration of HFE releases.

### *Issue 1: How would changes to flow and the sediment accounting period affect the probability of triggering HFE releases?*

Summary statistics for the probability and duration of HFE releases under each alternative are provided in **Table 3-22** and **Table 3-23**. These statistics reflect all 30 hydrology traces, despite a number of traces not having flow spikes or non-bypass fluctuations under respective alternatives. As discussed above, 6 of 30 traces contain flow spikes for the river mile 15 target; 12 of 30 traces contain flow spikes for the river mile 61 target; and 13 of 30 traces contain non-bypass fluctuations. The six traces containing flow spikes for the river mile 15 target also contained flow spikes for the river mile 61 target scenario, as well as the non-bypass fluctuations. Summary statistics for these traces are provided in **Table 3-24** and **Table 3-25** and discussed below.

**Table 3-22**
**Probability of HFE Releases by Alternative, Average of 30 Hydrology Traces**

| Probability | No Flow Spikes | Flow Spikes, River Mile 15 | Flow Spikes, River Mile 61 | Non-Bypass Alternative | No Action |
|---|---|---|---|---|---|
| Fall HFE | 0.31 | 0.31 | 0.30 | 0.30 | 0.60 |
| Spring HFE | 0.33 | 0.32 | 0.31 | 0.32 | 0.04 |
| At least 1 HFE in a year[1] | 0.60 | 0.59 | 0.56 | 0.58 | 0.60 |
| At least 1 ≥60-hour HFE in a year[1] | 0.50 | 0.50 | 0.48 | 0.49 | 0.48 |
| Fall HFE ≥60 hours | 0.19 | 0.19 | 0.19 | 0.19 | 0.48 |
| Spring HFE ≥60 hours | 0.31 | 0.31 | 0.29 | 0.31 | 0.004 |

Source: Yackulic et al. 2024, chap. 3
[1] The probability of more than one HFE in a year is very low under all alternatives.

**Table 3-23**
**HFE Release Duration Statistics by Alternative, Average of 30 Hydrology Traces**

| Statistic | No Flow Spikes | Flow Spikes, River Mile 15 | Flow Spikes, River Mile 61 | Non-Bypass Alternative | No Action |
|---|---|---|---|---|---|
| **HFE Release Duration, Fall (hours) – HFE months only** | | | | | |
| Mean | 57.2 | 55.8 | 57.8 | 56.5 | 97.5 |
| Median | 60 | 60 | 60 | 60 | 96 |
| **HFE Release Duration, Spring (hours) – HFE months only** | | | | | |
| Mean | 112 | 110 | 108 | 110 | 32.7 |
| Median | 96 | 96 | 96 | 96 | 24 |
| **HFE Release Duration, Overall (hours)** | | | | | |
| Mean, HFE months only | 84.8 | 83.2 | 83.3 | 84.3 | 93.4 |
| Mean, annual total | 54.3 | 52.7 | 50.6 | 52.7 | 60.2 |

Source: Yackulic et al. 2024, chap. 3

**Table 3-24**
**Probability of HFE Releases by Alternative, Average of 6 Hydrology Traces Representing Alternative Implementation Periods**

| Probability | No Flow Spikes | Flow Spikes, River Mile 15 | Flow Spikes, River Mile 61 | Non-Bypass Alternative | No Action |
|---|---|---|---|---|---|
| **Fall HFE** | 0.24 | 0.24 | 0.19 | 0.20 | 0.57 |
| **Spring HFE** | 0.35 | 0.31 | 0.26 | 0.33 | 0.07 |
| **At least 1 HFE in a year** | 0.56 | 0.52 | 0.41 | 0.50 | 0.57 |
| **At least 1 ≥60-hour HFE in a year**[1] | 0.43 | 0.41 | 0.35 | 0.43 | 0.41 |
| **Fall HFE ≥60 hours** | 0.09 | 0.09 | 0.09 | 0.09 | 0.39 |
| **Spring HFE ≥60 hours** | 0.33 | 0.31 | 0.26 | 0.33 | 0.02 |

Source: Yackulic et al. 2024, chap. 3
[1] The probability of more than one HFE in a year is very low under all alternatives.

**Table 3-25**
**HFE Release Duration Statistics by Alternative, Average of 6 Hydrology Traces Representing Alternative Implementation Periods**

| Statistic | No Flow Spikes | Flow Spikes, River Mile 15 | Flow Spikes, River Mile 61 | Non-Bypass Alternative | No Action |
|---|---|---|---|---|---|
| **HFE Release Duration, Fall (hours) – HFE months only** | | | | | |
| **Mean** | 64.6 | 55.4 | 69.6 | 62.2 | 100 |
| **Median** | 48 | 24 | 54 | 36 | 96 |
| **HFE Release Duration, Spring (hours) – HFE months only** | | | | | |
| **Mean** | 122.4 | 118 | 122 | 124 | 42 |
| **Median** | 96 | 96 | 96 | 96 | 36 |
| **HFE Release Duration, Overall (hours)** | | | | | |
| **Mean, HFE months only** | 98.9 | 90.8 | 100 | 100 | 93.5 |
| **Mean, annual total** | 58.6 | 50.4 | 44.4 | 54.0 | 60.6 |

Source: Yackulic et al. 2024, chap. 3

### No Action Alternative

Under the No Action Alternative, HFE releases would continue to occur when triggered, as described in the 2016 LTEMP FEIS (DOI 2016a). HFE releases would most likely be triggered in the fall, when they would have a median duration of 96 hours. Averaged across all months during which HFE releases would occur, HFEs would last an average of 93.4 hours.

Modeling only the six traces that contain all flow alternatives yielded similar results for fall HFE outcomes and mean duration for HFE releases both annually and during implementation months. The likelihood of triggering a spring HFE release increases approximately eightfold (from 4 percent to 33 percent likelihood) when constraining the analysis to the six traces (**Table 3-24** and **Table 3-25**).

**Alternatives with No Flow Spikes**

For modeling that considered all 30 traces, compared with the No Action Alternative, alternatives with no flow spikes would increase the likelihood of spring HFE releases by approximately 26 percent. This type of alternative would result in fewer or shorter fall HFE releases, and longer or more spring HFE releases (**Table 3-22** and **Table 3-23**). Additionally, the probability of at least one HFE release occurring in a year under this category of alternative would be approximately the same as under the No Action Alternative; the same applies for the probability of at least one HFE release lasting at least 60 hours.

Fall HFE releases, if implemented, would have a median duration of 60 hours, compared with 96 hours under the No Action Alternative. The median duration of spring HFE releases, which are more likely to be triggered and implemented, would be 96 hours, equal to the median duration of fall HFE releases under the No Action Alternative. Overall, the probability of 96-hour HFE releases would increase in spring and decrease in fall (**Figure 3-23** and **Figure 3-24**). Modeling for this category of alternative accounted for the flexibility to defer the consideration of a triggered fall HFE release to spring under the 1-year accounting period, provided that the projected sediment mass balance would allow for a spring HFE release.

When modeling for all 30 traces, as shown in **Figure 3-25**, the probability of triggering spring and fall HFE releases with durations of 72 hours and below under the alternatives with no flow spikes would be similar to the probabilities under the No Action Alternative. The probabilities of triggering HFE releases greater than or equal to 96 hours would slightly decrease under the alternatives with no flow spikes, compared with the No Action Alternative.

As shown in **Table 3-24** and **Table 3-25**, as well as **Figure 3-26** and **Figure 3-27**, modeling constrained to only the six traces that contain the flow spike and non-bypass fluctuations shows that under alternatives with no flow spikes, spring HFE releases are approximately 6 percent more likely than under the No Action Alterative, with median HFE release duration remaining 96 hours. Averaged over all months during which HFE releases would be implemented, alternatives with flow spikes would yield a mean HFE release duration of 98.9 hours, or a 6 percent increase. This would translate to an overall 13 percent decrease in mean HFE release duration when averaged over the entire year. Similar to the modeling for all 30 traces, implementing one of the alternatives with no flow spikes would not meaningfully change the probability of at least one HFE release occurring in a year, or the probability that such an HFE release would last at least 60 hours.

**Alternatives with Flow Spikes**

The alternatives with flow spikes are represented by the lines labeled "FS river mile 15" and "FS LCR" (with LCR representing river mile 61) in **Figure 3-23** through **Figure 3-25**. For all 30 traces, the modeled HFE regimes under the flow spike alternatives are approximately identical for river mile 15 and river mile 61. The HFE regimes would generally be similar to those that would occur under the alternatives that do not include flow spikes. However, in some years, flow spikes would cause sand export in the lead-up to HFE implementation, which would reduce the resulting HFE release duration.

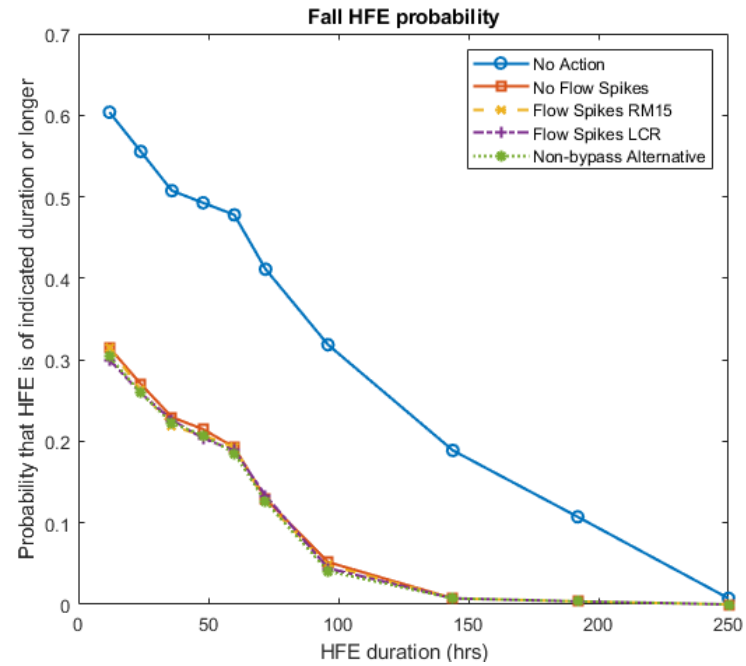
Modeling only the six traces that contain the flow spike and non-bypass fluctuations shows that under alternatives with flow spikes, the likelihood of spring HFE releases is slightly lower than under the No Action Alternative (6 percent lower for a target of river mile 15 and 21 percent lower for a target of river mile 61). Additionally, for a target of river mile 61, the probability of at least one HFE release occurring in a year would decrease by 28 percent compared with the No Action Alternative. The probability of at least one HFE release in a year lasting at least 60 hours would decrease by approximately 15 percent. Median spring HFE release duration would remain 96 hours, and the probability that HFE releases of this length would occur would increase in the spring and decrease in the fall. Relative to the No Action Alternative, the mean duration of HFE releases under flow spike alternatives would decrease by 3 percent for a river mile 15 target and increase by approximately 7 percent for a river mile 61 target. Mean annual total HFE release duration would decrease by 17 percent for a river mile 15 target and by 27 percent for a river mile 61 target (**Table 3-25**).

**Non-Bypass Alternative**

As shown in **Figure 3-23** through **Figure 3-25**, results of HFE modeling under the Non-Bypass Alternative are similar to those modeled under the cold-water alternatives when considering all 30 hydrology traces. The probability of spring HFE releases under this alternative is generally slightly lower than under the cold-water alternatives, except for spring HFE releases lasting between 50 and 100 hours. The median spring HFE release duration would be equal to 96 hours, which is comparable to the median length of spring HFE releases under the cold-water alternatives and three times longer than spring HFE release duration under the No Action Alternative. Mean HFE release duration over months in which HFE releases are implemented would be approximately 10 percent shorter than under the No Action Alternative (**Table 3-23**).

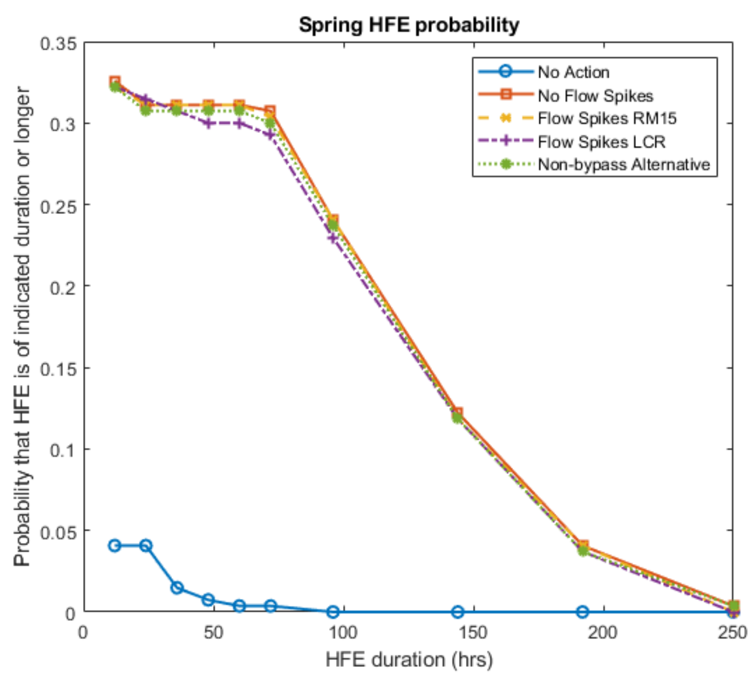
Considering only the six traces that contain flow spike and non-bypass fluctuations reduces the probability of spring HFE releases under the Non-Bypass Alternative from 32 percent to 7 percent (**Table 3-24**; **Figure 3-27**. The resultant 7 percent spring HFE probability represents a 79 percent decrease relative to the No Action Alternative. The probability of a fall HFE release under the Non-Bypass Alternative remains relatively low compared with the No Action Alternative. The probability of at least one HFE release occurring in a year would decrease by approximately 12 percent relative to the No Action Alternative, while the probability of such an HFE release lasting at least 60 hours would increase marginally. Median spring HFE release duration would remain at 96 hours. Relative to the No Action Alternative, the mean HFE release duration for months in which HFE releases are implemented would increase by approximately 7 percent, while the annual total mean HFE release duration would decrease by 11 percent (**Table 3-25**).

**Figure 3-23**
**Fall HFE Probability for Average of 30 Hydrology Traces**



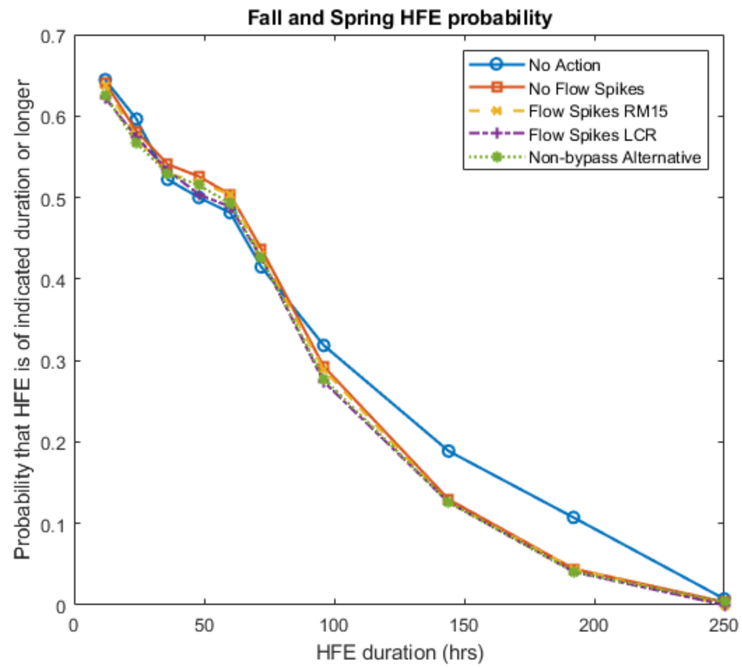

Source: Yackulic et al. 2024, chap. 3.
Note: Probability of triggered fall HFE releases is based on 90 modeled hydrology-Paria traces.

**Figure 3-24**
**Spring HFE Probability for Average of 30 Hydrology Traces**



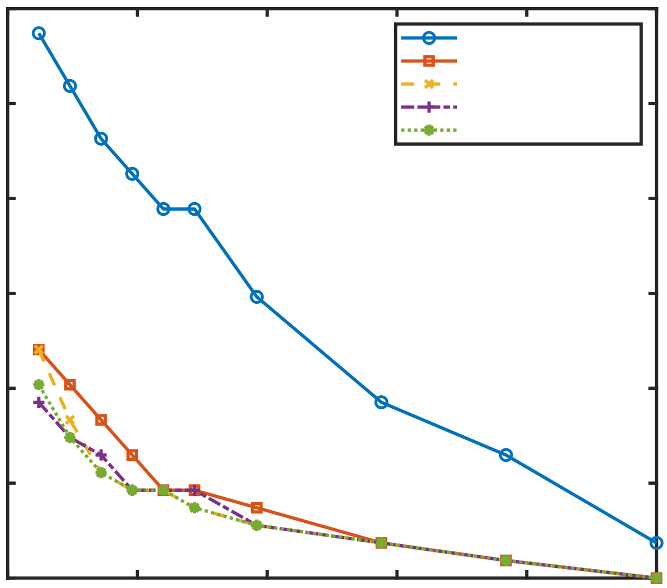

Source: Yackulic et al. 2024, chap. 3
Note: Probability of triggered spring HFE releases is based on 90 modeled hydrology-Paria traces.

**Figure 3-25**
**Fall and Spring HFE Probability for Average of 30 Hydrology Traces**



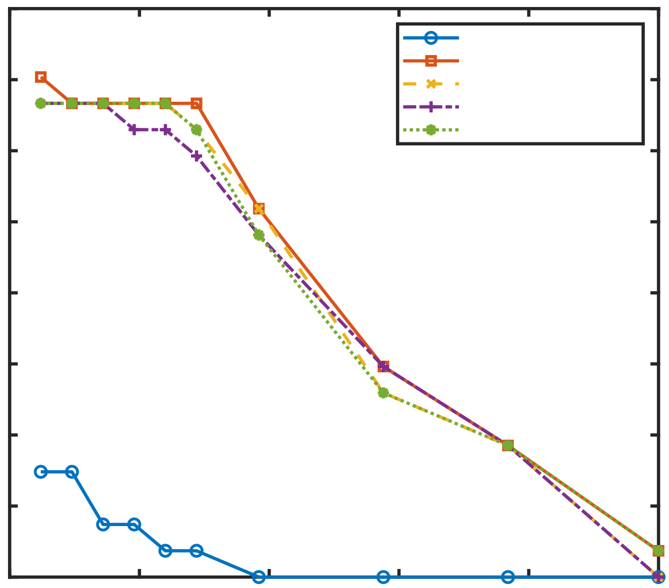

Source: Yackulic et al. 2024, chap. 3
Note: Overall probability of triggering any HFE release (either fall or spring) is based on 90 modeled hydrology-Paria traces.

## Figure 3-26
## Fall HFE Probability for Average of 6 Hydrology Traces Representing Alternative Implementation Periods



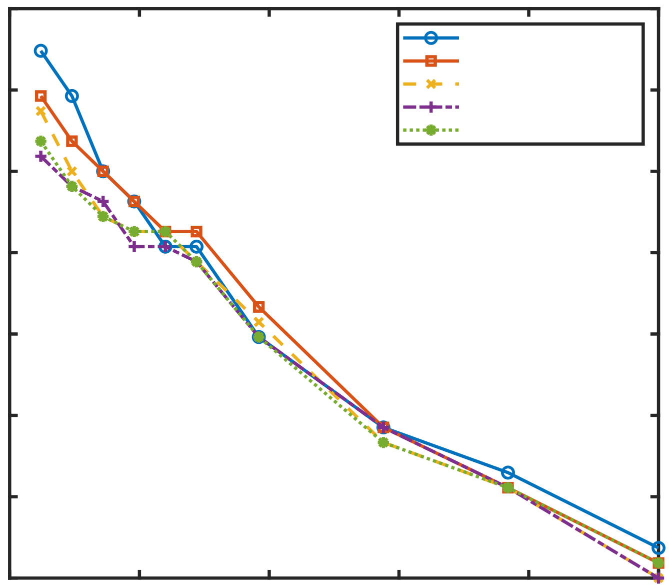
Source: Yackulic et al. 2024, chap. 3.
Note: Fall HFE release probability for traces under the flow spike river mile 15 scenarios includes flow spikes, which also include flow spikes under the river mile 61 target scenario and include non-bypass fluctuations under the Non-Bypass Alternative.

**Figure 3-27**
**Spring HFE Probability for Average of 6 Hydrology Traces Representing Alternative Implementation Periods**



Source: Yackulic et al. 2024, chap. 3
Note: Spring HFE probability for traces under the flow spike river mile 15 scenarios includes flow spikes, which also include flow spikes under the river mile 61 target scenario and include non-bypass fluctuations under the Non-Bypass Alternative.

**Figure 3-28**
**Fall Spring HFE Probability for Average of 6 Hydrology Traces Representing Alternative Implementation Periods**



Source: Yackulic et al. 2024, chap. 3
Note: The sum of fall and spring HFE release probabilities for traces under the flow spike river mile 15 scenarios includes flow spikes, which also include flow spikes under the river mile 61 target scenario and include non-bypass fluctuations under the Non-Bypass Alternative.

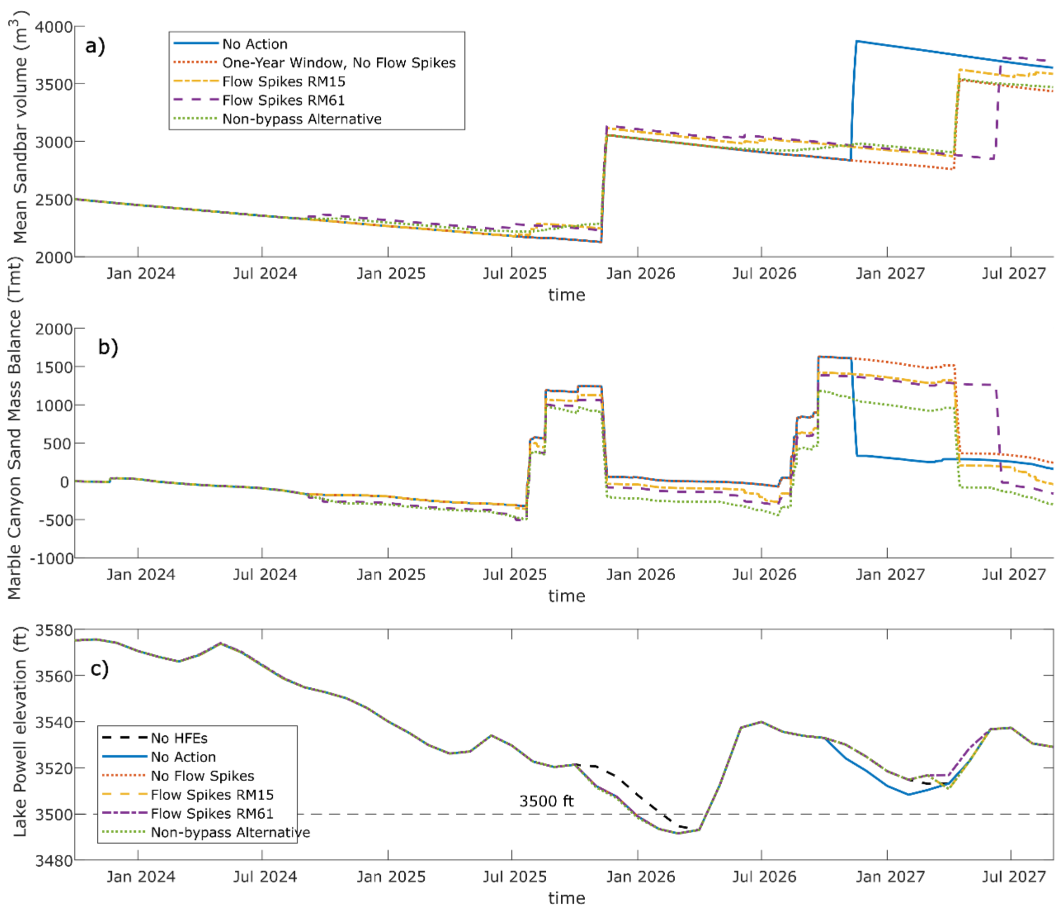
### *Issue 2: How would flow fluctuations and flow spikes affect sediment load transport, accumulation, and erosion?*

As discussed in the methodology, an important caveat that should be noted is that the Mueller and Grams (2021) sandbar model did not include any short-duration, high-magnitude discharge fluctuations (flow spikes and non-bypass fluctuations) in its calibration period. Caution should, therefore, be exercised in the interpretation of modeling results.

It should also be emphasized again that 6 of 30 traces contain flow spikes for the river mile 15 target; 12 of 30 traces contain flow spikes for the river mile 61 target; and 13 of 30 traces contain non-bypass fluctuations. For example, **Figure 3-29** shows mass balance and sandbar volume for a single trace and demonstrates how results may vary for individual traces in comparison with results based on 30 traces. Modeling results for the individual trace showed that flow spikes in the summers of 2024 and 2025 would result in slight sandbar building and sand export from Marble Canyon. All five alternatives trigger HFE releases in November of 2025; delay to spring was not possible due to reservoir elevations dropping below the threshold of 3500 feet. In November 2026, an HFE release is run under the No Action Alternative but is delayed to spring under the 1-year window. Under flow spike alternatives targeting river mile 61, the spring HFE release is further delayed to June in order to replace the first flow spike. Although the No Action Alternative results in a slightly larger sandbar than alternatives that do not include flow spikes, it is noted that if the November 2026 release were not possible to run due to hypothetical circumstances such as hydrologic conditions, the flexibility under the 1-year alternative to run a spring HFE release instead would result in much larger sandbars. Reservoir elevations below 3550 feet, which occur in **Figure 3-29(c)** for most of the modeled period, have in the past precluded fall HFE releases.

The impacts analysis discusses modeling constrained to a subset of the six traces that contain the river mile 15 target flow spikes, as they also contain river mile 61 flow spikes in addition to non-bypass fluctuations.

## Figure 3-29
## Comparison of Example Trace Results for Sediment Transport for All Alternatives



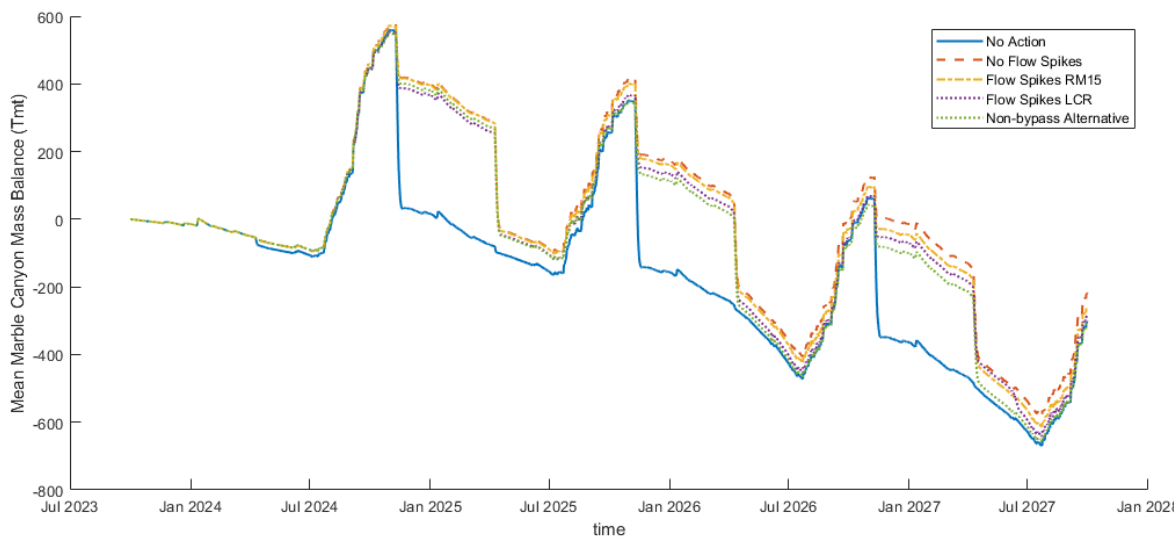

Source: Yackulic et al. 2024, chap. 3

Note: This example trace shows (a) sandbar volume, (b) Marble Canyon sand mass balance, and (c) Lake Powell reservoir elevation, with the black dashed horizontal line representing the threshold of 3500 feet. Flow spikes in the summers of 2024 and 2025 result in slight sandbar building and sand export from Marble Canyon.

### No Action Alternative

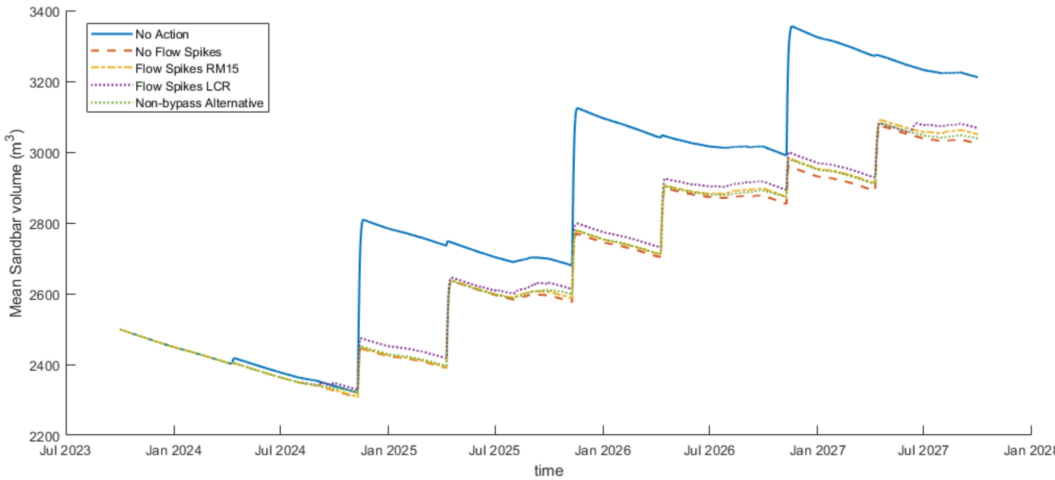
Under the No Action Alternative, operations of Glen Canyon Dam would not change. HFE releases would continue to occur when triggered, as described in the 2016 LTEMP FEIS. When conducted, the HFE releases would continue to contribute to sandbar building and sediment export in the Colorado River downstream of the dam. Sediment mass balance at Marble Canyon would continue to trend negative over the long term and decrease sharply following HFE releases (**Figure 3-30**). Sandbar building would continue to occur at its highest rate in the fall following fall HFE releases, due to their much higher probability under the No Action Alternative (**Figure 3-31**). The exact impacts on sediment resources would continue to be highly dependent on water availability for HFE releases, operational releases, and sediment input from tributaries.

**Figure 3-30**
**Comparison of Mean Marble Canyon Mass Balance Sand Routing Model Results for All Alternatives, Average of 30 Hydrology Traces**




Source: Yackulic et al. 2024, chap. 3
Note: Mean sand mass balance at Marble Canyon is based on 30 traces. Traces represent the average of 30 traces; drops in sand mass balance in fall and spring for alternatives sharing a 1-year accounting window do not imply that HFE releases are implemented in both fall and spring within individual years. They instead reflect an averaging together of some traces with fall implementation and some traces with spring implementation.

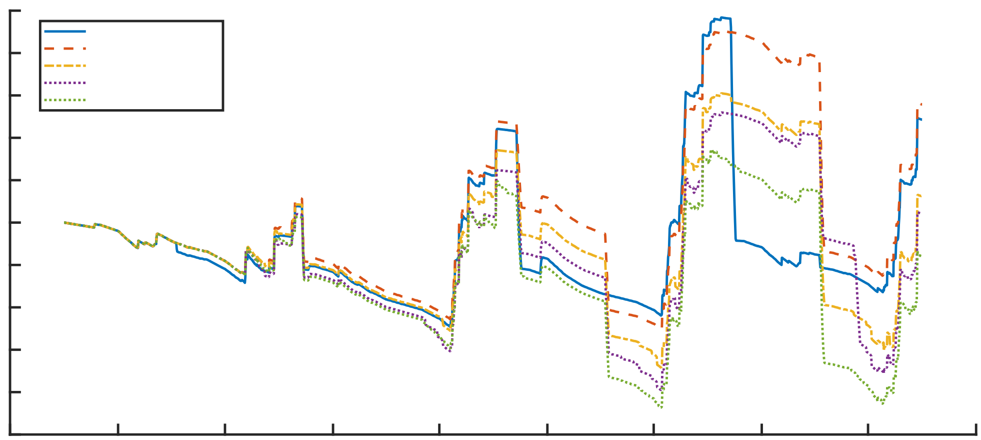
**Figure 3-31**
**Mean Sandbar Model Results for All Alternatives, Average of 30 Hydrology Traces**




Source: Yackulic et al. 2024, chap. 3
Note: Mean sandbar volume is based on 30 traces. Traces represent the average of 30 traces; increases in sandbar size in fall and spring for alternatives sharing a 1-year accounting window do not imply that HFE releases are implemented in both fall and spring within individual years. They instead reflect an averaging together of some traces with fall implementation and some traces with spring implementation.

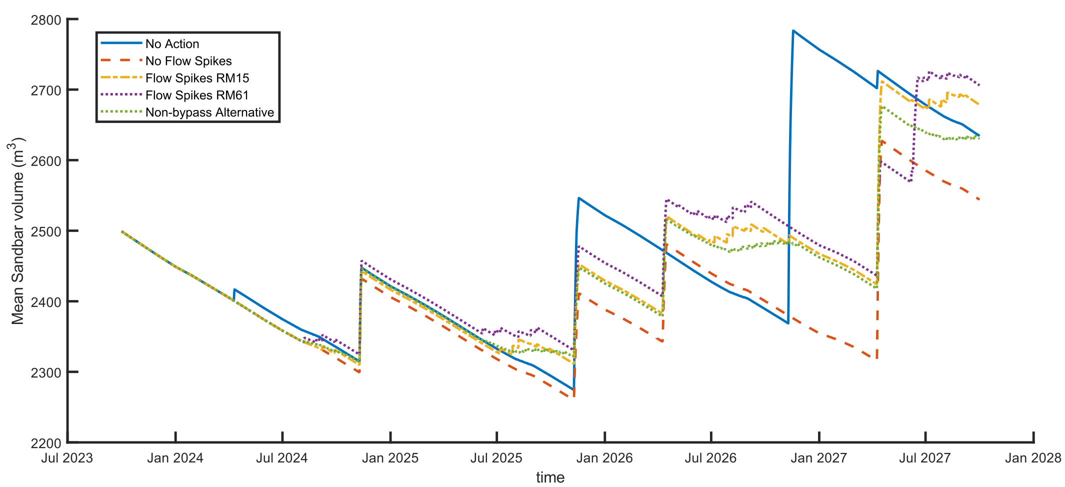
Modeling the six traces that contain all flow alternative options demonstrates that, relative to modeling for all 30 traces, sand mass balance would initially undergo a smaller degree of accumulation in the lead-up to HFE releases, with the degree of accumulation increasing in the following years (**Figure 3-32**). Sandbar erosion between HFE implementation periods is also shown to occur more rapidly, and overall sandbar volume is lower, when the 6 traces are modeled alone than when all 30 traces are modeled (e.g., 2500 cubic meters in the fall of 2024 under the 6-trace model, compared with 2800 cubic meters at the same point in time under the 30-trace model, as shown in **Figure 3-33**). For an average of all 30 traces, sandbar volume would undergo an increase of approximately 5 percent in the fall of 2024 under the No Action Alternative, whereas when modeled for only the 6 traces containing all flow alternative options, sandbar volume would increase by approximately 20 percent.

## Figure 3-32
## Comparison of Mean Marble Canyon Mass Balance Sand Routing Model Results for All Alternatives, Spring HFE Probability, Average of 6 Hydrology Traces Representing Alternative Implementation Periods



Source: Yackulic et al. 2024, chap. 3
Note: Average Marble Canyon sand mass balance for traces under the flow spike river mile 15 scenarios include flow spikes, which also include flow spikes under the river mile 61 target scenario and include non-bypass fluctuations under the Non-Bypass Alternative.

## Figure 3-33
## Mean Sandbar Model Results for All Alternatives, Average of 6 Hydrology Traces Representing Alternative Implementation Periods




Source: Yackulic et al. 2024, chap. 3
Note: Mean sandbar volume for traces under the flow spike river mile 15 scenarios include flow spikes, which also include flow spikes under the river mile 61 target scenario and include non-bypass fluctuations under the Non-Bypass Alternative.

**Alternatives with No Flow Spikes**

Under the Cool Mix and Cold Shock Alternatives, HFE releases would be triggered and implemented according to the 1-year sediment accounting period. For modeling of all 30 traces, alternatives with no flow spikes would result in a slightly higher mass balance on average (**Figure 3-30**) than under the No Action Alternative because the average HFE release duration would be slightly shorter under the 1-year sediment accounting period. Sandbar volume would continue to increase, albeit in smaller, more frequent increases relative to the No Action Alternative (**Figure 3-30**) due to the shorter duration of spring HFE releases. Secondary effects would include decreased HFE release magnitude, in addition to coarser bed grain size, which reduces suspended sand concentrations and, hence, sandbar deposition rate.

When modeling is constrained to the six traces that include all flow alternative options, sand mass balance and sandbar volume trends closely follow those of the No Action Alternative through the fall of 2025. Following the fall of 2025, sand mass balance under the alternatives without flow spikes would remain approximately 150 percent higher than under the No Action Alternative, before alternately yielding higher and lower sand mass balance relative to the No Action Alternative (**Figure 3-32**). Overall, modeling demonstrates negligible difference in sand mass export between the No Action Alternative and the alternatives with no flow spikes (G. Salter, personal communication, April 1, 2024).

Sandbar volume growth and erosion would approximate that of the No Action Alternative through the fall of 2025, with ultimately more modest increases in volume over time. As shown in **Figure 3-33**, the greatest difference in sandbar volume between the No Action Alternative and the alternatives with no flow spikes would occur between the fall of 2026 and spring of 2027, when sandbar volume under the action alternatives would be approximately 16 percent lower than under the No Action Alternative.

**Alternatives with Flow Spikes**

As shown in **Figure 3-30**, when modeling is performed for all 30 traces, trends in mass balance under the flow spike alternatives show similarities to trends under the alternatives without flow spikes, with the mean mass balance trending negative over the long term. Flow spike alternatives would result in slightly lower mass balance relative to alternatives without flow spikes because, in general, elevated flows with low suspended sediment concentrations have greater erosive potential, while elevated flows with high suspended sediment concentrations generate a greater potential for deposition (USGS 2011; Topping et al. 2019). More erosion would result from flow spikes targeting river mile 61 than flow spikes targeting river mile 15 because flow spikes targeting river mile 61 would be triggered more frequently.

Sand deposition for sandbar formation can occur only when there is available sand in the system (Topping et al. 2021). Sandbar formation trends would also roughly mirror those patterns modeled under the alternatives with no flow spikes. As shown in **Figure 3-31**, however, modeling for all 30 traces predicts that overall mean sandbar volume under the flow spike alternatives would slightly greater than sandbar volume under the alternatives that do not include flow spikes. If a flow spike occurred in the lead-up to an HFE release, it would increase sediment export, thereby decreasing the amount of available sand to perform an HFE release. This would cause a reduction in sandbar size, because HFE releases are the only mechanism for providing substantial deposition of high-elevation sandbars (Hazel et al. 2022).

When the analysis is constrained to the six flow spikes containing all flow alternative options, sand mass balance under flow spike alternatives would be slightly greater than under the No Action Alternative. Overall trends would remain the same compared with the No Action Alternative and other action alternatives. Evaluating sand mass balance with respect to the six traces containing all flow alternative options, it is estimated that relative to the No Action Alternative, flow spikes targeting river mile 15 would cause a 169 percent increase in sand export in the months during which they would occur (**Figure 3-27**). Flow spikes with a river mile 61 target would increase sand export by 222 percent relative to the No Action Alternative (G. Salter, personal communication, April 1, 2024).

**Figure 3-28** shows that, of the action alternatives, alternatives with flow spikes would result in overall larger sandbar volume, with periods of slight recovery in months leading up to HFE releases, though increases would remain below those that would occur under the No Action Alternative. However, as described under the *Methodology Caveats* section, the Mueller and Grams (2021) sandbar model assumes a constant exponential erosion rate independent of discharge and does not include high-discharge fluctuations. It is unable to capture the enhanced erosion rate that would likely result from elevated flows.

### Non-Bypass Alternative

Impacts under the Non-Bypass Alternative would be similar to those described under the cold-water alternatives, as shown in **Figure 3-30** and **Figure 3-31**. Compared with other action alternatives, the Non-Bypass Alternative would cause the greatest reductions in mass balance starting in the spring of 2025. When all 30 traces are modeled, this alternative would generally produce the second-smallest sandbars, slightly surpassing volumes that would be generated under alternatives without flow spikes.

More nuanced and contrasting patterns are observed in modeling the set of six traces containing flow alternative options. When constraining the analysis to the six traces containing flow spikes and non-bypass fluctuations, the Non-Bypass Alternative resulted in the greatest loss of sand mass balance out of all alternatives. Relative to the No Action Alternative, the Non-Bypass Alternative would cause a 196 percent increase in sand export during the months in which the fluctuations would occur (G. Salter, personal communication, April 1, 2024).

Sandbar volume growth would closely follow trends under the No Action Alternative through the fall of 2025. Non-Bypass Alternative sandbar volumes would then differ slightly for a roughly yearlong period, fluctuating approximately 5 to 10 percent higher and then lower than volumes under the No Action Alternative. Following this period, erosion that would likely result from the relatively frequent non-bypass fluctuations would cause slower sandbar volume recovery than under the No Action Alternative. Contrary to modeling for all 30 traces, this constrained modeling demonstrates that sandbar volumes in 2027 would be approximately 3 percent lower under the Non-Bypass Alternative than under the No Action Alternative (**Figure 3-33**).

The sandbar model predicts slightly smaller volumes for the Non-Bypass Alternative than under the flow spike alternatives because the maximum releases under the Non-Bypass Alternative are lower. These results should be interpreted cautiously; the Mueller and Grams (2021) sandbar model, which was not calibrated for short-duration and high-magnitude flows, may not reflect all the erosive effects of non-bypass fluctuations. These erosive effects may be much higher in practice, as the frequent fluctuations between short-duration low and high discharges may substantially erode sandbars and decrease sandbar volume (Yackulic et al. 2024, chap. 3; Alvarez and Schmeeckle 2013).

**Cumulative Effects**

The 1-year sediment accounting period would change the timing and duration of HFE releases, while allowing for the option to defer the consideration of a triggered fall HFE release to spring, depending on sediment conditions. Flow spikes that occur in the lead-up to an HFE release would increase the likelihood of HFE release deferral due to increased sediment export and subsequent decreased sediment available for transport via HFE release.

***Summary***

The 1-year sediment accounting period would enable decision-makers to more easily implement HFE releases in the spring, which would better approximate pre-dam conditions of high spring run-off flows. Alterations in the timing and duration of HFE releases would affect patterns of sediment transport and sandbar growth. The 1-year sediment accounting period would result in spring HFE releases with a median duration of 96 hours, with a higher probability of longer spring HFE releases under all action alternatives.

In comparison, HFE releases implemented under the No Action Alternative are much more likely to be triggered in the fall, with fall HFE releases approximately eight times more likely to occur relative to spring HFE releases when averaging over 30 hydrology traces, and almost twice as likely when averaging over the six traces that contain flow spike and non-bypass fluctuations. Regardless of the statistics presented in **Table 3-22** through **Table 3-25**, it would be at the discretion of decision-makers to decide whether to implement a triggered fall HFE release or defer it to the spring.

Under all action alternatives, which share the 1-year sediment accounting period, sand mass balance would undergo more gradual and frequent decreases following HFE releases, and this trend may be mirrored in sandbar growth patterns. It is important to note, however, the caveats of modeling sandbar volume using the Mueller and Grams (2021) sandbar model. Another caveat that must be reiterated is that sandbar volumes do not necessarily represent sand that would be usable for camping and other recreational uses.

Under all action alternatives, sandbars would be overall smaller and undergo slower growth than under the No Action Alternative. According to modeling for both 30-trace and 6-trace datasets, alternatives without flow spikes and the Non-Bypass Alternative would result in the smallest sandbars (for example, approximately 6 percent and 4 lower than the No Action Alternative, respectively, in the lead-up to a spring 2026 HFE release). Sandbars would erode between HFE releases, with flow spikes contributing modest growth. This erosion is especially apparent when modeling accounts only for the six traces that include all flow alternative options. This constrained modeling also shows that flow spikes and non-bypass fluctuations would contribute modest amounts of sandbar building, though literature (e.g., Topping et al. 2019, Alvarez and Schmeeckle 2013, and others) states that sandbars erode during high discharges when the antecedent sand supply is depleted and coarse. Of the action alternatives, the frequent fluctuations between short-duration, low discharges and short-duration, high discharges under the Non-Bypass Alternative pose the greatest risk of substantial sandbar erosion and consequent decline in sandbar volume.

Flow spikes targeting river mile 61 would cause the greatest increase in sand export during the months in which they occur, with 222 percent greater sand export than under the No Action Alternative. In comparison, the Non-Bypass Alternative would generate the second-greatest volume of exported sand during months of non-bypass fluctuation flows (196 percent greater than the No Action Alternative), and flow spikes targeting river mile 15 would generate the least sand export (169 percent greater than the No Action Alternative). This may be due to the increased frequency of flow spikes under the flow spike alternative targeting river mile 61. Calculations for the total amount of sand exported show that it is flow spikes and non-bypass fluctuations, rather than HFE release timing, that would contribute to increased overall sand export relative to the No Action Alternative (Yackulic et al. 2024, chap. 3; G. Salter, personal communication, April 1, 2024).

# 3.5 Aquatic Resources

## 3.5.1 Affected Environment

This section supplements the 2016 LTEMP FEIS (DOI 2016a) for aquatic resources with a summary of the affected environment as provided in the 2016 LTEMP FEIS and supplemented, as necessary, to include changes that have occurred since 2016.

As described in the 2016 LTEMP FEIS, the Colorado River ecosystem supports numerous species of aquatic organisms, including the aquatic food base (i.e., invertebrates, algae, rooted plants, and organic matter that serve as the base of the food web for fish; **Section 3.5.1**), native fish (including endangered and other special status species; **Section 3.5.2**), and nonnative fish (including cold-water and warmwater species; subsection *Nonnative Fish*) (DOI 2016a). Changes to river flows can affect these aquatic organisms and their habitats that occur in-channel, along shorelines, backwaters, and tributary mouths. The affected environment for this SEIS includes the same area potentially affected by the implementation of the 2016 LTEMP FEIS. For aquatic resources, this area includes the Colorado River ecosystem from Glen Canyon Dam downstream to the Lake Mead inflow.

The aquatic species described below are based on those covered in the 2016 LTEMP FEIS and any new species, species of increased concern, or species with changed status since 2016. Federally listed species are discussed in **Section 3.8**, Threatened and Endangered Species. The continued drought conditions in the southwestern US, declines in the water level of Lake Powell, and warm epilimnetic water (the layer of water above the thermocline) released from Glen Canyon Dam have likely influenced all aspects of the aquatic food web. These effects are still being determined, but the role of water temperature in sustaining the aquatic resources, management options in the Colorado River, the consequences of warming water, and the challenges of managing these conditions have increased in importance since the 2016 LTEMP FEIS. For some aquatic resources, language from the 2016 LTEMP FEIS is used herein to provide context to new data and information and to provide the reader with the background for a voluminous and complex subject area.

### *Aquatic Food Base*

The aquatic food base for fish in the Colorado River ecosystem includes invertebrates (animals without backbones), algae, rooted plants, and organic matter, as well as some vertebrates (small fish, reptiles, and amphibians) (Gloss et al. 2005). Although most of this food base is produced within the aquatic system, terrestrial inputs of organic matter (for example, leaf litter) and invertebrates also contribute. Instream production of both algae and invertebrates provides food for insectivorous birds, bats, reptiles, and waterfowl and indirect links to peregrine falcons, belted kingfishers, osprey, great blue herons, and bald eagles, which feed on fish or waterfowl that consume aquatic food base organisms (Bastow et al. 2002; Baxter et al. 2005; Sabo and Power 2002; Shannon et al. 2003b; Shannon et al. 2004; Stevens and Waring 1986a; Yard et al. 2004). See **Section 3.7** for a discussion of riparian and terrestrial wildlife. Flow patterns, temperature, and turbidity—all of which were and continue to be influenced by the presence and changing operations of Glen Canyon Dam—have a major influence on the food base of the Colorado River ecosystem within the Grand Canyon.

A description of the aquatic food base prior to and following the construction and operation of Glen Canyon Dam was provided in the 2016 LTEMP FEIS. This section supplements that information with findings following the FEIS publication. Included in the discussion are invasive aquatic species that have affected or may affect food base organisms of the Colorado River downstream of Glen Canyon Dam. The major groups of aquatic food base organisms include (1) periphyton (for example, algae, diatoms, and cyanobacteria that live attached to rocks and other surfaces) and rooted aquatic plants, (2) plankton (very small plants [phytoplankton] and animals [zooplankton] that occur in the water column), and (3) macroinvertebrates (i.e., invertebrates that are visible to the naked eye and are generally attached to rocks and other surfaces).

#### **Periphyton and Rooted Aquatic Plants**

Physical factors associated with dam releases that have the greatest influence on tailwater algal communities include (1) daily and seasonal constancy of water temperatures, (2) modifications of nutrient regimes, (3) reduced sediment and increased water clarity, (4) formation of stable armored substrates, (5) fluctuations in water levels that produce daily drying and wetting cycles, and (6) reductions in seasonal flow variability and alterations in the timing or occurrence of extreme flows (Blinn et al. 1998). These conditions allowed ubiquitous *Cladophora glomerata* (a filamentous green algae) to become the dominant algal species below Glen Canyon Dam within 6 years of dam closure in 1963 (Czarnecki et al. 1976; Carothers and Minckley 1981; Blinn et al. 1989, 1998; Stanford and Ward 1991). This species remained dominant until 1995 (Blinn and Cole 1991; Blinn et al. 1995; Benenati et al. 1998), when changes in flow regimes stopped the repeated episodes of exposure and desiccation of the varial zone[24] and diluted nutrient concentrations associated with higher reservoir volumes caused the decrease in dominance of *Cladophora* (Benenati et al. 1998, 2000, 2001).

[24] Varial Zone - the portion of the river bottom and shoreline that is alternately flooded and dewatered during dam operations, often on a daily basis

Prior to June 1995, *Cladophora* composed 92 percent of the phytobenthic community, but it decreased to less than 50 percent after that time (Benenati et al. 2000). The aquatic flora is now dominated by miscellaneous algae, macrophytes, and bryophytes, including filamentous green algae (mainly *Ulothrix zonata* and *Spirogyra* spp.), the stonewort (*Chara contraria*), species of the aquatic moss *Fontinalis*, and the macrophyte *Potamogeton pectinatus*. *Cladophora* is still present, but in much reduced levels, probably due to changes in reservoir and river chemistry and discharge regimes starting in 1991, as authorized in the 1995 FEIS that limited the daily range in dam releases to 8,000 cfs (Benenati et al. 2000; NPS 2005; Yard and Blinn 2001; Reclamation 1995).

Submerged macrophytes collected in the mainstem Colorado River included horned pondweed (*Zannichellia palustris*), Canadian waterweed (*Elodea canadensis*), Brazilian elodea (*Egeria densa*), pondweed (*Potamogeton* spp.), aquatic moss (*Fontinalis* spp.), and muskgrass (*Chara* spp. [green alga]) (Carothers and Minckley 1981; Valdez and Speas 2007). These species have persisted with dam operations since the 2016 LTEMP FEIS.

**Plankton**

Plankton occurring in the Colorado River downstream of Glen Canyon Dam includes both phytoplankton and zooplankton. The phytoplankton population downstream of the dam is diverse but sparse (with numbers never exceeding 3 million organisms per cubic meter [3,000 organisms per liter]) and decreases with distance downstream of Lees Ferry. A total of 122 species have been identified, with diatoms being dominant. In general, the phytoplankton of the Colorado River is considered relatively unproductive due to a combination of high flow rates, low temperatures, elevated turbidity (with increasing distance from the dam), and scouring action by rapids and suspended sediments, which limit reproduction and survival (Sommerfeld et al. 1976).

The factors that regulate zooplankton in the Colorado River below Glen Canyon Dam are the distribution and abundance of zooplankton in Lake Powell and the operation of the dam (AZGFD 1996; Speas 2000). The low levels of Lake Powell may result in increases in the composition and density of zooplankton downstream as waters are withdrawn from layers closer to the surface (Reclamation 1995). Cole and Kubly (1976) concluded that most zooplankton in the Colorado River originated from Lake Powell or tributaries (primarily Elves Chasm and Tapeats and Diamond Creeks). The mean zooplankton density in the 352 kilometers (approximately 219 miles) of the river downstream of Glen Canyon Dam was 614 organisms per cubic meter (0.614 organisms per liter) (Benenati et al. 2001).

It has been reported that backwaters are localities where zooplankton populations can persist (Haury 1986) and that zooplankton densities in backwaters are significantly higher than those of the main channel (AZGFD 1996). Backwaters were thought to support more zooplankton because they are warmer and more stable, and they may retain nutrients that benefit both phytoplankton and zooplankton. Some production of zooplankton occurs in eddies, backwaters, and other low-velocity areas (AZGFD 1996; Stanford and Ward 1986; Blinn and Cole 1991). However, given that even under stable flows, the water in backwaters is recycled 1.5 to 3.4 times per day, it seems unlikely that water-column resources such as zooplankton could ever become substantially higher in backwaters than in the mainstem river (Behn et al. 2010). These conditions have persisted with dam operations since the 2016 LTEMP FEIS.

**Macroinvertebrates**

Alterations in flow, temperature, and suspended sediment associated with the presence and operation of Glen Canyon Dam have resulted in a food base of low species diversity. Although aquatic productivity is relatively high in the Glen Canyon reach because of high water clarity and photosynthesis, macroinvertebrate food base production through the Grand Canyon is extremely low, falling in the bottom 10 percent of production values for streams and rivers throughout the world (Cross et al. 2013). Macroinvertebrate populations have responded to temperature regimes from dam releases by experiencing changes in their behavior, life cycles, and overall population dynamics. River temperatures at Lees Ferry ranged from 8 to 11°C (46.4–51.8°F) from 1995 to 2004, from 8 to 15°C (46.4–59°F) from 2005 to 2021, and from 8 to 18°C (46.4–64.4°F) and as high as 20°C (68°F) from 2022 to 2023. The temperature regimes and not the specific temperatures are the factors that influence life stage development of these macroinvertebrates.

The Colorado River in Glen and Grand Canyons supports very few mayflies (*Baetis* spp.), stoneflies, or caddisflies (*Hydroptila arctica*, *Rhyacophila* spp., *Hydropsyche oslari*, and others) because of a combination of stressors, including altered temperature regimes and a large varial zone (Stevens et al. 1997; Kennedy et al. 2016). Cold water released from Glen Canyon Dam can prevent aquatic insect eggs from hatching and may limit successful recruitment of these macroinvertebrates from warmer tributaries (Oberlin et al. 1999), while a large varial zone associated with hydropower production leads to desiccation-induced mortality of insect eggs laid along river edge habitats (Kennedy et al. 2016). The caddisfly *Ceratopsyche oslari* occurs throughout the Colorado River but at low abundance (Blinn and Ruiter 2009). Haden et al. (1999) believe that interspecific interactions between *Gammarus* and the net-building *C. oslari* may contribute to the caddisfly's limited presence in the Colorado River below Glen Canyon Dam. Since 1995, recent colonizers throughout the river (possibly as a result of reduced discharge variability from Glen Canyon Dam) include caddisflies, true flies (*Bibiocephala grandis* and *Wiedemannia* spp.), mayflies, beetles (*Microcylloepus* spp.), planarians, and water mites (Shannon et al. 2001). However, caddisflies and mayflies remain relatively sparse in the Colorado River, especially upstream of the Paria River.

Glen Canyon Dam operations have played an important role in the formation of the varial zone. Benthic communities subject to periodic stranding, desiccation, ultraviolet radiation, and winter freezing often have depleted species diversity, density, and/or biomass in the varial zone (Fisher and LaVoy 1972; Hardwick et al. 1992; Blinn et al. 1995; Stevens et al. 1997). Kennedy et al. (2016) hypothesized that dam operations actually constrain the abundance and diversity of aquatic insects in this varial zone and in the Colorado River downstream of Glen Canyon Dam, thereby limiting the amount of invertebrate prey that is available to support native fish and nonnative trout populations.

Included in the preferred alternative of the 2016 LTEMP FEIS was a macroinvertebrate production flow or "bug flow" experiment that proposed to stabilize flows and limit the varial zone. This experiment was implemented from May–August 2018, 2019, 2020, and 2022, to test the hypothesis proposed by Kennedy et al. (2016) that load-following flows from hydroelectric dams produce a population bottleneck for aquatic insects by short-circuiting recruitment processes. This phenomenon had been observed below Flaming Gorge Dam, a hydroelectric facility in the Upper Colorado River (Miller et al. 2020). Kennedy et al. (2016) showed that egg survivorship for Diptera (i.e., midges) and EPT taxa (Ephemeroptera [mayflies], Plecoptera [stoneflies], and Trichoptera [caddisflies]) was limited by fluctuating flows that desiccate egg masses and that the production and diversity of the invertebrate food base may be enhanced by steady flow releases. These species require nonembedded habitats. A study by Stevens et al. (2020) suggested that habitat quality (i.e., embeddedness of substrates) may also play a role in structuring invertebrate assemblages.

Metcalfe et al. (2020) found that distributions of the two most widespread caddisfly species downstream of Glen Canyon Dam were each predicted by water temperatures. However, they also found that the abundance of one species decreased by as much as tenfold as 24-hour flow stage change increased, despite the presence of female morphological adaptations for deepwater oviposition (egg-laying). These results show that net-spinning caddisflies have species-specific responses to environmental variation and suggest that environmental flows designed to reduce 24-hour stage change and destabilize water temperatures may improve habitat quality for these ubiquitous and important aquatic insects. These studies determined that more stable flows may benefit aquatic macroinvertebrates downstream of Glen Canyon Dam, and also that the effect of fluctuating flows depends on longitudinal locations downstream of the dam and whether the timing of insect egg-laying (i.e. usually in late afternoon or evening) aligns with the timing of daily high or low flows. For example, in Grand Canyon, reaches where daily low flows occur in the late afternoon and coincident with peak insect egg-laying have three times higher adult midge abundance than locations where daily high flows occur in the late afternoon (Kennedy et al. 2016).

Yard et al. (2023) demonstrated important linkages between nutrients (soluble reactive phosphorus), invertebrates, and rainbow trout populations below Glen Canyon Dam. In this work, declines in phosphorus drove declines in invertebrates and ultimately led to large declines (of greater than 85 percent) in rainbow trout populations in the tailwater reach in 2012–2016. This study suggests that lowered reservoir elevations from ongoing drought could limit the transport of phosphorous to the tailwater and result in less food production. This work highlights the important linkages between nutrient inputs, invertebrate production, and fish populations in Glen Canyon. Phosphorous concentrations in the Colorado River downstream of Glen Canyon Dam are sometimes very low and at limiting levels (Ker et al. 2022). Lower water levels (and warmer temperatures) will generally mean less soluble reactive phosphorous and possibly lower nutrient levels for macroinvertebrate production. This will translate to lower food production for fishes.

### Nonnative and Invasive Species

Some nonnative invertebrate species were introduced after dam construction to supplement the aquatic food base of the Colorado River downstream of Glen Canyon Dam. Because of the low benthic food base noted in the late 1960s, AZGFD biologists introduced macroinvertebrates into the Glen Canyon reach, including crayfish, snails, damselflies, caddisflies, crane flies, midges, true bugs, beetles, and leeches (McKinney and Persons 1999a). These introductions were not monitored for a sufficient length of time to determine their success; however, most of these taxa did not persist in the river (Carothers and Minckley 1981; Blinn et al. 1992). *Gammarus lacustris* was also introduced into the Glen Canyon reach in 1968 to provide food for native and nonnative fish (Ayers et al. 1998), and *Gammarus* and midges have become important components of the aquatic food base.

Other nonnative, invasive species that have potentially detrimental effects on both the food base and fish communities have become established in the Colorado River below Glen Canyon Dam.

The New Zealand mud snail was first detected in Glen Canyon in 1995. By 1997, densities on cobble/gravel substrates reached about 3,390 per square foot. The New Zealand mud snail has dispersed downstream through the Grand Canyon and was documented in Lake Mead in 2009 (Sorensen 2010). The mud snail accounted for 20 to 100 percent of the macroinvertebrate biomass at six cobble bars studied in the Colorado River downstream of Glen Canyon Dam. The snails probably consume the majority of available epiphytic diatom assemblage.

The New Zealand mud snail is a trophic dead-end and may adversely affect the food base in the Colorado River (Shannon et al. 2003b). Epiphytic diatom biomass estimates at Lees Ferry were an order of magnitude lower in 2002 than in 1992 (before New Zealand mud snails were present) (Benenati et al. 1998; Shannon et al. 2003b). However, the biomass of other dominant aquatic food base taxa has been variable and apparently not influenced by the presence of the snails (Cross et al. 2010). At high population levels (9,300 or more individuals per square foot), New Zealand mud snails can substantially modify lower trophic levels (Hall et al. 2006). Although the New Zealand mud snail occurs throughout the river from the Glen Canyon Dam to Lake Mead, its densities tend to be much higher in the upper reaches of the river (Cross et al. 2013). For example, in the Glen Canyon reach, densities of mud snails were an order of magnitude higher than downstream in the Grand Canyon, where sediment scouring and turbidity apparently limit the snails (Cross et al. 2013). Mud snails are free-living without an attachment device and are easily transported with flows.

The New Zealand mud snail has a good chance of being transported by either biological or physical vectors because of its small size and locally high population density (Haynes and Taylor 1984). Recreational fishing and fish stocking have been implicated in the spread and introduction of the New Zealand mud snail (Moffitt and James 2012). The New Zealand mud snail can also be carried by waterfowl from one system to another, by fish within a system (Haynes et al. 1985), and in caked mud on the boots and waders of anglers.

A reproducing population of the quagga mussel (*Dreissena bugensis*) has been established in Lake Powell since at least 2012 (NPS 2012b). Quagga mussels can alter food webs by filtering phytoplankton and suspended particulates (Benson et al. 2013). As of 2014, thousands of adult quagga mussels have been observed within the reservoir on canyon walls, Glen Canyon Dam, boats, and other underwater structures (Repanshek 2014), and these have continued to expand and increase in abundance. Quagga mussels established in Lake Powell may cause changes in dissolved nutrients, phytoplankton, and zooplankton within the reservoir, which would likely impact food web structure or trophic linkages below Glen Canyon Dam (Nalepa 2010).

The risk of quagga mussels becoming established within the Colorado River ecosystem was thought to be low, except in the Glen Canyon reach, where lower suspended sediment and higher nutrient levels (compared with downstream reaches) favor its establishment (Kennedy 2007). It is unlikely to establish at high densities within the river or its tributaries because of high suspended sediment, high ratios of suspended inorganic/organic material, and high-water velocities; all of these interfere with the mussel's ability to attach and effectively filter food. High concentrations of sand may cause abrasion and physically damage its feeding structures (Kennedy 2007). Quagga mussels were identified in sampling locations between Glen Canyon Dam and Lees Ferry in November 2014. The mussels continue to be found in the river below the dam. Their distribution is patchy and highly influenced by fluctuating water levels and location-specific flow regimes. Adult mussels have also been found downstream in the Grand Canyon. Mussel larvae (veligers) pass through the Glen Canyon Dam and seek to attach to substrates in the river.

Quagga mussels have become established in Lake Powell and have been seen in the river below Glen Canyon Dam as recently as 2022 and 2023. Their arrival in the river in 2014 happened sooner than expected. However, so far, there has not been a major infestation, and there is some thought by experts that the mussels will not become very well established in the river due to river currents and periodic sediment loads. Anglers are being advised to dry waders and boots before using them in any other body of water. Also, all private boaters are asked to drain all water from the boat and live wells as soon as they exit the river.

A few nonnative, invasive invertebrates are fish parasites that use food base organisms as intermediate hosts. For example, the internal parasite *Myxobolus cerebralis*, which causes whirling disease in salmonids (trout species), uses the oligochaete worm *Tubifex tubifex* as an intermediate host (see the *Cold-Water Nonnative Species* subsection for additional information on whirling disease). The parasitic trout nematode (*Truttaedacnitis truttae*) is present in rainbow trout in the Glen Canyon reach, but the ecological impact of this infestation is poorly understood. It may influence food consumption, impair growth, and reduce the reproductive potential and survival of rainbow trout. The nematode may require an intermediate host such as a copepod or other zooplankton taxa (McKinney et al. 2001).

The Asian tapeworm (*Bothriocephalus acheilognathi*) was first introduced into the United States with imported grass carp (*Ctenopharyngodon idella*) and was discovered in the Little Colorado River by 1990 (Choudhury et al. 2004). It now parasitizes the humpback chub population from the Colorado and Little Colorado Rivers. The tapeworm could infect all native and nonnative fish species in the Little Colorado River, where temperatures are more suitably warm (USGS 2004). Cyclopoid copepods are intermediate hosts for the tapeworm, although fish that prey upon small, infected fish can acquire tapeworm infections as well. Thus, large humpback chub that normally consume little zooplankton can become infected by preying on smaller infected fish (USGS 2004).

The Asian tapeworm requires at least 18°C (64°F) to complete its life cycle and may become an increasing threat to native fish as Lake Powell levels drop and dam release temperatures increase. Asian tapeworm monitoring occurs annually within the Little Colorado River, and additional monitoring is conducted on Asian fish tapeworms in humpback chub inhabiting the mainstem Colorado River as identified in the 2016 Biological Opinion. When wild humpback chub were screened for infection prevalence in spring 2015 (21.4 percent, n = 140) and fall 2015 (6.6 percent, n = 258), the relative frequency of infection was highest in juveniles and subadult fish (200–300 millimeters) (Campbell et al. 2019). Elevated levels of infection near the major spawning grounds of humpback chub in the Little Colorado River promote parasitic infection, which may continue to persist without treatment or actions to control infections.

Increased body loads of the parasitic copepod known as anchor worm (*Lernaea cyprinacea*) and the Asian tapeworm cause poorer body condition in humpback chub from the Little Colorado River (Hoffnagle et al. 2006). For fish collected from 1996 to 1999, the prevalence of anchor worm was found to be 23.9 percent, and the mean intensity was 1.73 per fish in the Little Colorado River compared with 3.2 percent and 1.0 per fish in the Colorado River. The prevalence of Asian tapeworm was 51.0 percent and 252 per fish in the Little Colorado River, but only 15.8 percent and 12 per fish in the Colorado River, where temperatures were colder.

Differences in parasite density and abundance between the Little Colorado River and the Colorado River are caused by temperature differences. Temperatures in the Colorado River near the Little Colorado River do not reach those necessary for either parasite to complete its life cycle (at least 18°C [64.4°F]); thus, these parasites were probably contracted while the humpback chub was in the Little Colorado River (Hoffnagle et al. 2006). Anchor worms persist in the system and may increase in abundance or distribution with warmer river temperatures. Warmer temperatures in the Colorado River from lower elevations of Lake Powell could result in an increased infestation of fish parasites in humpback chub and other native fish species. The high salinity content of the Little Colorado River also acts as a prophylactic for some parasites (Ward 2012).

**Food Web Dynamics**

Primary production, specifically diatoms, forms the base of the aquatic food web in Glen Canyon. In contrast, a combination of primary production and terrestrial and tributary inputs of organic matter is the basis of the aquatic food web in Marble and Grand Canyons, but high-quality algal matter supports the food web to an extent that is disproportionate to its availability. Midges and blackflies principally fuel the production of native and nonnative fish. Fish production throughout the river appears to be limited by the availability of these high-quality prey, and fish may exert top-down control on their prey (Carlisle et al. 2012).

Prior to the low fluctuating flows that started in 1995, the primary foods of humpback chub in the Colorado River through the Grand Canyon were simuliids, *Gammarus*, chironomids, and terrestrial invertebrates (Valdez and Ryel 1995). Fluctuating flows from power plant releases were hypothesized to desiccate egg masses in varial shoreline zones (Cross et al. 2013; Kennedy et al. 2016). Experiments to regulate dam releases on weekends and provide more stable flows ("bug flows") were implemented in 2018–2020 to encourage macroinvertebrate oviposition in varial habitats. It was determined that a 400 percent increase in caddisflies occurred during two of the three years, but it was uncertain if these increases were because of low sediment (Deemer et al. 2021).

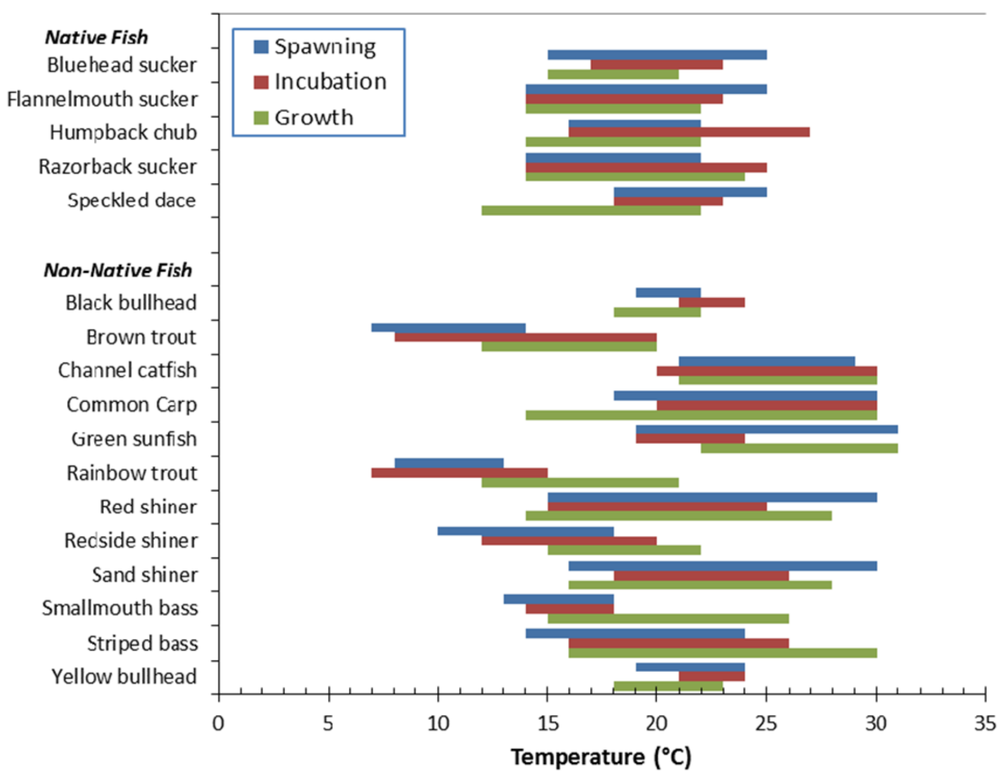
The food web of the Colorado River within Glen Canyon is rather simple. Complexity increases with distance from the dam (Cross et al. 2013). The New Zealand mud snail and nonnative rainbow trout dominate the food web in the Glen Canyon reach. The simple structure of this food web has a few dominant energy pathways (diatoms to a few invertebrate taxa to rainbow trout) and large energy inefficiencies (i.e., greater than 20 percent of invertebrate production consumed by fish). Epiphytic diatoms, *Gammarus*, midges, and blackflies provide the primary food base for rainbow trout (Cross et al. 2013).

Below large tributaries with substantial sediment input, invertebrate production declines about 18-fold, while fish production remains similar to upstream sites. However, sites below large tributaries have increasingly diverse and detritus-based food webs. Midges and blackflies are the dominant invertebrates consumed in downstream reaches (Cross et al. 2013). Fish populations are food-limited throughout most of the mainstem and tend to consume all of the available invertebrate production in downstream reaches (Cross et al. 2013).

### *Native Fish*

Of 11 species of native fish that were historically found within the analysis area, 5 have persisted (Valdez and Carothers 1998; **Table 3-26**). These include the humpback chub, razorback sucker (*Xyrauchen texanus*), bluehead sucker (*Catostomus discobolus*), flannelmouth sucker (*Catostomus latipinnis*), and speckled dace (*Rhinichthys osculus*) that are present within the mainstem Colorado River and its tributaries. Humpback chub and razorback sucker are federally listed and are addressed in **Section 3.8**, Threatened and Endangered Species. In addition, the flannelmouth sucker and bluehead sucker are included in the Arizona statewide conservation agreement for six native fish species (AZGFD 2006). These species are considered warmwater fishes, and temperature requirements of these and other species in the analysis area are shown in **Figure 3-34**. This figure illustrates the large overlap in temperature requirements of native and nonnative fish species found in the Colorado River and its tributaries, which may explain why nonnative and native fish species co-exist in a similar environment.

**Figure 3-34**
**Temperature Ranges for Spawning, Egg Incubation, and Growth by Native and Nonnative Fish of the Colorado River System below Glen Canyon Dam**




Source: Valdez and Speas 2007

The Zuni bluehead sucker (*Catostomus discobolus yarrowi*), Little Colorado sucker (*Catostomus* sp.), and Little Colorado spinedace (*Lepidomeda vittata*) are endemic to the upper reaches of the Little Colorado River. The bonytail (*Gila elegans*) and Colorado pikeminnow (*Ptychocheilus lucius*) have been extirpated from the mainstem between Glen Canyon Dam and Hoover Dam. Roundtail chub (*Gila robusta*) was historically present in the Colorado River and some of its tributaries in the project area (Little Colorado River). It is now extirpated from the Colorado River but remains in small numbers in Chevelon Creek, a tributary of the Little Colorado River (Valdez and Carothers 1998; Voeltz 2002). The extirpated species and those found only in the upper reaches of the Little Colorado River are considered outside the affected area considered in this SEIS. Currently, five species of native fish are known to exist in the Colorado River between Glen Canyon Dam and Lake Mead (**Table 3-26**); these are discussed in detail in the following sections.

**Table 3-26**
**Native Fish of the Colorado River in the Project Area**

| Species | Listing Status[1] | Presence in Project Area[2] (river miles) |
|---|---|---|
| Humpback chub (*Gila cypha*) | ESA-T, CH; AZ-SGCN | 30-Mile Spring (29.8) to Pearce Ferry (280.7); Little Colorado River (61.8); translocated to Shinumo (109.2), Havasu (157.3), and Bright Angel (88.3) creeks |
| Razorback sucker (*Xyrauchen texanus*) | ESA-E, CH; AZ-SGCN | Bright Angel Creek (88.3) confluence to Pearce Ferry (280.7); few upstream of Lava Falls (179.7) |
| Bluehead sucker (*Catostomus discobolus*) | NL, CSp; AZ-SGCN | Paria River (0.8) to Pearce Ferry (280.7), including tributaries |
| Flannelmouth sucker (*Catostomus latipinnis*) | NL CSp; AZ-SGCN | Glen Canyon Dam (-15.8) to Pearce Ferry (280.7), including tributaries |
| Speckled dace (*Rhinichthys osculus*) | NL CSp | Paria River (0.8) downstream to Pearce Ferry (280.7), including tributaries |

Sources: 56 *Federal Register* 54957; AZGFD 2001a, 2001b, 2002a, 2002b, 2003; Andersen 2009; Bezzerides and Bestgen 2002; Coggins and Walters 2009; Francis et al. 2015; Makinster et al. 2010; Ptacek et al. 2005; Rees et al. 2005; Rinne and Magana 2002; Service 2002; Ward and Persons 2006; Woodbury et al. 1959; Gloss and Coggins 2005; GCMRC 2014; Albrecht et al. 2014; Valdez and Carothers 1998

[1]ESA = Endangered Species Act; E = endangered, T = threatened; CH = federally designated critical habitat in project area; AZ-SGCN = Arizona species of greatest conservation need; NL = not listed; CSp = included in the Rangewide Conservation Plan and Agreement (AZGFD 2006)

[2]Habitat and life history information is presented in species-specific discussions in this section.

## Special Status Fish Species

### *Bluehead Sucker*

The bluehead sucker is a medium-sized river sucker (Catostomidae). Adults may reach 300 to 450 millimeters in total length in large rivers but may be smaller in tributaries; they may live from 6 to 8 years to as many as 20 years (Sigler and Sigler 1987; Bezzerides and Bestgen 2002; AZGFD 2003). This species has been reported to be as large as 500 millimeters total length in the mainstem Colorado River in Grand Canyon (Valdez and Ryel 1995; AZGFD 2003). A related subspecies, the

Zuni bluehead sucker, occurs in the headwaters of the Little Colorado River along with bluehead sucker that is the same subspecies as in the mainstem Colorado River (AZGFD 2002a).

*Distribution and Abundance.* Bluehead sucker populations are declining throughout the species' historic range, and the species has been identified as an Arizona species of greatest conservation need (AZGFD 2012). The bluehead sucker is included in the Arizona statewide conservation agreement for six native fish species (AZGFD 2006). In the Colorado River Basin, this species is found in the Colorado River and its tributaries from Lake Mead upstream into Arizona, Colorado, New Mexico, Utah, and Wyoming. This species is also found in the Snake River (Idaho and Wyoming), the Bear River (Idaho and Utah), and Weber River (Utah and Wyoming) drainages (Bezzerides and Bestgen 2002; AZGFD 2003).

Within the Grand Canyon, the bluehead sucker is found in the Colorado River mainstem and its tributaries, including the Little Colorado River, Clear Creek, Bright Angel Creek, Kanab Creek, and Havasu Creek (Rinne and Magana 2002; AZGFD 2003; Ptacek et al. 2005; NPS 2013c). Prior to 2014, it was also found in Shinumo Creek but was largely displaced from that system by large debris flows (Healy et al. 2014). Annual fish monitoring conducted between 2000 and 2009 in the Colorado River between Glen Canyon Dam and the inflow to Lake Mead shows the bluehead sucker to be present in all reaches of the river (Makinster et al. 2010). This species is rare in the upper sections of GCNP because of cold dam releases, and it increases in number near the Little Colorado River inflow and downstream with warmer water temperatures (Bunch et al. 2012a; Bunch et al. 2012b).

Abundance estimates using monitoring data and age-structured mark-recapture models show the abundance of age-1 (juvenile) bluehead suckers in the Grand Canyon declined from 1990 to 1995, increased from 1995 to 2003, and then declined through 2009 (Walters et al. 2012). Similar estimates for age-4 (adult) fish show abundance began increasing from the late 1990s until 2005 or 2006, after which abundance also declined. The estimated abundance of age-1 bluehead sucker has ranged from 1,000 or less to as many as 60,000 fish between 2000 and 2009 (Walters et al. 2012). The estimated abundance of age-4+ adults during this same period ranged from about 5,000 to as many as 75,000 fish.

Although the bluehead sucker was likely extirpated from Shinumo Creek following fires and debris flows in 2014 (Healy et al. 2014), relatively high numbers of individuals remain in the Lower Colorado River between Lava Falls Rapid (river mile 179) and Lake Mead (Bunch et al. 2012a; Bunch et al. 2012b). Sampling of the larval fish community in the western Grand Canyon between Lava Falls and Pearce Ferry collected bluehead sucker larvae throughout this area (Albrecht et al. 2014), where the bluehead sucker was the most abundant species in the larval fish community, composing almost 40 percent of the total catch. More recently expanded larval fish sampling efforts up to near Bright Angel Creek (river mile 88.5) and downstream to Pearce Ferry reports approximately 26 percent of the larval fish catch being that of bluehead sucker (Rogers et al. 2023).

Long-term fish monitoring by AZGFD (Rogowski et al. 2018) shows bluehead sucker in the Colorado River from Lees Ferry to Pearce Ferry increasing in catch-per-unit-effort from 2000 to 2010, followed by a general decline with some variability, and then increasing to former high levels in 2016 and 2017. The relative abundance of bluehead sucker shows some decline with high variability to 2023 (Rogowski et al. 2023).

*Habitat.* The bluehead sucker typically inhabits large streams and may also be found in smaller streams and creeks (Sigler and Sigler 1987; AZGFD 2003). Riverine habitats range from cold (12°C [53.6°F]), clear streams to warm (28°C [82°F]), turbid rivers. Large adults live in deep water (6 to 10 feet), while juveniles use shallower, lower velocity habitats (Bezzerides and Bestgen 2002). In clear streams, the bluehead sucker stays in deep pools and eddies during the day. It moves to shallower habitats (for example, riffles or tributary mouths) to feed at night, while in turbid waters they may use shallow areas throughout the day (Beyers et al. 2001; AZGFD 2003). In the Grand Canyon, larval and young bluehead suckers inhabit backwater areas and other nearshore, low-velocity habitats such as eddies, embayments, and isolated pools (Childs et al. 1998; AZGFD 2003; Albrecht et al. 2014).

*Life History***.** The bluehead sucker is an omnivorous benthic forager with a modified lower jaw used as a scraping radula. It feeds by scraping algae, invertebrates, and other organic and inorganic material off rocks and other hard surfaces (Ptacek et al. 2005). Larvae drift to backwaters and other areas of low current, where they feed on diatoms, zooplankton, and dipteran larvae.

In the Lower Colorado River, this species spawns in spring and summer after water temperatures exceed 15.5°C (60°F). Valdez and Ryel (1995) reported large concentrations of bluehead sucker and flannelmouth sucker in tributary mouths through Grand Canyon in spring as presumed spawning runs. Spawning in Grand Canyon tributaries occurs mid-March through June in water depths ranging from a few inches to more than 3 feet and at temperatures of 15.5 to 20°C (60 to 68°F) over gravel-sand and gravel-cobble substrates (AZGFD 2003; NPS 2013e). In Kanab Creek, spawning has been reported at temperatures of 18.2–24.6°C (64.8–76.3°F) (Maddux and Kepner 1988). Smaller tributaries may provide nursery grounds for populations of large adjacent rivers (Rinne and Magana 2002), such as Bright Angel Creek, Tapeats Creek, and Shinumo Creek in the Grand Canyon.

*Factors Affecting Distribution and Abundance in the Grand Canyon.* As with the humpback chub (threatened species addressed in **Section 3.8**), decreases in distribution and abundance of the bluehead sucker throughout its range, as well as in portions of the Colorado River and its tributaries below Glen Canyon Dam, have been attributed to two main factors: (1) habitat degradation through loss, modification, and fragmentation and (2) interactions with nonnative species (Gloss and Coggins 2005; Ptacek et al. 2005). Disturbance related to fire and flooding may also influence bluehead sucker distribution in tributaries (Healy et al. 2014). The construction and operation of Glen Canyon Dam have altered downstream temperature and flow regimes. Cold tailwaters below dams are below temperatures needed for spawning and recruitment (Rinne and Magana 2002; Walters et al. 2012). Past recruitment in the Colorado River below Glen Canyon Dam was low in the 1990s and then increased after 2000; the largest recruitment estimates coincided with brood years 2003 and 2004, when there was a sudden increase in mainstem water temperatures because of warmer releases from Glen Canyon Dam (Walters et al. 2012).

The introduction of nonnative fish has increased competition with and predation on bluehead sucker (AZGFD 2003; Ptacek et al. 2005). Large nonnative predators such as channel catfish and trout, midsized fish like sunfish, and even smaller nonnative minnows may all prey on one or more life stages of the bluehead sucker (Rinne and Magana 2002; Ptacek et al. 2005; Yard et al. 2011).

*Flannelmouth Sucker*

The flannelmouth sucker is a medium to large river sucker (Catostomidae). It has a maximum total length greater than 600 millimeters and a maximum weight of about 1,400 grams (AZGFD 2001b; Rees et al. 2005). It is a long-lived species, living as long as 30 years (AZGFD 2001b). The flannelmouth sucker is included in a statewide conservation agreement (AZGFD 2006).

*Distribution and Abundance.* Historically, the flannelmouth sucker ranged throughout the Colorado River Basin, in moderate to large rivers in Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming (Bezzerides and Bestgen 2002; Rees et al. 2005). Within the Grand Canyon, this species may be found in the mainstem Colorado River and its tributaries, including the Little Colorado and Paria Rivers and Shinumo, Bright Angel, Kanab, and Havasu Creeks (Douglas and Marsh 1998; Weiss 1993; AZGFD 2001b; Bezzerides and Bestgen 2002). In contrast to bluehead sucker, flannelmouth sucker are only found below the barrier falls in Shinumo and Havasu Creeks. Annual monitoring conducted between 2000 and 2009 found the flannelmouth sucker in all reaches of the river between Lees Ferry and the inflow to Lake Mead (Makinster et al. 2010).

Abundance, across all reaches and measured as catch-per-unit-effort, has been increasing since 2000, especially since about 2004 (Makinster et al. 2010). However, abundance had been decreasing within individual reaches between river mile 0 and river mile 179 since about 2005 but increasing downstream of river mile 179. Surveys of the small-bodied and larval fish communities in the western Grand Canyon (Lava Falls to Pearce Ferry) found flannelmouth sucker throughout the reach, accounting for over 38 percent of the total larval catch in this area (Albrecht et al. 2014). With warmer releases from Glen Canyon Dam, starting in 2015, flannelmouth sucker have expanded upstream of the Paria River and are now found more commonly in the Lees Ferry reach.

Abundance estimates using monitoring data and age-structured mark-recapture models show an increase in the abundance of age-1 (juvenile) and age-4 (adult) flannelmouth suckers in the Grand Canyon between 2000 and 2008 (Walters et al. 2012). The abundance of age-1 flannelmouth sucker increased from about 2,500 in 2000 to about 10,000 in 2008, while the abundance of age 4+ adults increased from about 10,000 to about 25,000 for this same period (Walters et al. 2012). Other abundance estimates based on electrofishing catch-per-unit-effort for this same time period showed an increase in abundance from less than 1,000 in 2000 to about 12,000 in 2009, while the estimated abundance of age-4+ adults increased from about 2,500 in 2001 to about 31,000 in 2009 (Walters et al. 2012).

Long-term fish monitoring by AZGFD (Rogowski et al. 2018) shows flannelmouth sucker in the Colorado River from Lees Ferry to Pearce Ferry increased slowly in catch-per-unit-effort from 2000 to 2011, followed by a general decline to 2014 and an increase to 2017. The relative abundance of adult flannelmouth sucker remained high to 2023 (Rogowski et al. 2023).

*Habitat.* This species prefers large to moderately large rivers. Adults may prefer deep water when not feeding (Rinne and Minckley 1991), while larvae and young are often associated with shallow, slow-moving nearshore areas such as backwaters and shoreline areas of slow runs or pools (AZGFD 2001b; Rees et al. 2005). Although it is a riverine species, in the Upper Colorado River Basin the flannelmouth sucker has been collected from Flaming Gorge and Fontenelle Reservoirs. In the Colorado River in the Grand Canyon, subadults are found in eddies and runs over sand bottoms. In the Little Colorado River, adult and juvenile flannelmouth suckers use low-velocity, nearshore habitats with large amounts of cover during the daylight, and their use of faster, more exposed midchannel habitats increases at night (Gorman 1994). Juveniles and adults may be considered habitat generalists and can be found using pool, run, and eddy habitats. Surveys of larval flannelmouth sucker in the western Grand Canyon (Lava Falls to Pearce Ferry) found the highest abundance of larvae in embayments, isolated pools, backwaters, and other low-velocity habitats (Albrecht et al. 2014).

*Life History.* The flannelmouth sucker is an omnivorous benthic feeder, foraging on invertebrates, algae, plant seeds, and organic and inorganic debris (Bezzerides and Bestgen 2002; Rees et al. 2005; Seegert et al. 2014). Larvae feed primarily on aquatic invertebrates, crustaceans, and organic debris (Childs et al. 1998). As they become juveniles and adults, their diet shifts and becomes primarily composed of benthic matter, including organic debris, algae, and aquatic invertebrates (Rees et al. 2005; Seegert et al. 2014).

This species has been reported to prefer water temperatures ranging from 10 to 27°C (50 to 80.6°F) and is most common at about 26°C (78.8°F) (Sublette et al. 1990). Water temperatures reported during spawning activity range from 6 to 18.5°C (42.8 to 65.3°F) but are usually above 14°C (57.2°F) (Bezzerides and Bestgen 2002). In the Lower Colorado River Basin, flannelmouth sucker spawning typically occurs in March and April (Bezzerides and Bestgen 2002). Water temperature has been suggested as a primary cue for spawning in other parts of this species range, but it does not appear to provide a spawning cue in the Grand Canyon, where relatively synchronized spawning has been reported among sucker stocks from creeks with different temperature and flow regimes (Weiss 1993; Weiss et al. 1998). In the Paria River, the timing of spawning has been correlated with the receding limb of the hydrograph (Weiss 1993).

In the Grand Canyon, flannelmouth suckers apparently spawn at only a limited number of tributaries, and fish may move considerable distances to reach spawning sites (Douglas and Marsh 1998; Weiss et al. 1998; Douglas and Douglas 2000). Tributary spawning in the Grand Canyon may be timed to take advantage of warm, ponded conditions at tributary mouths that occur during high flows in the mainstem Colorado River (Bezzerides and Bestgen 2002). Valdez and Ryel (1995) reported large concentrations of bluehead sucker and flannelmouth sucker in tributary mouths through Grand Canyon in spring as presumed spawning runs.

The body condition[25] of flannelmouth sucker is variable throughout the Grand Canyon, but it is greatest at intermediate distances from Glen Canyon Dam, possibly because of the increased

[25] Body condition refers to the physiological and nutritious state of fish and encompasses numerous metrics such as weight at given body length, fat reserves, and stress levels. In the aquaculture and fishery industries, it is used to monitor the health and welfare of fish populations.

number of warmwater tributaries in this reach (Paukert and Rogers 2004). Mean condition peaks during the pre-spawn and spawning periods and is lowest in summer and fall (McKinney et al. 1999b; Paukert and Rogers 2004). Sucker condition in September was positively correlated with Glen Canyon discharge during summer (June–August), possibly due to an increased euphotic zone and greater macroinvertebrate abundance observed during higher water flows (Paukert and Rogers 2004).

*Factors Affecting Distribution and Abundance in the Grand Canyon.* Flannelmouth sucker populations have declined throughout the species' historic range; in the Lower Colorado River, this decline has been attributed primarily to flow manipulation and water development projects (Rees et al. 2005). Cold-water releases from Glen Canyon Dam have altered the thermal regime of the main channel of the Colorado River, which for larvae may result in slow growth, delayed transition to the juvenile stage, and possibly higher mortality (Rees et al. 2005). However, since 2005, flannelmouth sucker numbers have been increasing and now represent one of the most abundant species in the Grand Canyon (Fonken et al. 2023).

In the cold tailwaters below Glen Canyon Dam, water temperatures (8 to 12°C [46.4 to 53.6°F]) were at the lower end of, or below, those needed for spawning and recruitment of flannelmouth suckers. Even though water temperatures tend to warm downstream, the cold summer water temperatures have been suggested as a major factor limiting survival of YOY, recruitment, and condition of this species in the main channel (Thieme et al. 2001; Walters et al. 2012). Past recruitment in the Colorado River below Glen Canyon Dam was low in the 1990s and then increased after 2000; the largest recruitment estimates were for 2003 and 2004, when there was a sudden increase in mainstem water temperatures because of warmer releases from Glen Canyon Dam (Walters et al. 2012). Paukert and Rogers (2004) reported post-spawn condition of flannelmouth sucker below Glen Canyon Dam to be variable but were typically greatest in the vicinity of warmwater tributaries such as the Paria River, the Little Colorado River, and Bright Angel Creek.

Walters et al. (2012) hypothesized that food availability and bioenergetics had a large influence on flannelmouth sucker and bluehead sucker. The food base of downstream areas where these species occur is driven by turbidity, temperatures, and proximity to tributaries. Thus, the food base affected by these variables influences the survival and recruitment of these species.

The flannelmouth sucker in the Grand Canyon may also be experiencing competition with and predation by nonnative species that are in the system (Rees et al. 2005). Potential competitors include species such as the channel catfish (*Ictalurus punctatus*) and the common carp (*Cyprinus carpio*). Potential predators include rainbow and brown trout (*Oncorhynchus mykiss* and *Salmo trutta*, respectively), channel catfish, and red shiner (*Cyprinella lutrensis*). Rainbow and brown trout diet sampling found enough juvenile flannelmouth suckers in trout stomachs to account for as much as 50 percent of the estimated annual mortality rates of juveniles (Yard et al. 2011; Walters et al. 2012). The ability of flannelmouth sucker to escape trout predation is also inhibited by colder water temperatures (Ward and Bonar 2003).

*Speckled Dace*

The speckled dace is native to the western United States and is one of eight species in the genus *Rhinichthys*. It is a small fish, typically less than 76 millimeters in length, and has a relatively short lifespan of about 3 years (Sigler and Sigler 1987).

*Distribution and Abundance.* This species is native to all major western drainages from the Columbia and Colorado Rivers south to Mexico (AZGFD 2002b). Within the Grand Canyon, this species occurs within the mainstem Colorado River and its tributaries, including the Little Colorado River (Robinson et al. 1995; Ward and Persons 2006; Makinster et al. 2010). Long-term fish monitoring of the Colorado River below Glen Canyon Dam since 2000 shows the speckled dace to be the third most common fish species (and most common native species) in the river between Glen Canyon Dam and the Lake Mead inflow. It was captured most commonly in the western Grand Canyon and the inflow to Lake Mead (Makinster et al. 2010).

Long-term fish monitoring by AZGFD (Rogowski et al. 2018) shows speckled dace in the Colorado River from Lees Ferry to Pearce Ferry increased slowly in catch-per-unit-effort from 2000 to 2011, followed by a decline to 2013 and an increase to 2017. Relative abundance of speckled dace shows a decline to 2023. The greatest decline was in the western Grand Canyon, coincident with dramatic increases in humpback chub abundance, suggesting competition or possibly predation by humpback chub (Rogowski et al. 2023).

*Habitat.* The speckled dace may be found in a variety of habitats, ranging from cold, fast-flowing mountain streams to warm, intermittent desert streams and springs. Where found, it occurs in rocky runs, riffles, and pools of headwater streams, creeks, and small to medium rivers, typically in waters with depths less than 1.6 feet (AZGFD 2002b); it rarely occurs in lakes (Page and Burr 1991). Valdez and Ryel (1995) reported the largest numbers of specked dace in gravel/cobble fans at arroyos and side canyons of the Colorado River through Marble and Grand Canyons.

*Life History.* The speckled dace is an omnivorous bottom feeder, feeding primarily on insect larvae and other invertebrates, as well as algae and fish eggs (Seegert et al. 2014). Its young are mid-water plankton feeders (Sigler and Sigler 1987). The speckled dace spawns twice, once in spring and again in late summer (AZGFD 2002b). Spawning occurs over gravel in areas prepared by the male.

*Factors Affecting Distribution and Abundance in the Grand Canyon.* The speckled dace is a widespread and abundant species in western North America (AZGFD 2002b). Speckled dace abundance and distribution could be affected by many of the same factors that affect the abundance and distribution of the other native fish in the ecosystem, namely altered temperature, water flow, sediment regimes, and predation by nonnative fish (AZGFD 2002b; Gloss and Coggins 2005).

### Nonnative Fish

As many as 25 species of nonnative fish have been reported with some regularity from Lakes Powell and Mead and the Colorado River and its tributaries between these reservoirs (Valdez and Speas 2007; Coggins et al. 2011; Reclamation 2011c; **Table 3-27**). Most of these introduced species are native to other basins in North America but not to the Colorado River system, and a few are species from outside North America. These fish occur in the Grand Canyon as a result of intentional and

**Table 3-27**
**Nonnative Fish Found in the Colorado River through Glen and Grand Canyons**

| Species | Native Origin | Presence in Project Area |
|---|---|---|
| **Cold-Water Species** | | |
| Rainbow trout (*Oncorhynchus mykiss*) | North America | Colorado River from Glen Canyon Dam to Havasu Creek; abundant from Glen Canyon Dam to Lees Ferry; abundance decreases through Marble Canyon to the confluence of the Little Colorado River, although substantial numbers may still be present in some locations in some years; locally abundant at the Little Colorado River confluence and cold-water tributary inflows (Bright Angel, Deer, and Tapeats Creeks) |
| Brown trout (*Salmo trutta*) | Europe | Colorado River from Glen Canyon Dam to Kanab Creek; locally abundant near the confluence with Bright Angel Creek, the Little Colorado River, and other cold-water tributary inflows |
| **Coolwater Species** | | |
| Walleye (*Sander vitreum*) | North America | Lake Powell; Colorado River from Lava Falls to Lake Mead; generally rare throughout Glen Canyon (but consistently observed during electrofishing surveys), Marble Canyon, and the Grand Canyon |
| Yellow perch (*Perca flavescens*) | North America | Lake Powell; Lake Mead; Upper Little Colorado River watershed |
| Northern pike (*Esox lucius*) | North America | Lake Powell; Lake Mead; Upper Little Colorado River |
| **Warmwater Species** | | |
| Black bullhead (*Ictalurus melas*) | North America | Lake Powell; Lake Mead; Colorado River at the Little Colorado River; Colorado River downstream of Diamond Creek; generally absent from Glen Canyon, rare in Marble Canyon, and locally common in some areas of the Grand Canyon |
| Yellow bullhead (*Ameiurus natalis*) | North America | Colorado River downstream of the Little Colorado River to Lake Mead; Little Colorado River abundance presumed similar to that of black bullhead |
| Channel catfish (*Ictalurus punctatus*) | North America | Lake Powell; Lake Mead; Little Colorado River, Colorado River from Marble Canyon to Lake Mead; generally absent from Glen Canyon, rare in Marble Canyon, and numerous in the Grand Canyon |
| Green sunfish (*Lepomis cyanellus*) | North America | Lake Powell; Lake Mead; Little Colorado River, Kanab Creek; discovered in abundance in a slough located 3 miles downstream of Glen Canyon Dam in 2015 (eradication efforts conducted); found in Glen, Marble, and Grand Canyons |
| Bluegill (*Lepomis macrochirus*) | North America | Lake Powell; Lake Mead; rare in the Grand Canyon; less abundant than green sunfish |

| Species | Native Origin | Presence in Project Area |
|---|---|---|
| Largemouth bass (*Micropterus salmoides*) | North America | Lake Powell; Kanab Creek; Lake Mead to Maxson Canyon; generally absent from Glen Canyon and Marble Canyon; rare in the Grand Canyon |
| Smallmouth bass (*Micropterus dolomieui*) | North America | Lake Powell; Colorado River at the Little Colorado River, below Glen Canyon Dam; found in small numbers from Glen Canyon through the Grand Canyon |
| Rock bass (*Ambloplites rupestris*) | North America | Lake Powell; Lake Mead; Upper Little Colorado River watershed |
| Black crappie (*Pomoxis nigromaculatus*) | North America | Lake Powell; Lake Mead; generally absent from Glen Canyon, Marble Canyon, and Grand Canyon |
| Fathead minnow (*Pimephales promelas*) | North America | Colorado River from the Paria River confluence to Lake Mead; generally absent from Glen Canyon and Marble Canyon; locally common in some areas of the Grand Canyon |
| Golden shiner (*Notemigonus crysoleucus*) | North America | Colorado River from Glen Canyon to Separation Canyon; Kanab Creek; generally rare throughout Glen Canyon, Marble Canyon, and the Grand Canyon |
| Redside shiner (*Richardsonius balteatus*) | North America | Lake Powell; Colorado River at the Little Colorado River; generally rare throughout Glen Canyon, Marble Canyon, and Grand Canyon |
| Red shiner (*Cyprinella lutrensis*) | North America | Colorado River at the Little Colorado River; Colorado River from Bridge Canyon to Lake Mead |
| Common carp (*Cyprinus carpio*) | Eurasia | Lake Powell; Lake Mead; Colorado River from Glen Canyon Dam to Lake Mead; found in the Little Colorado River |
| Goldfish (*Carassius auratus*) | Eurasia | Lake Powell; Lake Mead; Upper Little Colorado River watershed |
| Plains killifish (*Fundulus zebrinus*) | North America | Little Colorado River; Colorado River from Little Colorado River confluence to Lake Mead; generally absent from Glen Canyon and Marble Canyon; locally common in some areas of the Grand Canyon |
| Mosquitofish (*Gambusia affinis*) | North America | Lake Powell; Colorado River from Separation Canyon to Lake Mead; generally absent from Glen Canyon and Marble Canyon; locally common in some areas of the Grand Canyon |
| Striped bass (*Morone saxatilis*) | North America | Lake Powell; Colorado River from Havasu Creek to Lake Mead |
| Gizzard shad (*Dorosoma cepedianum*) | North America | Lake Powell; generally absent from Glen Canyon, Marble Canyon, and the Grand Canyon |
| Threadfin shad (*Dorosoma petenense*) | North America | Lake Powell; Lake Mead; Colorado River from Glen Canyon to Separation Canyon; Upper Little Colorado River watershed; generally rare in Glen Canyon, Marble Canyon, and the Grand Canyon |

Sources: Holden and Stalnaker (1975); Valdez and Ryel (1995); Gloss and Coggins (2005); Valdez and Speas (2007); Coggins et al. (2011); Reclamation (2011e); NPS (2018) unintentional introductions, especially into Lakes Powell and Mead. A number of species were stocked as game fish and others as forage fish for the stocked game fish (Valdez and Ryel 1995).

Nonnative fish species have generally increased in abundance and distribution in the last decade as a consequence of warmer dam releases. These include brown trout in the Lees Ferry reach, walleye (*Sander vitreus*) in Lees Ferry and Grand Canyon reaches, green sunfish (*Lepomis cyanellus*), bluegill (*Lepomis macrochirus*), smallmouth bass, largemouth bass (*Micropterus salmoides*), striped bass (*Morone saxatilis*), gizzard shad (*Dorosoma cepedianum*), and common carp in the Lees Ferry reach.

Among nonnative species, three are largely restricted to Lake Powell and/or Lake Mead and are found in the Colorado River and its tributaries below Glen Canyon Dam with increasing frequency due to lower lake elevations and warmer releases; these species are black crappie (*Pomoxis nigromaculatus*), bluegill, and gizzard shad (**Table 3-27**). Another four species—northern pike (*Esox lucius*), threadfin shad (*Dorosoma petenense*), rock bass (*Ambloplites rupestris*), and yellow perch (*Perca flavescens*)—are largely restricted to the upper Little Colorado River watershed (Ward and Persons 2006; Valdez and Speas 2007). The remaining 18 species have been reported from the mainstem Colorado River and/or its tributaries between Glen Canyon Dam and the inflow to Lake Mead. New introductions of nonnative fish species continue to be documented throughout the Colorado River Basin, and new introductions are likely to occur (Martinez et al. 2014).

Common nonnative fish species in Lake Powell include striped bass, smallmouth bass, largemouth bass, walleye, bluegill, green sunfish, common carp, and channel catfish. Species that occur in the reservoir and are also associated with tributaries and inflow areas downstream of Glen Canyon Dam, include fathead minnow, mosquitofish, red shiner, and plains killifish (NPS 1996; Reclamation 2007). Largemouth bass and black crappie populations were stocked initially and, following successful establishment, were the principal target species in the sport fisheries for many years. Both species have declined in years due to a lack of habitat structure for young fish. Filling and fluctuation of the reservoir resulted in changing habitat that eliminated most of the vegetation favored by many species (Reclamation 2007a). Smallmouth bass and striped bass were introduced following these changes in habitat structure and are now the dominant predators in the reservoir (Reclamation 2007a). Threadfin shad were introduced to provide an additional forage base and quickly became the predominant prey species (NPS 1996). Gizzard shad were accidentally introduced into Morgan Reservoir in the San Juan River drainage in 1996 and subsequently proliferated in Lake Powell (Mueller and Brooks 2004; Vatland and Budy 2007).

Reductions in Lake Powell's levels have lowered the epilimnetic (the upper, warmer layer of the lake) and mesolimnetic (the middle layer of the lake, located below the epilimnion and above the hypolimnion) layers in proximity to the dam penstocks where fish can become entrained. Some of these fish survive passage through the generators and end up downstream of Glen Canyon Dam. Two species that are believed to have become entrained in the penstocks and passed downstream into the Colorado River are substantial predators of native fish, including the humpback chub. These nonnative fish species include the smallmouth bass and the green sunfish. Smallmouth bass and green sunfish live in the warmer levels of the lake's waters, closer to the surface. As warmer water reaches the dam's water intakes, the nonnative, predatory fish have a greater chance of passing through the dam alive. This increases the threats to the native fish in the Grand Canyon and Glen Canyon's downstream rainbow trout fishery.

Juvenile smallmouth bass were first found in the Colorado River in a slough habitat about 3 miles below Glen Canyon Dam on June 30, 2022, and during July and August in 2023, underscoring the urgency of this emergent issue. In September 2022 and August 2023, the NPS deployed the fish piscicide rotenone (a compound approved by the US Environmental Protection Agency [EPA]) to kill these invasive, predatory fish.

The Comprehensive Fisheries Management Plan (NPS 2013a) and Expanded Non-Native Aquatic Species Management Plan (NPS 2019) for GCNRA and GCNP describe management actions and tools that can be taken in the Colorado River below Glen Canyon Dam to improve the recreational rainbow trout fishery in GCNRA while protecting native fish in the Grand Canyon. These plans were developed in close cooperation with AZGFD and other partners. They identify smallmouth bass, walleye, flathead catfish (*Pylodictis olivaris*), and brown trout as "very high threat level" and rainbow trout and green sunfish as "high threat level." Threat levels were assigned based on the species' current abundance and distribution and following reviews of published literature on their potential for adverse impact. These threats are assessed annually, and actions to address each of these threats are being developed.

Healy et al. (2022) described how management actions such as a fall HFE release can have unintended consequences, including triggering migration to, colonization of, and rapid population growth by brown in the Colorado River below Glen Canyon Dam. Brown trout are established in Bright Angel Creek and have expanded their distribution upstream to the tailwaters of Glen Canyon Dam likely aided by fall HFE releases and flow management (Healy et al. 2022). Increased flows during fall HFE releases likely initiated migration of adult brown trout to upstream spawning areas, thus resulting in expansion of the population (Runge et al. 2018).

In addition, the annual distribution of nonnative fish in the lower portions of the Grand Canyon is influenced by the elevation of Lake Mead at the interface of the Colorado River inflow. A lower lake elevation starting in early 2000 allowed the Colorado River to carve a new channel and form a large rapid about a mile downstream of Pearce Ferry. This rapid has sufficient drop and velocity to be at least a partial barrier to most fish species (Hansen 2021) and has reduced the access by nonnative fish species moving upstream in the Lower Colorado River from Lake Mead. This rapid could reduce the number of predaceous species in the lower Grand Canyon, like smallmouth bass, striped bass, walleye, and channel catfish that might otherwise move into the Colorado River.

**Smallmouth Bass**

The smallmouth bass is an invasive and large-bodied piscivorous fish that poses a substantial threat to native fish populations throughout the Upper Colorado River Basin (Breton et al. 2015). Based on results of a bioenergetics model, Johnson et al. (2008) ranked smallmouth bass as the most problematic invasive species in the Upper Basin because of their high abundance, habitat use that overlaps with most native fish, and ability to consume a wide variety of life stages of native fish (Bestgen et al. 2008). Expanded populations of piscivores, such as smallmouth bass, are a major impediment to conservation actions aimed at recovery efforts for the four endangered fish in the Upper Colorado River Basin (Service 2002a, 2002b, 2002c, 2018, 2022, 2023).

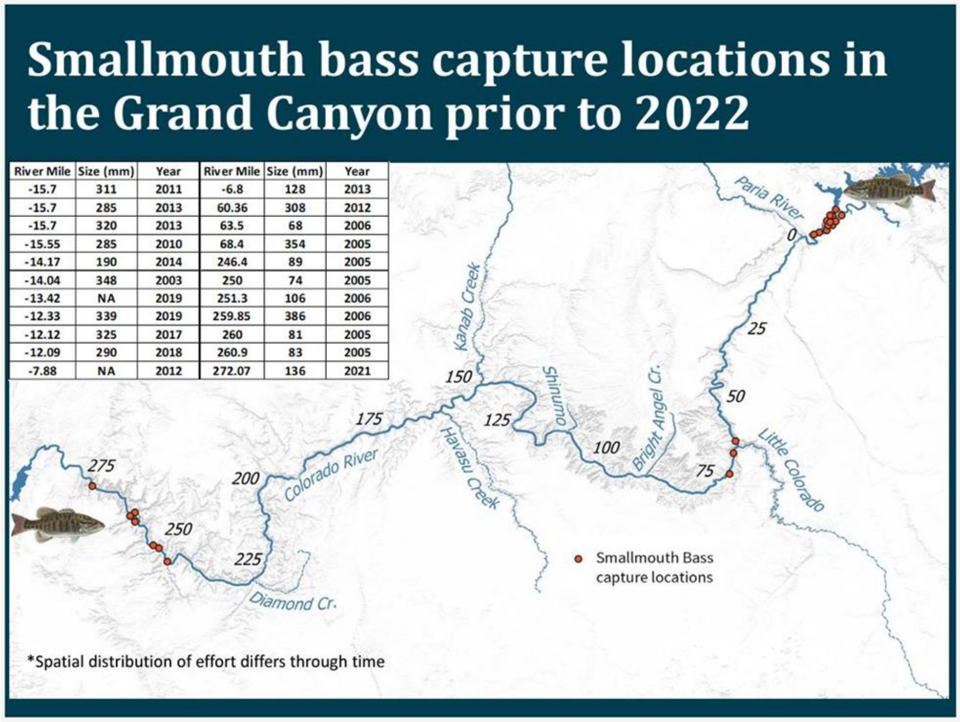
Smallmouth bass were stocked in reservoirs of the Upper Basin starting in 1967 and through the 1970s as sportfish and predators of Utah chub (*Gila atraria*). Smallmouth bass started expanding in the Yampa River of the Upper Basin in 2002 following record low flows (1.8 cfs at Maybell in August 2002). A concerted effort was made in the Upper Basin to control smallmouth bass starting in 2003, largely through mechanical removal, but after 20 years, this species has been temporarily reduced in abundance in some areas but not eliminated (Breton et al. 2015). Additional efforts continue to use prescribed flows to control the species (Bestgen 2018), but these studies are incomplete at this time. Smallmouth bass also pose a threat to other desirable species in the Grand Canyon, including rainbow trout that are considered sportfish.

*Distribution and Abundance.* The smallmouth bass is native to interior eastern North America west of the Appalachian Mountains, but it has been widely introduced throughout the United States. The smallmouth bass was stocked into Lake Powell in 1982 and has been observed in the Colorado River downstream of Glen Canyon Dam since early 2000, although the source of these fish is not certain. Prior to 2022, there are records of 22 individuals being caught between Glen Canyon Dam and Pearce Ferry (**Figure 3-35**). Capture locations show three concentrations of fish, including the Lees Ferry reach below the dam, near the confluence of the Little Colorado River, and in the newly exposed channel at the inflow to Lake Mead.

Smallmouth bass populations below Glen Canyon Dam have increased significantly over the past two years, and their distribution has expanded. Prior to 2022, there were records of 22 individuals being caught between Glen Canyon Dam and Pearce Ferry. These were mostly large adult or subadult fish that were more highly concentrated above Lees Ferry (12 captures) and at the inflow into Lake Mead (7 captures), only a few were found near the confluence of the Little Colorado River (3 captures). These fish likely originated from passage through the dam at low elevations or past Pearce Ferry rapid above Lake Mead, but release temperatures from the dam were likely too cold for reproduction. However, starting in 2022, many of the bass are smaller, indicating that these fish have been produced locally, probably in and around the -12 mile slough in Marble Canyon. In 2022, 361 smallmouth bass were captured and that number increased threefold to 1,073 smallmouth bass captured in 2023. These smallmouth bass were distributed more uniformly and consistently throughout the Colorado River below Glen Canyon Dam, but smallmouth bass are still most heavily concentrated in Marble Canyon above Lees Ferry, as shown in **Figure 3-35**.

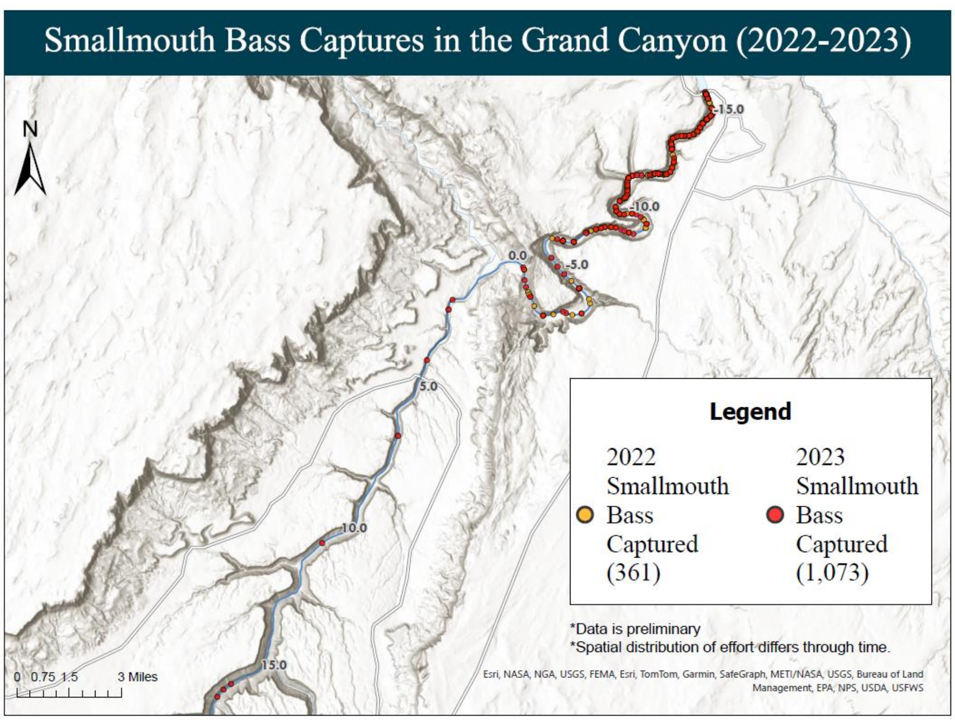
The likely origin of these fish is (1) passage through Glen Canyon Dam, (2) moving down the Little Colorado River from upstream reservoirs, and (3) moving upstream from Lake Mead. Some bass have also possibly moved or been transported downstream from the Lees Ferry reach. Greater numbers of smallmouth bass have been captured in the Lees Ferry reach in 2022 and 2023 that have either passed from Lake Powell through the penstocks or have been recently spawned in the area. Most of the smallmouth bass in the Lees Ferry reach have been caught in and near the -12 mile slough (located 3 miles downstream of Glen Canyon Dam), a small side channel of the Colorado River. Prior to 2022, the bass were mostly large subadults and adults, suggesting that these fish survived passing through the penstocks. Starting in 2022, many of the bass are smaller, indicating that these fish have been produced locally, probably in and around the -12 mile slough, and that the species spawned successfully in the Lees Ferry reach.

## Figure 3-35
## Smallmouth Bass Capture Locations in the Grand Canyon prior to 2022 and 2022–2023




| River Mile | Size (mm) | Year | River Mile | Size (mm) | Year |
|---|---|---|---|---|---|
| -15.7 | 311 | 2011 | -6.8 | 128 | 2013 |
| -15.7 | 285 | 2013 | 60.36 | 308 | 2012 |
| -15.7 | 320 | 2013 | 63.5 | 68 | 2006 |
| -15.55 | 285 | 2010 | 68.4 | 354 | 2005 |
| -14.17 | 190 | 2014 | 246.4 | 89 | 2005 |
| -14.04 | 348 | 2003 | 250 | 74 | 2005 |
| -13.42 | NA | 2019 | 251.3 | 106 | 2006 |
| -12.33 | 339 | 2019 | 259.85 | 386 | 2006 |
| -12.12 | 325 | 2017 | 260 | 81 | 2005 |
| -12.09 | 290 | 2018 | 260.9 | 83 | 2005 |
| -7.88 | NA | 2012 | 272.07 | 136 | 2021 |

Source: GCMRC 2014




Source: Reclamation GIS 2024

A preliminary integrated smallmouth bass model has been developed that predicts propagule pressure (entrainment or passage of smallmouth bass through Glen Canyon Dam) and downriver population growth (lambda) based on Lake Powell elevation and temperature, lake inflow volumes, and outflows (Yackulic et al. 2024, chap. 4). These predictions, which are for river mile 15 and river mile 61 at the Little Colorado River confluence, can be used to inform possible impacts of alternatives on smallmouth bass. Lambda values greater than 1 indicate population growth, whereas lambda values less than 1 indicate population decline. The smallmouth bass model does not link to other population models at this time, such as the humpback chub integrated model.

Lambda is a measure of population growth rate. It is calculated as the difference between the birth rate and the death rate, divided by the number of individuals in the population. Lambda is also known as the finite rate of growth of a population. It is used to help predict population growth and is a measure of how successful a population is at reproduction. Propagule pressure is the number of smallmouth bass passing through the penstocks at Glen Canyon Dam (entrainment) and surviving into the river downstream of the dam. The smallmouth bass model estimates the number of propagules (fish) that would become entrained and survive passing through the dam.

*Habitat and Life History.* Within its native range, the smallmouth bass is most abundant in streams that consist of a substantial proportion of pool and riffle habitat with clean, rocky, hard bottoms and gradients of 0.5 to about 5.0 meters per kilometer. In large rivers and lakes, smallmouth bass tend to congregate over hard, stony bottoms, where currents are present. Currently, smallmouth bass occur in the mainstem Colorado River, in the Verde River, and throughout the Salt River below about 2,200 meters in elevation (AZGFD 2005).

Temperature is one of the most important factors limiting the distribution of smallmouth bass (Bestgen 2018). Faster growth rates of adults are generally associated with higher summer temperatures. Faster growth rates occur in southern reservoirs, resulting in a shorter life span than in northern regions. In summer, smallmouth bass inhabit warmer shoreline areas of large lakes in the north and deeper, cooler waters in the south. Growth does not begin until water temperatures reach 10–14°C (50–57.2°F). Field data indicate that adults prefer temperatures of about 21–27°C (69.8–80.6°F) in summer. Smallmouth bass have been reported sunning themselves in pools with water temperatures of about 26.7°C (80°F) in summer (Edwards et al. 1983). When temperatures drop to 15–20°C (59–68°F), adults seek deep, dark areas. At about 10°C (50°F), bass become inactive and seek shelter. At 6–7°C (42.8–44.6°F), most smallmouth bass are beneath rock structures, with few remaining near the surface. The lower lethal temperature is near freezing. Bass will congregate around warm springs in winter when available.

Smallmouth bass spawn in spring, usually mid-April to July, depending on geographical location and starting at about 16°C (60.8°F). Smallmouth bass are nest builders where the male fans sediment from gravels to create a nest about 2 feet in diameter. The female deposits her eggs in the nest, which then incubates 5–10 days, with the eggs and subsequent fry guarded by the male. Whereas native fish such as humpback chub, flannelmouth sucker, bluehead sucker, and speckled dace are broadcast spawners where females scatter their eggs over a large area of gravel and cobbles many feet in diameter. The sticky eggs adhere to the cobble and hatch in 4–5 days without parental care, and the larvae then emerge and drift downstream to a suitable low-velocity habitat.

Large fluctuations in water level can affect the reproductive success of smallmouth bass (Pflieger 1975; Montgomery et al. 1980). Ideal spawning conditions include one or more substantial rises in water level a week or two prior to bass nesting (Pflieger 1975) and relatively stable water levels while nesting is in progress (Watson 1955; Pflieger 1975). Rising water may flush nest areas with cold water, causing nest desertion and halting embryo development (Watt 1959; Montgomery et al. 1980). Falling water levels may drive guarding males off, limit water circulation around eggs, and increase predation, resulting in lower reproductive success (Neves 1975; Montgomery et al. 1980).

Newly hatched fry are especially vulnerable to flood conditions and fluctuating water levels (Larimore 1975). A rapid drop in water level may trap them in areas that may become desiccated (Montgomery et al. 1980). A stream rise of only a few inches, and consequent increase in water velocity, may displace advanced fry newly risen from the nest (Webster 1954). Most fry remain in shallow water while being guarded by the male parent (Doan 1940; Forney 1972), although some may be found at depths of 4.6–6.1 meters (approximately 15–20 feet) (Stone et al. 1954; Forney 1972). Fry 20–25 millimeters (0.79–1 inch) in length cannot maintain themselves in current velocities faster than 200 millimeters per second (Larimore and Duever 1968). An increase in turbulence during floods creates conditions with which smallmouth fry appear unable to cope (Webster 1954). Fry also cannot tolerate and are displaced at high turbidities (2,000 Jackson Turbidity Units) combined with an increase in water velocity, but they will not be displaced at moderate turbidities (250 Jackson Turbidity Units) (Larimore 1975). Low water temperatures during flood conditions will reduce fry swimming ability (Larimore and Duever 1968).

Bestgen and Hill (2016b) studied patterns of smallmouth bass reproduction in partially regulated and unregulated reaches of the Green River and the unregulated Yampa River of the Upper Colorado River Basin. Patterns of reproduction in the Yampa River were in contrast with regulated or partially regulated Green River reaches, where smallmouth bass reproduction occurred later, and sometimes well after water temperatures reached the threshold 15.5°C (60°F). In the regulated reach of the Green River, successful hatching did not occur until relatively low and stable baseflow levels were reached, noting that high streamflow in 2011 delayed hatching. They hypothesized that stable baseflows were required for smallmouth bass, so spawning habitat was available and suitable for successful reproduction; spawning at higher flows may have been attempted but could not be determined.

Mature females may contain 2,000–15,000 golden yellow eggs. Males may spawn with several females on a single nest. On average, each nest contains about 2,500 eggs, but nests may contain as many as 10,000 eggs (Pflieger 1975). Eggs hatch in about 10 days at water temperatures of 12.8°C (55°F), but they can hatch in 2 to 3 days if temperatures are approximately 23.9°C (75°F). Males guard the nest from the time eggs are laid until fry begin to disperse, a period of up to a month (Pflieger 1975).

Smallmouth bass primarily prey on fish and crayfish. Based on predation rates and bioenergetics modeling, smallmouth bass are considered the greatest threat to native fish populations out of all invasive fishes present in the upper Colorado River Basin (Johnson et al. 2008). Smallmouth bass have the potential to dramatically reduce native fish populations in both the mainstem and in critical tributaries such as the Little Colorado River, just as they have done in other Arizona rivers (Rinne 1999; Marks et al. 2010; Bestgen and Tuttle 2022).

The degree to which turbidity effects the establishment of smallmouth bass is uncertain. It is highly unlikely that turbidity would influence the establishment of warmwater fish in the Colorado River tributaries and the reach of the Colorado River above the Little Colorado River, which is less turbid than downstream reaches.

**Cold-Water Nonnative Species**

Brown and rainbow trout make up the cold-water nonnative fish community of the Colorado River between Glen Canyon Dam and the inflow to Lake Mead. The rainbow trout is common in the Glen Canyon reach and in the mainstem Colorado River between the confluence with the Paria River and the confluence with the Little Colorado River (Makinster et al. 2010; Reclamation 2011c). Rainbow trout are also found in Bright Angel Creek, Shinumo Creek, Nankoweap Creek, Tapeats Creek, Kanab Creek, and Havasu Creek (Reclamation 2011c). Brown trout are found primarily in and near Bright Angel Creek, which supports a small spawning population (Reclamation 2011c), but they are also found throughout the upper reaches of the river corridor, including in Glen Canyon. The number of brown trout captured in Glen Canyon (Lees Ferry) increased starting in 2014–2015 with warmer releases from Glen Canyon Dam. Since 2017, brown trout have been captured relatively infrequently in the Grand Canyon with only 19 individuals captured between river miles 17.9 and 277.5 during sampling in 2022 (Fonken et al. 2023).

*Rainbow Trout*

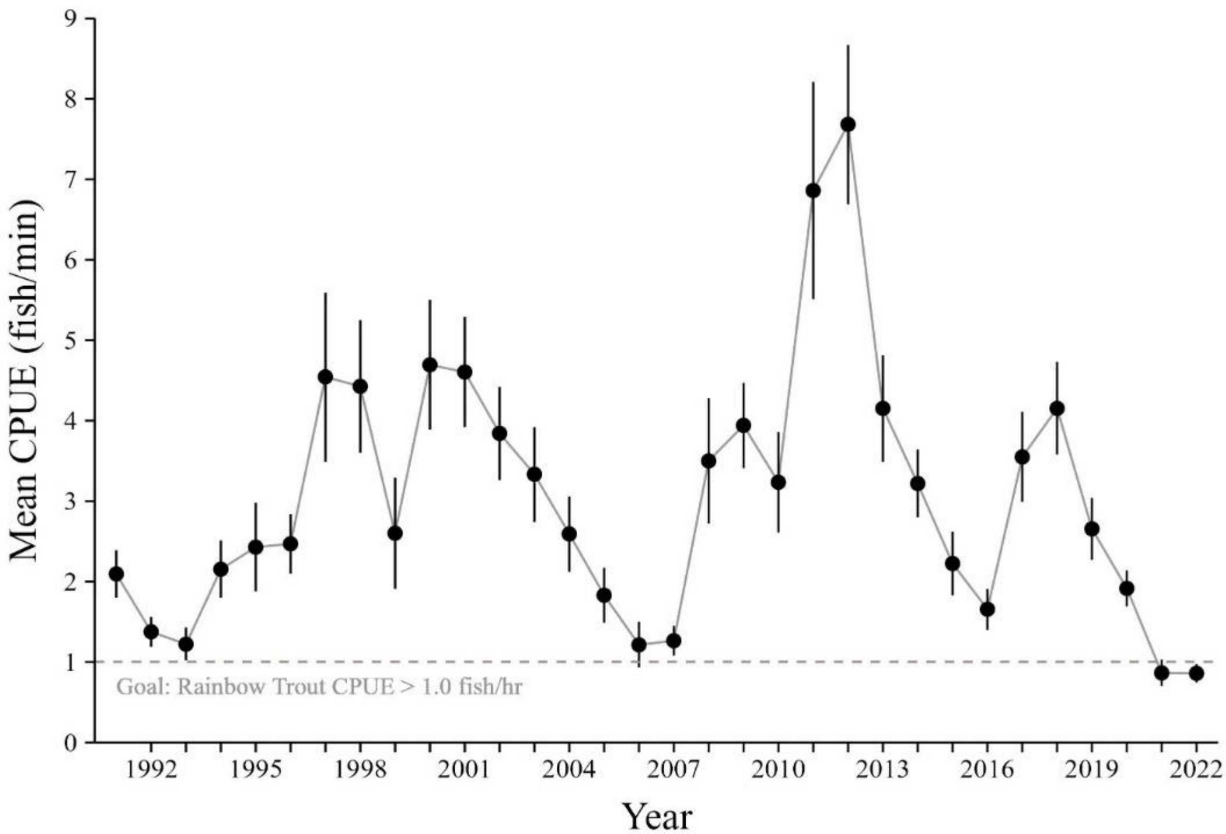
The rainbow trout is very common in the reach of the mainstem Colorado from Glen Canyon Dam to the Paria River, and this population serves as the principal basis for the trout fishery. This species is also found in relatively high abundance in Marble Canyon between the Paria River and the confluence of the Colorado River with the Little Colorado River (Makinster et al. 2010; Reclamation 2011c). Downstream of the Little Colorado River confluence, turbidity limits the numbers of rainbow trout, and smaller numbers are found in localized aggregations associated with some tributaries, such as Nankoweap Creek and Tapeats Creek.

Rainbow trout were initially introduced in the Grand Canyon region through the stocking of tributaries, such as Bright Angel Creek, during the 1920s. Additional introductions of rainbow trout were made downstream of Glen Canyon Dam in 1964 following the completion of dam construction. Prior to 1991, the population was maintained through annual stocking, and stocking continued through 1998 (Makinster et al. 2011). Since that time, the Glen Canyon (Lees Ferry) rainbow trout fishery has been maintained through natural reproduction rather than through stocking, and with the exception of localized spawning in some downstream tributaries, most of the rainbow trout production in the Colorado River downstream of Glen Canyon Dam occurs within the Glen Canyon reach.

Standardized annual monitoring of the population of rainbow trout in the 15-mile reach of the Colorado River between Glen Canyon Dam and Lees Ferry began in 1991. Based on catches of rainbow trout during annual monitoring surveys, the abundance of rainbow trout in Glen Canyon generally increased over the period from 1991 to 1997, remained at high levels until approximately

2001, and then declined to low levels by 2007 (**Figure 3-36**). From 2008 through 2010, the relative abundance of rainbow trout in the Glen Canyon reach again increased to near historic high levels. Relative abundance reached all-time high levels in 2011 and 2012, followed by a decline in 2013 consistent with previous high abundance estimates (AZGFD data as reported in GCMRC 2014; **Figure 3-36**). The decline continued to the lowest level in 2016 before rebounding in 2017 and 2018. Since 2018, rainbow trout relative abundance declined and fell below a catch rate of 1.0 fish per hour in 2021 and 2022 (Rogowski et al. 2023). This decline in rainbow trout in the Lees Ferry reach may be related to declines in nutrient levels from lower reservoir elevations of Lake Powell (Yard et al. 2023).

**Figure 3-36**
**Mean (±2 Standard Error) Electrofishing Catch Rates of Rainbow Trout in the Glen Canyon Reach, 1991–2022**




Source: Rogowski et al. 2023

Rainbow trout recruitment and population size within the Glen Canyon reach appear to be largely driven by dam operations (AZGFD 1996; McKinney et al. 1999a; McKinney et al. 2001; Makinster et al. 2011; Wright and Kennedy 2011; Korman et al. 2011; Korman et al. 2012). McKinney et al. (1999a) attributed the increase in abundance from 1991 to 1997 to increased minimum flows and reduced fluctuations in daily discharges resulting from the implementation of interim flows between 1991 and 1996 and the adoption of the current modified low fluctuating flow regime in 1996. These conditions apparently stabilized spawning and rearing habitats for trout and promoted photosynthetic food production. The decline in abundance from 2001 to 2007 has been attributed to the combined influence of increased trout metabolic demands due to warmer water releases from Glen Canyon Dam during that period, together with a static or declining food base, periodic dissolved oxygen deficiencies, and high numbers of the invasive New Zealand mud snail, which serves as a poor food source (Cross et al. 2011). Korman et al. (2012) also found that recruitment of rainbow trout in Glen Canyon was positively and strongly correlated with annual flow volume and reduced hourly flow variation, and also that recruitment increased after two of three high-flow releases related to the implementation of equalization flows.

Long-term monitoring of the rainbow trout population in Lees Ferry (**Figure 3-36**; Rogowski et al. 2023) shows the highest catch rate in 2011 and 2012, likely as a consequence of warmer releases from Glen Canyon Dam and an input of nutrients from a changed reservoir elevation of Lake Powell. This was after a fall steady flow experiment and equalization flows in 2011 that boosted food base production in the Lees Ferry reach and contributed to greater growth and an increase in abundance of rainbow trout. The population declined tenfold by 2016 due to a combination of lower recruitment and reduced survival of larger trout, likely driven by changes in nutrients and invertebrate prey availability (Yard et al. 2023). Survival rates for trout 8.8 inches or longer in 2014, 2015, and 2016 were, respectively, 11 percent, 21 percent, and 22 percent lower than average survival rates between 2012 and 2013. Abundance would have been threefold to fivefold higher had survival rates for larger trout remained at the elevated levels estimated for 2012 and 2013.

Rainbow trout growth declined between 2012 and 2014 due to reduced prey availability, which led to very poor fish condition[26] by the fall of 2014 (approximately 0.9–0.95 fish condition). Poor condition resulted in low survival rates of larger fish during the fall of 2014 and winter of 2015, which contributed to the population collapse. In Glen Canyon, large recruitment events can potentially lead to increases in the population that cannot be sustained due to limitations in prey supply. In the absence of the ability to regulate prey supply, flows that reduce the probability of large recruitment events can be used to avoid boom-and-bust population cycles (Korman et al. 2017).

*Brown Trout*

As with rainbow trout, brown trout are not native to the Colorado River and were stocked in the Grand Canyon in the first half of the 1900s. Brown trout are no longer stocked in the Colorado River downstream of Glen Canyon Dam and are now found primarily in Glen Canyon below the dam as NPS removals have substantially decreased brown trout numbers around Bright Angel Creek (Healy et al. 2020).

[26] Fish condition index is a measure of the physical condition of a fish and can be an indicator of overall health. It is calculated by comparing a fish's weight with the typical weight of other fish of the same species and similar length. A fish of normal weight would yield a condition index of 1; a fish with relatively poor condition would yield a condition index of less than 1; and a fish with relatively good condition would yield a condition index of greater than 1.

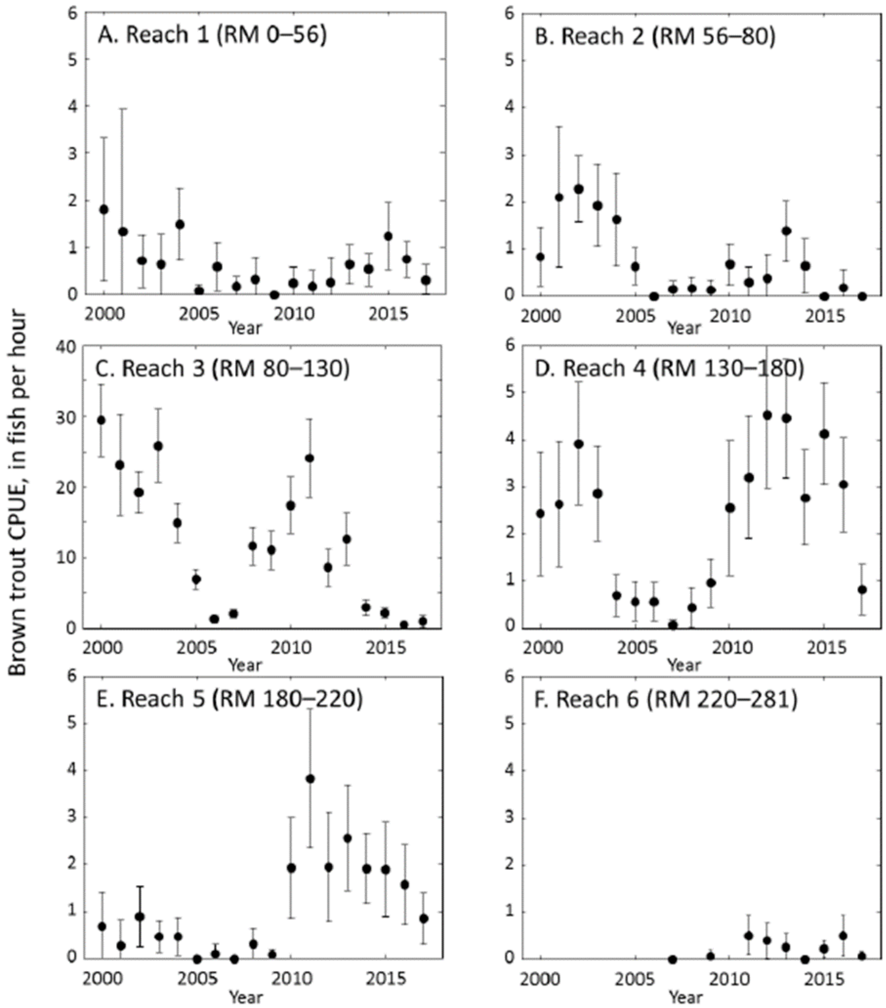
Overall, the abundance (based on electrofishing surveys) of brown trout in the Colorado River between Lees Ferry and Pearce Ferry at the Lake Mead inflow declined from 2000 to 2006; abundance may have increased somewhat between 2007 and 2009 (**Figure 3-37**; Makinster et al. 2010), but increases were observed concurrently with more frequent HFE releases during the fall (Runge et al. 2018; Yackulic et al. 2020; Healy et al. 2023). Because spawning by brown trout in the Grand Canyon reach occurs primarily in tributaries (for example, Bright Angel Creek), recruitment rates may be less affected by conditions in the mainstem than recruitment rates of rainbow trout. However, increases in brown trout recruitment were observed in 2014–2015 in the Lees Ferry reach (Stewart 2016), and adult brown trout immigration to Lees Ferry is likely influenced by management actions both in tributaries and the mainstem (Healey et al. 2023). Brown trout were observed spawning near the 4-mile bar in Glen Canyon during the fall of 2014, and an increase in age-1 brown trout, likely as a result of spawning and recruitment in 2014, was observed in 2015 (Korman et al. 2015). Spawning of brown trout was also observed during October and November of 2015 near the 4-mile bar in Glen Canyon (Korman et al. 2015).

Although the number of brown trout was small relative to rainbow trout, Yard et al. (2011) found that, on an individual basis, the brown trout is a more effective predator of native fish in the Colorado River than rainbow trout (see subsection *Rainbow Trout*). Yard et al. (2011) also found a significant positive correlation between temperature and the levels of predation by brown trout. Other studies have indicated that water temperature may influence the susceptibility of native fish to predation from brown and rainbow trout in different ways. For example, while the incidence of predation attempts increased, the success of predation by rainbow trout on YOY humpback chub decreased as temperatures increased from 10°C to 20°C (50°F to 68°F) (Ward 2011). Swimming performance, and the ability of humpback chub to escape predators, increases with temperature, whereas swimming performance of rainbow trout decreases with temperature. In contrast, the success of predation by brown trout did not change significantly over the same temperature range (Ward 2011), indicating that brown trout maintain swimming performance over a range of temperatures.

The brown trout population at Lees Ferry historically consisted of a small number of large fish supported by low levels of immigration from downstream reaches. Over the period 2014–2016, the number of nonnative brown trout captured during routine monitoring in the Lees Ferry reach began increasing and persisted into 2018 (Healy et al. 2023). From 2018 to 2023, the abundance index of brown trout increased by about fourfold (**Figure 3-38**). Management agencies and stakeholders questioned whether this increase in brown trout represents a threat to the humpback chub, to the rainbow trout sport fishery, or to other resources of concern.

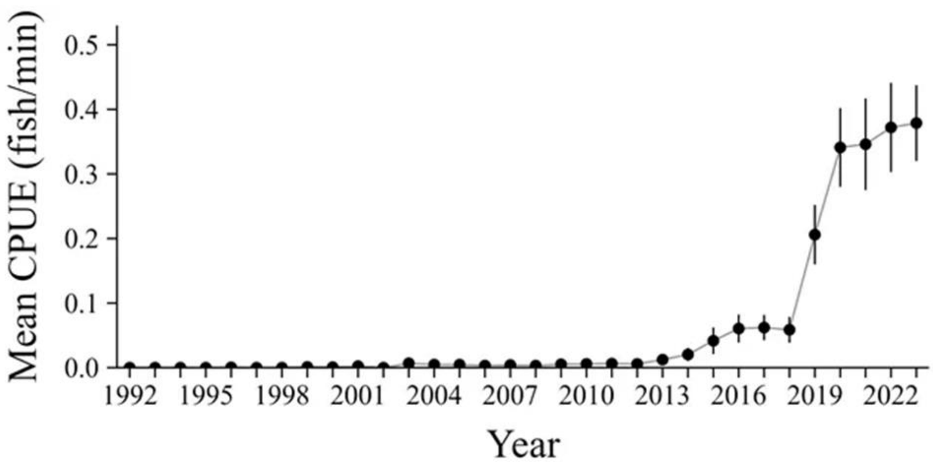
This population of brown trout has recently expanded upstream from a population center in Bright Angel Creek and is presently spawning in the Lees Ferry reach. The proximate causes of this change in status are a large pulse of immigration in the fall of 2014 and higher reproductive rates in 2015–2017 (Runge et al. 2018). The ultimate causes of this change are not clear. The pulse of immigrants from downstream reaches in the fall of 2014 may have been induced by three sequential November HFE releases from the dam in 2012–2014, but they may also have been the result of a unique set of circumstances unrelated to dam operations. The increase in reproduction may have been the result

**Figure 3-37**
**Mean Catch-per-Unit Effort of Brown Trout between Lees Ferry and Pearce Ferry (2000–2017)**




Sources: Data from AZGFD; figure from Runge et al. 2018
Notes: Captures occurred during electrofishing surveys on the Colorado River between Lees Ferry and Pearce Ferry for reaches 1–6 (plots A–F), 2000–2017. Reach locations are provided in river miles downstream of Lees Ferry (river mile 0). Most surveys occurred during the spring (April–June). The closed circles show the mean value; error bars represent 95 percent confidence intervals; note change in y-axis scales. Reach 6 (F) was sampled in 2004–2006 and in 2010, but data were not included because of high turbidity, and no sampling occurred in 2008 for Reach 6.
CPUE - Catch per unit effort
RM - River mile

**Figure 3-38**
**Abundance of Adult Brown Trout in the Lees Ferry Reach, 2000–2023**




Source: Rogowski 2024 (GCMRC Annual Reporting Meeting)
CPUE - Catch per unit effort

of any number of changes, including an Allee effect (that is, the numbers of adults reached a level sufficient for individuals to find each other and spawn), warmer water temperatures, a decrease in competition from rainbow trout, or fall high-flow releases.

Correlations over space and time among predictor variables do not allow for a clear inference about the cause of the changes. Brown trout incidence of predation was higher (8 to 70 percent) than rainbow trout (0.5 to 3.3 percent); however, rainbow trout were 50 times more abundant than brown trout in the study area (Yard et al. 2011). Brown trout are also able to thrive in warmer river water than rainbow trout and are better adapted to finding other fish in the murky river water of the Colorado River when the Paria River and side canyons are flowing.

The numbers of brown trout in Lees Ferry increased from 2014 to 2016, primarily in adult size classes (Runge et al. 2018). Healy et al. (2022) document how the use of a weir to block access to tributary spawning areas in Bright Angel Creek combined with fall HFE releases from Glen Canyon likely lead to increases in brown trout immigration to the Glen Canyon Dam tailwaters. Runge et al. (2018) also evaluated the impact of brown trout expansion on humpback chub downstream and proposed and evaluated management options. The abundance of brown trout in the Lees Ferry reach increased dramatically from 2018 to 2023 (**Figure 3-38**), and this increase will potentially affect rainbow trout n the Lees Ferry reach, humpback chub and other native species downstream (depending on movement patterns of brown trout), and the aquatic food base.

There are interventions that may be effective in moderating the growth of the brown trout population in the Lees Ferry reach. Across causal hypotheses, it is predicted that removal strategies (for example, a concerted electrofishing effort or an incentivized angler harvest program targeted at large brown trout) could reduce brown trout abundance by approximately 50 percent relative to status quo management. Reductions in the frequency or a change in the seasonal timing of high-flow releases from Glen Canyon Dam could be even more effective, but only if the causal hypotheses that involve the effects of such releases on immigration or reproduction are found to be correct. Brown trout management flows (i.e., dam releases designed to strand young fish at a vulnerable stage) may be able to reduce brown trout abundance to some degree but are not forecast to be the most effective strategy under any causal hypothesis (Runge et al. 2018).

Runge et al. (2018) considered six alternatives to managing the brown trout population, including the status quo, two strategies aimed at removing adult brown trout, and three strategies designed to discourage immigration or reproduction through dam operations. These six alternatives were not meant to be comprehensive. There was a much larger set of possible interventions, including large infrastructure options like building a temperature-control device on the dam, but the focus was on practical approaches whose implementation seemed to be possible in the near term (say, the next 5 years).

One strategy was to reward anglers who catch and keep brown trout as an incentive to remove the fish from the river. The incentivized harvest began on November 11, 2020. For the next 5 to 6 years, eligible anglers will be offered a reward of at least 25 dollars for each brown trout over 6 inches in length removed from the Colorado River between Glen Canyon Dam and the mouth of the Paria River. This reward varied with the seasons or was adjusted annually but was typically in the range of 25–33 dollars. As of spring 2024, the current reward is 33 dollars per brown trout plus 15 dollars for each PIT-tagged brown trout. In December of 2023, there was a monthly payout of 2,046 dollars to 8 anglers with one angler receiving 1,257 dollars. A total of 57 brown trout were removed in May with 11 PIT tags returned. The incentivized harvest program shows a decline in the numbers of brown trout in the Lee's Ferry reach, indicating the effectiveness of this program (NPS 2024).

**Interactions with Native Species**

Surveys of the Colorado River and its tributaries between Glen Canyon Dam and the inflow to Lake Mead, as well as experimental fish removal studies, indicate the presence of 20 nonnative warmwater fish species (Trammell and Valdez 2003; Ackerman et al. 2006; Makinster et al. 2010; Coggins et al. 2011; Albrecht et al. 2014; Rogowski et al. 2017; **Table 3-27**). Among the species collected, the common carp, fathead minnow, and red shiner are generally the most common warmwater species in the mainstem (Ackerman et al. 2006; Makinster et al. 2010; Coggins et al. 2011).

Small-bodied species, such as fathead minnow, red shiner, plains killifish, and bullhead, are found primarily in tributaries, especially in the Little Colorado River (**Table 3-28**). Other species collected from this reach include green sunfish, smallmouth bass, striped bass, redside shiner, golden shiner, and walleye (Service 2008). During July 2015, a large (compared with previous green sunfish captures), reproducing population of green sunfish was discovered in the -12 mile slough, approximately 3 miles downstream of Glen Canyon Dam. Neither the source nor the mechanism of introduction for some of these species (such as green sunfish and smallmouth bass) into the Glen Canyon reach is known with certainty; however, the nearest source for a number of these species is Lake Powell, and their most likely entrance into this reach is entrainment through the dam. These species are also reproducing in and around the -12 mile slough.

**Table 3-28**
**Nonnative Warmwater Fish Species Reported from the Little Colorado River Watershed**

| Species | Below Chute Falls | Above Chute Falls |
|---|---|---|
| Black bullhead | X | X |
| Yellow bullhead | X | X |
| Common carp | X | X |
| Channel catfish | X | X |
| Green sunfish | X | X |
| Fathead minnow | X | X |
| Plains killifish | X | X |
| Red shiner | X | X |
| Threadfin shad | – | X |
| Goldfish | – | X |
| Golden shiner | – | X |
| Northern pike | – | X |
| Mosquitofish | – | X |
| Rock bass | – | X |
| Bluegill | – | X |
| Smallmouth bass | – | X |
| Largemouth bass | – | X |
| Black crappie | – | X |
| Yellow perch | – | X |

Sources: Ward and Persons 2006; Stone et al. 2007
Notes: X = present; – = absent. Fish reported from below and above Chute Falls within the 21-mile perennially flowing portion of the Little Colorado River corridor.

Over the 23 years of AZGFD monitoring, the relative abundance of most nonnative fish species has decreased, and the abundance of most native species has increased. In 2022, fish distribution patterns similar to those of recent years (e.g., 2016–present) were observed, with nonnative rainbow trout composing most (89.4 percent) of the electrofishing catch in Marble Canyon, and native fish composing most of the catch (98.7 percent) downstream of the Little Colorado River confluence (USGS 2023b).

Nonnative fish in the Colorado River are considered to adversely affect native fish in the system through predation or competition and by serving as hosts for parasites (Minckley 1991; Coggins et al. 2002, 2011; Gloss and Coggins 2005; Olden and Poff 2005).

*Predation and Competition*
Piscivory by rainbow and brown trout has been suggested as a large source of mortality for native fish in the Colorado River and its tributaries below Glen Canyon Dam (Blinn et al. 1993; Marsh and Douglas 1997; Yard et al. 2011; Whiting et al. 2014). Near the confluence of the Little Colorado River, Yard et al. (2011) found that 90 percent of the vertebrate prey consumed by rainbow and

brown trout were fish and estimated that rainbow and brown trout consumed over 30,000 fish in the vicinity of the Little Colorado River during a 1-year study period.

The incidence of piscivory (proportion of individuals feeding on fish) by species was 70 percent for brown trout and only up to 3.3 percent for rainbow trout. However, rainbow trout were approximately 50 times more abundant during the study period, and it was estimated that they accounted for more than half of the total number of fish consumed in the analysis area (Yard et al. 2011). Overall, trout ate 85 percent more native fish than nonnative fish, even though native fish composed less than 30 percent of the small fish available as prey in the analysis area.

Of ingested fish that were identifiable, 56 percent was composed of native fish, while another 28.8 percent was composed of unidentified suckers (presumably native flannelmouth and bluehead suckers). Of the identified native fish consumed by the trout, about 27 percent were humpback chub, 15 percent were speckled dace, 11 percent were flannelmouth sucker, and 3 percent were bluehead sucker (Yard et al. 2011). Because the majority of humpback chub consumed by trout during the study were YOY and subadults (less than 3 years old), predation on such fish could affect recruitment to the humpback chub population in the Grand Canyon (Coggins and Walters 2009; Yard et al. 2011). Because of differences in the levels of piscivory exhibited by brown and rainbow trout, decisions to implement removal actions at the Little Colorado River to benefit humpback chub were triggered by levels of both brown trout and rainbow trout present in the reach, as well as consideration of the status (estimated size) of the humpback chub population (Coggins et al. 2011).

In the Grand Canyon, brown trout, rainbow trout, channel catfish, and black bullhead are considered the primary predators of humpback chub, while common carp are a major humpback chub egg predator in the Little Colorado River (Marsh and Douglas 1997; Valdez and Ryel 1997; Service 2008). Fathead minnow, red shiner, and plains killifish may be important predators and competitors of young humpback chub, especially in the Little Colorado River (Marsh and Douglas 1997; Valdez and Ryel 1997; Service 2008). Marsh and Douglas (1997) examined predation of native fish by nonnative fish in the Little Colorado River and found rainbow and brown trout, channel catfish, and black and yellow bullhead to be predators of native fish. In the stomachs of these species that contained food, native fish composed about 14 percent of the ingested materials. Ingested species included humpback chub, speckled dace, and bluehead and flannelmouth suckers. Whiting et al. (2014) evaluated the diets of rainbow and brown trout from Bright Angel Creek and found that native fish (primarily speckled dace) composed approximately 4 percent of the diet for larger rainbow trout and 19 percent of the diet for larger brown trout.

While trout predation on humpback chub has been demonstrated, it is uncertain whether or not trout piscivory has had (or has) a population-level effect on the humpback chub (Yard et al. 2011). Although survival and recruitment of humpback chub have increased following trout removal in 2003 and 2006, it is not known if this increase is due to trout removal or other environmental factors (including warming water temperature), and further experimentation would be needed to tease apart other system-level dynamics that could have contributed to the adult humpback chub population increases observed since 2000. For example, the temperature of water released from Glen Canyon Dam increased during the trout removal study period to temperatures that may have improved humpback chub growth and survival (Coggins et al. 2011) and that caused negative impacts on trout populations. Ongoing studies have indicated that low water temperature may negatively influence the susceptibility of native fish to predation from brown and rainbow trout (for example, Ward 2011; Ward and Morton-Starner 2015).

Research on the food web dynamics of the Grand Canyon provides further evidence that competition between native fish and nonnative fish is likely occurring. Invertebrates, primarily blackflies and midges, are important food items for both humpback chub and nonnative fish, particularly rainbow trout. Throughout Marble and Grand Canyons, invertebrate production is low, and fish consume most of this production. Cross et al. (2013) hypothesized that an influx of rainbow trout from upstream, coupled with this limited resource base, may lead to strong competition among fish in the Grand Canyon and that dam operations that alter fish populations, such as HFE releases, may exacerbate this effect. However, the habitat conditions in Grand Canyon are not currently suitable to support a large population of rainbow trout and the possibility of a population influx is unlikely at this time.

Humpback Chub were once found between Glen Canyon Dam and Lees Ferry by Holden and Stalnaker (1975), but they are absent now due to colder water temperatures. Warmer releases could provide more suitable conditions for humpback chub, but the rehabitation of this reach could be limited or precluded by smallmouth bass and green sunfish. Because humpback chub are not currently found in the Glen Canyon (Lees Ferry) reach, recent increases in green sunfish and smallmouth bass in this reach will not affect the humpback chub in this stretch of river. However, green sunfish and smallmouth bass can be displaced downstream through natural migration and, to a lesser extent, potentially high dam releases.

While smallmouth bass populations are largely present in the Lees Ferry reach (to river mile 0), a small number of juvenile smallmouth bass have been detected as far downstream as river mile 16 (31 miles below the dam). With the furthest upstream recent detection of humpback chub currently at river mile 30, warmwater invasives have already migrated two-thirds of the way toward contact with chub populations. Without intense control efforts, smallmouth bass populations can be expected to expand their range downstream, as seen in many other streams in the Desert Southwest. These species have the potential to affect humpback chub through predation and competition. Furthermore, native flannelmouth suckers, bluehead sucker, and speckled dace occur in the Lees Ferry reach, where they may be negatively affected by these predators.

*Parasites and Diseases*

The potential for expansions and infestations of nonnative parasites is also influenced by water temperatures. Rahel and Olden (2008) suggested that climate change could facilitate the expansion of nonnative parasites through warmer water temperatures. This may be an important threat to humpback chub. Optimal Asian tapeworm development occurs at 25–30°C (77–86°F) (Granath and Esch 1983), and optimal anchor worm temperatures are 23–30°C (73.4–86°F) (Bulow et al. 1979). Cold water temperatures in the mainstem Colorado River in Marble and Grand Canyons have likely prevented these parasites from completing their life cycles and limited their distribution, but these parasites occur in tributaries such as the Little Colorado River. Warmer climate trends or operational alternatives could result in warmer overall water temperatures, thereby increasing the prevalence of these parasites, which can weaken humpback chub and increase mortality rates. Declines in the elevation of Lake Powell have resulted in warmer releases from Glen Canyon Dam, and these warmer temperatures will likely provide more suitable conditions for the proliferation of a number of fish parasites that could negatively affect native fish species in the mainstem Colorado River (see **Figure 3-46**).

### Nonnative Fish Control Activities and Effects of Flow Conditions

A number of management actions have been designed and implemented to test their efficacy for controlling and reducing the abundance and distribution of nonnative fish in the Colorado River and its tributaries below Glen Canyon Dam. These control actions included (1) flow releases from Glen Canyon Dam designed to reduce trout recruitment, and (2) mechanical removal of trout and warmwater nonnative fish in the vicinity of the Colorado River–Little Colorado River confluence (Coggins et al. 2011; Reclamation 2011c).

A series of HFE releases was conducted in 1996, 2004, 2008, 2012, 2013, 2014, 2016, 2018, and 2023 to benefit sandbar resources, improve camping beaches, and potentially improve the quality of shoreline habitats for native fish in GCNP (Melis et al. 2010, 2012). Dodrill et al. (2015) reported that, although experimental floods increased the prevalence and extent of backwaters, the effects were modest and would be expected to dissipate quickly. There was a large increase in rainbow trout early life stage survival rates and abundance of rainbow trout following the 2008 spring HFE release. Whether such increases would be supported by future spring HFE releases is unclear, and the effects of fall HFE releases on rainbow trout are less clear. However, preliminary analyses of recent studies indicate that the abundance of age-0 rainbow trout did not increase due to fall HFE releases in 2012, 2013, and 2014 (VanderKooi 2015; Gimbel 2015).

The potential effects of HFE releases on trout are described below, as are the possible effects of equalization flows on trout. Despite the high abundance of rainbow trout in Glen and Marble Canyons in 2011 and 2012, the humpback chub population has continued to increase throughout the river. Additional experimentation would be needed to tease apart other system-level dynamics that could have contributed to the adult humpback chub population increases observed since 2000.

Interactions between native fish and increasing numbers of smallmouth bass and green sunfish are likely to increase, and these native fish will be subjected to higher predation levels from warmwater nonnative fish as they become established. Increases in smallmouth bass, green sunfish, walleye, and other nonnative species would likely reduce young native fish survival levels.

#### *Nonnative Fish Suppression Flows*

Flows designed to reduce trout recruitment in Lees Ferry were tested in 2003–2005. These flows, conducted from January through March, were intended to dewater and expose rainbow trout redds (i.e., trout nests where eggs are deposited and incubated) in the Glen Canyon reach to lethal air temperatures for part of the day, thereby reducing the survival of trout eggs and fry in the exposed redds (Korman et al. 2005; Korman et al. 2011; Korman and Melis 2011). The flow regimes tested during this period consisted of increasing the extent of daily flow variation during winter and early spring from the normal range of 10,000–18,000 cfs in January and 7,000–13,000 cfs in February–March to a range of 5,000–20,000 cfs in January–March. These operations also resulted in longer periods of dewatering for redds at lower elevations than would occur under normal operations.

The fluctuating flows were determined to have resulted in increasing the incubation mortality rate from 5–11 percent under normal flow conditions to 23–49 percent under fluctuating flows (Korman et al. 2005; Korman et al. 2011; Korman and Melis 2011). However, no measurable reduction in age-0 abundance was observed, presumably due to increased survival that compensated for the mortality of the eggs. This compensatory response may not occur under different flow conditions and rainbow trout population sizes. The present rainbow trout population is at its lowest level since sampling began in 1991 (**Figure 3-36**), and it may not be able to rebound from a flow scenario that would induce substantial mortality of the eggs and fry. Flow alternatives with particularly low dam releases would dewater spawning areas of trout and induce mortality to eggs and fry from which the low population may be unable to recover.

These results suggest that the increased level of incubation mortality (from the flow fluctuation) did not exceed compensatory survival responses (Korman et al. 2011). Because of these results, it has been suggested that a more limited fluctuating flow regime may be effective, targeting juvenile trout after the majority of density-dependent responses to egg incubation and hatching success have been realized but before age-0 trout leave habitats that are potentially more sensitive to flow fluctuations (Korman et al. 2011; Korman and Melis 2011). Testing flow regimes with flow variation that are increased during late spring and summer months when small age-0 trout are utilizing potentially flow-sensitive, low-angle habitat has been suggested (Korman et al. 2005; Korman and Melis 2011).

*Nonnative Fish Removal*

The removal of predatory, nonnative fish has been conducted in various locations in the Upper and Lower Basins of the Colorado River since the mid-1990s with varying degrees of success (Mueller 2005). Since 2003, the Upper Colorado River Endangered Fish Recovery Program has mechanically removed (primarily with boat electrofishing) smallmouth bass from various regions of the Upper Colorado River Basin to reduce predation and competition on humpback chub, Colorado pikeminnow, razorback sucker, and bonytail.

From 1997 to 2023, the Upper Colorado River Endangered Fish Recovery Program ￼￼ million dollars on nonnative fish control and management in the Upper Basin, with a focus on smallmouth bass starting in 2003. Annual expenditures since 2003 have ranged from 267,840 dollars in 2003 to 1,080,000 dollars in 2017, or about 6 percent to 27 percent of total Upper Colorado River Endangered Fish Recovery Program expenditures, respectively[27]￼ This removal program has reduced the numbers of smallmouth bass in some areas and for short time periods, but the numbers rebound when suitable low-flow conditions prevail with warm temperatures.

Recent (2021 and 2022) experimental releases from Flaming Gorge Dam have been used to disrupt smallmouth bass spawning in the Green River (Bestgen 2018; USGS 2023b). Preliminary results from the 2021 experiment indicate spawning was interrupted; however, it is unclear whether smallmouth bass recruitment overall declined, which would be needed for flow modifications to be effective at reducing smallmouth bass populations (Bestgen 2018).

27 Highlights - Program Brochure and Briefing Book - Colorado River Recovery Programs.

Removal of nonnative fish in the Colorado River near the Little Colorado River confluence was conducted from 2003 to 2006 and in 2009 (Korman et al. 2005; Makinster et al. 2009; Coggins et al. 2011). Fish removal activities in 2003–2006 captured more than 36,000 fish, of which 23,266 were nonnative species, including 19,020 rainbow trout (Korman et al. 2005; Coggins et al. 2011). The removal of trout was estimated to have reduced rainbow trout abundance in this reach from about 6,500 in January 2003 to about 620 in February 2006. Immigration and recruitment account for the difference between the number of trout removed and the abundance estimates.

During the 2003–2006 removal activities, large increases in the abundance of fathead minnow and black bullhead were reported beginning in September 2005, suggesting increases in immigration, survival, or both. The observed increase may have been due to increased emigration from the Little Colorado River, where these species spawn, or because the combination of reduced predation by rainbow trout and increasing water temperatures may have caused these species to be more abundant and susceptible to capture (Coggins et al. 2011).

Coincident with the 2003–2006 removal activities, the humpback chub population stabilized and increased, suggesting that the nonnative fish removal (especially the removal of rainbow trout) may have allowed higher survival and recruitment by humpback chub (Coggins and Walters 2009; Coggins et al. 2011). However, the relationship between trout removal and survival of humpback chub is not clear because there was a systemwide decrease in rainbow trout abundance and drought-induced increases in river water temperatures during the time of the removal activities that could also have led to increased survival and recruitment of juvenile native fish (Coggins et al. 2011).

As indicated in **Figure 3-42**, stabilization and increases in the adult humpback chub population may have begun as early as 2002, prior to the nonnative fish removal actions. Because changes in the adult humpback chub population rely, in part, on the survival and recruitment of juvenile humpback chub, increases in survival rates may have occurred for several years prior to the fish removal activities. Further, even though the abundance of trout appeared to return to pre-removal levels by 2009, the estimated adult abundance of humpback chub continued to increase.

Nonnative fish removal was also conducted in 2009, the results of which indicated that rainbow trout abundance in the vicinity of the Little Colorado River had rebounded from the declines observed in 2006–2007 (Coggins et al. 2011; Reclamation 2011e). The number of rainbow trout in the vicinity of the Little Colorado River prior to the 2009 removal activities was estimated to be similar to the high densities estimated in 2002 prior to the 2003 fish removal activities (Wright and Kennedy 2011).

Nonnative fish removal is also being conducted in Shinumo and Bright Angel Creeks to restore and enhance the native fish communities and to reduce predation and competition on threatened humpback chub from nonnative fish. These removals are being conducted to implement conservation measures identified in the 2008 Biological Opinion, the 2009 Supplement, the 2011 Biological Opinion on the operation of Glen Canyon Dam, and the 2016 LTEMP FEIS (Service 2008, 2009; Reclamation 2011e; DOI 2016a). Nonnative fish (primarily rainbow trout) are being removed from Shinumo Creek to minimize predation on newly translocated humpback chub and to reduce competition.

From 2009 through 2014, 5,569 rainbow trout were removed from Shinumo Creek using netting, angling, and electrofishing. Brown trout do not occur in Shinumo Creek above a waterfall barrier near the mouth, but brown trout were removed below the waterfall. Rainbow trout densities were reduced between the summer of 2011 and the winter of 2012 but rebounded with a strong cohort in June 2012 (likely a compensatory response). The abundance of bluehead sucker increased in the lower reaches downstream of translocation areas, and speckled dace increased throughout Shinumo Creek as rainbow trout densities were reduced. A sequence of headwater fires and floods occurred in the summer of 2014 that almost eliminated all nonnative and native fish from Shinumo Creek (Healy et al. 2023). The NPS plans to remove the remaining nonnative trout and monitor the native fish. Nonnative fish, primarily rainbow trout, occur in small numbers in Havasu Creek and are also removed when encountered (Healy et al. 2014).

From 2010 to 2012, trout reduction efforts in Bright Angel Creek included the installation and operation of a fish weir trap and backpack electrofishing in the lower portion of the creek, including the confluence of Bright Angel Creek to Phantom Creek. From 2012 to 2015, removals were expanded to the entire length of Bright Angel Creek (approximately 16 kilometers [about 10 miles]) and Roaring Springs (approximately 3 kilometers [about 2 miles]). The operation of the weir was also extended from October through February to capture greater temporal variability in the trout spawning migration. From 2010 to December 2014, about 28,000 brown trout and 4,800 rainbow trout were removed from Bright Angel Creek from both the weir and by electrofishing.

Between 2012 and 2018, trout numbers declined by 89 percent, and native fishes abundance increased (by approximately 480 percent) once trout suppression surpassed 60 percent. Native fish distribution has expanded upstream with increases in abundance, especially in YOY (Healy et al. 2014, 2018, 2020; Nelson et al. 2012, 2015). As determined through consultation with Traditionally Associated Tribes and others, and consistent with the MOA between the NPS and the Arizona State Historic Preservation Office, trout removed from the creeks were preserved and distributed for beneficial use through human consumption, or for use by the Tribes for other purposes.

In July 2015, AZGFD biologists discovered an unusually large, reproducing population of green sunfish in the -12 mile slough connected to the mainstem Colorado River approximately 3 miles downstream of Glen Canyon Dam. Although the downstream end of the slough is connected to the main channel under the typical range of releases from Glen Canyon Dam, the upstream end of the slough is isolated from the main channel except during high flows. Green sunfish are known to be prolific, with a single female capable of producing up to 10,000 eggs. Green sunfish are considered likely predators of small-bodied native fish and native fish eggs. Biologists with the AZGFD, NPS, USGS, Service, and Reclamation have determined that green sunfish pose a threat to native fish, including the humpback chub. Two removal efforts using electrofishing, seine netting, and trapping were conducted in August 2015 but failed to deplete the population despite removing more than 3,000 fish. Biologists from the NPS and AZGFD constructed and installed a large block net at the downstream end of the main slough to minimize the escapement of green sunfish. After analyzing alternative methods for control, the agencies authorized a short-term targeted treatment of the slough with the fish toxin rotenone.

In 2017, the slough was treated with liquid ammonia to kill the green sunfish that were present, following techniques developed by Ward et al. (2013) in controlled ponds. The treatment was partly effective at killing fish but was considered impractical because of technical considerations and the short-term effect of the treatment. Despite these efforts, green sunfish are regularly captured by fish monitoring efforts in the mainstem river. In 2018, a project was proposed by Reclamation (Greimann et al. 2018) with the goal of cooling water temperatures in the upper slough so that invasive green sunfish and other warmwater fish do not find warmwater conditions that allow them to propagate in this off-channel slough area. The proposed design showed that connecting the slough to the mainstem Colorado River would reduce temperatures in the slough sufficiently to not meet the thermal requirements of green sunfish for spawning. NPS is considering whether to mechanically modify the slough to allow the river to flow through the area and eliminate the effect of pooling water that provides a warm, low-velocity habitat for nonnative fish.

**High-Flow Experiments**

HFE releases build on nearly three decades of extensive scientific research, experimentation, and analysis of the Colorado River downstream of Glen Canyon Dam. Spring HFE releases increase the productivity of the aquatic food base, whereas fall HFE releases do not appear to affect the long-term composition of the aquatic food base and may scour the food base prior to the winter nongrowing season. HFE releases do not appear to directly affect humpback chub or the rainbow trout fishery, but there may be indirect effects tied to food base and trout production. Fall HFE releases may be connected to the recent increase in brown trout at Lees Ferry and consequent increased predation on rainbow trout and on downstream native fish populations (Yackulic et al. 2014; Healey et al. 2023).

HFE releases are generally conducted in April (spring) or November (fall), when most fish species are not actively spawning in the mainstem Colorado River between Glen Canyon Dam and Pearce Ferry. Although humpback chub spawn in the Little Colorado River from March to May, their young do not descend into the mainstem until late June or July with monsoonal storms (Yackulic et al. 2014). Similarly, other native species, such as flannelmouth sucker and bluehead sucker, spawn either in tributaries in April or May, or in the mainstem in June or July, during a time when HFE releases are not being conducted and when high flows and water velocities are unlikely to affect large numbers of young fish.

## 3.5.2 Environmental Consequences

### *Methodology*

Previous research and monitoring conducted within the Colorado River and its tributaries were evaluated and analyzed to inform the results of this analysis. The environmental consequences for fisheries and aquatics within the project area are based on relationships of how flow alterations would impact the food base; fish habitat; native species, including special status species; and nonnative species that are potential predators of native species within the Colorado River. This analysis used qualitative relationships between changes in flow and habitat, food base abundance and distribution, specific species' distribution based on habitat requirements, and impacts from interactions of native with nonnative aquatic species.

Results of hydrologic models were used to evaluate the effects of flows on aquatic resources; these included the CRSS model and the GTMax. Preliminary quantitative models integrating information on smallmouth bass population dynamics, potential entrainment rates, water temperature, and other variables to assess invasion risk and potential management options for smallmouth bass were also used for this SEIS.

**Impact Analysis Area**

The affected environment includes the area potentially affected by the implementation of the 2016 LTEMP FEIS. For aquatic resources, this area includes the Colorado River ecosystem from Glen Canyon Dam downstream to the Lake Mead inflow. More specifically, the scope primarily encompasses the Colorado River ecosystem, which includes the Colorado River mainstem corridor, the affected tributary mouths, and interacting resources in the associated riparian zones, located primarily from the forebay of Glen Canyon Dam to Pearce Ferry. The aquatic species described above are based on those covered in the 2016 LTEMP FEIS and any new species, species of increased concern, or species with changed status since 2016.

The 2016 LTEMP FEIS and SMB EA were used to provide background and for the analysis of the effects of flow on aquatic resources. Special status fish species were identified using the Bureau of Land Management (BLM) Sensitive Species Lists Arizona statewide conservation agreement for six native fish species. The Lower Colorado River Multi-Species Conservation Program's Habitat Conservation Plan was used for analysis of areas downstream of Separation Canyon.

**Assumptions**

- Flow alterations will not impact tributary streams except fish access and habitat at the mouths.
- Lake Mead and Lake Powell will not be influenced because annual flows will remain the same.
- The biological analyses depend on the available reports and publications, data inputs, modeling assumptions, and validity of the models.

**Impact Indicators**

Impacts were evaluated for aquatic species that use the Colorado River; these species were included in the affected environment section. The indicators included:

- Changes in distribution and abundance of food base items, including primary and secondary producers such as algae and macroinvertebrates
- Changes in the river channel area affected by flows, including the main channel and shallow-water habitats
- Changes in the distribution and abundance of native and nonnative fish species
- Changes in fish habitats, including talus shorelines and backwaters

### *Issue 1: How would flow alterations at Glen Canyon Dam affect the aquatic food base, native fish species, and nonnative fish species?*

The following alternatives summarize impacts on the aquatic food base, native fish, and nonnative fish. These alternatives are being considered through 2027 if certain conditions are met, and it is anticipated that other mitigation factors will be present by 2027. There is substantial uncertainty in how the alternatives may impact the aquatic food base, native fish, and nonnative fish populations in the Colorado River ecosystem below Glen Canyon Dam. Predictive models can be useful for making comparisons of different alternatives under a specific set of assumptions. Modeling efforts to assess the complex interactions between physical factors, including reservoir levels, river warming, and river discharge; biological factors, including native and nonnative fish populations (and the interactions between them); and aquatic food base responses were helpful in assessing impacts.

No significant effects are expected to the food base from any of the alternatives, except possibly the Non-Bypass Alternative when frequent dewatering from the large fluctuations that go down to 2,000 cfs every weekend could impact macroinvertebrate populations. Also, alternatives with high flows may transport large numbers of organisms downstream, including the New Zealand mud snail. These modeling efforts should be recognized as descriptions of how the Colorado River ecosystem downstream of Glen Canyon Dam may respond to these different alternatives using the best available information. The evaluations of the flow alternatives below are based on the best available information for the Upper and Lower Basins of the Colorado River and, where applicable, information from other river basins.

The smallmouth bass model (Yackulic et al. 2024, chap. 4) was used to estimate the downstream population response as lambda, where lambda > 1 means the population is expected to increase and lambda < 1 means the population is expected to decline. The model was also used to assess the numbers of smallmouth bass passing through Glen Canyon Dam from Lake Powell, referred to as propagule pressure or entrainment. On average, smallmouth bass entrainment and passage through Glen Canyon Dam into the Lees Ferry tailwater reach is expected to be less than 50 propagules per year across all SEIS alternatives from 2024 through 2026, but more extreme entrainment rates (> 100 propagules per year) are possible in 2025 and 2026.

Smallmouth bass entrainment rates are expected to be similar between the No Action Alternative and the five action alternatives under most, but not all, hydrologic traces. For example, under dry hydrologic conditions, an action alternative is expected to increase smallmouth bass entrainment relative to the No Action Alternative (Yackulic et al. 2024, chap. 4). Hence, in low elevations of Lake Powell during dry years, more smallmouth bass are expected to be in the region of the penstocks where they can become entrained and pass through the dam to the downstream river. All models, while valuable, are limited by data quality and assumptions. The Yackulic et al. (2024, chap. 4) population growth model assumes temperature is the only factor influencing smallmouth population growth. The model assumes there is no population density limitation for habitat or prey availability and assumes no effects of turbidity. It may not accurately predict entrainment rates due to uncertainties in future conditions and potential biases in the model's structure or input data selection. Nonetheless, it provides valuable insights and can be a useful tool when interpreted cautiously.

The alternatives proposed in this SEIS were modeled through 2027, with the anticipation that other mitigation factors will be present by 2027. If such factors are not present or are insufficient to avoid the establishment of smallmouth bass, however, implementation of these alternatives may be considered for extension past 2027 following further analysis.

**No Action Alternative**

The changing climate and aridity have resulted in Lake Powell's low elevation and warmer releases from Glen Canyon Dam (Reclamation 2022). Under the No Action Alternative, these conditions would likely continue. This alternative also would continue to allow nonnative, invasive fish species passage through the dam, likely with increased abundances and ranges in the Colorado River downstream of Glen Canyon Dam. Increased abundances of these species could increase interactions between competitive and predatory, invasive species and native species (Coggins et al. 2011). The lower lake elevation means that the penstocks would continue to withdraw warmer water from the epilimnion and mesolimnion, where fish populations occur, rather than from the deeper, colder, fishless water of the hypolimnion.[28]

With the No Action Alternative, no additional flow-based actions would be implemented under LTEMP to disrupt the spawning of smallmouth bass downstream of Glen Canyon Dam. The smallmouth bass population could continue to grow and expand in the Lees Ferry reach and potentially farther downstream. A preliminary model from Yackulic et al. (2024, chap. 4) was developed to assess the potential for smallmouth bass population growth rate at river mile 15 and river mile 61 (Little Colorado River confluence) under each of the six alternatives. Based on assumed functional relationships between smallmouth bass population dynamics, available habitat, predicted temperature responses, and rate of entrainment, the model predicts smallmouth bass intrinsic rate of population growth (lambda) at river mile 15 and river mile 61 for each year 2024–2027 (**Table 3-29**). For river mile 15, the predicted lambda is ≤ 1 for all of the traces in 2024 but is predicted to be > 1 for 17 percent of the traces evaluated by 2027. For river mile 61, the model predicted lambda is > 1 for 3 percent of the traces in 2024 but is predicted to be > 1 for 17 percent of the traces evaluated by 2027.

This means that for the No Action Alternative, the smallmouth bass population would be expected to grow (that is, lambda > 1) in 3 of the 4 years at river mile 15 and in all 4 years at river mile 61; hence, this alternative may not be effective at controlling reproduction and recruitment of smallmouth bass at either location. Average lambdas and ranges (maximum and minimum values) of 30 traces are provided in **Figure 3-39**. This shows that for some traces, lambdas could exceed 2, which means that smallmouth bass population growth could double in years 2025–2027 at both river mile 15 and 16 for the No Action Alternative.

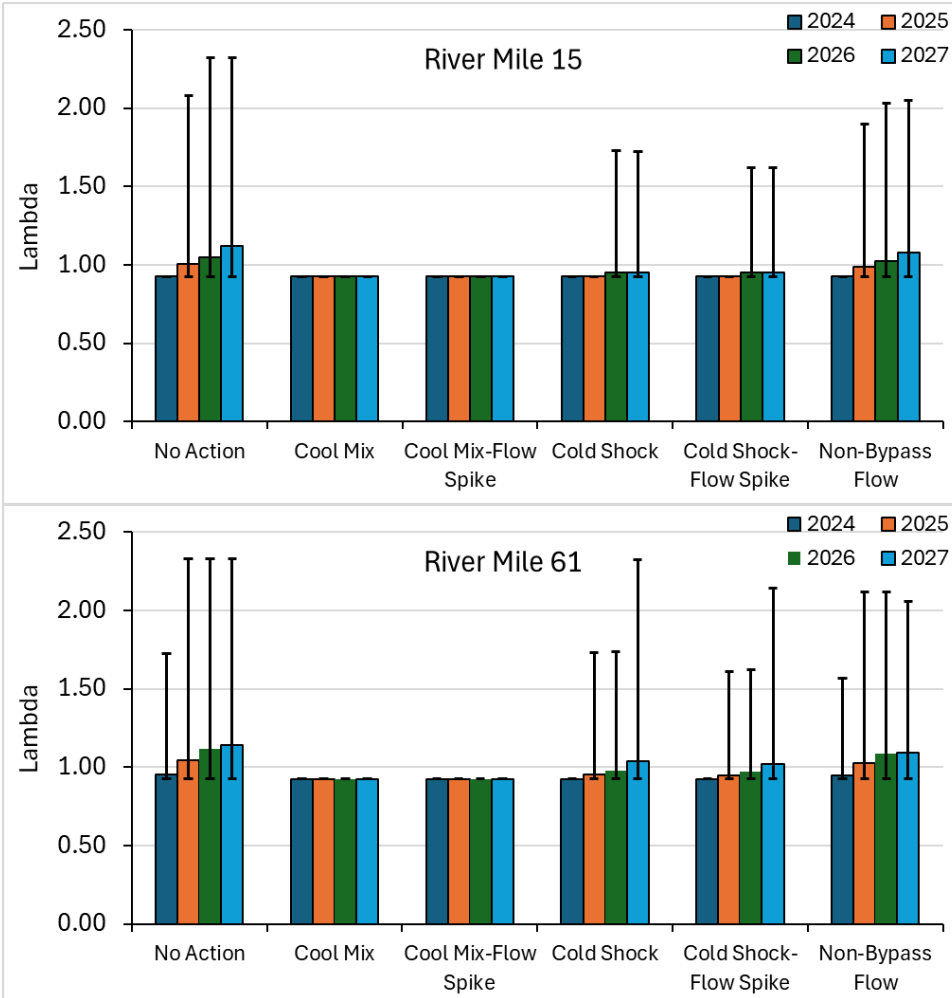
[28] In summer, Lake Powell has three thermally stratified layers: the epilimnion (top), mesolimnion or thermocline (middle), and hypolimnion (bottom). The epilimnion is warm and oxygenated. The mesolimnion is characterized by a rapid change in temperature with the depth, and it is sufficiently oxygenated to support fish. The hypolimnion is devoid of oxygen and is the coldest.

**Table 3-29**
**Percentage of 30 Traces in Which Lambda Was Predicted to Exceed 1 for That Year and Alternative at River Miles 15 and 61**

| Alternative | River Mile 15 (Glen Canyon Dam) | | | |
|---|---|---|---|---|
| | 2024 | 2025 | 2026 | 2027 |
| No Action | 0 | 7 | 10 | 17 |
| Cool Mix | 0 | 0 | 0 | 0 |
| Cool Mix with Flow Spike | 0 | 0 | 0 | 0 |
| Cold Shock | 0 | 0 | 3 | 3 |
| Cold Shock with Flow Spike | 0 | 0 | 3 | 3 |
| Non-Bypass | 0 | 7 | 10 | 17 |
| **Alternative** | **River Mile 61 (Little Colorado River)** | | | |
| | **2024** | **2025** | **2026** | **2027** |
| No Action | 3 | 10 | 17 | 17 |
| Cool Mix | 0 | 0 | 0 | 0 |
| Cool Mix with Flow Spike | 0 | 0 | 0 | 0 |
| Cold Shock | 0 | 3 | 7 | 10 |
| Cold Shock with Flow Spike | 0 | 3 | 7 | 10 |
| Non-Bypass | 3 | 10 | 17 | 17 |

Source: Yackulic et al. 2024 (chap. 4)
Note: Percentages are rounded to the nearest percent.

**Figure 3-39**
**Average Lambdas and Ranges (Maximum and Minimum Values) from 30 Traces by Alternative and Year for River Mile 15 and River Mile 61**




Source: Eppehimer 2024 (Unpublished data).

Native fish interactions with invasive, piscivorous fish like smallmouth bass would likely increase as the nonnative fish range expands. This could result in increased predation and competition and possibly decreased abundance of native fish species. Smallmouth bass are a major concern in the Upper Basin and are considered a contributing factor to the low abundance of native fish. If under the No Action Alternative smallmouth bass and other invasive fish (for example, green sunfish, walleye, and striped bass) become established in the Lower Colorado River despite other management actions to prevent further distribution (for example, mechanical removal), the No Action Alternative could detrimentally affect native species. This is largely because of continued regional drought conditions and the potential for continued decline in Lake Powell's elevation, and the consequential potential increase in nonnative fish entrainment, passage, and warmwater releases conducive to spawning and improved survival by these nonnative fish species (Summit Technologies Inc. 2022). Continued warmer releases under the No Action Alternative may likely increase the infestation rates of certain fish parasites, including the Asian tapeworm and the lernaean copepod (*Lernaea cyprinacea*).

The No Action Alternative would likely result in warmer dam releases compared with the action alternatives. This could increase growth rates of rainbow trout in the Lees Ferry reach but could also increase the abundance and numbers of brown trout that are known predators and competitors of rainbow trout and native fish (Runge et al. 2018). The potential for increased abundances of invasive fish species in the Lees Ferry reach, like smallmouth bass and green sunfish, would also increase the chances for these species to expand farther downstream, possibly as far as Pearce Ferry in the Lake Mead inflow and into population centers of humpback chub and razorback sucker. Coolwater releases may still impact smallmouth bass further downstream, but below river mile 88 the effects will be less pronounced due to warming caused by solar radiation and air temperature (Mihalevich et al. 2020).

*Native Fish*

Warmer water temperatures would likely increase the growth rates of native fish species (flannelmouth sucker, bluehead sucker, and speckled dace); however, they would also increase the chances of parasites and diseases in these species, as well as competition and predation by the invasive species. Warmer releases could also provide more suitable thermal continuity in the mainstem between tributaries and enable warmwater invasive fish species (for example, channel catfish, carp, black bullhead, fathead minnow, and red shiner) to expand their range and numbers, potentially resulting in increased impacts to native species.

Flannelmouth sucker, bluehead sucker, and speckled dace in their juvenile and adult life stages are tolerant to the high range of river flows that would occur under the No Action Alternative. The direct effect of spring or fall HFE releases on these life stages is expected to be minimal. Spring HFE releases could displace recently hatched larvae and post-larvae and subject these life stages to stress, starvation, and predation; however, the effect is not expected to be at a population level. Fall HFE releases could negatively affect flannelmouth sucker and bluehead sucker indirectly by altering the availability of their food base. Speckled dace generally occupy sheltered shorelines or cobble and gravel bars at the mouths of tributaries or side canyons, where changes in the flow stage cause them to shift to available habitats (Valdez and Ryel 1995). Benthic periphyton and drifting macroinvertebrates become displaced with HFE releases as the high velocities scour the riverbed. In the fall, there is less solar radiation and less photosynthesis at the river level, and recovery of the primary and secondary producers is slower than in the spring. Although HFE releases under the No Action Alternative would scour the food base, the food base recovers more quickly in spring than in fall, and these fish species are capable of weeks with little or no food.

*Nonnative Fish*

It is difficult to determine definitively if and to what extent fish move during HFE releases due to a lack of tagged fish. It is unclear how quickly nonnative fish, such as green sunfish and smallmouth bass, would move into population centers of humpback chub under the No Action Alternative. Rainbow trout dispersal downstream has been largely influenced by trout densities upstream (Korman et al 2016). Despite the high abundance of rainbow trout in Glen and Marble Canyons in 2011 and 2012, there was no apparent decline in the humpback chub population. Smallmouth bass are much more piscivorous than rainbow trout and pose a greater threat if dispersal occurs. However, if displacement occurs during HFE releases, it could also reduce the survival of nonnative fish through habitat deficiency, predation, starvation from reduced food supply, or decreased water clarity from sediment inputs, especially below tributaries, which can impede sight-feeders.

HFE releases would back up water into tributary mouths, creating a large ponding effect; this could potentially allow nonnative fish to more readily access these tributaries and interact with native fish species. In the Little Colorado River, the 1996 HFE release backed up the river water for nearly 1 mile upstream and inundated areas occupied by native fish, possibly leading to higher levels of competition and predation (Webb et al. 1999). In Havasu Creek, the 1996 HFE release inundated small waterfalls that are otherwise upstream fish barriers, allowing mainstem fish to access the stream that is otherwise inaccessible under normal powerplant operations.

The majority of rainbow trout in this alternative's affected area are found in the 15-mile Lees Ferry reach immediately downstream of Glen Canyon Dam. The No Action Alternative would continue to release warm waters as Lake Powell is expected to continue to decline in elevation. Warmer temperatures would increase the growth rate of trout but also bioenergetic demand. Yard et al. (2023) determined that low reservoir elevations result in warmer water temperatures but also lower nutrient concentrations that translate to less production in the Lees Ferry reach and less food for trout. These factors would likely result in lower numbers of rainbow trout in the Lees Ferry reach. Because young fish generally occupy low-angle shoreline habitats that can be inundated or desiccated with changes in flow stage (Korman et al. 2011), HFE releases can have a substantial effect on rainbow trout in Lees Ferry, as the high velocities can displace fish, especially the younger and smaller fish, downstream to reaches where the water clarity, food supply, and habitat are not as suitable.

*Aquatic Food Base*

Under the No Action Alternative, flow regimes would remain like the conditions modeled in the 2016 LTEMP FEIS (DOI 2016a). Low reservoir volumes above the dam would continue to provide low-nutrient waters to areas below the dam, which would result in lower primary and secondary production. This could be offset by the decreased sediment load, where increased light availability would lead to high productivity directly below the dam and through the Lees Ferry reach. Productivity would remain variable farther downstream (Deemer et al. 2022). Under current conditions, phytoplankton populations would remain diverse but less abundant, and the abundance and diversity of macroinvertebrates would continue to provide a limited food supply for native and desired nonnative fish populations, such as rainbow trout (DOI 2016a; Kennedy et al. 2013).

Macroinvertebrate production flows (bug flows) were conducted in 2018, 2019, 2020, and 2022 to improve the productivity and diversity of the aquatic food base and to learn more about the response of the food base to steady flow releases. These experiments demonstrated that steady flow releases increased the abundance of adult life stages of midges and caddisflies, which are dependent on stable nearshore habitats for egg-laying (Kennedy et al. 2016, 2023). Under the No Action Alternative, HFE releases would also continue to be conducted with available sediment supplies in either spring or fall. Under the No Action Alternative, HFE releases would continue under favorable conditions of hydrology and sediment. All HFE releases scour the food base in the Lees Ferry reach, but there is a more rapid recovery following a spring HFE release when higher solar radiation provides a more continuous and relatively greater level of photosynthetic production than after a fall HFE release.

**Cool Mix Alternative**

Under the Cool Mix Alternative, a mix of water would be released simultaneously through the penstocks and the river outlet works to maintain a daily average water temperature of about 15.5°C (60°F) from below Glen Canyon Dam to the Little Colorado River (river mile 61). Cool temperatures of less than 15.5°C (60°F) year-round are expected to lead to minimal to no initiation of spawning by smallmouth bass and possibly other species, such as green sunfish, as well as poor growth and survival of early life stages. These species generally require higher temperatures to successfully spawn and incubate their eggs, and survival and growth of early life stages would lead to little or no recruitment if these temperatures could be maintained year-round. In spring, summer, and fall, water temperatures warm longitudinally downstream of Glen Canyon Dam. Temperatures downstream of the Little Colorado River (river mile 61) have reached 15.5°C (60°F) in recent years, but only occurred rarely before 2022.

A preliminary model from Yackulic et al. (2024, chap. 4) was developed to assess the potential for smallmouth bass population growth rate at river mile 15 and river mile 61 under each of the six alternatives. Based on assumed functional relationships between smallmouth bass population dynamics, available habitat, predicted temperature responses, and rate of entrainment, the model predicts smallmouth bass intrinsic rate of population growth (lambda) at river mile 15 and river mile 61 for each year 2024–2027. For river mile 15, predicted lambda is < 1 for all of the traces in 2024–2027 (**Table 3-29**). For river mile 61, the model predicted lambda is < 1 for all of the traces in 2024–2027. This means that under the Cool Mix Alternative, the smallmouth bass population would not be expected to grow (lambda < 1) in any year at river mile 15 or at river mile 61; hence, this alternative may be effective at controlling reproduction and recruitment of smallmouth bass at either location. Average lambdas and ranges (maximum and minimum values) of 30 traces are provided in **Figure 3-39**. This shows that lambdas would not exceed 1, which means that the smallmouth bass population would not be expected to grow in years 2024–2027 for the Cool Mix Alternative.

*Native Fish*

Cooler temperatures are not expected to negatively affect the following species and their food base: flannelmouth sucker, bluehead sucker, or speckled dace. Native fish species below Glen Canyon Dam routinely encounter temperatures colder than the target temperatures for all flow options (Yackulic et al. 2014). While this alternative would aim to reduce water temperatures, native fish naturally experience water temperatures colder than those expected from this flow option. Cooler temperatures would slow the growth of these species but also increase their survival if abundance and predation rates of nonnative species decline under cooler water conditions. Cooler temperatures may also benefit these species by limiting the maturation and reproductive capabilities of parasites such as the Asian tapeworm and the anchor worm, which require water temperatures of 18°C (64.4°F) or higher to mature and reproduce.

Model results from Yackulic et al. (2024, chap. 4) indicate no smallmouth bass population growth for any of the years at either river mile location. Since lambda values are < 1 for the Cool Mix

Alternative, smallmouth bass population is expected to decline. The Cool Mix Alternative should reduce pressure of negative interactions (i.e., predation) of native fishes by smallmouth bass.

*Nonnative Fish*

Cool temperatures could negatively affect nonnative, warmwater fish, such as smallmouth bass, green sunfish, fathead minnows, red shiners, channel catfish, and common carp. This is the point of the Cool Mix Alternative. Cool temperatures could, in turn, benefit the native fish by potentially reducing competition and predation from nonnative species. For example, the cooler temperatures are intended to delay or disrupt maturation and spawning by smallmouth bass, based on observations in the Upper Colorado River (Bestgen and Hill 2016b). Smallmouth bass typically spawn from May through July in the Upper Basin shortly after the first day when temperatures increase above 15.5°C (60°F) (Bestgen and Hill 2016b). Cool temperatures of less than 15.5°C (60°F) year-round are expected to lead to minimal to no initiation of spawning in smallmouth bass and possibly other species, such as green sunfish, as well as poor growth and survival of early life stages. These species generally require higher temperatures to successfully spawn and incubate their eggs, and survival and growth of early life stages is poor at these temperatures.

Timing the releases of the Cool Mix Alternative to maximize the impact on smallmouth bass spawning in a way that integrates with the natural downstream warming of the Colorado River to river reaches occupied by a higher abundance of native species, such as the confluence with the Little Colorado River (river mile 61), requires detailed assessment. An important unknown is whether nearshore thermal environments may persist that would offer warmer refuge for nonnative species.

Colorado River temperatures throughout the Grand Canyon are highly dependent on release temperature, discharge, solar radiation, and air temperatures (Mihalevich et al. 2020). When discharge is high, downstream temperatures are highly influenced by release temperatures throughout the canyon. However, when discharge is low, river temperatures will more rapidly respond to heat fluxes driven by solar radiation and air temperature, resulting in modest warming before river mile 61. Therefore, when dam release temperatures are warm due to relatively shallow penstock depths and monthly release volumes are low, the downstream extent to which maintaining temperatures below 15.5°C (60°F) will be limited. Mixing cold water from the deeper bypass outlets with warm penstock releases would increase the distance downstream temperatures can be maintained (USGS 2022), mitigating the influence of heat fluxes on lower release volumes. Since smallmouth bass have been detected mainly in the Glen Canyon reach, implementation of this alternative could be effective at reducing the likelihood of successful spawning of smallmouth bass where most fish have been found as of the end of 2023. The effect of cool water releases farther downstream, particularly below river mile 88, would be less pronounced due to warming caused by solar radiation and air temperature, but may still impact smallmouth bass.

Cooler temperatures would create a more favorable thermal environment for rainbow trout. This species has persisted with these lower temperatures since the dam began releasing cold, hypolimnetic waters (deep, colder waters located below the thermocline) in the 1970s. Cooler temperatures may reduce upstream movement of brown trout into the Lees Ferry reach, which would reduce competition and predation on rainbow trout (Runge et al. 2018). Cooler temperatures are not expected to negatively affect rainbow trout's food base.

*Aquatic Food Base*
The cooler temperatures are not expected to negatively affect the aquatic food base. Cooler temperatures could support higher nutrient concentrations, which could stimulate food base production and favor coolwater-adapted macroinvertebrate species, such as midges and blackflies.

**Cool Mix with Flow Spike Alternative**
The Cool Mix with Flow Spike Alternative would release a mix of water through the penstocks and river outlet works to maintain a daily average water temperature below 15.5°C (60°F) from below Glen Canyon Dam to the Little Colorado River (river mile 61), with the goal of disrupting smallmouth bass spawning (same as the Cool Mix Alternative). This target temperature is similar to temperatures observed from 2005 to 2021, when smallmouth bass production was not observed and the humpback chub population increased. For modeling purposes, river mile 15 and river mile 61 were analyzed to cover the area where smallmouth bass may be found. Additionally, up to three 8-hour flow spikes (up to 45,000 cfs) would be added between June and mid-July, if sufficient water is available.

The flow spike would likely disrupt spawning in margin habitats that may be warmer than the mainstem river by cooling these margins. Also, the higher velocity of the flow spikes could scour and displace eggs and fry from nests and likely displace the females during egg construction and deposition, as well as the males that later guard the fertilized eggs and newly hatched fry. The concept of flow spikes is being tested to disrupt the spawning of smallmouth bass in the Green River downstream of Flaming Gorge Dam (Bestgen 2018). Available data to date suggest these flow spikes interrupt smallmouth bass spawning, but it is unclear if smallmouth recruitment is lowered.

A preliminary model from Yackulic et al. (2024, chap. 4) was developed to assess the potential for smallmouth bass population growth rate at river mile 15 and river mile 61 under each of the six alternatives. Based on assumed functional relationships between smallmouth bass population dynamics, available habitat, predicted temperature responses, and rate of entrainment, the model predicts smallmouth bass intrinsic rate of population growth (lambda) at river mile 15 and river mile 61 for each year 2024–2027. For river mile 15, predicted lambda is < 1 for all of the traces in 2024–2027 (**Table 3-29**). For river mile 61, the model predicted lambda is < 1 for all of the traces in 2024–2027. This means that for the Cool Mix with Flow Spike Alternative, the smallmouth bass population would not be expected to grow (lambda < 1) in any year at river mile 15 or at river mile 61; hence, this alternative may be effective at controlling reproduction and recruitment of smallmouth bass at either location. Average lambdas and ranges (maximum and minimum values) of 30 traces are provided in **Figure 3-39**. This shows that lambdas would not exceed 1, which means that the smallmouth bass population would not be expected to grow in the years 2024–2027 for the Cool Mix with Flow Spike Alternative.

In spring, summer, and fall, water temperatures warm longitudinally downstream of Glen Canyon Dam, and temperatures downstream of the Little Colorado River (river mile 61) are expected to warm above 15.5°C (60°F). Also, the high wave of flow spikes is expected to dampen with the distance downstream of Glen Canyon Dam, such that the effect of these stage changes may not be as great downstream of the Little Colorado River, where most native fish populations occur.

*Native Fish*

Cooler temperatures are also not expected to negatively affect the flannelmouth sucker, bluehead sucker, or speckled dace or their food base over the long term. While this alternative would aim to reduce water temperatures, native fish naturally experience water temperatures colder than those expected from this alternative and have increased over the last two decades under a similar thermal regime. Flow spikes are not expected to affect the juveniles and adults of flannelmouth sucker and bluehead sucker; however, they could displace larvae and early juveniles from backwaters and shoreline habitats, leading to reduced survival. This effect is not expected to be at the population level.

Flow spikes would inundate cobble and gravel deposits at the mouths of tributaries and side canyons where speckled dace are common, but this species is able to temporarily relocate along talus shorelines (Valdez and Ryel 1995; Webb et al. 1999). Cooler temperatures would slow the growth of these species but also increase their survival (Yackulic et al. 2014). Cooler temperatures may also benefit these species by limiting the maturation and reproductive capabilities of parasites such as the Asian tapeworm and the anchor worm, which require 18°C (64.4°F) or higher to mature and reproduce (Hoffnagle et al. 2006).

*Nonnative Fish*

Cool temperatures of less than 15.5°C (60°F) year-round are expected to lead to minimal to no initiation of spawning in smallmouth bass and possibly other species, such as green sunfish, as well as poor growth and survival of early life stages. These species generally require higher temperatures to successfully spawn and incubate their eggs, and survival and growth of early life stages is poor at these temperatures. These cool temperatures could also negatively affect other nonnative, warmwater fish, such as fathead minnows, red shiners, channel catfish, and common carp. This could, in turn, benefit the native fish by potentially reducing competition and predation from nonnative species.

The combination of cool temperatures and flow spikes would likely have a greater negative effect on smallmouth bass than cool temperatures alone. Cool temperatures may not reach all habitats or be moderated by warmed shorelines, but spike flows would likely generate high velocities that would affect smallmouth bass nest areas at various depths, depending on the nests' location. These higher velocities would likely scour some nests and displace eggs, fry, and juvenile fish and disrupt the spawning behaviors of adult fish. Also, increased water depths over nest areas would likely make these areas unsuitable for spawning and cause the adults to abandon the nests.

Cooler temperatures are expected to create a more favorable thermal environment for rainbow trout, especially in the Lees Ferry reach. This species has persisted and thrived with these lower temperatures since after Glen Canyon Dam was completed and hypolimnial flows began. Cooler temperatures may reduce upstream movement of brown trout into the Lees Ferry reach, which would reduce the competition and predation on rainbow trout (Runge et al. 2018). Cooler temperatures are not expected to negatively affect the rainbow trout's food base. Spike flows in

May–July could displace juvenile rainbow trout and lead to lower recruitment. These spike flows would not likely affect spawning by rainbow trout because most spawning in the Lees Ferry reach takes place during January–March. Downstream displacement of rainbow trout could lead to increases in interactions with other fish species (Avery et al. 2015).

*Aquatic Food Base*

The cooler temperatures are not expected to negatively affect the aquatic food base, as this temperature range is not colder than the dam release of the last five decades. Similar to the cool mix alternative, cooler temperatures could stimulate food base production through increases in dissolved nutrients and could potentially favor cold-water-adapted taxa such as midges and blackflies. Short-term spike flows would scour the benthos and have negative short-term effects on primary production and macroinvertebrate populations. However, the food base reduction would be temporary and would recover quickly due to relatively high solar radiation and photosynthesis productivity between May and July.

**Cold Shock Alternative**

The Cold Shock Alternative would release water for at least 48 hours through the river outlet works, releasing the minimum amount of water required to create a cold shock all the way down to river mile 61 (confluence with the Little Colorado River) to disrupt smallmouth bass spawning and rearing. A cold shock is achieved through a sudden drop in temperature, with a target temperature of 13°C (55.4°F) or below. This option would begin as soon as daily water temperatures near river mile 61 reach 15.5°C (60°F); after this, weekly use of the river outlet works, anticipated to occur during weekends, would be initiated and would last for up to 12 weeks.

Based on assumed functional relationships between smallmouth bass population dynamics, available habitat, predicted temperature responses, and rate of entrainment, the smallmouth bass model predicts smallmouth bass intrinsic rate of population growth (lambda) at river mile 15 and river mile 61 for each year 2024–2027. For river mile 15, predicted lambda is < 1 for all of the traces in 2024 or 2025 but is predicted to be > 1 for 3 percent of the traces evaluated by 2026 and 2027 (**Table 3-29**). For river mile 61, the model predicted lambda is < 1 for all of the traces in 2024 but is predicted to be > 1 for 3 to 10 percent of the traces evaluated in 2025–2027. This means that for the Cold Shock Alternative, the smallmouth bass population would be expected to grow (lambda > 1) in 2026 and 2027 at river mile 15 and in 2025–2027 at river mile 61; hence, this alternative may not be effective at controlling reproduction and recruitment of smallmouth bass at either location. Average lambdas and ranges (maximum and minimum values) of 30 traces are provided in **Figure 3-39**. This shows that lambdas could be as high as 1.7 with some traces in 2025–2027 at river mile 15 and up to 2.3 in 2027 at river mile 61, which means that the smallmouth bass population would be expected to grow in years 2025–2027 for the Cold Shock Alternative.

*Native Fish*

This alternative would reduce water temperatures, but not to levels that are colder than what native fish likely experienced in a pre-Glen Canyon Dam environment. Adult and large juvenile flannelmouth and bluehead suckers would likely experience slower growth (Hansen et al. 2023). A cold-shock effect could also result in direct mortality of post-larvae and juveniles if it occurred when these life stages are present, in April–May.

*Nonnative Fish*

The Cold Shock Alternative would likely have a negative effect on nonnative, warmwater fish, such as smallmouth bass, green sunfish, channel catfish, common carp, fathead minnows, and red shiners. These species evolved in warmwater environments and are more susceptible to sudden decreases in water temperature than cold-water species; they also have lower growth and survival in cold water. Reduced populations of warmwater nonnative fish would benefit the native, cold-water fish by reducing competition and predation. The cold shock is expected to disrupt nesting and spawning by smallmouth bass. The cold shock would result in direct mortality of eggs and fry, and it could cause abandonment of nest sites by nesting females and males that subsequently guard the eggs and larvae. However, under the most extreme high temperatures, it may not be effective at limiting growth as denoted by the modeling above.

Although adult and juvenile rainbow trout are less susceptible to cold shocks than warmwater species, cold shock treatments may still negatively affect trout physiology and behavior. Recently hatched fry and early juveniles would likely be negatively affected by the sudden decrease in temperature, especially in the Lees Ferry reach, if these cold-shock releases happen between January and June. A sudden cold release could weaken the young fish and displace them from their habitats, resulting in predation, starvation, or eventual death due to a lack of suitable habitat. Downstream displacement of rainbow trout could lead to increases in interactions with other rainbow trout and humpback chub (Avery et al. 2015).

*Aquatic Food Base*

Cold-shock releases would likely negatively affect the aquatic food base, as these cold-water pulses might disrupt macroinvertebrate development and life cycles and could lead to high accidental and behavioral drift of macroinvertebrates. Certain multivoltine species would not be able to complete their life cycles as they otherwise do in warmer temperatures. However, the alternative would also have the smallest range of discharges, which could benefit sensitive macroinvertebrate species that have river-edge egg laying habits. It could also negatively affect univoltine species (that is, those producing a single brood in a season) that have become acclimated to warmer water, especially in the Lees Ferry reach. This could affect the availability of some macroinvertebrate species that constitute the food base. Depending on the magnitude of these releases, the combination of cold temperatures and higher velocities could displace the benthos and reduce the food base; this reduction would persist if these releases were to be continuous.

**Cold Shock with Flow Spike Alternative**

The Cold Shock with Flow Spike Alternative would release water for at least 48 hours through the river outlet works for the minimum amount of time required to create a cold shock all the way down to the Little Colorado River (river mile 61) to disrupt smallmouth bass spawning; this would be the same as the Cold Shock Alternative. In addition, up to three 8-hour flow spikes would be added between June and mid-July, if sufficient water is available. The flow spike would likely disrupt bass spawning in margin habitats that may be warmer than the mainstem river. As much water as possible (up to 45,000 cfs, depending on water availability) would be released through the penstocks and river outlet works during flow spikes. This option would begin as soon as daily water temperatures near the Little Colorado River warm to 15.5°C (60°F). This option would provide weekly 48-hour cold-shock releases for up to 12 weeks and at least one 8-hour spike flow.

A preliminary model from Yackulic et al. (2024, chap. 4) was developed to assess the potential for smallmouth bass population growth rate at river mile 15 and river mile 61 under each of the six alternatives. Based on assumed functional relationships between smallmouth bass population dynamics, available habitat, predicted temperature responses, and rate of entrainment, the model predicts smallmouth bass intrinsic rate of population growth (lambda) at river mile 15 and river mile 61 for each year 2024–2027. For river mile 15, the predicted lambda is < 1 for all of the traces in 2024 or 2025 but is predicted to be > 1 for 3 percent of the traces evaluated in 2026 and 2027 (**Table 3-29**). For river mile 61, the model predicted lambda is < 1 for all of the traces in 2024 but is predicted to be > 1 for 3–10 percent of the traces evaluated by 2025–2027. This means that for the Cold Shock with Flow Spike Alternative, the smallmouth bass population would be expected to grow (lambda > 1) in 2026 and 2027 at river mile 15 and in 2025–2027 at river mile 61; hence, this alternative may not be effective at controlling reproduction and recruitment of smallmouth bass at either location. Average lambdas and ranges (maximum and minimum values) of 30 traces are provided in **Figure 3-39**. This shows that lambdas would be as high as 1.6 with some traces in 2026–2027 at river mile 15 and up to 2.1 in 2027 at river mile 61, which means that the smallmouth bass population would be expected to grow in years 2025–2027 for the Cold Shock with Flow Spikes Alternative.

*Native Fish*

While this alternative would aim to reduce water temperatures, native fish naturally experience water temperatures colder than those expected from each flow option. Adult and older juvenile flannelmouth suckers and bluehead suckers would not likely be negatively affected by the Cold Shock with Flow Spike Alternative, although colder water and higher water velocity would be expected to result in slower growth rates (Hansen et al. 2023). Weekly use of cold-shock events could reduce the growth and survival of young flannelmouth suckers and bluehead suckers. A cold-shock effect combined with flow spikes could also result in direct mortality of post-larvae and juveniles if it occurred when these life stages are present, April–May. The Yackulic et al. (2024, chap. 4) model indicated that this alternative results in less smallmouth bass population growth than the No-Bypass or No Action Alternative, and therefore, this Alternative would likely result in somewhat reduced pressure from interactions of native fish with nonnative fishes compared with the No-Bypass and No Action Alternatives.

*Nonnative Fish*

The Cold Shock with Flow Spike Alternative would likely have a larger impact on nonnative, warmwater fish, such as smallmouth bass, green sunfish, channel catfish, common carp, fathead minnows, and red shiners, than native species. These species evolved in warmwater environments and have lower growth and survival in cold water. However, these species also have very large native population ranges, which demonstrate their ability to adapt and persist across a wide range of climates. Reduced populations of warmwater nonnative fish would possibly benefit the native cold-water fish by reducing competition and predation.

The Cold Shock with Flow Spike Alternative is designed to disrupt smallmouth bass spawning by keeping temperatures below suitable spawning conditions and by increasing the depths and velocities at nest locations. This option is based on experimental work in the Upper Basin (Bestgen 2018). In theory, this option would disrupt maturation and spawning by smallmouth bass and also disrupt water and habitat conditions in nest areas. The higher velocity and deeper water could likely displace females in the act of spawning, as well as males guarding eggs and fry. The higher velocity could also displace eggs and fry; combined with cold temperatures, the higher velocity might kill most of the embryos. However, under the most extreme high temperatures, it may not be effective at limiting growth as denoted by the modeling above.

Adult and juvenile rainbow trout are more resistant to cold shocks than warmwater species. These cold releases could adversely affect trout physiology and behavior but are not expected to substantially affect the population in the Lees Ferry reach. However, recently hatched fry and early juveniles would likely be negatively affected by the sudden decrease in temperature, especially in the Lees Ferry reach. A sudden cold release could weaken the young fish and displace them from their habitats, resulting in predation, starvation, or eventual death due to a lack of suitable habitat. Flow spikes in spring could displace juvenile rainbow trout from low-angle shoreline habitats and expose them to predation or starvation (Korman et al. 2011). Downstream displacement of rainbow trout could lead to increases in interactions with other rainbow trout and humpback chub (Avery et al. 2015). It is unclear how a cold shock would affect rainbow trout, but reduced feeding behavior and metabolic and growth rates may be anticipated (Yackulic et al. 2014; Van Haverbeke et al. 2017), as indicated by the 15.5°C–18°C (60°F–64.4°F) optimal growth range for rainbow trout (Mishra et al. 2021).

Additionally, spike flows could create spawning and rearing habitat for rainbow trout on high-elevation cobble and gravel bars (USGS 2011), if spawning were to occur between June and mid-July. The survival of trout eggs and fry in these high-elevation habitats would depend on the duration of the elevated flow; flows of short duration would likely strand the eggs and fry (Korman and Melis 2011).

*Aquatic Food Base*

Cold-shock releases would likely negatively affect the aquatic food base, as these cold-water pulses might disrupt macroinvertebrate development and life cycles and could lead to high accidental and behavioral drift of macroinvertebrates. Certain multivoltine species would not be able to complete their life cycles as they otherwise do in warmer temperatures. However, the Cold Shock with Flow Spike Alternative would also have the smallest range of discharges, which could benefit sensitive macroinvertebrate species that have river-edge egg laying habits. It could also negatively affect univoltine species that have become acclimated to warmer water, especially in the Lees Ferry reach. This could affect the availability of some macroinvertebrate species that constitute the food base. Depending on the magnitude of these releases, the combination of cold temperatures and higher velocities could displace the benthos and reduce the food base; this reduction would persist if these releases were to be continuous. Flow spikes that coincide with spring or early summer (May–July) could stimulate food base production, and recovery of the food base would be quicker. Flow spikes that occur later in the summer (August–September) may not have a stimulatory effect, and recovery of the food base would likely take longer owing to natural seasonal declines in primary production and a greater likelihood of high suspended sediment conditions, which reduce productivity rates.

**Non-Bypass Alternative**

The Non-Bypass Alternative consists of weekly flow spikes using a combined action of lowering and then increasing the river stage within the range of the powerplant's capacity; this alternative would use only the penstocks and would not involve the river outlet works. This alternative is proposed as an experiment that would use low releases to cause smallmouth bass to abandon nests in shallower nearshore habitats, such as backwaters and sloughs, and higher-velocity releases to displace eggs and fry, or cause abandonment by male smallmouth bass, from nests in deeper water nearer the main channel. It would also disrupt and potentially cause stranding and desiccation to eggs and fry of smallmouth bass.

Based on assumed functional relationships between smallmouth bass population dynamics, available habitat, predicted temperature responses, and rate of entrainment, the smallmouth bass model predicts smallmouth bass intrinsic rate of population growth (lambda) at river mile 15 and river mile 61 for each year 2024–2027. For river mile 15, the predicted lambda is < 1 for all of the traces in 2024 but is predicted to be > 1 for 7–17 percent of the traces evaluated for 2025–2027 (**Table 3-29**). For river mile 61, the model predicted lambda is < 1 for 3 percent of the traces in 2024 and 3–17 percent of the traces evaluated in 2025–2027. This means that for the Non-Bypass Alternative, the smallmouth bass population would be expected to grow (lambda > 1) in all years but 2024 at river mile 15 and in all years (2024–2027) at river mile 61; hence, this alternative may not be effective at controlling reproduction and recruitment of smallmouth bass at either location. Average lambdas and ranges (maximum and minimum values) of 30 traces are provided in **Figure 3-39**. This shows that lambdas would be about 2 for some traces in 2025–2027 at river mile 15 and at river mile 61, which means that the smallmouth bass population could be expected to double in these locations for the years 2025–2027 under the Non-Bypass Alternative.

For timing, low releases would occur late Sunday night (9:00 p.m. to 1:00 a.m.) and high releases would occur early Monday morning (7:00 a.m. to 11:00 a.m.). For the duration, low releases would be long enough (4 hours) to dewater active, low-angle spawning habitats but short enough to allow for a subsequent high flow to collapse the low-flow trough at some desired point downstream (as part of the longitudinal kinematic wave). High releases would be long enough (4 hours) to increase the velocity in active spawning habitat and collapse the low-flow trough at some desired point downstream. The magnitude of releases would be low enough to dewater active, low-angle spawning habitat (2,000 cfs) and high enough to increase the velocity in active spawning habitat (powerplant capacity of up to 30,000 cfs); a stage change would provide a 1.6- to 3.3-foot change below and a 3.3- to 6.6-foot change above the minimum for normal operations.

The frequency of releases would be weekly to keep bass from successfully renesting. The weekly spikes would be triggered when temperatures reach 15.5°C (60°F) in areas where bass are observed spawning (that is, the -12 mile slough). By keeping the durations of the low flow and the high flow short (that is, 4 hours), the trough created by the low flow would be collapsed by the wave created by the high flow such that the minimum flow at the Little Colorado River would never fall below 5,000 cfs (the minimum flow specified in the ROD) and the high flow would attenuate in such a way that the maximum flow at the Little Colorado River would stay below 25,000 cfs (the maximum nonexperimental flow specified in the ROD).

*Native Fish*

High flows within the powerplant's capacity would be experienced by flannelmouth sucker, bluehead sucker, and speckled dace. Young life stages would likely remain along sheltered talus shorelines. Although some young fish may become displaced from shorelines or backwaters and exposed to predation and starvation, the effect of these high flows on these species is expected to be minimal. Weekend flows of 2,000 cfs, if they occurred April–June, could negatively affect young and juvenile flannelmouth suckers and bluehead suckers that could be displaced from dewatered shoreline habitats and backwaters. Older juveniles and adults are not expected to be negatively affected by short-term low flows followed by high flows. Speckled dace have been observed to move and adjust locations along shoreline habitats with flow stages (Valdez and Ryel 1995; Webb et al. 1999).

The native Colorado River Basin fish evolved in a highly variable flow environment of flow, turbidity, and temperature variation. Under the Non-Bypass Alternative, a low short-term release would be followed by a high short-term release. This flow variability is not characteristic of Colorado River hydrology, which is better described as increasing flows in late winter and early spring to peak flows in spring than a declining hydrograph, all taking place generally from about April to mid-June. Monsoonal floods in summer may be akin to the high releases of this alternative, but they are not generally preceded by an extremely low flow (2,000 cfs). Hence, the response by the native fish to the hydrology of this alternative is uncertain, but the contrast in hydrology between low and high flows could displace and stress some fish, especially younger fish. Also, the extremely low flows of 2,000 cfs are likely to dewater shallow and shoreline habitats. Although these flow variations are expected to ameliorate downstream, effects on habitat and fish displacement could be experienced by the humpback chub aggregation at river mile 30 and possibly further downstream to the mouth of the Little Colorado River at river mile 61. Continued warmer releases under the Non-Bypass Alternative are likely to increase the infestation rates of certain fish parasites, including the Asian tapeworm and the Lernaea copepod.

*Nonnative Fish*

High flows within the powerplant's capacity are not expected to negatively affect adult nonnative fish; however, some young could be displaced from their habitats, as these fish experience this flow range under current operations. Weekend flows of 2,000 cfs could negatively affect nonnative, warmwater fish, such as smallmouth bass, green sunfish, channel catfish, common carp, fathead minnows, and red shiners. These low flows would dewater shallow shoreline habitats and backwaters that are preferred (but not required) habitats of these species and displace them to the mainstem, leading to increased predation and starvation. For smallmouth bass, rising water would flush solar-warmed shoreline nest areas with water at the temperature of the main river, potentially causing nest desertion and halting embryo development if the main river temperatures are significantly lower. Rising flows could also displace juvenile and adult smallmouth bass from preferred habitats and possibly lead to starvation and predation. Subsequent falling water levels could drive spawning females and guarding males from nests, exposing the eggs and fry to predation and to less water circulation and aeration of the eggs. The low flow (2,000 cfs) element of the non-bypass flow alternative will dewater margins and shallow habitats, negatively affecting young trout and their food base.

High flows within the powerplant's capacity would be experienced by rainbow trout. No effect is expected on adults. Changes in the flow stage are expected to displace young and juvenile trout and expose these fish to starvation and predation, or possibly displace them downstream to population centers of native fish where they can prey on and compete with those fish. Downstream displacement of rainbow trout could lead to increases in interactions with other rainbow trout and humpback chub (Avery et al. 2015). Weekend flows of 2,000 cfs could negatively affect eggs and fry through desiccation, if they occurred January–March. These flows could displace juveniles and lead to reduced survival from predation or starvation. Adult rainbow trout would not be as negatively affected, as the larger fish are able to shift habitat during dramatic flow changes.

*Aquatic Food Base*

The Non-Bypass Alternative could negatively affect the food base in Lees Ferry and the Grand Canyon. The effects of high flows following low flow events would likely result in lower diversity and productivity rates. Although the low flow would occur for 4 hours during the nighttime in Lees Ferry, during hot summer months, Blinn et al. (1995) found nighttime exposure and desiccation had similar adverse effects on food base organisms as daytime desiccation. Specifically, the 12-hour daytime desiccation and 12-hour nighttime desiccation treatments repeated over 5 days described in Blinn et al. (1995) both resulted in greater than 50 percent loss of algae (Cladophora) biomass, greater than 75 percent reduction in Chironomid biomass, and greater than 75 percent reduction in Gammarus biomass compared with control treatments that were not exposed to desiccation.

The low flow would only be around 2,000 cfs and shorter than 4 hours near the Little Colorado River owing to hydrodynamics. This could still have an adverse impact on the food base, however, because most of the primary and secondary production in the Grand Canyon is restricted to shallow shelves that would be exposed by the low flow (Hall et al. 2015; Cross et al. 2013). The low flows would last for 4 hours at Lees Ferry and would be of even shorter duration at downstream locations, which would probably reduce the impact of the low flow compared with the 12-hour desiccation trials repeated over 5 days that are described in Blinn et al. (1995).

Additionally, the low flows would only occur once per week, which could allow for some recovery of the food base, compared with the 5 sequential days of desiccation that are described in Blinn et al. (1995). However, the low flow would be repeated for 12 weeks, including late in the summer, which may potentially limit the recovery of the food base. The low flows would also be followed by a high flow of up to 28,000 cfs (the magnitude would decrease in the downstream direction), which could scour food base organisms that had previously been desiccated and weakened by the low flow. Thus, the Non-Bypass Alternative could have an adverse impact on food base diversity and production in both Lees Ferry and the Grand Canyon.

**Cumulative Effects**

Overall, the cumulative effects of these Action Alternatives on native and federally listed fish would likely be temporary and beneficial overall. This is because the flow options are meant to disrupt smallmouth bass spawning and recruitment.

Cumulative impacts on adult rainbow trout would likely be negligible because rainbow trout can adjust to changes in flow and temperature. While cooler temperatures would likely create a more favorable thermal environment for rainbow trout, cold shocks may adversely affect trout physiology and behavior, particularly in juveniles. Additionally, young rainbow trout would likely be displaced from low-angle shoreline habitats by changing flow volumes and temperatures (Korman and Campana 2009). This could lower their overall survival rates and potentially decrease the abundance of trout in Lees Ferry. Therefore, cold shocks may reduce the number of trout migrating downstream to sites in the Grand Canyon and potentially decrease interactions with native fish.

The cumulative impacts on the aquatic food base from the Action Alternatives would likely be temporary and likely would not have major impacts on the productivity, abundance, or diversity of aquatic organisms. These impacts would result from changes to the water quality (derived from fluctuations in the water temperature and nutrient concentrations, in particular) and the fluctuation of water depth downstream of the dam. All flow options (except the Non-Bypass Alternative) would operate within the spatial and temporal bounds and under the assumptions of the existing analysis conducted in the 2016 LTEMP FEIS (DOI 2016a). Therefore, cumulative impacts on organisms of the aquatic food base would not differ substantively from those included in the 2016 LTEMP FEIS.

The effects of a low flow of 2,000 cfs on the food base have not been studied; however, the alternative could result in lower diversity and productivity rates because the low flows would be followed by a high flow of up to 28,000 cfs, which could scour food base organisms that had previously been desiccated and weakened by the low flow. The low flow would be repeated for 12 weeks, including late in the summer, which may temporarily limit the recovery of the food base; however, the effect is not expected to be long-term.

NPS is considering whether to mechanically modify the slough located 3 miles downstream of Glen Canyon Dam, where nonnative fish, including green sunfish and smallmouth bass, have been found to persist and have recently (in 2022 and 2023) reproduced. Removal of this known spawning site for these species should help to reduce the threat of these species in the Lees Ferry reach and possibly downstream.

### *Summary*

Five action alternatives, as well as a no action alternative, are evaluated. The primary goal of the five action alternatives is to disrupt spawning and cause recruitment failure by invasive smallmouth bass through the use of high- or low-flow releases from Glen Canyon Dam and changes in water temperatures. These alternatives are based on information provided by various working groups and the scientific literature in both the Upper and Lower Colorado River Basins.

For the Colorado River ecosystem below Glen Canyon Dam, efforts are ongoing to develop predictive models that integrate information from the native and introduced range of smallmouth bass into a framework that allows for the evaluation of these different alternatives as a predictive model. The results of this model, which predicts smallmouth bass population responses to each alternative, were included in this evaluation and as well as the report from Yackulic et al. (2024, chap. 4). The provided modeling efforts do not integrate predicted smallmouth bass and native fish population dynamics under each of the alternatives; the model only predicts smallmouth bass population responses. The evaluations of the five action alternatives are based on the information that is available, including the SMB EA (BOR 2023) and the Smallmouth Bass Ad Hoc Group report (2023). This report encapsulated the combined efforts and contributions of all AMWG members, including federal agencies engaged in plan implementation. The document titled "Invasive Fish Species below Glen Canyon Dam: A Strategic Plan to Prevent, Detect and Respond" (Smallmouth Bass Ad Hoc Group 2023) received approval from the AMWG.

The cold-water alternatives use both penstock releases and the river outlet works to generate either high flows or spikes and cooler releases or cold shocks. Only the Non-Bypass Alternative uses the penstocks and not the river outlet works. Each of the five action alternatives has the potential to disrupt smallmouth bass spawning and recruitment by either dewatering or inundating nesting areas, creating unsuitable water temperatures and water velocities, or both. Potentially, the most effective alternatives for disrupting smallmouth bass spawning are the Cool Mix and the Cool Mix with Flow Spike Alternatives, as these alternatives theoretically would disrupt the physical habitat of smallmouth bass nesting as well as the suitable and necessary temperature regimes. This is supported by the preliminary modeling work by Yackulic et al. (2024, chap. 4), along with the explicit assumptions in that model. A detailed evaluation of model uncertainties, such as how available habitat changes under different alternatives, the influence of turbidity, prey resources, and the entrainment rate of smallmouth bass, would help to characterize the uncertainty of the model predictions.

From the Upper Basin, the preliminary analyses of the 2021 and 2022 flow experiment below Flaming Gorge Dam to disrupt smallmouth bass spawning document that spawning was disrupted, but it is unclear from the available data whether smallmouth bass spawning and recruitment were interrupted (Bestgen et al. 2022). Previous flow experiments below Glen Canyon Dam to interrupt rainbow trout spawning caused mortality of rainbow trout eggs and fry, but recruitment did not decline because of compensatory survival of the remaining young rainbow trout (Korman et al. 2011).

Generally, the five action alternatives are not expected to have a negative population-wide effect on native fish, as these species have adapted to a large range of flows and temperatures in the Colorado River. However, all alternatives assume that the establishment of smallmouth bass will have impacts on native fish populations, consistent with information in the Smallmouth Bass Ad Hoc Group report (2023). These action alternatives are not expected to have long-term negative effects on rainbow trout in the Lees Ferry reach or on the aquatic food base. The No Action Alternative and Non-Bypass Alternative are expected to result in warmer water temperatures and lower dissolved oxygen in the Lees Ferry Reach, which could be detrimental to rainbow trout.

The proposed flow alternatives are intended to disrupt nest-builders (smallmouth bass, green sunfish, bluegill, largemouth bass). There is less effect on native broadcast spawners because of the widespread area and elevation of incubating eggs and the emergence and transport of the larvae.

# 3.6 Terrestrial Resources and Wetlands

## 3.6.1 Affected Environment

### *Riparian Vegetation*

This section supplements the 2016 LTEMP FEIS (DOI 2016a) for vegetation with a summary of the affected environment, as provided in the 2016 LTEMP FEIS, and supplemented, as necessary, to include changes that have occurred since 2016.

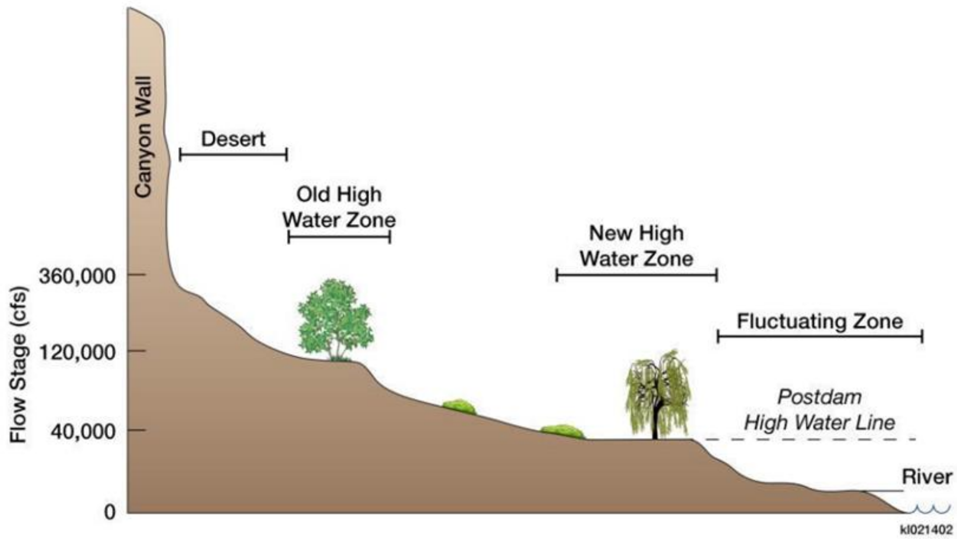
As described in the 2016 LTEMP FEIS, vegetation along the Colorado River corridor from Glen Canyon Dam to Lake Mead is affected by the peak magnitudes, daily fluctuations, and seasonal pattern of river flows. Most evidence indicates that riparian vegetation composition, structure, distribution, and function are closely tied to ongoing Glen Canyon Dam operations (DOI 2016a). Since Glen Canyon Dam operations began, there have been dramatic changes in the distribution and composition of riparian vegetation communities (Sankey et al. 2015; Turner and Karpiscak 1980; Webb et al. 2011). There has been a net increase in riparian vegetation cover and density as a result of altered flow regimes, including increases in both native and nonnative species (Durning et al. 2021; Sankey et al. 2015; Stevens et al. 1995).

Along the Colorado River ecosystem, a steep temperature gradient of approximately 5°C (41°F) drives broader floristic patterns. Four distinct floristic groups occur longitudinally and are associated with Glen Canyon (river miles -15.5 to 0), Marble Canyon (river miles 0 to 61), eastern Grand Canyon (river miles 61 to 160), and western Grand Canyon (river miles 160 to 240) (Yackulic et al. 2024, chap. 7). Within those floristic groups, plant communities are structured by hydrologic zones related to dam operations (described below). Communities differ among the areas inundated by daily river fluctuations (inundated by flows up to 25,000 cfs), HFE releases (between 25,000 and 45,000 cfs), and exceptional and rare releases over 45,000 cfs.

There are indications that the hotter temperatures of eastern and western Grand Canyon modify preferred hydrologic conditions for some plant species, particularly on large sandbars (Yackulic et al. 2024, chap. 7). The prevalence of native species in this system is related to the timing of both high- and low-flow periods, where high flows during the summer maximize native plant richness and low flows in the winter are associated with greater proportions of native species relative to nonnative species. Thus, air temperature, the minimum discharge of the daily fluctuations during the lowest streamflow period, the peak discharge of daily fluctuations during the highest streamflow period, and the maximum discharge of the year (larger for HFE years) are key variables shaping riparian plant communities along the Colorado River corridor (Yackulic et al. 2024, chap. 7).

Existing vegetation communities are described in detail in the 2016 LTEMP FEIS (DOI 2016a). For the purpose of this SEIS, the definition of the riparian zone is consistent with the definition provided in the 2016 LTEMP FEIS. Riparian vegetation includes all plant species found within the fluctuating zone, new high-water zone (NHWZ), and old high-water zone (OHWZ) of the mainstem Colorado River downstream of Glen Canyon Dam, as first described by Carothers and Brown (1991) and shown in **Figure 3-40**.

**Figure 3-40**
**Riparian Vegetation Zones along the Colorado River below Glen Canyon Dam**




Sources: Adapted from Carothers and Brown 1991; Reclamation 1996; DOI 2016a

### Historical and Remnant Riparian Communities

Prior to Glen Canyon Dam's construction, the riparian community was shaped by seasonal flow patterns, sediment transport, turbidity, and nutrient pulses (Johnson 1991). Large-stature woody tree species were largely absent from the system; however, individual specimens of Fremont cottonwood (*Populus fremontii*) and willows (*Salix* spp.) were identified and recorded prior to the dam's construction (DOI 2016a). Other historical woody species in this reach of the Colorado River included mesquite (*Prosopis glandulosa*), New Mexico olive (*Forestiera pubescens*), Apache plume (*Fallugia paradoxa*), and netleaf hackberry (*Celtis reticulata*) (DOI 2016a; Ralston et al. 2005).

Nonnative tamarisk (*Tamarix ramosissima*) was introduced to the Colorado River Basin in the 1800s and documented before the dam (Ralston 2005). Theis species mainly occupied areas of the OHWZ and relied primarily on surface water flows and periodic flooding events to saturate the soil (DOI 2016a). The OHWZ provides important habitat for nesting birds, reptiles, amphibians, mammals, and insects (Carothers and Brown 1991; Reclamation and NPS 2016). Although there has been an increasing trend in riparian vegetation aerial cover and density since the dam's operation began, desirable plant species, such as cottonwoods and willows, remain extremely rare (Durning et al. 2017; Palmquist et al. 2018).

### Existing Riparian Communities

Since Glen Canyon Dam operations began in 1963, the riparian environment has become more stable, with increased and more consistently available groundwater and few destructive floods; this is due to regulated flow releases and cessation of seasonal flooding events (Johnson 1991). Geomorphological and physical changes caused by low water volumes have led to a downslope migration of riparian vegetation, resulting in the designation of an NHWZ (DOI 2016a). The NHWZ is dominated by grasses and fast-growing shrub species such as arrowweed (*Pluchea sericea*), seepwillow (*Baccharis salicifolia* and *B. emoryi*), desert broom (*Baccharis sarothroides*), honey mesquite (*Prosopis glandulosa*), and nonnative tamarisk (Reclamation and NPS 2016; Johnson 1991).

The fluctuating zone (also referred to as the varial zone) is the lowest riparian zone adjacent to the river's wetted edge. The fluctuating zone is subjected to frequent changes in water flow, and vegetation is composed of a mix of mainly grasses and flood-tolerant shrubs with a few forbs, sedges, and rushes that can withstand periodic scouring events and inundation (Reclamation and NPS 2016; Durning et al. 2021; Palmquist et al. 2018). Prior to the dam's construction, fluvial marsh and wetland habitats were primarily associated with perennial tributaries and springs (Webb et al. 2002). However, decreased seasonal variability of flow levels and increased base flows have led to the expansion of perennial species in the fluctuating zone and NHWZ (Sankey et al. 2005).

The distribution and diversity of both native and nonnative plant species have increased since the dam's operations began (DOI 2016a). For example, the recruitment of some species, such as mesquite and hackberry, is rarely observed in the OHWZ; however, these species are now recruiting in the NHWZ (DOI 2016a). Arrowweed, a dominant native woody species, is found in both the OHWZ and NHWZ (DOI 2016a). Other native species, such as Goodding's willow (*Salix gooddingii*) and Fremont cottonwood, have experienced a decline in population due, at least in part, to the reduction in flood flows on upper riparian terraces and foraging by beavers on cottonwood seedlings (Reclamation and NPS 2016; Mortenson et al. 2008; Stevens et al. 2001). Tamarisk, however, has become widespread throughout all riparian zones below the dam. Also, there has been a general increase in vegetation since dam operations began (Bedford et al. 2018; Mortenson et al. 2008). Increased riparian vegetation, regardless of its native status, provides valuable habitat for many wildlife, avian, amphibious, and invertebrate populations (DOI 2016a).

During the development of the 2016 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 2016 LTEMP ROD.

The restoration project specifically seeks to address four specific vegetation issues influenced by dam operations that emerged in the 2016 LTEMP FEIS: (1) encroachment of vegetation on sandbars, (2) the decrease in native plant species, (3) erosion of archaeological resources, and (4) narrowing and loss of plants in the OHWZ (DOI 2016a). Implementation of HFE releases under LTEMP has influenced riparian vegetation in this reach. In 2012, an HFE protocol was developed to improve sediment conservation downstream of the Paria River. This protocol was adopted under LTEMP and has influenced riparian vegetation in this reach. Since 2012, six HFE releases have been conducted; the most recent was in April 2023.

In August 2021, the NPS, in coordination with GCMRC, developed a Long-Term Experimental and Management Plan Riparian Vegetation Project Plan (NPS and GCMRC 2021) that provides guidance for non-flow experimental vegetation treatments to accomplish the following objectives:

(1) control nonnative plant species affected by dam operations, including tamarisk and other highly invasive species; (2) develop native plant materials for replanting through partnerships and the use of regional greenhouses; (3) replant native plant species at priority sites along the river corridor, including native species of interest to Tribes; (4) remove vegetation encroaching on campsites; and (5) manage vegetation to assist with cultural site protection.

#### *Special Status Plant Species*

Several special status species found within the Colorado River corridor are outside the zone of the dam's operational effects (DOI 2016a); therefore, they were dismissed from further consideration.[29]

### 3.6.2 Environmental Consequences

#### *Methodology*

Analysis in this section is informed by hydrologic and vegetation models showing the effects of dam releases on the hydrology and riparian vegetation. As discussed in the 2016 LTEMP FEIS, the primary effects on riparian vegetation below Glen Canyon Dam would be a direct function of the changes in flow regimes under each alternative. The vegetation model (Butterfield and Palmquist 2023) has several limitations that should be noted when considering the modeling results. The model was designed as a conceptual model, as opposed to a predictive model; therefore, the results are used in this analysis carefully and in combination with the literature, because the model is a simplification with limitations in the ability to assess on-the-ground changes. However, it is the best available tool for the impact analysis, when used in conjunction with field studies and literature. The environmental consequences for riparian vegetation are presented as a discussion of how each alternative may affect the proportion of native cover, total species richness, and total vegetation cover relevant to the plant community composition.

**Impact Analysis Area**

The analysis area is consistent with the 2016 LTEMP FEIS and includes the Colorado River mainstem corridor and associated riparian zones located primarily from the forebay of Glen Canyon Dam to Pearce Ferry above Lake Mead. Modeling data were subdivided for the analysis into three regions: Marble Canyon, eastern Grand Canyon, and western Grand Canyon. These regions are floristically distinct and experience different climate conditions; thus, it was determined appropriate to provide separate assessments for each region.

**Assumptions**

- Upland habitat would not be impacted by flow alterations.
- Lake Mead and Lake Powell would not be influenced because annual flows will remain the same.
- The biological analyses depend on the data inputs, modeling assumptions, and validity of the models.

[29] Zoom call between Emily Palmquist, USGS, and Stephen Zipper and Katelyn Cary, SWCA Environmental Consultants, on December 1, 2022.

- The vegetation modeling (Yackulic et al. 2024) assumptions include the following:
  - Five alternative scenarios were compared against the No Action Alternative, such that results indicate changes in suitable habitat relative to the No Action Alternative.
  - Thirty hourly traces provided by the GCMRC for each scenario were used in the analysis.
  - Riparian plant community data from 44 Northern Arizona University sandbar sites collected in 2014 through 2019, coupled with the digital elevation models of those sandbars provided by the GCMRC, were used to train the models. The elevation of each plant community monitoring plot above the river stage was calculated at 15-minute intervals during the year prior to data collection. These elevations were used as estimates of the depth to groundwater and inundation experienced by the plants in those plots. Three hydrologic variables were extracted from the distribution of elevations above river stage: the 95th percentile, 5th percentile, and minimum elevation. These hydrologic variables reflect the trough of daily fluctuations during the lowest streamflow month of the year, the peak of daily fluctuations during the highest streamflow month of the year, and the peak of the HFE release.
  - Analyses were also subdivided into groups of traces with similar lake elevations: 0–10 percent; 10–25 percent; 25–50 percent; and 50–100 percent. The driest 10th percentile traces are represented in the discussion of impacts below.
  - The three hydrologic variables (native cover, total species richness, and total vegetation cover), along with the minimum temperature, mean annual precipitation, and insolation, were used as predictor variables to train the habitat suitability models for each of 47 common riparian plant species using maximum entropy (Maxent) algorithms.
  - This modeling approach can address changes to shifts in the highest flows and lowest flows (that is, no HFE releases versus having HFE releases), but it does not account for flow frequency or timing. Thus, changes in plant species' habitat suitability due to alterations in the frequency, timing, or duration of HFE releases are not reflected by these analyses.
  - The plant communities represented by these analyses are the floristic communities of Marble Canyon, eastern Grand Canyon, and western Grand Canyon on large sandbars of considerable recreational and ecological value.

#### Impact Indicators
The indicators are changes in riparian vegetation composition, structure, and distribution.

### *Issue 1: How would flow alterations at Glen Canyon Dam affect riparian vegetation?*

#### No Action Alternative
Under the No Action Alternative, no changes would be made to Glen Canyon Dam's operations. The flow regime and sediment transport conditions would remain consistent with the management actions described in the 2016 LTEMP FEIS (DOI 2016a). Riparian vegetation communities would continue along current trajectories. As water volumes in the Colorado River continue to decrease in response to regional drought conditions, it is likely that species' recruitment would continue to occur

in the lower riparian zones, unless sediment availability and habitat become limiting factors. Upper riparian zones may transition to desert ecosystems.

**Cool Mix Alternative**

The Cool Mix Alternative is a mix of water released simultaneously through the penstocks and the river outlet works to maintain a daily average water temperature of about 15.5°C (60°F) from below Glen Canyon Dam to the Little Colorado River to disrupt smallmouth bass spawning. Under this alternative, HFE releases would also be implemented. The Cool Mix Alternative would have consistent releases that result in flow patterns similar to the patterns under current management. Therefore, overall, this alternative is expected to have similar impacts on riparian vegetation as the No Action Alternative described above.

In Marble Canyon, this alternative would result in a negligible increase in the proportion of native versus nonnative vegetation cover, a negligible decrease in species richness, and a small increase in total vegetation cover, compared with the No Action Alternative. In eastern Grand Canyon, this alternative would result in a negligible decrease in the proportion of native versus nonnative vegetation cover, a negligible increase in species richness, and a small increase in total vegetation cover, compared with the No Action Alternative. In western Grand Canyon, this alternative would result in a negligible decrease in the proportion of native versus nonnative vegetation cover, a small increase in species richness, and a small increase in total vegetation cover, compared with the No Action Alternative.

**Cool Mix with Flow Spike Alternative**

The Cool Mix with Flow Spike Alternative would include consistent releases from the river outlet works to maintain a daily average water temperature of about 15.5°C (60°F) with flow spikes that would consist of 8-hour periods of elevated flows between May and July to reduce water temperatures and disrupt smallmouth bass spawning. Because these flow spikes would be of a similar magnitude as HFE releases previously conducted (up to 45,000 cfs), spikes would have similar impacts on riparian vegetation as HFE releases.

In Marble Canyon, this alternative would result in no change in the proportion of native versus nonnative vegetation cover, a negligible decrease in species richness, and no change to a negligible increase in total vegetation cover (depending on the flow spike scenario), compared with the No Action Alternative. In the eastern Grand Canyon, this alternative would result in a negligible decrease in the proportion of native versus nonnative vegetation, no change in species richness, and a negligible to small increase in total vegetation cover (depending on the flow spike scenario), compared with the No Action Alternative. In the western Grand Canyon, this alternative would result in a negligible decrease in the proportion of native versus nonnative vegetation cover, a negligible decrease or negligible increase in species richness (depending on the flow spike scenario), and a negligible to small increase in total vegetation cover (depending on the flow spike scenario), compared with the No Action Alternative.

**Cold Shock Alternative**

The Cold Shock Alternative would release water for at least 48 hours through the river outlet works, releasing the minimum amount of water required to create a cold shock all the way down to the

Little Colorado River to disrupt smallmouth bass populations. The Cold Shock Alternative would also include the implementation of HFE releases of similar magnitude to flow spikes under the Cool Mix with Flow Spike Alternative. Therefore, the impacts on riparian vegetation from the Cold Shock Alternative would be similar to those described for the Cool Mix with Flow Spike Alternative.

**Cold Shock with Flow Spike Alternative**

The Cold Shock with Flow Spike Alternative would release water for at least 48 hours through the river outlet works for the minimum amount of time required to create a cold shock all the way down to the Little Colorado River to disrupt smallmouth bass spawning. In addition, up to three 8-hour flow spikes would be added between June and mid-July. The flow spikes would be similar in magnitude to HFE releases; thus, the Cold Shock with Flow Spike Alternative would have flow patterns like those under the Cool Mix with Flow Spike Alternative. Impacts on riparian vegetation would be the same as those listed above for the Cool Mix with Flow Spike Alternative.

**Non-Bypass Alternative**

The Non-Bypass Alternative would result in higher daily fluctuations in flows with weekly drops in flow to a minimum of 2,000 cfs followed by a steep increase in flow to a maximum of approximately 27,300 cfs. These changes would last for approximately 8 hours at the dam. Compared with the other flow alternatives, the Non-Bypass Alternative would have daily flow fluctuations that could reduce shoreline stability.

In Marble Canyon, this alternative would result in a small increase in the proportion of native versus nonnative species cover, a small increase in species richness, and a small decrease in total vegetation cover, compared with the No Action Alternative. In the eastern Grand Canyon, this alternative would result in a small increase in the proportion of native versus nonnative species cover, a small increase in species richness, and a small decrease in total vegetation cover, compared with the No Action Alternative. In the western Grand Canyon, the effects of this alternative would be most pronounced and would result in a moderate increase in the proportion of native versus nonnative species cover, a small increase in species richness, and a small decrease in total vegetation cover, compared with the No Action Alternative.

**Cumulative Effects**

The effects of the LTEMP SEIS alternatives on riparian vegetation would be negligible to small; they are not expected to contribute significantly to cumulative impacts along the Colorado River corridor. The -12 mile slough (approximately 3 miles downstream of Glen Canyon Dam) currently provides warmwater spawning habitat for nonnative fish and supports patchy wetland vegetation. There is a proposal to modify and restore a side channel and narrow the lower slough, which would result in a temporary loss of wetland habitat. This loss would be temporary and the alternatives would not be affected by this action. Therefore, no cumulative effects on vegetation are anticipated.

**Summary**

Overall, the impacts of any of the action alternatives on riparian vegetation are expected to be negligible to small, with nearly all changes expected to be below a 1 percent change. This is due to the minor changes in monthly volumes and HFE releases, with the caveat that changing the timing of HFE releases could have impacts on riparian plant communities that are not captured by the vegetation modeling approach described above.

# 3.7 Wildlife

## 3.7.1 Affected Environment

To supplement the 2016 LTEMP FEIS (DOI 2016a), this section summarizes the affected environment for wildlife, including, as necessary, changes that have occurred since 2016.

The affected environment for wildlife includes the area that may be influenced by the implementation of the alternative flow options at Glen Canyon Dam, as discussed in the SMB EA (Reclamation 2023a), specifically the Colorado River ecosystem from Glen Canyon Dam downstream to the Pearce Ferry boat ramp. Because the action alternatives would maintain the upper and lower bounds of water releases consistent with the 2016 LTEMP FEIS (DOI 2016a), Reclamation assumes wildlife species that primarily use upland habitat would not be affected by daily fluctuations in flows. Thus, this section covers both general wildlife (except fish, which are discussed in **Section 3.4**) and special status species that primarily use riparian habitat zones. Special status species are those listed by the State of Arizona as species of greatest conservation need. Federally listed species are discussed in **Section 3.8**, Threatened and Endangered Species.

As described in the 2016 LTEMP FEIS, the Colorado River ecosystem supports numerous invertebrates, amphibians, reptiles, birds, and mammals (DOI 2016a). Changes to water volume, flows, and sediment transport can affect vegetation and thus habitat for riparian wildlife and waterbirds. The wildlife species described below are those most likely to be found in the Colorado River ecosystem downstream of Glen Canyon Dam in the riparian zone, as described in the 2016 LTEMP FEIS (DOI 2016a).

#### *Invertebrates*

Thousands of invertebrate species are known to occur in the Grand Canyon's riparian corridor (DOI 2016a). These are predominately terrestrial and aquatic flies, herbivorous insects (especially cicadas, leafhoppers, and aphids), spiders and scorpions, beetles, and many different species of wasps, bees, and ants. These invertebrates fill a variety of ecological roles; they serve as pollinators, regulate populations of other invertebrates, and provide food resources for many terrestrial and aquatic wildlife species. A detailed discussion of the affected environment for invertebrates can be found in Section 3.7.1 of the 2016 LTEMP FEIS (DOI 2016a).

Changes that have occurred since the 2016 LTEMP FEIS analysis and that may have resulted in changes to invertebrates or invertebrate habitat include the following:

- *Changes to riparian vegetation health along the river corridor resulting from ongoing dam operations.* Riparian vegetation composition, structure, distribution, and function along the Colorado River corridor downstream of Glen Canyon Dam are closely tied to Glen Canyon Dam operations (DOI 2016a). As described in the 2016 LTEMP FEIS, the effects of dam operations include the potential for long-term declines in native plant communities along the river and increases in nonnative vegetation and monoculture species (DOI 2016a).
- *Changes in riparian vegetation resulting from HFE releases and other experimental vegetation treatments.* Riparian vegetation communities can be affected through scouring and erosion during high

flows (Reclamation 2023a). HFE releases and other vegetation experiments conducted since the 2016 LTEMP FEIS may have influenced riparian vegetation along this reach of the river, directly influencing riparian invertebrate habitat (Reclamation 2023a).

- *Changes in the occurrence and distribution of invasive invertebrates.* The NPS has identified several species of invasive invertebrates in the area, including the New Zealand mud snail (*Potamopyrgus antipodarum*) and quagga mussel (*Dreissena bugensis*), which have been detected downstream of Glen Canyon Dam (Reclamation 2023a). These are discussed further in **Section 3.5**.
- *Changes in the abundance, diversity, and distribution of invertebrates.* The introduction and increased abundance of nonnative fish species, such as smallmouth bass, may have affected the composition of several native species. These invasive species are aggressive predators known to prey on a wide range of organisms (Sanderson et al. 2009).

Invertebrate abundance and species richness largely depend on the supporting vegetation. Thus, changes in vegetation in the riparian zone resulting from ongoing dam operations, drought conditions, HFE releases, and other vegetation experiments may have directly influenced invertebrate abundance and biodiversity. Similarly, changes in the abundance and distribution of invasive vegetation and invasive invertebrate species may have occurred, affecting native species and larger riparian ecosystems.

Changes to special status invertebrates that have occurred since the 2016 LTEMP FEIS analysis are discussed in the *Special Status Invertebrates* subsection.

### *Amphibians and Reptiles*

The Colorado River ecosystem provides habitat for numerous reptile and amphibian species, including five amphibian and 24 reptile species documented in the riparian zone of the river corridor (DOI 2016a). As described in the 2016 LTEMP FEIS, the highest densities and diversity of amphibians and reptiles tend to occur in riparian areas nearer the river's edge due to the presence of water, abundant vegetation, and invertebrate food (DOI 2016a). The common amphibian species along the river corridor are the canyon treefrog (*Hyla arenicolor*), red-spotted toad (*Bufo punctatus*), Woodhouse's toad (*Anaxyrus woodhousii*), and tiger salamander (*Ambystoma mavortium*). The most common lizard species along the river corridor are the side-blotched lizard (*Uta stansburiana*), western whiptail (*Aspidoscelis tigris*), desert spiny lizard (*Sceloporus magister*), and tree lizard (*Urosaurus ornatus*). The more common snake species in riparian areas downstream of Glen Canyon Dam include the Grand Canyon western rattlesnake (*Crotalus oreganus*), speckled rattlesnake (*Crotalus mitchellii*), black-tailed rattlesnake (*Crotalus molossus*), common king snake (*Lampropeltis getula*), and gopher snake (*Pituophis catenifer*).

Amphibians tend to use backwaters or shallow waters of aquatic and riparian habitats, while lizards and snakes tend to use a mix of riparian and shoreline habitat. The introduction of nonnative fish species, such as smallmouth bass and green sunfish (*Lepomis cyanelus*), can have profound impacts on amphibian populations (Walston and Mullins 2007; Hecnar and M'Closkey 1997). These invasive species are aggressive predators known to prey on a wide range of organisms, including amphibians and reptiles. Amphibians, particularly frog species, can fall prey to these invasive fish, leading to population declines (Kiesecker and Blaustein 2008), although the severity of the impact may vary depending on factors such as the presence of other invasive species and the life stage of the amphibians (Kiesecker and Blaustein 2008). Studies have shown that the invasion of fish into amphibian habitats can result in significant changes to the composition of amphibian communities (Sexton and Phillips 1986).

While tortoises are present in the greater Colorado River area, they primarily use adjacent upland habitat (for example, Mojave desert scrub, creosote bush flats in basins and mountain bajadas, and Joshua tree forests); therefore, they are not discussed further. A more detailed discussion of the affected environments for amphibians and reptiles can be found in Section 3.7.2 of the 2016 LTEMP FEIS (DOI 2016a). Special status amphibian and reptile species are discussed below.

Changes that have occurred since the 2016 LTEMP FEIS analysis may have resulted in changes to vegetation, as described in **Section 3.6**. (DOI 2016a). Changes that have occurred since the 2016 LTEMP FEIS analysis and that may have resulted in changes to the affected environment for amphibians and reptiles are similar to those described for invertebrates in the *Invertebrates* subsection.

### *Birds*

As described in the 2016 LTEMP FEIS, upward of 300 bird species have been documented in the greater Grand Canyon region; several of these are considered obligate riparian species. Common riparian birds include Lucy's warbler (*Oreothlypis luciae*), Bell's vireo (*Vireo bellii*), common yellowthroat (*Geothlypis trichas*), yellow warbler (*Dendroica petechia*), yellow-breasted chat (*Icteria virens*), and black-chinned hummingbird (*Archilochus alexandri*) (DOI 2016a). Riparian habitats along the river provide breeding habitat, migratory stopover sites, and wintering areas for birds throughout the year (DOI 2016a). Birds that nest in the riparian zone are directly and indirectly affected by river flows, which influence vegetation distribution and composition, the abundance of invertebrates that serve as food sources, and the availability of nest sites.

Terrestrial and waterbird (for example, ducks, geese, herons, sandpipers, and killdeer) species, especially winter waterfowl, also inhabit the river corridor (DOI 2016a). Common waterfowl species include American coot (*Fulica americana*), American widgeon (*Anas americana*), bufflehead (*Bucephala albeola*), common goldeneye (*B. clangula*), common merganser (*Mergus merganser*), gadwall (*A. strepera*), green-winged teal (*A. crecca*), lesser scaup (*Aythya affinis*), mallard (*A. platyrhynchos*), ring-necked duck (*Aythya collaris*), and Canada goose (*Branta canadensis*).

As discussed in the 2016 LTEMP FEIS, increased riparian habitat and productivity resulting from Glen Canyon Dam operations have benefited several bird species (DOI 2016a). A more detailed discussion of the affected environments for birds can be found in Section 3.7.3 of the 2016 LTEMP FEIS (DOI 2016a). Special status bird species are discussed in the *Special Status Species* subsection (DOI 2016a).

Changes that have occurred since the 2016 LTEMP FEIS analysis may have resulted in changes to vegetation, as described in **Section 3.6**. Of the 30 riparian bird species that inhabit the river corridor, at least 76 percent eat insects or feed insects to their young (DOI 2016a). Changes to vegetation in riparian areas (for example, tamarisk levels) can influence the availability of invertebrate prey and nest sites. Changes that have occurred since the 2016 LTEMP FEIS analysis and that may have resulted in changes to the affected environment for birds are similar to those described for invertebrates in the *Invertebrates* subsection.

### *Mammals*

The habitat along the river also supports numerous mammals, including those that use aquatic habitat and riparian zones. The only aquatic mammals in the area are beaver (*Castor canadensis*), muskrat (*Ondatra canadensis*), and river otter (*Lontra canadensis*). Beavers occur throughout the river corridor from Glen Canyon Dam to the Grand Wash Cliffs, where riparian vegetation is well established (DOI 2016a). Their populations have increased since the construction of the dam due to increased riparian vegetation. Muskrats and river otters are rarely documented along the river corridor, in part because the river otter is classified as extirpated from the Grand Canyon (DOI 2016a).

Rodents are the most abundant small mammals within the riparian zone, including the cactus mouse (*Peromyscus eremicus*), rock pocket mouse (*Chaetodipus intermedius*), deer mouse (*Peromyscus maniculatus*), and rock squirrel (*Spermophilus variegatus*) (DOI 2016a). Bats are documented downstream of Glen Canyon Dam, occupying rock crevices, caves, and upland trees and feeding on insects along the Colorado River and its tributaries. GCNP has one of the highest bat diversities in the US, with 22 documented species (NPS 2024).

Changes that have occurred since the 2016 LTEMP FEIS (DOI 2016a) analysis may have resulted in changes to vegetation; thus, changes to the affected environments for mammals are similar to those described for invertebrates in the *Invertebrates* subsection.

### *Special Status Species*

Consistent with the 2016 LTEMP FEIS (DOI 2016a), special status species are defined as those that may exist along the Colorado River corridor between Glen Canyon Dam and Lake Mead and that are either State of Arizona species of greatest conservation need (AZ-SGCN) or bald or golden eagles protected by the Bald and Golden Eagle Protection Act of 1940 (BGEPA) (**Table 3-30**). Those species that are designated as AZ-SGCN and that are also federally listed are discussed in **Section 3.8**, Threatened and Endangered Species.

**Table 3-30**
**Species Listed on the Arizona Species of Greatest Conservation Need List in 2012 and in 2022**

| Common Name | Scientific Name | Status in 2012 | Status in 2022 |
|---|---|---|---|
| **Invertebrates** | | | |
| Niobrara (Kanab) ambersnail* | *Oxyloma haydeni kanabensis* | ESA-E; AZ-SGCN Tier 1 | AZ-SGCN Tier 1 |
| **Amphibians and Reptiles** | | | |
| Northern leopard frog | *Lithobates pipiens* | AZ-SGCN Tier 1 | AZ-SGCN Tier 1 |
| Lowland leopard frog | *Rana yavapaiensis* | AZ-SGCN Tier 1 | AZ-SGCN Tier 1 |

| Common Name | Scientific Name | Status in 2012 | Status in 2022 |
|---|---|---|---|
| **Birds** | | | |
| American peregrine falcon | *Falco peregrinus* | AZ-SGCN Tier 1 | AZ-SGCN Tier 1 |
| Bald eagle | *Haliaeetus leucocephalus* | AZ-SGCN Tier 1; BGEPA | AZ-SGCN Tier 1; BGEPA |
| Golden eagle | *Aquila chrysaetos* | AZ-SGCN Tier 2; BGEPA | AZ-SGCN Tier 2; BGEPA |
| Ridgway's rail (Yuma)* | *Rallus obsoletus yumanensis* | ESA-E; AZ-SGCN Tier 1 | ESA-E; AZ-SGCN Tier 1 |
| California condor* | *Gymnogyps californianus* | ESA-XN; AZ-SGCN Tier 1 | ESA-E; AZ-SGCN Tier 1 |
| Western yellow-billed cuckoo* | *Coccyzus americanus* | ESA-T; AZ-SGCN Tier 1 | ESA-T; AZ-SGCN Tier 1 |
| Southwestern willow flycatcher* | *Empidonax traillii extimus* | ESA-E; AZ-SGCN Tier 1 | AZ-SGCN Tier 1 |
| **Mammals** | | | |
| Spotted bat† | *Euderma maculatum* | AZ-SGCN Tier 1 | AZ-SGCN Tier 2 |
| Pale Townsend's big-eared bat† | *Corynorhinus townsendii pallescens* | AZ-SGCN Tier 3 | AZ-SGCN Tier 1 |

Sources: DOI 2016a; AZGFD 2022

Notes: AZ-SGCN = Arizona species of greatest conservation need; BGEPA = bald or golden eagles protected by the Bald and Golden Eagle Protection Act of 1940; ESA-E = ESA endangered; ESA-T = ESA threatened; ESA-XN = Non-essential Experimental Population

*Indicates a species that is federally listed as threatened or endangered (discussed in **Section 3.8**).

† Indicates a change in status between 2012 and 2022.

Osprey were not included in the 2022 AZ-SGCN list and are therefore not included in the table.

Special status species found in the area include the northern leopard frog (*Lithobates pipiens*), lowland leopard frog (*Rana yavapaiensis*), American peregrine falcon (*Falco peregrinus*), bald eagle (*Haliaeetus leucocephalus*), golden eagle (*Aquila chrysaetos*), osprey (*Pandion haliaetus*), and spotted bat (*Euderma maculatum*) (**Table 3-30**). The northern leopard frog has not been observed since 2004. The species is presumed extirpated in Glen and Grand Canyons downstream of Lees Ferry (DOI 2016a). A distinct genetic lineage of the lowland leopard frogs has been observed in perennial streams in the western Grand Canyon (Oláh-Hemmings et al. 2010).

The American peregrine falcon is a migratory bird that nests in upland habitat in the summer and feeds on prey commonly found in the river corridor, including fish, songbirds, and bats (DOI 2016a). Multiple peregrines were observed hunting at Yaki and Lipan Points during 2008 migration studies (HawkWatch 2009). Downstream of Glen Canyon Dam, bald eagles have been observed wintering in areas with ample fish populations. Golden eagles prefer to nest along cliffs and mesas and generally feed on small mammals such as rabbits and ground squirrels; however, they also prey on large insects, birds, reptiles, and carrion. Observations of bald and golden eagles have been declining (DOI 2016a). Large numbers of ospreys use the Colorado River corridor during fall migration, usually August–September, and feed almost exclusively on fish, although they will also prey on snakes, frogs, shorebirds, and waterfowl (DOI 2016a).

Spotted bats are the only special status mammals in the area, and they are rarely encountered in Arizona. However, they may occur in areas where cliffs and water sources are available. Dominant prey items are moths but also include June beetles and sometimes grasshoppers that are taken while on the ground (DOI 2016a).

**Table 3-30** includes those species that may exist along the river corridor as listed in the 2016 LTEMP FEIS (DOI 2016a). Changes to special status species that have occurred since the 2016 LTEMP FEIS analysis are outlined in **Table 3-30** and include the following:

- The addition of the pale Townsend's big-eared bat to the AZ-SGCN tier 1
- The addition of the lowland leopard frog to reflect known occurrence in the western Grand Canyon
- A change from AZ-SGCN tier 1 to tier 2 for the spotted bat

## 3.7.2 Environmental Consequences

### *Methodology*

Wildlife-specific models were not available for use in this analysis due, in part, to limited data availability. The analysis in this section is informed by hydrologic and vegetation models showing the effects of dam releases on the hydrology and riparian vegetation (**Sections 3.2**, Hydrology, and **3.6**, Terrestrial Resources and Wetlands). As discussed in the 2016 LTEMP FEIS, the primary effects on wildlife and special status species below the Glen Canyon Dam would be a direct function of the changes in distribution and abundance of wildlife habitat and aquatic species that result under each alternative. The environmental consequences for wildlife and special status species are presented as a qualitative discussion of how each alternative may affect vegetation, riparian habitat, and the aquatic food sources on which wildlife and special status species depend.

#### Impact Analysis Area

The analysis area is consistent with that used in the 2016 LTEMP FEIS. It includes the Colorado River mainstem corridor and interacting resources in associated riparian zones located primarily from the forebay of Glen Canyon Dam to Pearce Ferry above Lake Mead.

#### Assumptions

Two assumptions were made for the wildlife analysis:

- The proposed flow alternatives would not impact upland habitat.
- The analyses of impacts on wildlife and special status species depend on the data inputs, modeling assumptions, and validity of the models.

#### Impact Indicators

Impacts were evaluated for species that primarily use riparian and wetland habitat zones in the following species groups: invertebrates, amphibians and reptiles, birds, and mammals (collectively, general wildlife), and species status species. For each group, the impacts of each alternative were evaluated based on the following indicators:

- Change in riparian and open-water habitat
- Change in aquatic habitat and food base
- Direct effects of HFE releases and other flow and non-flow actions

### *Issue 1: How would flow alterations at Glen Canyon Dam affect general wildlife?*

**No Action Alternative**

Under the No Action Alternative, no changes would be made to Glen Canyon Dam operations. Models indicate that there would not be substantial changes to riparian habitat abundance or composition (Yackulic et al. 2024). Vegetation and habitat conditions would remain consistent with those described for the management actions in the 2016 LTEMP FEIS (DOI 2016a). As described in the 2016 LTEMP FEIS, under current management, water volumes in the Colorado River will continue to decrease in response to regional drought conditions. Frequent, extended high flows would result in an overall decrease in native plant communities and a decrease in wetland habitat. Upper riparian zones would likely transition to desert ecosystems (DOI 2016a).

This alternative would also continue to allow nonnative, invasive fish species to pass through the dam, likely resulting in increased abundances and ranges of these species downstream of Glen Canyon Dam. Therefore, the No Action Alternative may reduce the abundance and diversity of native species of invertebrates, small mammals, small birds, reptiles, and amphibians due to predation by nonnative, invasive species. Additionally, the introduction of nonnative fish may indirectly impact species by introducing pathogens that can be transmitted to amphibians (Blaustein et al. 1994; Adams et al. 2017).

**Cool Mix Alternative**

The Cool Mix Alternative is a mix of water released simultaneously through the penstocks and the river outlet, and it would work to maintain a daily average water temperature of about 15.5°C (60°F) from below Glen Canyon Dam to the Little Colorado River to disrupt smallmouth bass spawning. The Cool Mix Alternative would have consistent releases that would result in flow patterns similar to the patterns under current management (Reclamation 2023a). This alternative is not expected to have substantial impacts on riparian habitat (Yackulic et al. 2024). However, the Cool Mix Alternative is predicted to reduce population growth for smallmouth bass (Yackulic et al. 2024), which would subsequently decrease the effects of heightened predation from nonnative fish and the potential spread of pathogens, in contrast to the No Action Alternative. While the Cool Mix Alternative is predicted to limit population growth for smallmouth bass, smallmouth bass would not be extirpated completely, resulting in the continued predation of native species.

Under this alternative, Reclamation would also implement HFE releases. A summary of anticipated impacts from higher flows associated with HFE releases on invertebrates, amphibians and reptiles, birds, and mammals is presented below.

*Invertebrates*

Increased flows associated with HFE releases could result in temporary displacement of aquatic insects that use shoreline habitat for feeding and reproduction. These impacts would be temporary because invertebrate species can move in response to fluctuations in flow, and they would recolonize after HFE releases have ended. Higher flows are not expected to change the amount of overall riparian vegetation. HFE releases and flow spikes may enhance germination for certain riparian plant species and prevent the establishment of other species, changing composition in ways that could have beneficial impacts on invertebrate biodiversity and abundance (Yackulic et al. 2024).

*Amphibians and Reptiles*

Impacts on amphibians and reptiles would be the same as those listed for invertebrates (that is, temporary displacement and negligible changes in riparian vegetation composition). Additionally, many amphibians rely on specific water flow patterns, such as slow-moving or stagnant water for breeding. Changes in flow rates can destroy or modify these habitats, making them unsuitable for breeding, and high flows could flush eggs or juvenile individuals downstream.

*Birds*

Impacts on birds would include those described for invertebrates. In addition to temporary impacts from fluctuations in flows, HFE releases could have additional impacts on nesting bird species. HFE releases implemented during the breeding season could impact birds that use riparian and shoreline habitat through higher water elevations washing away nests.

*Mammals*

Beaver, mice, and other small rodents are the most abundant mammals in riparian zones. The impacts of the Cool Mix Alternative on riparian mammals would include the potential for displacement of individuals in the flood zone during HFE releases; however, no long-term population-level effects are expected. HFE releases could provide critical water resources to obligate riparian mammals at higher elevations if the HFE releases occur during the hottest months.

**Cool Mix with Flow Spike Alternative**

The Cool Mix with Flow Spike Alternative would include consistent releases from the river outlet works to maintain a daily average water temperature of about 15.5°C (60°F) with flow spikes that would consist of 8-hour periods of elevated flows between May and July to reduce water temperatures and disrupt smallmouth bass spawning. Because these flow spikes would be of a similar magnitude as the HFE releases previously conducted (up to 45,000 cfs), spikes would have similar impacts as the HFE releases previously discussed in the Cool Mix Alternative. This alternative is expected to impact riparian habitat similarly to the Cool Mix Alternative discussed above (that is, no substantial impacts). This alternative is also expected to impact smallmouth bass populations similarly to the Cool Mix Alternative discussed above (that is, limit population growth); thus, impacts on wildlife from smallmouth bass would be similar to those described in the Cool Mix Alternative.

In addition, this alternative would have periods of steady flows that are consistent or higher than the minimum daily flow (8,000 cfs) under the 2016 LTEMP FEIS. Higher discharge rates during these consistent flow periods could provide additional benefits to obligate wetland species that favor wet environments.

**Cold Shock Alternative**

The Cold Shock Alternative would release water for at least 48 hours through the river outlet works, releasing the minimum amount of water required to create a cold shock all the way down to the Little Colorado River to disrupt smallmouth bass populations. The Cold Shock Alternative would also include the implementation of HFE releases of similar magnitude to flow spikes under the Cool Mix with Flow Spike Alternative. Models indicated that the Cold Shock Alternative would not substantially change riparian habitat abundance or composition; therefore, impacts on wildlife would be limited to those associated with flows from HFE releases and would be similar to those described for the Cool Mix Alternative.

Moreover, the Cold Shock Alternative would decrease the growth of the smallmouth bass population compared with the No Action Alternative. However, it would not halt population growth, as observed with the cool mix alternatives. As such, the continued increases in nonnative fish species could result in population-level impacts on native species; this is because smallmouth bass and other nonnative species are aggressive predators known to prey on a wide range of organisms, including invertebrates, small mammals, amphibians, and reptiles (Sanderson et al. 2009). Continued introduction of nonnative fish may also indirectly impact species by introducing pathogens that can be transmitted to amphibians (Blaustein et al. 1994; Adams et al. 2017).

**Cold Shock with Flow Spike Alternative**

The Cold Shock with Flow Spike Alternative would release water for at least 48 hours through the river outlet works for the minimum amount of time required to create a cold shock all the way down to the Little Colorado River to disrupt smallmouth bass spawning. In addition, up to three 8-hour flow spikes would be added between June and mid-July. The flow spikes would be similar in magnitude to HFE releases; thus, the Cold Shock with Flow Spike Alternative would have flow patterns like those under the Cool Mix with Flow Spike Alternative. The impacts on invertebrates, amphibians, reptiles, birds, and mammals would be similar to those listed above for the Cool Mix Alternative, except that impacts would include greater smallmouth bass population growth, which could result in continued predation from nonnative fish and the potential spread of pathogens, as described above in the Cold Shock Alternative.

**Non-Bypass Alternative**

The Non-Bypass Alternative would result in higher daily fluctuations in flows, with weekly drops in flow to a minimum of 2,000 cfs followed by a steep increase in flow to a maximum of approximately 27,300 cfs. These changes would last for approximately 8 hours at the dam. Compared with the other flow alternatives, the Non-Bypass Alternative would have daily flow fluctuations that could reduce shoreline stability. This instability could lead to a decrease in the abundance of aquatic invertebrates and greater disruption to wildlife habitat, as compared with the other action alternatives. During low-flow periods, foraging habitat for certain waterfowl could also decrease. These impacts would be temporary and followed by higher flows that would increase foraging habitat. More mobile species, such as waterfowl, would likely adjust by foraging in Lake Powell, Lake Mead, or farther downriver, whereas amphibians, reptiles, and insects may be less able to adapt to the less stable shoreline environment, resulting in decreased biodiversity or abundance.

The Non-Bypass Alternative is the only alternative that would result in substantial differences in riparian habitat when compared with the No Action Alternative. Generally, the Non-Bypass Alternative would increase native-to-nonnative cover and species richness and decrease total vegetation, although changes would be small (less than 1 percent; Yackulic et al. 2024). Reductions in riparian habitat could have minor impacts on species that use riparian habitat for foraging or nesting (for example, osprey and heron). Impacts on invertebrates, amphibians, reptiles, birds, and mammals under the Non-Bypass Alternative would be similar to those listed above for the Cool Mix Alternative (that is, displacement of individuals during high flows and potential disruption of breeding and foraging habitat). Under this alternative, impacts would also include continued predation from nonnative fish and the potential spread of pathogens, as described above in the Cold Shock Alternative.

**Cumulative Effects**

The effects of the LTEMP SEIS alternatives on wildlife would be relatively small and would not be expected to contribute substantially to cumulative impacts along the Colorado River corridor or within the Colorado Basin at large. The -12 mile slough (approximately 3 miles downstream of Glen Canyon Dam) currently provides warmwater spawning habitat for nonnative fish, which is also habitat for amphibians and aquatic invertebrates. There is a proposal to modify and restore a side channel and narrow the lower slough. This habitat change, in combination with the changes in flow or temperature proposed here, would replace the warm, still-water habitat with flowing water that is similar to mainstem temperatures. However, this is one of many backwater areas that support wildlife, and no population-level impacts on any species are anticipated. Therefore, no cumulative effects on wildlife are anticipated.

### *Issue 2: How would flow alterations at Glen Canyon Dam affect special status species?*

Special status species are defined as those that may occur along the Colorado River corridor between Glen Canyon Dam and Lake Mead and that are either AZ-SGCN or bald or golden eagles protected by the BGEPA. Environmental consequences for those species that are also federally listed are discussed in **Section 3.8**, Threatened and Endangered Species.

The impacts on species status species are similar under each alternative. Thus, this section summarizes impacts on non-ESA special status species groups (invertebrates, amphibians and reptiles, birds, and mammals) under all alternatives.

**All Alternatives**

*Special Status Invertebrates*

There are no non-ESA special status invertebrates in the analysis area.

*Special Status Amphibians and Reptiles*

As compared with the No Action Alternative, all other alternatives that alter releases have the potential to impact amphibians and reptile species dependent on shoreline habitats, including the northern and lowland leopard frog, which is the only special status amphibian species in the analysis area. Impacts would be similar to those described under the general wildlife section. Alternatives with higher daily fluctuations (the Non-Bypass Alternative) would have the potential to lower insect production and alter breeding habitat, potentially resulting in relatively greater impacts on the lowland and northern leopard frogs. Additionally, under both the No Action Alternative and the Non-Bypass Alternative, impacts would include the growth of smallmouth bass populations and other nonnative fish that would likely result in continued predation of native amphibians.

*Special Status Birds*

None of the alternatives are anticipated to impact the American peregrine falcon, bald eagle, or golden eagle. These species would not be as sensitive to fluctuations in flows and changes to riparian habitat; this is because they are not riparian-obligate species, and they can forage in a variety of habitats. Nesting sites for these species are in upland zones that would not be impacted by any of the alternatives. The only alternative that would result in substantial differences in riparian habitat, when compared with the No Action Alternative, was the Non-Bypass Alternative, which generally would increase native-to-nonnative cover and species richness and decrease total vegetation. Some species protected under the Migratory Bird Treaty Act (16 US Code 703–712) nest in riparian habitat (for example, osprey and heron); thus, reductions in total vegetation cover associated with the Non-Bypass Alternative could impact the availability of suitable nesting habitat for these species, although overall changes are expected to be minor (less than 1 percent change; Yackulic et al. 2024).

*Special Status Mammals*

None of the alternatives are anticipated to have population-level impacts on the spotted bat or pale Townsend's big-eared bat. Under the alternatives that would decrease the shoreline stability, which potentially would decrease the abundance of insects, bat species may experience a shift in foraging habitat.

#### Cumulative Effects

The effects of the LTEMP SEIS alternatives on special status species would be relatively small and would not be expected to contribute significantly to cumulative impacts along the Colorado River corridor or within the Basin at large. The -12 mile slough (approximately 3 miles downstream of Glen Canyon Dam) currently provides warmwater spawning habitat for nonnative fish, which is also habitat for amphibians. There is a proposal to modify and restore a side channel and narrow the lower slough. This habitat change, in combination with the changes in flow or temperature proposed here, would replace the warm, still-water habitat with flowing water that is similar to mainstem temperatures. However, this is one of many backwater areas that support amphibians, and no population-level impacts on any species are anticipated. Therefore, no cumulative effects on special status species are anticipated.

### *Summary*

#### Summary of Impacts of General Wildlife

Riparian wildlife populations depend on suitable habitat, food, and water resources. While changes in water temperature would not impact riparian wildlife, changes in releases from Glen Canyon Dam have the potential to directly and indirectly impact riparian habitat and wildlife species. Alternatives with more fluctuations, and less consistent monthly release volumes, would have a greater impact on species that use nearshore habitats or that feed on insects. Impacts from daily, weekly, and monthly water release changes would likely be temporary. For instance, under all alternatives, HFE releases could displace invertebrates, amphibians, reptiles, birds, and mammals who use shoreline habitat for foraging, nesting, and breeding. These species can move in response to fluctuations in flow and would return after HFE releases or flow spikes end.

In some cases, HFE releases or flow spikes may have more permanent impacts on certain species (for example, destruction of a nest during an HFE). However, higher-flow events also have the potential to provide critical water resources to obligate riparian species at higher elevations during the hottest months. Under the No Action and Non-Bypass Alternatives, continued smallmouth bass population growth would impact native populations of invertebrates, small mammals, amphibians, and reptiles due to increased predation and the potential introduction of pathogens transmitted to amphibians.

Periods of low flows under the Non-Bypass Alternative could impact the availability of foraging habitat for certain waterfowl, which would likely adjust by foraging in Lake Powell, Lake Mead, or farther downriver. Steady releases, such as those under the Cool Mix with Flow Spike, Cold Shock, and Cold Shock with Flow Spike Alternatives, could also provide benefits to obligate wetland species that favor wet environments. All alternatives, except the Non-Bypass Alternative, are not expected to significantly alter the composition or abundance of riparian and wetland habitat (Butterfield and Palmquist 2023). The Non-Bypass Alternative is expected to increase native-to-nonnative cover and species richness and decrease total vegetation, resulting in minor (less than 1 percent) changes to available riparian habitat (Yackulic et al. 2024).

While all action alternatives are expected to reduce the growth of smallmouth bass populations, none are predicted to entirely extirpate smallmouth bass. Therefore, impacts on wildlife under all alternatives would include continued predation by invasive aquatic species and the potential for the introduction and transmission of pathogens. Although some temporary impacts could occur under all alternatives, none of the alternatives are expected to have long-term population-level effects on wildlife.

**Summary of Impacts on Special Status Wildlife**

All alternatives that would result in flow fluctuations could have negligible to minor impacts on lowland and northern leopard frogs, which depend on wetland and riparian habitat. Additionally, under all alternatives (except the Cool Mix Alternative and Cool Mix with Flow Spike Alternative), impacts would include the continued growth of smallmouth bass populations and other nonnative fish, which would likely result in continued predation of native amphibians. All other special status species identified within the analysis area do not depend on riparian or shoreline habitats, or they would not be expected to be suitable prey for smallmouth bass. Therefore, there would be no additional impacts on special status wildlife species.

# 3.8 Threatened and Endangered Species

## 3.8.1 Affected Environment

Two species of native fish that are listed under the ESA (16 US Code 1531, as amended), the humpback chub and the razorback sucker, occur in the potentially affected portions of the Colorado River and its tributaries between Glen Canyon Dam and the inflow to Lake Mead. These two species are also designated as AZ-SGCN. The bonytail, also listed under the ESA, has been extirpated from the Grand Canyon for over five decades, but it has recently been stocked in Lake Powell (Pennock and Gido 2021). Some fish have been passing through the penstocks at Glen Canyon Dam and have been captured in the Colorado River in the Lees Ferry reach. The number of bonytail in the analysis area is too small to consider in this SEIS.

### *Humpback Chub*

The humpback chub is a large, long-lived species endemic to the Colorado River system. This member of the minnow family attains a total length of about 450 millimeters (17.7 inches) and a weight of about 1,000 grams (2.2 pounds), and it may live as long as 40 years (Hendrickson 1994; Valdez and Ryel 1995; Andersen 2009). The humpback chub was federally listed as endangered in 1967 and was grandfathered into protection with the passage of the ESA in 1973. It was reclassified from endangered to threatened with a 4(d) rule[30] on October 18, 2021 (Service 2021).

In downlisting the humpback chub, the Service evaluated the stressors associated with the five listing factors detailed in the species' status assessment (Service 2018b). These include river flows (Factor A) and predatory, nonnative fish (Factor C) in the Upper Basin populations. They also include water temperature (Factor A), food supply (Factor A), and predatory, nonnative fish (Factor C) in the Lower Basin population (Service 2021). Minimizing these factors was important in downlisting the species. Downlisting of the species was also possible because a large, reproducing aggregation became established in the western Grand Canyon following the decline of Lake Mead's water level, which exposed historical habitat, and in Lake Powell with warmer releases from Glen Canyon Dam (Rogowski et al. 2018; Van Haverbeke et al. 2017). Critical habitat for the humpback chub includes the Colorado River from Nautaloid Canyon (river mile 35) to Granite Park (river mile 209), and the lower 8 miles of the Little Colorado River (Service 1994).

**Distribution and Abundance**

Historically, this species occurred in warm whitewater regions of the Colorado River and some larger tributaries from below Hoover Dam upstream into Arizona, Utah, Colorado, and Wyoming. Currently, the humpback chub is restricted to six population centers, five in the Upper Colorado River Basin and one in the Lower Basin (Service 2018a). The Upper Basin populations occur in (1) the Colorado River in Cataract Canyon, Utah; (2) the Colorado River in Black Rocks, Colorado; (3) the Colorado River in Westwater Canyon, Utah; (4) the Green River in Desolation and Gray Canyons, Utah; and (5) the Green and Yampa Rivers in Dinosaur National Monument, Colorado. The last population is considered extirpated, and an effort began in 2021 to reintroduce the species

[30] Allows the Secretary to issue regulations deemed "necessary and advisable to provide for the conservation of " threatened species.

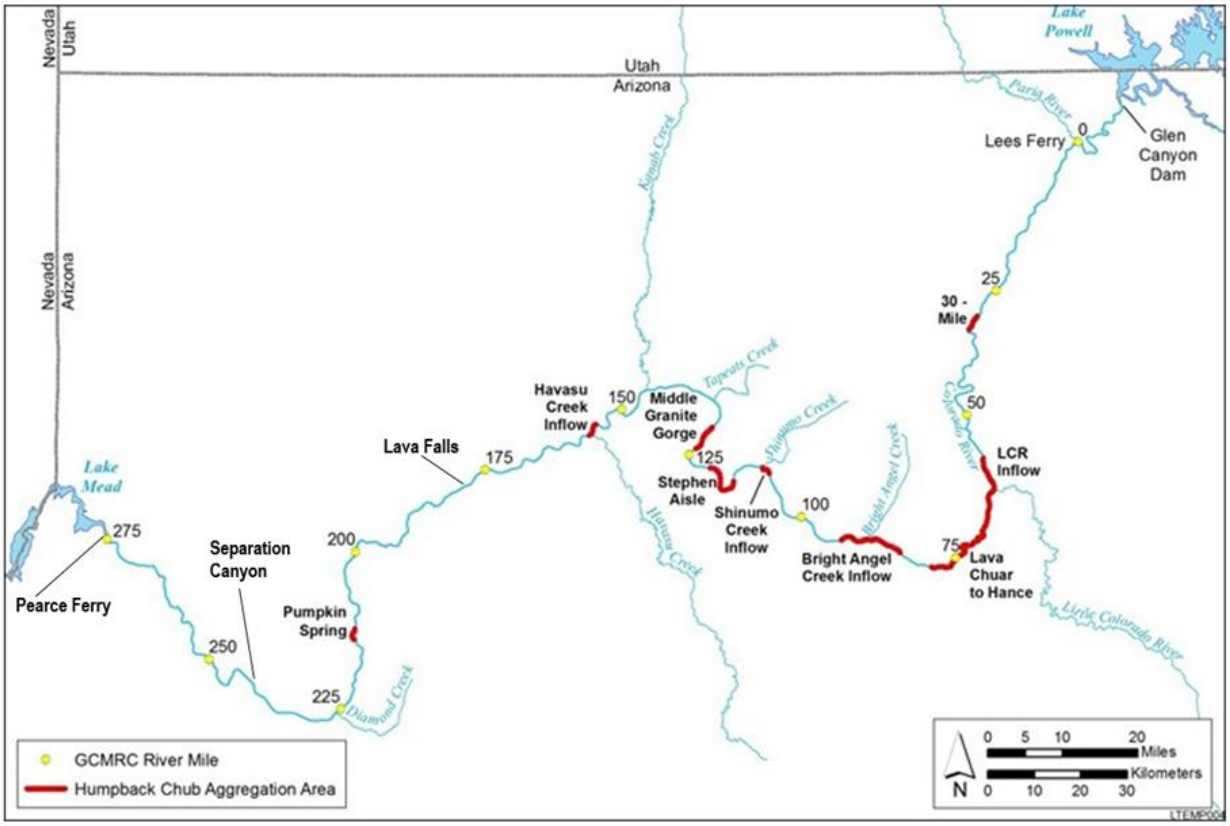
and reestablish a new population in the Green and Yampa Rivers within Dinosaur National Monument (Valdez et al. 2021). The only population in the Lower Basin occurs in the Colorado River from about 30-Mile Spring downstream to the Lake Mead inflow (Rogowski et al. 2018), and in the Little Colorado River, with translocations to several tributaries (Service 2018a).

Although the humpback chub is a warmwater fish species, it has persisted in the Colorado River through the Grand Canyon after the construction of Glen Canyon Dam and subsequent cold-water releases. The aggregations identified by Valdez and Ryel (1995) were mostly associated with warm springs and warm tributary mouths that enabled the species to persist in the mainstem, while the largest and only reproducing aggregation was found in the Little Colorado River. With a lower elevation of Lake Powell and warmer dam releases, the humpback chub expanded in range and numbers through the mainstem and especially in the western Grand Canyon (Rogowski et al. 2018). Cold water temperatures from 1970 until about 2000 provided suitable conditions for the species to persist in the mainstem with annual movements to the Little Colorado River for reproduction (Valdez and Ryel 1995). These cold temperatures limited growth but enabled the species to live longer (Yackulic et al. 2014) with better body conditions and abated infestations of diseases and parasites (Hoffnagle et al. 2006).

The Colorado River population in the Grand Canyon is the largest of the five remaining population centers of the humpback chub. Within the Grand Canyon, this species was most abundant in the vicinity of the confluence of the Colorado River and Little Colorado River prior to 2017 (Paukert et al. 2006), but it has expanded into the western Grand Canyon, where the largest population of humpback chub is now found, as described below. In addition, eight other areas (aggregations) where humpback chub were regularly collected have been identified; these aggregation areas are located at 30-Mile, Lava Chuar-Hance, Bright Angel Creek inflow, Shinumo Creek inflow, Stephen Aisle, Middle Granite Gorge, Havasu Creek inflow, and Pumpkin Spring (**Figure 3-41**; Valdez and Ryel 1995).

Since 2009, translocations of humpback chub have been made by the Service to introduce juvenile fish upstream of Chute Falls in the Little Colorado River, and by the NPS to introduce juvenile fish into Shinumo and Havasu Creeks, with the goal of establishing additional spawning populations within the Grand Canyon (NPS 2012b, 2013g; Healy et al. 2019). A large debris flow in August 2014 scoured the Shinumo Creek channel and displaced or killed most of the fish that were translocated into that creek (Nelson et al. 2014). Survey data collected in 2013, 2014, and 2015 suggest that translocated humpback chub have successfully spawned in Havasu Creek (NPS 2013g).

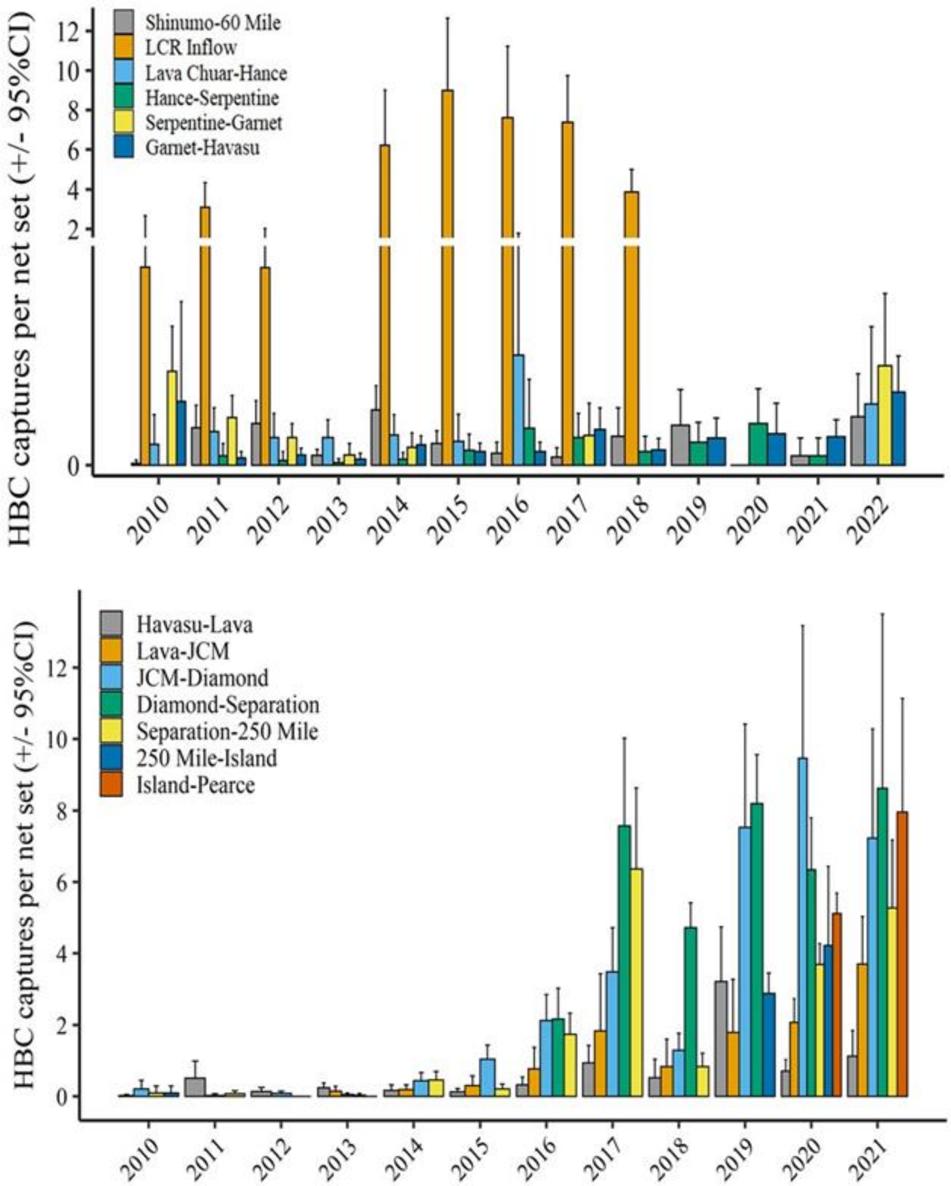
**Figure 3-41**
**Humpback Chub Aggregation Areas along the Colorado River between Glen Canyon Dam and Lake Mead, and the Area of Western Grand Canyon with the Expanded Population of Humpback Chub**




Sources: Valdez and Ryel 1995; VanderKooi 2011; NPS 2013b

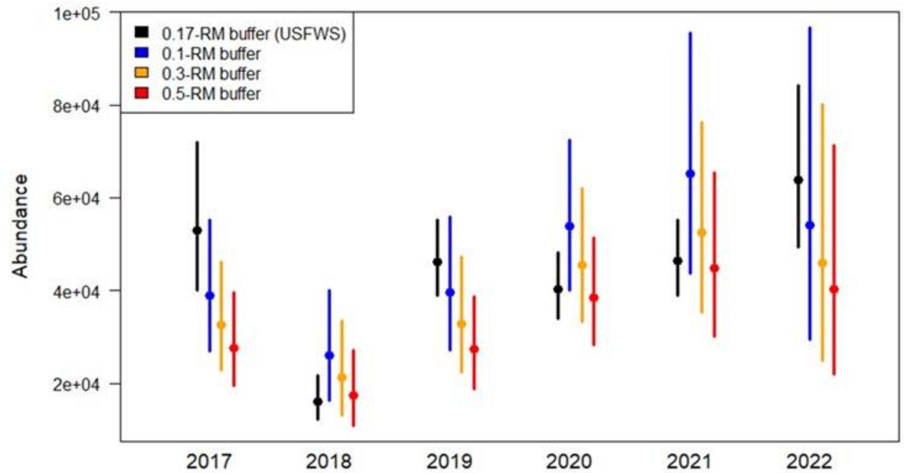
In about 2015, catch rates of humpback chub captured downstream of Havasu Rapids began to increase and then tripled starting in 2017 (**Figure 3-42**; Van Haverbeke et al. 2017; Dzul et al. 2023). Mark-recapture estimates of adults in the Colorado River in the western Grand Canyon (Havasu Rapids to Pearce Ferry) showed an increase in numbers of about 20,000 in 2018 to about 66,000 in 2022 with high survival (**Figure 3-43**; Dzul et al. 2023; Van Haverbeke et al. 2023). Since about 2017, the western Grand Canyon has been populated by humpback chub representing all size classes, with the highest densities of adults consistently between Lava Falls and Separation Canyon (river miles 180–240; Dzul et al. 2023). It is unclear whether the humpback chub downstream of Havasu Rapids constitute a new population or an expansion of the aggregations found upstream, but the fish in this area now compose the largest group of humpback chub in the Colorado River system. These numbers of adults compare to about 10,000–15,000 adults in the Little Colorado River/Colorado River aggregation (Yackulic et al. 2022; GCDAMP 2023a).

**Figure 3-42**
**Annual Catch-per-unit Efforts of Humpback Chub at Sample Sites above (top) and below (bottom) Havasu Rapids, 2010–2022**




Source: Dzul et al. 2023

**Figure 3-43**
**Abundance Estimates of Humpback Chub in Western Grand Canyon (Havasu Rapids to Pearce Ferry), 2017–2022**




Source: Dzul et al. 2023

### Habitat

Throughout the humpback chub's current range, adults are found in turbulent, high-gradient, canyon-bound reaches of large rivers and in deep pools separated by turbulent rapids (Service 2018a). Within the Grand Canyon, the humpback chub is found in the Colorado River in the vicinity of the Little Colorado River (river miles 30–110; **Figure 3-41**), in the western Grand Canyon (Van Haverbeke et al. 2017; Dzul et al. 2023), and various aggregations. Adults are associated with large eddy complexes (Valdez and Hoffnagle 1999) and warm tributaries or springs (Valdez and Ryel 1995). Converse et al. (1998) found that densities of subadult humpback chub in the mainstem Colorado River downstream of the Little Colorado River were greater along shoreline areas with vegetation, talus, and debris fans than in areas with bedrock, cobble, and sand substrates. Korman et al. (2004) found that juvenile humpback chub responded to changing flows by shifting locations to maintain similar habitat conditions.

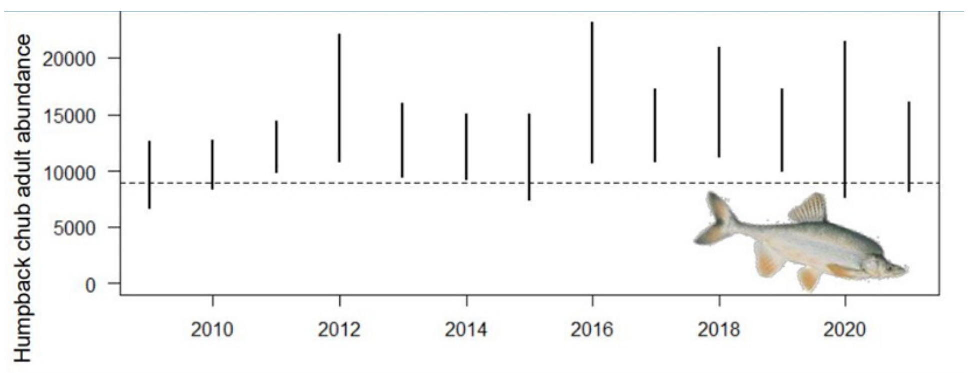
One recent mark-recapture study reported that approximately 87 percent of recaptured fish were collected in the same mainstem river reach or tributary where they were originally tagged, with 99 percent of all recaptures occurring in and around the Little Colorado River (Paukert et al. 2006). However, some of the marked fish were determined to have moved as much as 96 miles throughout the Grand Canyon.

Recent surveys of an expanding population in the western Grand Canyon found humpback chub in open, silt-laden habitats, suggesting this species may be able to occupy a wider range of habitats. This habitat is found in exposed deltaic sediments at the inflow of Lake Mead following a decline in lake elevation. Hoop net catch data showed no difference in juvenile/subadult humpback chub catch between hoop nets set in rocky habitat compared with habitat with only fine sediment.

Humpback chub catch for all life stages in a river segment characterized by silt banks exceeded or was not significantly different from catch in rocky segments (Boyer et al. 2024).

The main spawning area for the humpback chub within the Grand Canyon has been the Little Colorado River, which provides warm temperatures suitable for spawning and shallow, low-velocity pools for larvae (Gorman 1994). Many of the larval fish remain in the Little Colorado River for one or more years, and growth rates and survival are relatively high compared with estimates for the colder waters of the mainstem Colorado River (Dzul et al. 2014; Yackulic et al. 2014). Spring abundance estimates for age-1 humpback chub within the Little Colorado River from 2009 to 2012 ranged from approximately 1,000 to more than 9,000 individuals (Dzul et al. 2023), and numbers of adults ranged from about 10,000 to 15,000 (**Figure 3-44**). Within the Little Colorado River, young humpback chub prefer shallow, low-velocity, nearshore pools and backwaters; they move to deeper and faster areas with increasing size and age (AZGFD 2001a). In the mainstem Colorado River, YOY fish may be found in backwater and other nearshore, slow-velocity areas that serve as nursery habitats (Valdez and Ryel 1995; Robinson et al. 1998; AZGFD 2001a; Stone and Gorman 2006).

**Figure 3-44**
**Abundance of Adult Humpback Chub that Spawn in the Little Colorado River, 2009–2021**




Sources: Yackulic 2022; GCDAMP 2023a

The Humpback Chub Near-Shore Ecology Study collected juvenile humpback chub (under 3 years old) in all types of nearshore habitats, with the highest numbers collected from talus slopes (Dodrill et al. 2015). Since about 2017, large numbers of young humpback chub have been found in the mainstem Colorado River, especially downstream of Havasu Rapid (Dzul et al. 2023). This indicates that mainstem spawning is occurring and may be widespread with increased water temperatures from Lake Powell's low elevations.

These nearshore habitats may be beneficial to the humpback chub (and other native fish) because they provide shallow, productive, warm refugia for juvenile and adult fish (Reclamation 1995; Hoffnagle 1996). Temperature differences between main channel and nearshore habitats can be pronounced in backwaters and other low-velocity areas. The extent of warming is variable and depends on the timing of the daily minimum and maximum flows, the difference between air and water temperatures, and the topography and orientation of the backwater relative to solar insolation (Korman et al. 2006). For example, summertime water temperatures in backwaters have been reported as high as 25°C (77°F), while main channel temperatures have been near 10°C (50°F) (Maddux et al. 1987) and have warmed in recent decades.

The amount of warming that occurs in backwaters is affected by daily fluctuations, which drain and fill backwater habitats with cold main channel waters (Valdez 1991; Angradi et al. 1992; AZGFD 1996; Behn et al. 2010). During the low, steady, summer flow experiment conducted in 2000 of about 8,000 cfs, temperatures in one backwater were as much as 13°C (23°F) warmer than in the adjacent main channel during some portions of the day; temperature differences were much less at night (Vernieu and Anderson 2013). Backwater temperatures in summer have been reported as much as 2°C to 4°C (3.6°F to 7.2°F) warmer under steady flows than under fluctuating flows (Hoffnagle 1996; Trammell et al. 2002; Korman et al. 2006; Anderson and Wright 2007). In general, the levels of warming observed in nearshore areas and backwaters during the low summer, steady flows in 2000 persisted only for short periods and were smaller than seasonal changes in water temperatures (Vernieu and Anderson 2013). Consequently, the temperature effects of steady flows on native fish were probably small.

While juvenile humpback chub have been reported to show positive selection for backwater habitats, the spatial extent of such habitats in the Colorado River is small compared with other nearshore habitats, such as talus slopes (Dodrill et al. 2015). Dodrill et al. (2015) reported that the total abundance of juvenile humpback chub was much higher in talus than in backwater habitats, and that when relative densities were extrapolated using estimates of backwater prevalence after an HFE release, the majority of juvenile humpback chub were still found outside backwaters. This suggests that the role of HFE releases designed to maintain backwater habitats in influencing native fish population trends in the Colorado River may be limited.

**Life History**

The humpback chub is primarily an insectivore, with larvae, juveniles, and adults all feeding on a variety of aquatic insect larvae and adults, including dipterans (primarily chironomids and simuliids), Thysanoptera (thrips), Hymenoptera (ants, wasps, and bees), and amphipods (such as *Gammarus lacustris*) (Kaeding and Zimmerman 1983; Valdez and Ryel 1995; AZGFD 2001a; Cross et al. 2013). Feeding by all life stages may occur throughout the water column, at the water surface, and on the river bottom.

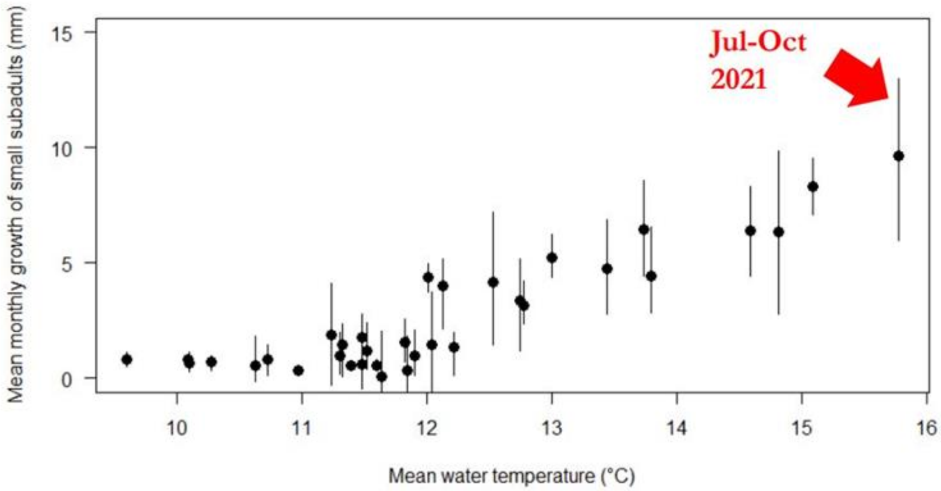
The Grand Canyon humpback chub population has changed dramatically in the last 10–15 years. Humpback chub were mostly unable to reproduce in the mainstem Colorado River because of cold water temperatures, with the exception of local reproduction at the 30-Mile Spring (Valdez and Masslich 1999; Andersen et al. 2010). Nearly all reproduction was thought to occur in the lower 8 miles of the Little Colorado River (AZGFD 2001a; Van Haverbeke et al. 2017). Declining reservoir elevations began in about 2002 (Vernieu et al. 2005; Dibble et al. 2021). Warmer water in the mainstem Colorado River allowed for juvenile humpback chub survival and growth in the eastern part of the Grand Canyon in the mainstem Colorado River near the Little Colorado River (Limburg et al. 2013; Yackulic et al. 2014; Finch et al. 2016) and likely increases in the Little Colorado River population. In the western Grand Canyon, warmer water conditions have likely led to recruitment in the mainstem (Van Haverbeke et al. 2017), which supports what is now the largest population of humpback chub in the entire Colorado River. Additional work is underway to understand the demographics of this population (Dzul et al. 2023).

The life history model for humpback chub is mostly known from the Little Colorado River population. Here, adult humpback chub move into the Little Colorado River from the Colorado River to spawn from March to May (Kaeding and Zimmerman 1983; Gorman and Stone 1999; Valdez and Ryel 1995; Service 2008). This species requires a minimum temperature of 15.5°C (60°F) to reproduce, but mainstem water temperatures typically have ranged from 7°C to 12°C (45°F to 54°F) because of water releases from Glen Canyon Dam (Andersen 2009). Temperatures now exceed these levels in the eastern Grand Canyon and are much higher in the Lower Colorado River and western Grand Canyon (Dzul et al. 2023). For example, drought-induced warming and the lower levels of Lake Powell have resulted in mainstem water temperatures since 2003 consistently exceeding 12°C (54°F) in the summer and fall months. Although some increases in spawning may have played a role in the estimated increase in the humpback chub population in the system since that time, it is likely that the increased temperatures resulted in higher survival of juveniles in the mainstem (Andersen 2009; Coggins and Walters 2009; Yackulic et al. 2014) coupled with the rapid and large expansion of humpback chub in western Grand Canyon.

Increasing water temperatures have been shown in the laboratory to increase humpback chub hatching success, larval survival, and larval and juvenile growth; improve swimming ability; and reduce predation vulnerability (Hamman 1982; Ward 2011; Ward and Morton-Starner 2015). It is postulated that, with warmer water, the growth and survival of juveniles in the mainstem will be greater and result in increased mainstem recruitment, contributing to the overall adult population (Yackulic et al. 2014; Van Haverbeke et al. 2017; Dzul et al. 2023). There was rapid growth of small subadults in the mainstem Colorado River in the vicinity of the Little Colorado River during 2021, which coincided with the warmest water temperatures observed in decades during July–October 2021 (**Figure 3-45**).

Increased water temperatures may also affect predation of YOY humpback chub by rainbow and brown trout (*Salmo trutta*) (Ward 2011; Ward and Morton-Starner 2015; Yard et al. 2011) and allow for the establishment of warmwater nonnative species, which can also prey on humpback chub. Ward and Morton-Starner (2015) conducted laboratory studies that indicated the predation success of rainbow trout on YOY humpback chub decreased from approximately 95 percent to 79 percent as water temperature increased from 10°C to 20°C (50°F to 68°F); predation success by brown trout was about 98 percent and did not change significantly over the same temperature range. Yard et al. (2011) examined the effects of temperature on trout piscivory in the Colorado River and reported no relationship between water temperature and the incidence of piscivory by rainbow trout, but a significant positive correlation was found between water temperature and the incidence of piscivory for the brown trout.

**Figure 3-45**
**Mean Monthly Growth of Small Subadult Humpback Chub in the Mainstem Colorado River in the Vicinity of the Little Colorado River**



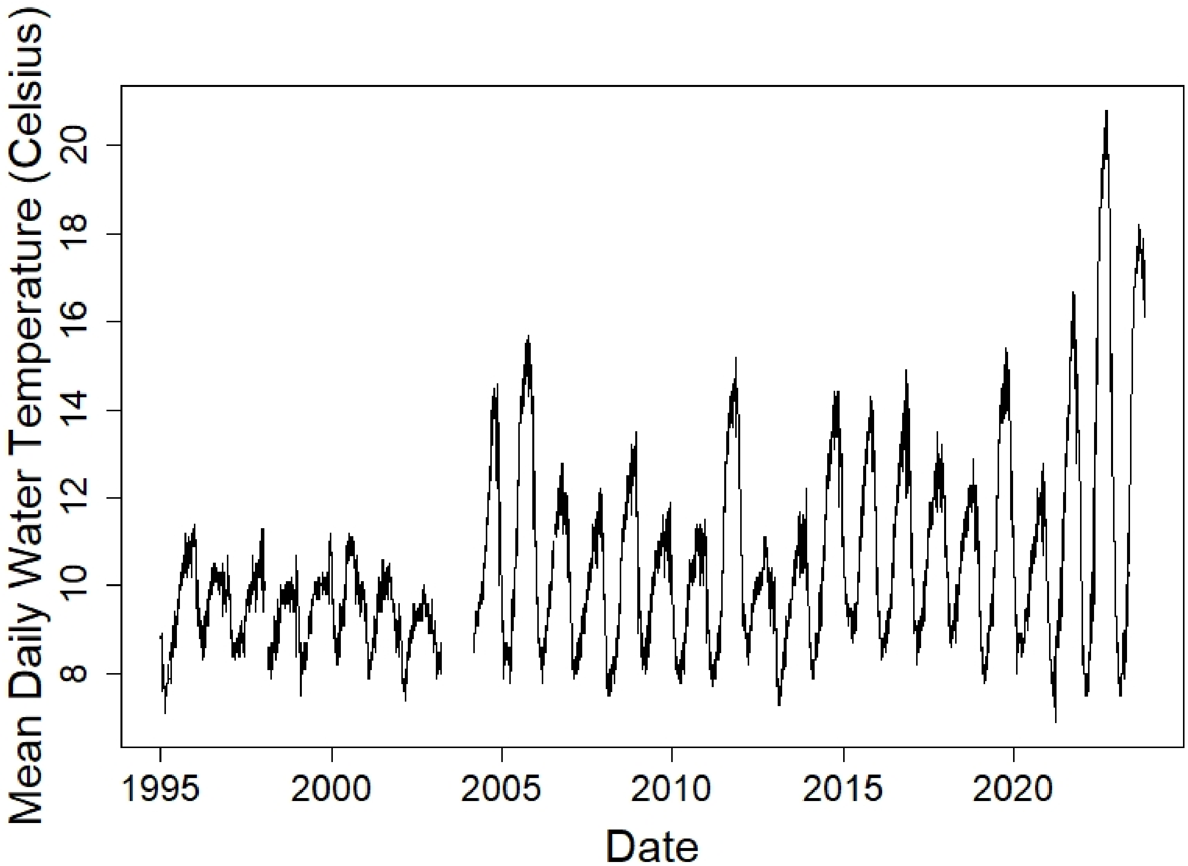

Source: Yackulic 2022

### Factors Affecting Distribution and Abundance in the Grand Canyon

Factors that affect the distribution and abundance of humpback chub in the Grand Canyon include habitat alterations associated with dams and reservoirs and the introduction of nonnative fish that act as competitors or predators (see *Interactions with Native Species*) (AZGFD 2001a; Andersen 2009; Yard et al. 2011; Kennedy et al. 2013). The abundance and distribution of nonnative fish are discussed in *Cold-water Nonnative Species*. In addition, the Colorado River now includes nonnative fish parasites, such as the Asian tapeworm and anchor worm, which may infect some humpback chub and affect survival (Clarkson et al. 1997; Hoffnagle et al. 2006; Andersen 2009). While cold-water releases from Glen Canyon Dam have limited reproduction and recruitment of humpback chub (and other native fish) in the mainstem Colorado River, warmer mainstem temperatures over the last two decades have been sufficiently high to allow for growth, survival, and recruitment of humpback chub, contributing to the improving status of this species in the Grand Canyon (Reclamation 2011e; Yackulic et al. 2014).

In 2022 and 2023, observed river temperatures below the dam were the highest since the filling of Lake Powell; the temperatures fell within the range of spawning temperatures for smallmouth bass and other warmwater nonnative fish (**Figure 3-46**). Smallmouth bass and humpback chub share overlapping temperature preferences for growth, survival, and recruitment. However, prior to 2022, temperatures were sufficient for humpback chub populations to increase while smallmouth bass were unable to recruit. As of the fall 2023, the increasing abundance of humpback chub in the western Grand Canyon is currently an area of important research (Van Haverbeke et al. 2017; Gilbert et al. 2022; Dzul et al. 2023).

**Figure 3-46**
**Water Temperatures of the Colorado River at Lees Ferry as Measured at USGS Gage #09380000, 1995 to Present**




Source: USGS 2023
Note: The warmest temperatures of greater than 20°C (68°F) in 2022 were in late September and early October.

Population estimates indicate that the number of adult humpback chub that spawn in the Little Colorado River has ranged from about 10,000 to 15,000 (**Figure 3-44**). A number of factors have been suggested as being responsible for the observed increases, including experimental water releases, trout removal, declines in trout abundance due to low DO levels during 2006, and drought-induced warming (Andersen 2009; Coggins and Walters 2009). Some experimental releases, such as the November HFE release in 2004, may have adversely affected rainbow trout and improved humpback chub habitat along the main channel (Korman et al. 2010). However, the March 2008 HFE release may have improved rainbow trout spawning habitat quality and age-0 survival rates in the Glen Canyon reach (Korman et al. 2011). Following this release, the abundance of rainbow trout (using catch-per-unit effort as a surrogate for abundance) in this reach was reported to be about 300 percent greater in 2009 than in 2007 (about 3.9 fish per minute versus 1.3 fish per minute) (Makinster et al. 2011). A similar increase in rainbow trout abundance between 2007 and 2009 was observed at the Little Colorado River confluence (river miles 56–69) (Kennedy and Ralston 2011).

Predation by rainbow and brown trout at the Little Colorado River confluence has been identified as an additional mortality source affecting humpback chub survival, reproduction, and recruitment (Valdez and Ryel 1995; Marsh and Douglas 1997; Yard et al. 2011). Predation by channel catfish and black bullhead is also thought to threaten humpback chub in the Grand Canyon, particularly if warmer water conditions occur (NPS 2013e). Because of their size, adult humpback chub are less likely to be preyed on by trout; however, emergent fry, YOY, and juvenile humpback chub are susceptible to predation in the mainstem Colorado River in the vicinity of the Little Colorado River (Yard et al. 2011).

Water temperatures below Glen Canyon Dam began increasing in 2003 as a result of drought conditions that lowered the level of Lake Powell and resulted in the release of warmer water from the dam (Andersen 2009; Andersen et al. 2010); temperatures have remained elevated relative to operations during the 1980s and 1990s due to continued drought-induced lower Lake Powell reservoir levels and somewhat due to relatively high inflows in 2008, 2009, 2011, and 2023. In 2005, the maximum mainstem water temperature exceeded 15°C (59°F) at Lees Ferry and approached 18°C (64°F) in the vicinity of the Little Colorado River (river mile 61); these were the warmest temperature at those locations since the reservoir was filled in 1980 (**Figure 3-46**). Maximum water temperature in the mainstem at Lees Ferry reached about 14°C (57°F) in 2008 (USGS 2014b); this was similar to temperatures in 2003 when drought effects from low Lake Powell levels began to raise Glen Canyon Dam release temperatures.

In 2011, maximum mainstem water temperatures at Lees Ferry and the Little Colorado River confluence (river mile 61) reached about 15°C (59°F) and 15.5°C (60°F), respectively (**Figure 3-46**). In recent years, including 2022, water temperatures at Lees Ferry and the Little Colorado River confluence reached 20°C (68°F) (GCMRC 2023b). This warmer water likely benefited the humpback chub and other native fish, but it may also have benefited nonnative, warmwater species (such as channel catfish and striped bass) that are more common over a wider spatial range (Andersen 2009; Coggins and Walters 2009; Kennedy and Ralston 2011; Smallmouth Bass Ad Hoc Group 2023). Although still relatively low, increases in nonnative fish abundance could threaten the humpback chub population.

#### *Razorback Sucker*

The razorback sucker is a large river sucker (Catostomidae) endemic to the Colorado River system. It is a large fish that may live up to 40 years, with adults reaching a total length of up to 1,000 millimeters (39 inches) and weights of 5–6 kilograms (11–13 pounds). However, they are more typically found within the 400–700 millimeter (16–28 inch) total length range and weigh less than 3 kilograms (7 pounds) (Service 2018b). The razorback sucker was listed as endangered in 1991 (56 *Federal Register* 54957). Critical habitat was designated in 1994 and includes the Colorado River and its 100-year floodplain from the confluence of the Paria River downstream to Hoover Dam (a distance of about 500 miles), including Lake Mead to full pool elevation (59 *Federal Register* 13374).

##### Distribution and Abundance

The razorback sucker is endemic to large rivers of the Colorado River system from Wyoming to Mexico. The species currently is found in the Green River, Upper Colorado River, and San Juan River subbasins of the Upper Basin, and in the Lower Colorado River in Lake Powell (Francis et al.

2015), in Lake Mead and Lake Mohave, between Lake Havasu and Davis Dam, and in tributaries of the Gila River subbasin (Service 2018b). The largest remaining wild-spawned population was in Lake Mohave (Marsh et al. 2003); however, the wild fish have died from old age, and the population is being supported by the rearing of wild-spawned larvae in hatcheries and the release of those fish to the reservoir. Within the Grand Canyon, this species historically occurred in the Colorado River from Lake Mead into Maxson Canyon (river mile 252.5), with several documented captures at the Little Colorado River inflow in 1989 and 1990, and at the Paria River mouth in 1963 and 1978 (NPS 2013e).

Until recently, the last razorback sucker collected from the Grand Canyon (river mile 39.3) was caught in 1993, and the species was considered extirpated from the Grand Canyon. However, razorback suckers and flannelmouth-razorback sucker hybrids have recently been captured from the Little Colorado River (Douglas and Marsh 1998) and from the western Grand Canyon (Bunch et al. 2012a; Bunch et al. 2012b; Rogowski and Wolters 2014; Rogowski et al. 2015). Four fish that were sonic tagged in Lake Mead in 2010 and 2011 were detected in the spring and summer of 2012 in GCNP up to Quartermaster Canyon (river mile 260) (Kegerries and Albrecht 2012, as cited in NPS 2013e). An additional untagged adult razorback sucker was captured in GCNP near Spencer Creek (river mile 246) in October 2012 (Bunch et al. 2012b), and another adult was collected in late 2013 (GCMRC 2014) at the same location. Recent sampling of channel margin habitats has also documented razorback sucker larvae as far upstream as river mile 179 (just upstream of Lava Falls), indicating that spawning is occurring in the mainstem river in the western Grand Canyon (Albrecht et al. 2014).

Razorback sucker studies were conducted in the Lake Mead inflow in 2010 and in the lower Grand Canyon since 2014. Larval fish sampling verified razorback sucker spawning and larval production in the Colorado River within GCNP for the first 6 years of the project (2014–2019) (Rogers et al. 2023). In 2019, eight larval razorback suckers were captured during April and May and distributed from river mile 127.3 to river mile 279.0. A razorback sucker captured in May 2019 at river mile 127.3 was the farthest upstream that razorback sucker larvae had been captured within the expanded study area (2016–2019; river miles 88.6–279.0). This finding extended the distribution of age-0 razorback sucker 17.5 river miles farther upstream than the previously identified most-upstream capture of razorback sucker in 2018 (one captured, river mile 144.8).

This information indicates that the razorback sucker may be slowly expanding upstream from Lake Mead into the Colorado River through Grand Canyon, but most fish captured are in western Grand Canyon. Although captures of any life stage of razorback sucker are rare in the upper half of the Grand Canyon, telemetry efforts have been useful in documenting use and movement since 2014 (Albrecht et al. 2014). Most recently, an adult razorback sucker was detected via sonic telemetry to have been near river mile 15. Since 2014, a total of six telemetry detections have been recorded to occur above river mile 30 (Rogers et al. 2023).

A science panel (Pennock et al. 2022) recently evaluated the prospect of augmenting the population of razorback sucker in GCNP. The majority (but not all) of the panelists agreed that augmentation should occur in Lake Mead at multiple locations to spread the risk of post-stocking survival that is thought to be location specific. The panel recommended stocking about 600 fish per year (300 from

Lake Mead and 300 from Lake Mohave), with fish smaller than 200 millimeters (8 inches) included to evaluate size effect. Stocking should be conducted once per year for 3 years with assessment and evaluation.

**Habitat**

The razorback sucker uses a variety of habitats, ranging from mainstem channels to slow backwaters of medium and large streams and rivers (AZGFD 2002c; Service 2018b). In rivers, habitat requirements of adults in spring include deep runs, eddies, backwaters, and flooded off-channel areas; in summer, runs and pools, often in shallow water associated with submerged sandbars; and in winter, low-velocity runs, pools, and eddies. In reservoirs, adults prefer areas with water depths of 1 meter (3.3 feet) or more over sand, mud, or gravel substrates. Young require nursery areas with quiet, warm, shallow water such as tributary mouths, backwaters, and inundated floodplains along rivers, and coves or shorelines in reservoirs. Captures of larval razorback sucker in the western Grand Canyon found the highest density of larvae in isolated pools, which comprised less than 2 percent of all habitats sampled (Albrecht et al. 2014; Rogers et al. 2023). Similar results were found in 2015, when the highest catch of larval razorback sucker was found in isolated pools, followed by backwaters, which comprised 2.1 percent and 9.1 percent of habitats sampled, respectively (Kegerries et al. 2015).

**Life History**

Both adults and immature fish are omnivorous, feeding on algae, zooplankton, and aquatic insect larvae. In Lake Mohave, their diet has been reported to be dominated by zooplankton, diatoms, filamentous algae, and detritus (Marsh 1987). Razorback suckers exhibit relatively fast growth in the first 5 to 7 years of life, after which growth slows and possibly stops (AZGFD 2002c). Both sexes are sexually mature by age 4. Spawning in rivers occurs over bars of cobble, gravel, and sand substrates during spring runoff at widely ranging flows and at water temperatures typically greater than 14°C (57°F) (Service 2002a, 2018b). In reservoirs, spawning occurs over rocky shoals and shorelines. Temperatures for spawning, egg incubation, and growth of this species range from 14°C to 25°C (57°F to 77°F).

Hatching success is temperature dependent, with complete mortality occurring at temperatures less than 10°C (50°F); optimum temperatures for adults are around 22°C–25°C (72°F–77°F) (AZGFD 2002c). Based on back calculation from the dates of larval collection, Kegerries et al. (2015) estimated that the onset of spawning in the western Grand Canyon was in mid-February when average daily water temperatures were between 10°C and 12°C (50°F and 54°F). Spawning appeared to peak toward the end of March when water temperatures were in the range of 12°C–14°C (54°F–57°F), although the entire spawning period was estimated to range from mid-February to July (Kegerries et al. 2015).

Historically, this species exhibited upstream migrations in spring for spawning, although current populations include groups that are sedentary and others that move extensively (Minckley et al. 1991). Adults in the Green River subbasin have been reported to move as much as 62 miles to specific areas to spawn (Tyus and Karp 1990). In Lake Mohave, individuals have been reported to move 12 to 19 miles between spring spawning and summer use areas (Mueller et al. 2000). Kegerries et al. (2015) reported that sonic-tagged razorback suckers either stayed near spawning areas or moved up to 361 kilometers (224 miles) within the western Grand Canyon, the Colorado River inflow to Lake Mead, and throughout Lake Mead.

**Factors Affecting Distribution and Abundance in the Grand Canyon**

The decline of the razorback sucker throughout its range has been attributed primarily to habitat loss due to dam construction, the loss of spawning and nursery habitats as a result of diking and dam operations, and alteration of flow hydrology (AZGFD 2002c; Service 2018b). For example, the 80 percent reduction in the historical distribution of this species has been attributed to the construction of Hoover, Parker, Davis, and Glen Canyon Dams on the Colorado River and Flaming Gorge Dam on the Green River (Valdez et al. 2012). In addition, competition with and predation by nonnative fish have also been identified as important factors in the decline of this species (Minckley et al. 1991; Service 2002a). In the Grand Canyon, the decline of native fish, including razorback sucker, has been attributed to multiple factors, including modifications to river temperatures and discharge patterns due to Glen Canyon Dam and the subsequent establishment of nonnative fish populations. This has led to more than two decades of experimental actions to understand the factors that influence the occurrence, abundance, and distribution of native fish in the Grand Canyon (Gloss and Coggins 2005; Coggins et al. 2015; Service 2018b).

As described above, efforts to better understand the use of the western Grand Canyon by razorback sucker have revealed that the species is more widespread there than previously thought; it occupies and spawns in the river from at least Lava Falls through the entirety of Lake Mead, and it maintains a reproducing population in the project area (Albrecht et al. 2014; Kegerries et al. 2015). Currently, there is little information on the habitat use and life history needs of the species in the Grand Canyon and Lake Mead. Additional research and monitoring are needed to better understand the management implications for the recovery of razorback sucker in this reach of its range (Albrecht et al. 2014; Service 2018b).

### *Southwestern Willow Flycatcher*

The southwestern willow flycatcher (*Empidonax traillii extimus*) was listed as endangered in 1995 (60 *Federal Register* 10694). Critical habitat was designated in 2013 (78 *Federal Register* 344), but no critical habitat was designated between Glen Canyon Dam and Lake Mead. The southwestern willow flycatcher is designated as a tier 1 species of greatest conservation need in Arizona.

Southwestern willow flycatchers are neotropical migrants that typically breed in dense, riparian habitats near saturated soils or surface water. They arrive on their breeding grounds in the southwestern US in May through mid-June and depart in late July through early September. Southwestern willow flycatchers rarely breed in linear habitats that are more than 10 meters (33 feet) wide, though they will use these habitats during migration (Sogge et al. 2010). Southwestern willow flycatchers use native riparian vegetation (for example, willows [*Salix* spp.]) as well as tamarisk (*Tamarix* spp.) and are generalist insectivores.

Disjunct breeding locations in the Grand Canyon have been documented below Lees Ferry in Marble Canyon and in the lower Grand Canyon below Diamond Creek (river miles 225.5–277) (Braden and McKernan 2006; McLeod et al. 2008; Sogge et al. 1997). No southwestern willow flycatcher nests or nesting behavior have been identified in the inner gorge (river miles 77.9–116.5).

Habitat quality declined between the 1980s and the mid-2010s, and detections of breeding southwestern willow flycatchers declined accordingly. No breeding southwestern willow flycatchers were detected between Lees Ferry and Diamond Creek from 2004 through 2015. During that period, breeding or territorial southwestern willow flycatchers were detected downstream of Diamond Creek at Burnt Springs (2007) and river mile 275 (2004, 2006, and 2010) (reviewed in Reclamation and NPS 2016).

Surveys were completed in 2019 and 2021 from river mile 0 through river mile 280. No southwestern willow flycatchers were detected during surveys in 2019. In 2021, four willow flycatchers were detected in May between Lees Ferry and Diamond Creek, but no willow flycatchers were detected during subsequent surveys. The detected birds were likely spring migrants and were not confirmed to be southwestern willow flycatchers (Terwilliger and Holm 2021). Surveys were completed in 2023 between Diamond Creek (river mile 225) and Pearce Ferry (river mile 280). Suspected southwestern willow flycatchers were detected at Burnt Springs (two individuals) and at river mile 275 (two individuals); however, the birds did not produce diagnostic vocalizations, and their identity was not confirmed (Terwilliger and Whyte 2023).

Most patches of riparian vegetation in the Grand Canyon lack a consistent, dependable source of water for maintaining moist/saturated soil conditions and slow-moving or standing surface water (Stroud-Settles et al. 2013). As a result, most habitat in the Grand Canyon that might be used by southwestern willow flycatchers is of marginal quality, and these patches are likely to continue to decline without an increase in surface water. Furthermore, the tamarisk leaf beetle has transformed and will continue to transform the patches of dense tamarisk into unpredictable, diminished patches (Stroud-Settles et al. 2013; Terwilliger and Holm 2021). Riparian vegetation in the only two sites (river mile 259.5 [Burnt Springs] and river mile 275) where breeding southwestern willow flycatchers have been detected over the past 20 years is maintained by water in tributary canyons or from springs; it does not depend on flow in the mainstem of the Colorado River. The Colorado River corridor continues to provide habitat for migrating willow flycatchers.

#### *Western Yellow-Billed Cuckoo*

The western yellow-billed cuckoo (*Coccyzus americanus*) distinct population segment was listed as threatened in 2014 (79 *Federal Register* 59992). Critical habitat was designated in 2021 (86 *Federal Register* 20798), but no critical habitat was designated between Glen Canyon Dam and Lake Mead. The western yellow-billed cuckoo is designated as a tier 1 species of greatest conservation need in Arizona.

Western yellow-billed cuckoos are neotropical migrants that typically breed in blocks of riparian woodland that are 50 acres or larger (Halterman et al. 2016; 78 *Federal Register* 61622). Occupied lowland riparian habitat generally consists of mature, multilayered cottonwood and willow forest, although other riparian tree species, such as mesquite and tamarisk, may be present. Nest locations typically have high canopy closure (McNeil et al. 2013). Western yellow-billed cuckoos are late-spring migrants. Some individuals can arrive in mid- to late May, but most do not arrive until mid-June. Nesting generally peaks during July and early August and can continue into September. Fall migration begins in August, and most birds leave by mid-September (McNeil et al. 2013). Large prey items such as cicadas, katydids, grasshoppers, and caterpillars form the bulk of the cuckoo's diet (78

*Federal Register* 61622). Arrival on the breeding grounds may be timed to coincide with abundant prey.

The Grand Canyon upstream of Separation Canyon does not support the large blocks of mature riparian forests used by western yellow-billed cuckoos as breeding habitat. Western yellow-billed cuckoos were regularly detected between Spencer Creek (river mile 246) and Pearce Ferry in the late 1990s and into the early 2000s when high water levels in Lake Mead supported cottonwood-willow vegetation (McKernan and Braden 2002). Declining water levels in Lake Mead in the early 2000s left riparian vegetation along the mainstem between Separation Canyon and Pearce Ferry on high, dry riverbanks, where the vegetation subsequently died (McLeod et al. 2008). After the early 2000s, the only stands of mature, riparian habitat in the analysis area were in side canyons, such as Burnt Springs, and at the spring-fed river mile 275 site. These stands did not depend on flow in the mainstem of the Colorado River. An incidental detection of a western yellow-billed cuckoo was recorded at Burnt Springs during southwestern willow flycatcher surveys in 2021 (Terwilliger and Holm 2021). Riparian vegetation along the mainstem provides habitat that could be used by migrating western yellow-billed cuckoos.

### 3.8.2 Environmental Consequences

#### *Methodology*

Previous research and monitoring conducted within the Colorado River and its tributaries were evaluated and analyzed to inform the results of this analysis. The environmental consequences for threatened and endangered fish within the project area are based on relationships between flow alterations and impacts on the food base, fish habitat, native species (including special status species), and nonnative species that are potential predators of native species within the Colorado River. This analysis used qualitative relationships to assess changes in flow and habitat, food base abundance and distribution, specific species' distribution based on habitat requirements, and impacts from interactions of native species with nonnative aquatic species.

Results from the hydrologic models, including the CRSS model and the GTMax, were used to evaluate the effects of flows on aquatic resources. Preliminary quantitative models for smallmouth bass that are ongoing by USGS scientists were also used as part of the evaluation (Yackulic et al. 2024, chap. 4).

The analysis for threatened and endangered birds is informed by hydrologic and vegetation models showing the effects of dam releases on the hydrology and riparian vegetation, and the resulting impacts on vegetation. As discussed in the 2016 LTEMP FEIS, the primary effects on riparian vegetation below the Glen Canyon Dam will be a direct function of the changes in flow regimes under each alternative. The vegetation model has several limitations that should be noted when considering the modeling results. The model was designed as a conceptual, as opposed to a predictive, model; therefore, the results are used in this analysis carefully and in combination with the literature, because the model is a simplification with limitations in the ability to assess on-the-ground changes. However, it is the best available tool for impact analysis, when used in conjunction with field studies and literature. Therefore, the environmental consequences for riparian vegetation are presented as a qualitative discussion of how each alternative may affect riparian vegetation cover.

**Impact Analysis Area**

The analysis area is consistent with that used in the 2016 LTEMP FEIS. It includes the Colorado River mainstem corridor, affected tributary mouths, and interacting resources in associated riparian zones located primarily from the forebay of Glen Canyon Dam to Pearce Ferry above Lake Mead.

This area includes the Colorado River ecosystem from Glen Canyon Dam downstream to the Lake Mead inflow. More specifically, the scope primarily encompasses the Colorado River mainstem corridor and interacting resources in associated riparian zones located primarily from the forebay of Glen Canyon Dam to Pearce Ferry.

**Assumptions**

- Flow alterations would not impact tributary streams except fish access and habitat at the mouths.
- Lake Mead and Lake Powell would not be influenced because annual flows will remain the same.
- The results of biological analyses and the ecological modeling that are available depend on the data inputs, modeling assumptions, and validity of the models.
- The 2016 LTEMP FEIS and the SMB EA were used to provide background and for the analysis of the flows' effects on aquatic resources.
- The BLM Sensitive Species Lists Arizona statewide conservation agreement for six native fish species was used to identify special status fish species.
- The Lower Colorado River Multi-Species Conservation Program's Habitat Conservation Plan was used for areas downstream of Separation Canyon.

**Impact Indicators**

- Changes in distribution and abundance of food base items, including primary and secondary producers such as algae and macroinvertebrates
- Changes in river channel area affected by flows, including the main channel and shallow-water habitats
- Changes in distribution and abundance of native and nonnative fish species and hypothesized interactions between these groups of fish
- Changes in fish habitats, including talus shorelines and backwaters
- Changes in woody riparian vegetation or marsh vegetation

### *Issue 1: How would flow alterations at Glen Canyon Dam impact threatened and endangered bird species using habitats along the Colorado River?*

**Southwestern Willow Flycatcher**

Riparian habitat that supports breeding southwestern willow flycatchers in the Grand Canyon exists only in areas where vegetation is maintained by tributaries or springs. The habitat is not influenced by flows in the mainstem Colorado River. Migratory southwestern willow flycatchers could use riparian vegetation along the mainstem Colorado River.

**Section 3.6**, Terrestrial Resources and Wetlands, describes anticipated changes in the characteristics of riparian vegetation communities. However, no alternative is expected to result in important structural changes in riparian habitat or vegetation productivity that could affect migrating southwestern willow flycatchers.

As discussed in **Section 3.7**, Wildlife, invertebrates with only terrestrial life stages are not expected to be affected differentially by the alternatives. Those invertebrates with both aquatic and terrestrial life stages are expected to benefit from the alternatives with more stable flows. These changes in food production are expected to result in negligible impacts on the southwestern willow flycatcher.

#### Western Yellow-billed Cuckoo

Riparian habitat that could support breeding western yellow-billed cuckoos in the Grand Canyon occurs only in areas where vegetation is maintained by tributaries or springs. The habitat is not influenced by flows in the mainstem Colorado River. Migratory or transient western yellow-billed cuckoos could use riparian vegetation along the mainstem Colorado River. No impacts on western yellow-billed cuckoos are anticipated from any alternatives analyzed herein.

#### California Condor

Along the Colorado River in Glen and Grand Canyons, California condors use cliffs for nesting and roosting and beaches for bathing, resting, preening, and feeding. No impacts on California condors are anticipated from any alternatives analyzed herein.

### *Issue 2: How would flow alterations at Glen Canyon Dam impact threatened and endangered fish species in the Colorado River?*

#### Humpback Chub and Razorback Sucker

*No Action Alternative*

Under the No Action Alternative, the humpback chub and razorback sucker may be subjected to increasing levels of predation and competition from nonnative fish, especially smallmouth bass and possibly green sunfish and other invasive, aquatic species. Although population levels of humpback chub are likely the highest since the construction of Glen Canyon Dam, invasions of nonnative species, especially smallmouth bass, could lead to the decline of some population centers of native fish species, such as near the mouth of the Little Colorado River. Based on how smallmouth bass populations have expanded in many other southwestern US rivers, this species can be expected to spread downstream to overlap with chub populations at the confluence of the Little Colorado River. Populations have the potential to expand as far downstream as below Havasu Rapid and the Lake Mead inflow, where they could negatively affect the expanded population of humpback chub and interfere with movement of razorback sucker into the Colorado River from Lake Mead.

*Cool Mix Alternative*

The humpback chub and razorback sucker would not likely be negatively affected by this lower-temperature regime because these fish existed in the Colorado River downstream of Glen Canyon

Dam when dam release temperatures were generally below 15°C (59°F) prior to 2022. Although humpback chub is found upstream of the Little Colorado River (as an aggregation at 30-Mile Spring and near the confluence of the Little Colorado River at river mile 61), the majority of the population is now found downstream in western Grand Canyon between Havasu Rapid (river mile 157) and Pearce Ferry (river mile 280) (Rogowski et al. 2018; **Figure 3-43**). The razorback sucker is found primarily in the Lake Mead inflow, with a few individuals moving upstream into the Colorado River.

Under the Cool Mix Alternative, the presumed distributions of these species would remain about the same; they are expected to persist under this alternative. Cooler water temperatures would likely slow the growth of humpback chub and razorback sucker; however, these could lead to improvements in survival if the predation risk by nonnative species declines. The temperatures proposed under this alternative would be consistent with the conditions present when the analysis for the 2016 LTEMP FEIS (DOI 2016a) was conducted. In other words, impacts on the humpback chub would not likely be different from those analyzed in the 2016 LTEMP FEIS. Cooler temperatures may also benefit humpback chub and razorback sucker by limiting the reproductive capabilities of parasites, such as Asian tapeworm and anchor worm, which require 18°C (64.4°F) or higher to mature and reproduce (Hoffnagle et al. 2006).

*Cool Mix with Flow Spike Alternative*

The humpback chub and razorback sucker would not likely be negatively affected by the proposed lower-temperature regime or by the flow spikes. This is because these fish existed in the Colorado River downstream of Glen Canyon Dam when dam release temperatures were generally below 15°C (59°F) prior to 2022. These species have also persisted through nine HFE releases since 1996 (Webb et al. 1999; Melis 2011). Cooler water temperatures are expected to slow the body growth of these species; however, they could also increase the species' survival (depending on interactions with nonnative species) and decrease their susceptibility to parasites. The temperatures proposed under this alternative would be consistent with the conditions present when the analysis for the 2016 LTEMP FEIS (DOI 2016a) was conducted. Impacts on the humpback chub and razorback sucker from the temperature would not likely be different from those analyzed in the 2016 LTEMP FEIS.

The proposed timing of the flow spikes between June and mid-July would occur during a time of year when flow spikes have not been conducted below Glen Canyon Dam. Although flow spikes and HFE releases are conceptually similar, HFE releases have been conducted in April and November. Flow spikes from June to mid-July could displace newly hatched larvae and early juvenile humpback chub from shoreline habitats and subject them to starvation and predation. However, this effect is expected to dissipate with distance downstream of Glen Canyon Dam and especially downstream of the Little Colorado River where the majority of humpback chub and razorback sucker occur; it also is not expected to be a population-level effect.

Flow spikes between June and mid-July would occur before the highest seasonal water temperature warming below Glen Canyon Dam; these could create different thermal conditions in the Colorado River ecosystem below Glen Canyon Dam than what has been observed during previous HFE releases. Large juvenile and adult humpback chub are able to adjust their position along talus shorelines with changes in flow stage (Converse et al. 1998; Webb et al. 1999; Korman et al. 2004; Dodrill et al. 2015; Finch et al. 2015). They are not expected to be greatly affected by these spike flows. The number of razorback sucker upstream of the Little Colorado River is small, and this alternative is not expected to substantially affect this species.

Cooler temperatures are not expected to negatively affect the food base of humpback chub and razorback sucker, but short-term spike flows could scour the benthos. This would temporarily reduce the food base; however, the food base is expected to recover quickly because solar radiation and photosynthesis are high during May–July. Cooler temperatures may benefit these species by limiting the reproductive capabilities of parasites, such as the Asian tapeworm and the anchor worm, which require 18°C (64.4°F) or higher to mature and reproduce.

This alternative would be most likely to lower water temperatures below 15.5°C (60°F) from Glen Canyon Dam to river mile 45 in Marble Canyon, depending on the temperature and volume of water through the penstocks (USGS 2022), and increase the distance of effect to river mile 61 at the confluence with the Little Colorado River. Because smallmouth bass have most recently been documented in the region of river immediately below Glen Canyon Dam, this alternative would have the greatest effect on river temperature and stage in the area where smallmouth bass have been found; however, both the temperature and flow spike effects would be reduced near the first large aggregation of humpback chub near the Little Colorado River inflow.

*Cold Shock Alternative*

A sudden surge of cold water would not likely negatively affect large juvenile and adult humpback chub or razorback sucker. However, low water temperatures could impair larvae and small juvenile humpback chub's swimming ability and increase the predation risk (Ward and Morton-Starner 2015). The risk of this effect depends on the extent and timing of the cold shock. For example, the cold shock would most likely have its largest effect near Glen Canyon Dam, where smallmouth bass have been spawning. However, the impact of the cold shock in areas of the Colorado River where native fish are found in higher abundance, including the Little Colorado River inflow, would likely be less than near Glen Canyon Dam; this is because the water would warm with distance.

*Cold Shock with Flow Spike Alternative*

A sudden surge of cold water would not likely negatively affect large juvenile and adult humpback chub or razorback sucker, but it could cold shock and displace young and early juvenile fish from secure talus shoreline habitats or backwaters (Clarkson and Childs 2000). It could also expose them to predation by cold-water predators like rainbow trout and brown trout. This effect would likely be greater if flow spikes are released during May–July when humpback chub are generally younger and smaller and are not able to maintain their position within different habitat types at higher water velocity. This risk would be reduced if flow spikes occur after July when juvenile humpback chub would have had a longer opportunity to reach older ages, larger body sizes, and better swimming ability.

This displacement effect is likely proportional to the size of the flow spike. As the flow spike effect on the river stage dissipates with distance downstream, so does the risk of displacement. Weekly use of cold-shock events could reduce the growth and survival of young humpback chub and razorback suckers, but the effect is not expected to be a population-level effect. Periodic flow spikes are not expected to negatively affect large juvenile and adult humpback chub or razorback suckers.

However, high water velocity could displace young and early juveniles, especially if they are cold shocked, and expose them to starvation and predation.

There are limited reports available of razorback suckers in the affected reach of the Colorado River (from Glen Canyon Dam to the confluence with the Little Colorado River at river mile 61). Water temperatures and flow volumes from this proposed flow alternative would affect downstream reaches occupied by adult razorback suckers moving into the lower Grand Canyon from Lake Mead. The effects, however, would be dissipated with distance downstream, especially below the Little Colorado River. Also, the few larvae and juvenile razorback suckers produced in the lower Grand Canyon could be affected as flow changes inundate or dewater backwaters used by juveniles. However, the effects are expected to be minor because flow characteristics would moderate with distance from the dam.

*Non-Bypass Alternative*

High flows of up to 30,000 cfs are not expected to negatively affect large juvenile and adult humpback chub or razorback suckers. These species experience this level of river discharge within the powerplant's capacity during normal operations and some HFE events. Although some young fish may become displaced and exposed to increased predation risk, the effect of these high flows on humpback chub and razorback suckers is expected to be minimal. Low-flow events, including discharge levels of 2,000 cfs, have rarely been seen in the Colorado River downstream of Glen Canyon Dam in recent decades. In 1990–1991, "research flows" were released as low as 1,000 cfs on weekends from Labor Day to Easter, but an in-depth evaluation was not conducted on resource responses to these low-flow events.

Studies of humpback chub (Valdez and Ryel 1995; Converse et al. 1998) indicated that much of the shoreline talus habitat and the backwaters used by juveniles were dewatered during extreme low-flow events, forcing the fish to move to mainstem habitats where they were possibly at greater risk of predation. Adult humpback chub and razorback suckers most likely moved to more suitable habitats during extreme low flows and were not affected by these short-term events. Age-0 and juveniles of both species could be at risk of predation or starvation if they are displaced from their habitats by the extreme low (2,000 cfs) and high (27,300 cfs) flows of this alternative. Also, the upstream reproducing aggregation of humpback chub at river mile 30 (Valdez and Masslich 1999) could be negatively affected by the low flows that could strand the warm shoreline spring that provides a warmwater refugium in an otherwise cold river. If larvae or age-0 fish are present, the low flow could strand the fish, and the high flow could displace them downstream, reducing survival.

High and low flows under this alternative are proposed to occur such that as the high-flow wave travels downstream, it catches and then collapses the low-flow trough by the time it reaches the Little Colorado River. Doing this would prevent the minimum flow near the Little Colorado River from decreasing below 5,000 cfs. Similarly, with distance from Glen Canyon Dam, the duration of any low-flow trough would also be reduced. However, the phenomenon of a collapsed trough is not likely to occur at the location of the upstream-most population of the humpback chub at river mile 30. However, the fish of this population have exhibited an ability to withstand large variations in flow.

*Cumulative Effects*
The cumulative effects of these action alternatives on threatened and endangered fish would likely be temporary and beneficial overall. This is because the action alternatives are meant to disrupt smallmouth bass spawning and recruitment. At present, smallmouth bass are detected near Glen Canyon Dam, which is spatially separated from the first large aggregation of humpback chub near the Little Colorado River confluence (river mile 61). This spatial separation between smallmouth bass near Glen Canyon Dam and the humpback chub aggregation near the Little Colorado River likely reduces the potential impacts of the proposed flow alternatives on native fish; this is because of the attenuation of either a flow or temperature treatment between Glen Canyon Dam and the Little Colorado River confluence. At present, small numbers of smallmouth bass are reported near the Little Colorado River and in the western Grand Canyon near Diamond Creek.

However, if smallmouth bass populations expand to include the Colorado River near the Little Colorado River confluence, then the potential effectiveness of the proposed flow scenarios may be reduced. If one or more of these alternatives were to effectively control the expansion in range and abundance of smallmouth bass, the cumulative effect on the threatened and endangered fish would be beneficial by reducing the levels of predation and competition.

Nonnative fish have a long history of negatively impacting native fish populations in many Desert Southwest waterways (Minckley and Marsh 2009), and smallmouth bass are considered one of the most problematic invasive fish species (Johnson et al. 2008). Smallmouth bass spread throughout hundreds of miles of the river in less than 5 years after their initial invasion in the Upper Colorado River Basin (Haines and Modde 2007). Smallmouth bass have the potential to dramatically reduce native fish populations in both the mainstem and in critical tributaries such as the Little Colorado River, just as they have done in other Arizona rivers (Rinne 1999; Marks et al. 2010; Bestgen and Tuttle 2022).

The humpback chub in the Colorado River downstream of Glen Canyon Dam is now at its highest population level since monitoring began following the construction of Glen Canyon Dam (for the recent abundance trend in the western Grand Canyon, see **Figure 3-43**). The recent invasion of smallmouth bass below Glen Canyon Dam above Lees Ferry is a new threat that could negatively affect the humpback chub and the razorback sucker, if the smallmouth bass are displaced or move downstream. Implementation of one or more of the five action alternatives could negatively affect the smallmouth bass and benefit the threatened and endangered species by reducing the risk of predation by nonnative fish on native species and by reducing the competition between nonnative and native fish species. The cumulative effects of any of the five action alternatives are not likely to negatively affect the aquatic resources of the Colorado River downstream to Lake Mead.

### *Summary*
Altogether, five action alternatives and the No Action Alternative were evaluated (see the summary table). The primary goal of the five alternatives is to disrupt spawning by invasive smallmouth bass through the use of high- or low-flow releases from Glen Canyon Dam and by lowering the water temperature through the use of the river outlet works. The five action alternatives are based on a series of models developed by various working groups with information from the scientific literature

and ongoing work in the Upper Colorado River Basin, where efforts to reduce smallmouth bass populations through mechanical removal and flow operations have been ongoing since 2003.

For the Colorado River ecosystem below Glen Canyon Dam, efforts are ongoing to develop predictive models that integrate information from elsewhere into a framework that allows for the evaluation of these different alternatives as a predictive model. These modeling efforts for the Colorado River ecosystem below Glen Canyon Dam are not completed; thus, they are not included in this evaluation. The evaluations of the five action alternatives here are informed by the information that is publicly available in the references described.

Four of the alternatives presented would use both penstock releases and the river outlet works to generate either high flows or spikes and cooler releases or cold shocks. Only one action alternative (the Non-Bypass Alternative) would use the penstocks and not the river outlet works. Each of the five alternatives would have the potential to disrupt smallmouth bass spawning by either dewatering or inundating nesting areas and/or by creating unsuitable water temperatures. The alternatives with the most potential effect for disrupting smallmouth bass spawning are the Cool Mix and Cool Mix with Flow Spike Alternatives; this is because these alternatives disrupt both the suitable and necessary temperature regimes and physical habitat of smallmouth bass nesting and the rearing. Furthermore, the cool-mix alternatives and to a lesser extent the cold-shock alternatives could benefit the rainbow trout fishery by maintaining a colder system that is advantageous to the species and by reducing warmwater predators that also negatively affect this species within the temperature ranges where they coexist.

Generally, the five alternatives are not expected to have a negative population-wide effect on native fish, as these species have adapted to a large range of flows and temperatures in the Colorado River. However, all alternatives do assume that smallmouth bass populations will have impacts on native fish populations. These alternatives are not expected to have long-term, negative effects on the rainbow trout in the Lees Ferry reach.

## 3.9 Air Quality

### 3.9.1 Affected Environment

Air quality is primarily affected by air emission sources, both natural (e.g., wildfires and windblown dust) and human-made (e.g., emissions from stationary sources like fossil fuel–fired powerplants, industrial facilities, and space heating, as well as on-road and off-road mobile sources such as vehicles).

Changes in operations at Glen Canyon Dam can result in more or less hydroelectricity being produced at certain times of the day to meet regional electricity demand. If less electricity is available at Glen Canyon Dam, demand must be met by other means, which may include powerplants fueled by fossil fuels (including coal, oil, and gas turbine plants) and nuclear, other hydroelectric, wind, and solar energy sources, or by demand-side management. Changes in the operation of Glen Canyon Dam, therefore, may indirectly affect air quality by potentially changing the degree to which electricity demand is met within the region, with either non-emission 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 changes can also affect GHG emissions that can influence climate change. Information on GHGs and climate change is discussed in **Section 3.17**, Climate Change.

#### *Local Air Quality*

The Clean Air Act (CAA), as amended (42 US Code 7401), established Prevention of Significant Deterioration (PSD) provisions to protect the nation's air quality and visibility. The PSD provisions apply to new or modified major stationary sources and are designed to maintain an attainment area's compliance with the NAAQS. Major stationary sources are industrial-type facilities and include powerplants and manufacturing facilities that emit more than 100 tons per year of a regulated pollutant.

No major stationary sources are proposed for construction or modification by the proposed alternatives; therefore, the statutory provisions specific to PSD are not applicable. However, there are criteria pollutants for which thresholds for increases in pollution concentrations have been established. These criteria pollutants include $SO_2$, nitrogen dioxide ($NO_2$), and particulate matter (PM), which are often analyzed.

The PSD standards are most stringent in Class I areas and are progressively less stringent in the Class II and Class III areas (**Table 3-31**). The GCNRA and LMNRA are designated as Class II areas, while GCNP is the nearest designated Class I area. Coconino and Mohave Counties in Arizona were chosen as the local air quality analysis area because they contain both the Glen Canyon Dam facility and the GCNP Class I area.

**Table 3-31**
**CAA PSD Designations**

| Designation | Definition |
|---|---|
| Class I Area | Visibility is protected more stringently than under the NAAQS; these areas include national parks, wilderness areas, monuments, and other areas of special national and cultural significance. |
| Class II Area | Moderate change is allowed, but stringent air quality constraints are nevertheless desired. |
| Class III Area | Substantial industrial or other growth is allowed, and increases in concentration up to the NAAQS would be considered insignificant. |

Source: NPS 1981

**Table 3-32** presents criteria pollutant and volatile organic compound (VOC) emission totals in 2020 for Coconino and Mohave Counties in Arizona (EPA 2023a), which encompass the GCNP Class I area. The data represent 13 source categories (e.g., fuel combustion by power generation and industry, highway vehicles, off-highway vehicles, and miscellaneous sources). Miscellaneous sources, including prescribed/structural fires, wildfires, fugitive dust, and agricultural production, account for a predominant portion of the two-county totals of PM with an aerodynamic diameter less than or equal to 2.5 micrometers ($PM_{2.5}$), particulate matter with an aerodynamic diameter less than or equal

**Table 3-32**
**Criteria Pollutant and VOC Emissions (tons) in Counties Encompassing GCNP**

| County | CO | $NO_x$ | VOCs | $PM_{2.5}$ | $PM_{10}$ | $SO_2$ |
|---|---|---|---|---|---|---|
| Coconino, AZ | 102,498 | 11,499 | 105,687 | 7,440 | 14,398 | 643 |
| Mohave, AZ | 48,202 | 8,996 | 37,360 | 1,988 | 6,229 | 109 |
| Total | 150,700 | 20,495 | 143,047 | 9,428 | 20,627 | 752 |

Source: EPA 2023a

to 10 micrometers ($PM_{10}$), and $SO_2$. Highway vehicles are primary contributors to emissions of total carbon monoxide (CO), VOC, and NOx.

Data on emissions from Tribal lands in Coconino and Mohave Counties are hard to find because the emissions data are presented in total emissions for Tribal lands that span many counties and states. On November 18, 2019, after the publication of the 2016 LTEMP FEIS, the Navajo Generating Station, which was a major source of air pollutants in the area, ceased generating emissions when the facility was closed down.

### *Regional Air Quality*

Changes in operations at Glen Canyon Dam can affect regional air quality if these changes result in corresponding increases or decreases in power generation at other facilities in the Western Interconnection grid. The regional air quality analysis area encompasses an 11-state area that includes Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. The Western Interconnection encompasses these states and parts of Canada, however the interconnection boundaries do not align exactly with state boundaries due to the locations of transmission lines and population centers. The 11-state regional analysis area was chosen because emissions inventory data is available by US state but not for the Western Interconnection boundaries.

Under the CAA, the EPA has established the NAAQS for six criteria pollutants considered harmful to public health and the environment (40 CFR 50): $SO_2$, $NO_2$, CO, ozone ($O_3$), $PM_{2.5}$, $PM_{10}$, and lead (Pb) (EPA 2015). Each state in this 11-state area may have its own state ambient air quality standards for criteria pollutants. If a state does not have a standard corresponding to one of the NAAQS or has a less stringent standard than NAAQS, the NAAQS apply. In addition, states can establish standards for pollutants other than criteria pollutants. Several states have adopted standards for additional pollutants: visibility-reducing particles, sulfates, hydrogen sulfide ($H_2S$), and vinyl chloride for California; fluorides for Idaho; $H_2S$, settled PM, and fluoride in forage for Montana; $H_2S$ for Nevada; total suspended particulates, $H_2S$, and total reduced sulfur for New Mexico; particle fallout for Oregon; radionuclides and fluorides for Washington; and $H_2S$, suspended sulfates, fluorides, and odors for Wyoming.

Parts of the 11-state area have not yet attained the NAAQS for $SO_2$, 8-hour $O_3$, $PM_{2.5}$, $PM_{10}$, and Pb. Currently, there are no nonattainment areas for $NO_2$ and CO in the United States and, thus, in the 11-state area. Each state within the 11-state area has one or more nonattainment areas. Arizona has nonattainment areas for all five of the above air pollutants. California has nonattainment areas for four air pollutants. Utah has nonattainment areas for three air pollutants. Two states (Montana and

New Mexico) have nonattainment areas for two air pollutants, while six states (Colorado, Idaho, Nevada, Oregon, Washington, and Wyoming) have nonattainment areas for one air pollutant (EPA 2023b).

There are regional air pollution problems, such as ozone, acid deposition, and visibility degradation, in some areas in the western United States. $O_3$ issues are most prevalent around urban centers, except for elevated wintertime $O_3$ at higher elevations near oil and gas fields in Utah, Wyoming, and Colorado, where atmospheric conditions can prevent pollutants from dispersing and snow cover reflects sunlight needed for $O_3$ formation back to the atmosphere. Impacts of acid deposition have been observed in the Desert Southwest, where excess nitrogen deposition facilitates the invasion of nonnative grass species that compete with native plant species and increase fire risk as a result of increased biomass fuel loading. Acid deposition may also affect high-elevation lakes where excess nitrogen deposition can alter aquatic species composition.

Visibility impairment is a widespread and pervasive problem throughout the country and in many national parks and wilderness areas where the CAA specifically requires visibility protection. Visibility degradation is caused by cumulative emissions of air pollutants from a myriad of sources scattered over a wide geographical area. In general, the primary cause of visibility degradation is the scattering and absorption of light by fine particles, with a secondary contribution provided by gases. In general, visibility conditions in the western United States are substantially better than those in the eastern United States because of the higher pollutant loads and humidity levels in the East (EPA 2006). The typical visual range in most of the western United States is about 60 to 90 miles, while that in most of the eastern United States is about 15 to 30 miles.

Most visibility degradation is associated with combustion-related sources, while fugitive dust sources contribute to some extent. In particular, smaller particles such as $PM_{2.5}$ scatter light more efficiently; these particles include ammonium sulfate, ammonium nitrate, particulate organic matter, light-absorbing carbon (or soot), mineral fine soil, and sea salt. Ammonium sulfate and ammonium nitrate are formed by chemical reactions in the atmosphere that include emissions of $SO_2$ and $NO_x$, respectively. Particulate organic matter can be emitted directly from vegetation or can form in the atmosphere from a variety of gaseous organic compounds.

The Interagency Monitoring of Protected Visual Environments program is a network of monitoring sites for visibility located in Class 1 areas (IMPROVE Program 2023). The Hance Camp at GCNP (monitoring site number GRCA2) is the longest-running site in GCNP. The data from the monitor show that on the most impaired days, ammonium sulfate is the largest contributor to visibility impairment; on the haziest days, particulate organic matter is the largest contributor to visibility impairment; and on the clearest days, ammonium sulfate is the largest contributor to visibility impairment (Federal Land Manager Environmental Database 2023).

Visibility was singled out for particular emphasis in the CAA Amendments of 1977. Visibility in a Class I area is protected under two sections of the CAA Amendments. Section 165 provides for the PSD program for new sources. Section 169(A), for older sources, describes requirements for both reasonably attributable single sources and regional haze, which address multiple sources. Federal land managers thus have a responsibility to protect visibility in Class I areas. There are 156 mandatory federal Class I areas in the United States. In 1999, the EPA issued the final Regional Haze Rule (64 *Federal Register* 35714, July 1, 1999), which sets a national visibility goal for preventing future and remedying existing impairment to visibility in Class I areas. The rule is designed to reduce visibility impairment from existing sources and limit visibility impairment from new sources.

States with Class I areas or states affecting visibility in Class I areas must revise their state implementation plans, prepare emission-reduction strategies to reduce regional haze, and establish glide paths for each Class I area. States are required to periodically review whether they are making reasonable progress toward meeting the goal of achieving natural conditions by 2064. Wildfires and windblown dust storms can significantly degrade visibility at Class I areas in the 11-state area. Emissions of $SO_2$ and $NO_x$ from fossil fuel combustion are the major human-made causes of visibility impairment; these emissions have been substantially reduced in the past few decades in response to state and federal requirements (Air Resource Specialists, Inc. 2013; EPA 2023c).

#### *Regional Air Emissions*

**Table 3-33** presents statewide criteria pollutants and VOC emissions for the 11-state area within the Western Interconnection grid in 2020 (EPA 2023a). As discussed above, emissions data are sorted into 13 source categories. Emissions from wildfires were removed from the data presented in the summary below because they can vary widely from year to year and, in years with large occurrences, can exceed emissions of some pollutants from all other sources. California had the highest emissions of VOCs and all the criteria pollutants except $PM_{2.5}$, $PM_{10}$, and $SO_2$; Oregon had the highest emissions of $PM_{2.5}$ and $PM_{10}$; and New Mexico had the highest emissions of $SO_2$. **Table 3-33** also shows total statewide gross GHG emissions on a consumption basis in terms of carbon dioxide equivalent[31] ($CO_2e$). California had the highest GHG emissions in the 11-state area, followed by Arizona and Washington.

[31] The carbon dioxide equivalent is a measure used to compare the emissions from various GHGs on the basis of their global warming potential (GWP), which is defined as the ratio of heat trapped by one unit mass of the GHG to that of one unit mass of $CO_2$ over a specific time period. Because the persistence in the atmosphere of some GHGs differs from $CO_2$, the GWP factors are typically given for 20- and 100-year time scales. For example, the 20-year GWP factor is 82.8 for methane ($CH_4$) and 273 for nitrous oxide ($N_2O$), and the 100-year GWP factor is 29.8 for $CH_4$ and 273 for $N_2O$. Accordingly, $CO_2e$ emissions are estimated by multiplying the mass of each gas by the GWP (IPCC 2023).

## Table 3-33
## Criteria Pollutant, VOC, and GHG Emissions for 2020, over the 11-State Regional Affected Area

| State | 2020 Annual Emissions (tons)* | | | | | | 2020 Annual Emissions (metric tons)* | 2020 Annual Emissions (metric tons)* |
|---|---|---|---|---|---|---|---|---|
| | CO | $NO_x$ | VOCs | $PM_{2.5}$ | $PM_{10}$ | $SO_2$ | 20-year $CO_2e$ | 100-year $CO_2e$ |
| Arizona | 697,606 | 107,896 | 547,837 | 27,499 | 115,711 | 717 | 40,414,236 | 40,229,110 |
| California | 2,116,621 | 379,782 | 2,146,321 | 132,917 | 439,718 | 9,475 | 178,257,920 | 177,709,461 |
| Colorado | 670,917 | 105,876 | 532,376 | 52,623 | 247,085 | 617 | 28,553,063 | 28,392,067 |
| Idaho | 352,579 | 57,336 | 386,668 | 60,685 | 362,242 | 879 | 12,805,704 | 12,644,640 |
| Montana | 393,235 | 72,053 | 444,785 | 77,664 | 411,568 | 1,662 | 10,526,410 | 10,303,246 |
| Nevada | 333,093 | 66,942 | 247,390 | 20,346 | 106,118 | 566 | 16,370,120 | 16,294,329 |
| New Mexico | 428,660 | 144,439 | 629,044 | 27,659 | 110,383 | 78,291 | 17,930,604 | 17,843,361 |
| Oregon | 1,259,833 | 103,392 | 767,764 | 137,060 | 594,496 | 5,115 | 29,610,840 | 28,183,686 |
| Utah | 350,140 | 71,870 | 345,887 | 23,531 | 129,388 | 1,004 | 18,294,832 | 18,181,531 |
| Washington | 890,479 | 139,753 | 576,991 | 58,983 | 131,771 | 2,199 | 35,100,815 | 34,834,000 |
| Wyoming | 162,234 | 49,917 | 226,108 | 43,418 | 337,728 | 269 | 8,103,502 | 8,058,545 |
| **11-State Total**** | **7,655,398** | **1,299,257** | **6,851,172** | **662,385** | **2,986,208** | **100,794** | **395,968,045** | **392,673,977** |

Source: EPA 2023a; IPCC 2023

*Emissions from wildfires were removed from the emissions data because the unpredictable differences in wildfire from year to year can skew results.

**Numbers may not add up precisely due to rounding.

## 3.9.2 Environmental Consequences

### *Methodology*

Glen Canyon Dam hydropower generation does not generate air emissions. However, dam operations can affect emissions within the power grid. Operations can also impact emissions and ambient air quality over the 11-state Western Interconnection region, which includes Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming, because hydropower generation offsets generation from other generating facilities (i.e., coal-fired or natural gas-fired) that do generate air emissions in the Western Interconnection region. Differences among alternatives in the amount of generation could affect regional air emissions, if lost generation is offset by generation from units fueled by coal, natural gas, oil, or other sources that generate air emissions.

Air quality issues within the analysis area are discussed above. Coal, natural gas, and oil units emit $SO_2$ and $NO_x$, which are precursors to sulfate and nitrate aerosols, respectively. These aerosols play an important role in visibility degradation by contributing to haze. Among human-caused sources, sulfate is a primary contributor to regional haze in the Grand Canyon, and nitrate is a minor contributor.

Effects on visibility are analyzed through a comparison of regional $SO_2$ and $NO_x$ emissions under the various alternatives. Fossil fuel units also emit other criteria pollutants that can harm human health and the environment; potential effects are analyzed through a comparison of the highest emission case levels of criteria pollutants emissions (CO, $NO_x$, Pb, $PM_{2.5}$, $PM_{10}$, and $SO_2$) under the various alternatives.

To compute total air emissions under the alternatives, emissions were summed from all generating facilities in the United States portion of the WECC region, which approximately matches the 11-state analysis area. Pollutant emission factors (in pounds per megawatt-hour [lb/MWh]) for the WECC region for the year 2021, available in the Emissions and Generation Resource Integrated Database (eGRID) (EPA 2023d) were used to compute emissions. Composite emission factors that are representative of power generation from all types of generation currently in operation over the Western Interconnection were employed. Composite emission factors are estimated to be 0.22 lb/MWh for $SO_2$ and 0.537 lb/MWh for $NO_x$.

Exact emissions of replacement power are difficult to estimate. Two low-cost sources, wind and solar generation, typically produce at their maximum generation level based on the solar or wind conditions at the given moment. Generation sources that are able to quickly adjust output to meet high demand or to replace short-term generation reductions elsewhere on the grid—sometimes called “peaker” plants—are typically fueled by gas or oil, although battery energy storage systems can meet the same need and are growing in popularity. Higher-cost sources such as coal, natural gas, and oil-fueled power generation facilities often do not run at full capacity if lower-cost generation sources (that is, hydropower and other renewables) are able to meet most grid demand. However, if there are reductions in longer-term baseload generation of the type provided by hydropower facilities like the Glen Canyon Dam as a result of the proposed alternatives, coal or natural gas–

generated power could be the lowest cost source with available generation capacity for baseload power replacement.

New renewable generation facilities coming online will increase the amount of renewable energy on the grid, potentially reducing overall grid emissions in the Western Interconnection region, which would, in turn, reduce emissions from any replacement of reduced generation at the Glen Canyon Dam facility. Additionally, over time, older and higher-emitting facilities are replaced by new zero- or lower-emission sources, and emissions-reduction equipment in existing facilities is upgraded, resulting in reduced emissions. Although it is likely that average grid emissions would decrease over the timeline of this plan, it is difficult to estimate the amount of that decrease. Because of these unknowns, the analysis of air quality employed two scenarios: one using the existing average emissions of all generation in the WECC region as an approximate expected emissions scenario, and one using the average emissions of coal power generation facilities, the highest emission source, as a highest emission "worst-case" air quality impacts scenario.

Pollutant emission factors (in lb/MWh) specific to coal power generation for the WECC region were also obtained from eGRID for use in modeling a highest emissions scenario. Coal generation emission factors are estimated to be 1.13 lb/MWh for $SO_2$ and 1.71 lb/MWh for $NO_x$. For other criteria pollutants, facility-level data for power generation facilities in the 11-state Western Interconnection region were obtained from the 2020 National Emissions Inventory (EPA 2023b) and matched to generation facilities with coal listed as the primary fuel type from eGRID (EPA 2023d) to determine an emission factor per MWh from coal generation. Coal generation emission factors for criteria pollutants using this method were estimated to be 0.676 lb/MWh for CO, 0.130 lb/MWh for $PM_{2.5}$, 0.189 lb/MWh for $PM_{10}$, 0.032 lb/MWh for VOCs, and 0.00004 lb/MWh for Pb. Because some of the generating units in the National Emissions Inventory dataset listing coal as a primary fuel also burn a secondary fuel, the $SO_2$ and $NO_x$ emissions factors derived using this method were slightly different from the eGRID results, so the eGRID emissions factors were used for calculating $SO_2$ and NOx emissions.

Potential impacts on regional ambient air quality associated with dam operations are compared in terms of air emissions among alternatives relative to air emissions for the No Action Alternative.

**Impact Analysis Area**

Emissions are considered on an 11-state area regional basis; replacement power generation facilities may be anywhere in the region.

**Assumptions**

It is assumed that:

- The reservoir level would not change significantly under any proposed alternative.
- Power replacement would be 1:1 (i.e., 1 MWh of generation lost from the Glen Canyon Dam would be replaced by 1 MWh from another facility).
- Information to determine the facilities at which replacement generation would occur is not available. All replacement generation would occur in the WECC region.

- The average air emissions per MWh from power generation on the regional grid will not change substantially during the temporal extent of the project.
- Generating facilities would not offer capacity that would result in violation of the conditions of their state or federal air permits.

**Impact Indicators**

- Change in the expected amount of power produced in MWh
- Change in the emissions of Environmental Protection Agency (EPA) criteria air pollutants (in tons or pounds per year) produced to generate an equivalent amount of power to replace reduced generation from Glen Canyon
- Change in violation status for any NAAQS or state ambient air quality standards; or any increase in the levels of visibility impairment at any Class I or Class II areas

***Issue 1: How would reductions in hydropower generation from Glen Canyon Dam due to proposed flow alterations impact air quality because of the replacement of power using generation sources with greater air emissions?***

**No Action Alternative**

Under the No Action Alternative, the existing level of generation from the Glen Canyon Dam facility would continue; no change in emissions of criteria pollutants would occur due to changes at the facility.

**Impacts Common to All Action Alternatives**

Each of the cold-water alternatives (the action alternatives except the Non-Bypass Alternative) considers both implementing the proposed management actions at the level needed to meet cooling targets at river mile 15, which would allow Reclamation to target smallmouth bass in the more heavily populated areas, and implementing the proposed management actions at the level needed to meet cooling targets at river mile 61 (the confluence with the Little Colorado River), which would allow Reclamation to target smallmouth bass that have traveled farther downstream.

Although differences are expected in air quality and associated impacts among the various alternatives, potential air quality impacts are anticipated to be negligible.

Emissions of $SO_2$ and $NO_x$ are of interest due to their contribution to visibility impairment. The modeled differences among alternatives are presented in **Table 3-34** below, which shows the emissions levels of $SO_2$ and $NO_x$ under each of the alternatives, assuming the reduction in generation from the Glen Canyon Dam facility is replaced by power with the average level of emissions across the WECC regional grid. In 2020, there was a total of 1,299,257 tons of $NO_x$ emissions and 100,794 tons of $SO_2$ emissions within the 11-state analysis area (EPA 2023a).

**Table 3-34**
**Grid Average Emissions Scenario Summary Table for 5-year Difference in Total Emissions**

| Criteria Pollutant | No Action | Cool Mix (river mile 61) | Cool Mix (river mile 15) | Cool Mix with Flow Spike (river mile 61) | Cool Mix with Flow Spike (river mile 15) | Cold Shock (river mile 61) | Cold Shock (river mile 15) | Cold Shock with Flow Spike (river mile 61) | Cold Shock with Flow Spike (river mile 15) | Non-Bypass |
|---|---|---|---|---|---|---|---|---|---|---|
| $NO_x$ (tons) | 0.000 | 61.707 | 38.963 | 55.045 | 37.562 | 27.617 | 18.808 | 22.312 | 17.466 | -11.209 |
| $SO_2$ (tons) | 0.000 | 25.280 | 15.963 | 22.551 | 15.388 | 11.314 | 7.706 | 9.141 | 7.156 | -4.592 |

Source: EPA 2023a

All criteria pollutants are of interest due to their potential contribution to air quality impairment. The modeled differences among alternatives are presented in **Table 3-35** below, which shows the emissions levels of each of the alternatives under a highest emissions scenario. This scenario assumes the reduction in generation from the Glen Canyon Dam facility would be replaced entirely by power with the average emissions of the coal generation facilities on the WECC regional grid. Although it is not expected that the reduction in generation from the Glen Canyon Dam facility would be replaced entirely by power from coal generation facilities, this scenario is analyzed to provide a maximum value for possible emissions under the proposed action alternatives.

**Table 3-35**
**Highest Emissions Scenario Summary Table for 5-year Difference in Total Emissions**

| Criteria Pollutant | No Action | Cool Mix (river mile 61) | Cool Mix (river mile 15) | Cool Mix with Flow Spike (river mile 61) | Cool Mix with Flow Spike (river mile 15) | Cold Shock (river mile 61) | Cold Shock (river mile 15) | Cold Shock with Flow Spike (river mile 61) | Cold Shock with Flow Spike (river mile 15) | Non-Bypass |
|---|---|---|---|---|---|---|---|---|---|---|
| CO (tons) | 0.000 | 77.720 | 49.074 | 69.329 | 47.309 | 34.784 | 23.689 | 28.102 | 21.999 | -14.118 |
| $NO_x$ (tons) | 0.000 | 196.497 | 124.073 | 175.283 | 119.610 | 87.944 | 59.893 | 71.051 | 55.619 | -35.694 |
| Pb (tons) | 0.000 | 0.004 | 0.003 | 0.004 | 0.003 | 0.002 | 0.001 | 0.002 | 0.001 | -0.001 |
| $PM_{2.5}$ (tons) | 0.000 | 14.892 | 9.403 | 13.285 | 9.065 | 6.665 | 4.539 | 5.385 | 4.215 | -2.705 |
| $PM_{10}$ (tons) | 0.000 | 21.746 | 13.731 | 19.398 | 13.237 | 9.733 | 6.628 | 7.863 | 6.155 | -3.950 |
| $SO_2$ (tons) | 0.000 | 129.849 | 81.990 | 115.830 | 79.041 | 58.115 | 39.578 | 46.952 | 36.754 | -23.587 |
| VOCs (tons) | 0.000 | 3.689 | 2.329 | 3.290 | 2.245 | 1.651 | 1.124 | 1.334 | 1.044 | -0.670 |

Sources: EPA 2023a, 2023d

**Cool Mix Alternative**

*River Mile 61*

Under this alternative, total LTEMP-related air emissions over the 5-year project timeline would be 61.707 tons for $NO_x$ and 25.280 tons for $SO_2$ under the grid average emissions scenario, and would be 196.497 tons for NOx and 129.849 tons for $SO_2$ under the highest emissions scenario.

As shown in the tables above, this alternative would result in the greatest increase in emissions over the No Action Alternative. The Cool Mix Alternative's total emissions under the highest emissions scenario were compared with the total criteria pollutant emissions in the 11-state regional affected area shown in **Table 3-33**, to examine the potential contribution of the project to regional emissions under the highest potential emissions case. The percentage contribution of the calculated emissions during the highest emissions year of the highest emissions scenario under this alternative compared with the total 11-state regional area emissions for each of the criteria pollutants is shown in **Table 3-36** below.

**Table 3-36**
**Percentage of Analysis Area Emissions Expected under Highest Emissions Scenario Highest Emissions Year for Cool Mix Alternative at Little Colorado River**

| CO | NOx | VOCs | Pb | $PM_{2.5}$ | $PM_{10}$ | $SO_2$ |
|---|---|---|---|---|---|---|
| 0.000% | 0.006% | 0.000% | 0.022% | 0.001% | 0.000% | 0.052% |

Sources: EPA 2023a, 2023d

*River Mile 15*

Under this alternative, total LTEMP-related air emissions over the 5-year project timeline would be 38.963 tons for $NO_x$ and 15.963 tons for $SO_2$ under the grid average emissions scenario, and 124.073 tons for $NO_x$ and 81.990 tons for $SO_2$ under the highest emissions scenario.

**Cool Mix with Flow Spike Alternative**

*River Mile 61*

Under this alternative, total LTEMP-related air emissions over the 5-year project timeline would be 55.045 tons for $NO_x$ and 22.551 tons for $SO_2$ under the grid average emissions scenario, and 175.283 tons for $NO_x$ and 115.830 tons for $SO_2$ under the highest emissions scenario.

*River Mile 15*

Under this alternative, total LTEMP-related air emissions over the 5-year project timeline would be 37.562 tons for $NO_x$ and 15.388 tons for $SO_2$ under the grid average emissions scenario, and 119.610 tons for $NO_x$ and 79.041 tons for $SO_2$ under the highest emissions scenario.

### Cold Shock Alternative

*River Mile 61*

Under this alternative, total LTEMP-related air emissions over the 5-year project timeline would be 27.617 tons for $NO_x$ and 11.314 tons for $SO_2$ under the grid average emissions scenario, and 87.944 tons for $NO_x$ and 58.115 tons for $SO_2$ under the highest emissions scenario.

*River Mile 15*

Under this alternative, total LTEMP-related air emissions over the 5-year project timeline would be 18.808 tons for $NO_x$ and 7.706 tons for $SO_2$ under the grid average emissions scenario, and 59.893 tons for $NO_x$ and 39.578 tons for $SO_2$ under the highest emissions scenario.

### Cold Shock with Flow Spike Alternative

*River Mile 61*

Under this alternative, total LTEMP-related air emissions over the 5-year project timeline would be 22.312 tons for $NO_x$ and 9.141 tons for $SO_2$ under the grid average emissions scenario, and 71.051 tons for $NO_x$ and 46.952 tons for $SO_2$ under the highest emissions scenario.

*River Mile 15*

Under this alternative, total LTEMP-related air emissions over the 5-year project timeline would be 17.466 tons for $NO_x$ and 7.156 tons for $SO_2$ under the grid average emissions scenario, and 55.619 tons for $NO_x$ and 36.754 tons for $SO_2$ under the highest emissions scenario.

### Non-Bypass Alternative

Under the Non-Bypass Alternative, the implementation of high-flow events routed through the generation facility would result in a slight increase in power generation compared with the No Action Alternative. As a result, under this alternative, total LTEMP-related air emissions over the 5-year project timeline would be reduced by 11.209 tons of $NO_x$ and 4.592 tons of $SO_2$ under the grid average emissions scenario. Under the highest emissions scenario, total LTEMP-related air emissions over the 5-year project timeline would be reduced by 35.694 tons of $NO_x$ and 23.587 tons of $SO_2$.

### Cumulative Effects

The potential impacts from future projects, such as the slough restoration or thermal curtain at the Glen Canyon Dam, would not have any substantial cumulative effects on air quality. There could be minor impacts on local air quality during any potential construction.

Over time, older and higher-emitting facilities are likely to be retired and their generation capacity replaced by new zero- or lower-emission sources. Additionally, emissions-reduction equipment on some existing facilities is likely to be upgraded. All of these trends are expected to result in a reduction in average grid air emissions over time.

## *Summary*

Although differences are expected in potential ambient air quality and associated impacts among the various alternatives, potential air quality impacts are anticipated to be negligible. The Cool Mix

Alternative at Little Colorado River would result in the greatest increase in air emissions of $NO_x$, $SO_2$, and other criteria air pollutants compared with the No Action Alternative. The increase in emissions under any of the action alternatives is not expected to result in any significant deterioration of air quality; any violation or significant increase in the level of an existing violation of any NAAQS or state ambient air quality standards; or any increase in the levels of visibility impairment at any Class I or Class II areas, including GCNP, GCNRA, and LMNRA.

## 3.10 Visual Resources

### 3.10.1 Affected Environment

Visual resources are the physical features that compose 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. To supplement the 2016 LTEMP FEIS (DOI 2016a), this section provides a summary of the affected environment from the 2016 LTEMP FEIS, modified as necessary to include changes that have occurred since 2016.

As described in the 2016 LTEMP FEIS, visual resources are important for visitors to GCNP and GCNRA, as well as to American Indian communities who use these lands for subsistence or ceremonial uses. The Grand Canyon Protection Act of 1992 specifically calls for the conservation of visual resources in addition to visual resources being an important component of federal management of these areas. Also, regarding American Indian communities, the 2016 LTEMP FEIS states, "The Canyons have a significant place in the traditional cosmology of the indigenous communities of the Southwest. American Indian communities may visually experience the Canyons quite differently than recreational users who experience the Canyons not only during recreational activities but also while gathering natural resources or performing religious ceremonies" (DOI 2016a, 3-192).

The 2016 LTEMP FEIS identified the following visual resource issues that may be affected by the No Action and action alternatives:

- Exposure of lake deltas in Lake Mead and Lake Powell
- Changes in vegetation and sandbar size

Since the proposed flow alterations at Glen Canyon Dam would not change yearly release amounts, resulting in no changes to water levels in Lake Mead or Lake Powell, the inventory of visual resources focuses on the portion of the Colorado River between Glen Canyon Dam and the inlet of Lake Mead. Specifically, the analysis examines how flow alterations at Glen Canyon Dam would affect landscape character along the Colorado River.

The landscape character along the Colorado River within GCNP and GCNRA, as well as within the Hualapai and Navajo Indian Reservations, is defined by sweeping vistas of red rock towers, buttes, and mesas typical of the Colorado Plateau's physiographic province (Fenneman 1931). Recreational activities along this portion of the Colorado River include boating, kayaking, swimming, and fishing, in addition to viewing this varied, high-quality landscape from both locations along the river and from scenic overlooks above the river. The 2016 LTEMP FEIS further states, "Stewart et al. (2000) found that the more valued aspects of a river rafting trip include simply being in a natural setting, having the opportunity to stop in scenic places, and being able to view flora, fauna, and geology… For many Tribes, trails that enter the Canyons are sacred, and the scenic setting along these trails plays an important part in the travel and ceremonial experience" (DOI 2016a, 3-193).

Vegetation along the river comprises 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. Vegetation farther upslope along rock terraces includes saltbush, arrowweed, rabbitbrush, and other arid-adapted plant species. Previously planned and implemented HFE releases from Glen Canyon Dam, which help recreate natural floods common before the construction of the dam, have allowed for the transportation and deposition of sand, resulting in the formation of sandbars along the river. In some areas, these HFE releases can decrease the extent of bank armoring [32]and strip vegetation along the existing sandbars, including tamarisk, allowing the landscape to appear more similar to its natural character. The 2016 LTEMP FEIS further states, "Vegetation increases the visual interest of many places by adding variety in color and texture and is also a visual cue for Tribes in determining the health of the ecosystem. For example, sandbars and marshes along the river may contain stands of native vegetation which are important for many Tribal communities" (DOI 2016a, 3-193).

The construction of Glen Canyon Dam has altered the landscape character along the Colorado River, as "prior to construction of Glen Canyon Dam, the banks of the Colorado River consisted primarily of open sandy beaches and bare talus slopes with native riparian vegetation established above the elevation of annual scouring flows within the Grand Canyon" (DOI 2016a, 3-197). Additionally, "Prior to construction of Glen Canyon Dam, the Colorado River carried such a large sediment load that it ran a reddish-brown color throughout the canyon. Now, the river downstream of the dam is relatively clear and green in color. During high releases or after large tributary inputs of suspended sediment, water becomes much more reddish-brown; this effect is ephemeral, however, and water quickly returns to a bluish-green color" (DOI 2016a, 3-198).

Specific details regarding visual resources and common recreational activities in GCNRA and GCNP are discussed in the 2016 LTEMP FEIS (DOI 2016a, 3-193 through 3-198). This includes an overview of the management of visual resources in the 1979 GCNRA General Management Plan (NPS 1979) and 1995 GCNP General Management Plan (NPS 1995).

## 3.10.2 Environmental Consequences

### *Methodology*

Compared with the 2016 LTEMP FEIS, this SEIS focuses on proposed hourly, daily, or monthly flow alterations at Glen Canyon Dam, as there would be no adjustments to the yearly release amounts. Based on this narrower focus, the assessment of visual impacts did not consider changes to water levels in Lake Mead or Lake Powell, as these changes would be minor over the long term.

[32] During lower flow rates, natural erosive processes along the river's edge would be reduced, resulting in tall banks supporting dense riparian vegetation (bank armoring), which often screens views from the river toward adjacent lands.

These shorter-term flow alterations have the potential to affect the existing landscape character along the Colorado River, including potential changes to vegetation, such as bank armoring, and the formation of sandbars. As part of these proposed flow alterations, a 1-year sediment accounting window approach to conducting HFE releases from Glen Canyon Dam has been proposed under all but the No Action Alternative.

To assess potential changes to landscape character along the Colorado River, this analysis focuses on a qualitative assessment of effects associated with these changes in flow from Glen Canyon Dam as well as the modified approach to identifying when to conduct HFE releases. This analysis also considers and references analyses contained in **Section 3.4**, Geomorphology/Sediment, **Section 3.6**, Terrestrial Resources and Wetlands, and **Section 3.14**, Recreation, which assess the effects of the flow alterations under different alternatives on the prevalence of riparian vegetation and the formation of sandbars. Sandbar volume predictions were generated using the Mueller and Grams (2021) sandbar model, which is also referenced in **Section 3.4**, Geomorphology/Sediment. Butterfield and Palmquist (2023) was used for riparian vegetation, which is also referenced in **Section 3.6**, Terrestrial Resources and Wetlands. For more information regarding these studies and assumptions for their use, refer to **Section 3.4**, Geomorphology/Sediment, and **Section 3.6**, Terrestrial Resources and Wetlands.

### *Impact Analysis Area*

The visual resource impact analysis area was defined as the area from rim to rim of the canyon along the stretch of the Colorado River between Glen Canyon Dam and the inlet of Lake Mead (**Map 1-1**). The 2016 LTEMP FEIS did not specifically identify an analysis area for visual resources. The tall canyon walls along this stretch of the Colorado River would visually constrain the effects from this SEIS, limiting the visual resource impact analysis area to this canyon landscape.

### *Assumptions*

- Vegetation at a certain distance from the river would not be impacted by proposed flow alterations.
- Lake Mead and Lake Powell would not be influenced, as yearly flows would remain the same.
- The 1-year sediment accounting window approach to conducting HFE releases from Glen Canyon Dam would not result in additional HFE releases.

### *Impact Indicators*

The assessment of potential impacts associated with proposed flow alterations at Glen Canyon Dam on landscape character along the Colorado River was developed focusing on a qualitative assessment considering modeling associated with **Section 3.4**, Geomorphology/Sediment, **Section 3.6**, Terrestrial Resources and Wetlands, and **Section 3.14**, Recreation.

### *Issue 1: How would flow alterations at Glen Canyon Dam affect landscape character along the Colorado River?*

**No Action Alternative**

Under the No Action Alternative, there would be no changes to daily, weekly, monthly, or yearly flows from Glen Canyon Dam; therefore, existing trends of bank armoring associated with dense riparian vegetation (including tamarisk) would continue under the No Action Alternative. The current LTEMP rules for HFE releases, which focus these events in the fall with limited occurrences in the spring, would remain in effect. In response to regional drought conditions and aridification, the upper riparian zones may transition to desert ecosystems, further modifying the area's landscape character. For additional analysis related to riparian vegetation, refer to **Section 3.6**, Terrestrial Resources and Wetlands. When conducted, the HFE releases would continue to contribute to sandbar building and sediment export in the Colorado River. For additional analysis related to sandbar building, refer to **Section 3.4**, Geomorphology/Sediment, and **Section 3.14**, Recreation.

**Cool Mix Alternative**

Impacts on landscape character under the Cool Mix Alternative would be similar to those under the No Action Alternative, as most short-term and all long-term flows would remain the same, with changes in water temperature along the Colorado River having minimal effects on riparian vegetation and sandbar building. Based on modeling associated with sandbar building this alternative, with the 1-year accounting window resulting in more spring HFEs, would generate smaller sandbars compared with the No Action Alternative (Yackulic et al. 2024, chap. 3). For additional analysis related to riparian vegetation, refer to **Section 3.6**, Terrestrial Resources and Wetlands, and for additional analysis related to sandbar building, refer to **Section 3.4**, Geomorphology/Sediment, and **Section 3.14**, Recreation.

**Cool Mix with Flow Spike Alternative**

Under the Cool Mix with Flow Spike Alternative, increased flow events during flow spikes would be similar to HFE releases. Based on modeling associated with sandbars and riparian vegetation (Yackulic et al. 2024, chap. 3, 7), however, these flow spikes would have negligible effects on riparian vegetation and would result in smaller sandbars compared with the No Action Alternative, in consideration of the 1-year accounting window with the potential for more spring HFEs. The change in water temperature along the Colorado River would have minimal effect on riparian vegetation and sandbar building, with the flow spikes having the primary beneficial effect on landscape character. Overall, landscape character along the Colorado River under this alternative would be similar to the No Action Alternative except for smaller anticipated sandbars. For additional analysis related to riparian vegetation, refer to **Section 3.6**, Terrestrial Resources and Wetlands. For additional analysis related to sandbar building, refer to **Section 3.4**, Geomorphology/Sediment, and **Section 3.14**, Recreation.

**Cold Shock Alternative**

Impacts on landscape character under the Cold Shock Alternative would be similar to those under the No Action Alternative and Cool Mix Alternative, as most short-term and all long-term flows would remain the same, with changes in water temperature along the Colorado River having minimal effects on riparian vegetation and sandbar building. Based on modeling associated with sandbar building, this alternative, with the 1-year accounting window resulting in more spring HFEs, would generate smaller sandbars compared with the No Action Alternative (Yackulic et al. 2024, chap. 3). For additional analysis related to riparian vegetation, refer to **Section 3.6**, Terrestrial Resources and Wetlands. For additional analysis related to sandbar building, refer to **Section 3.4**, Geomorphology/Sediment, and **Section 3.14**, Recreation.

**Cold Shock with Flow Spike Alternative**

Under the Cold Shock with Flow Spike Alternative, increased flow events during flow spikes would be similar to HFE releases. Based on modeling associated with sandbars and riparian vegetation (Yackulic et al. 2024, chap. 3, 7), however, these flow spikes would have negligible effects on riparian vegetation and would result in smaller sandbars compared with the No Action Alternative in consideration of the 1-year accounting window, with the potential for more spring HFEs. The change in water temperature along the Colorado River would have minimal effect on riparian vegetation and sandbar building, with the flow spikes having the primary beneficial effect on landscape character. Overall, landscape character along the Colorado River under this alternative would be similar to the No Action Alternative except for smaller anticipated sandbars. For additional analysis related to riparian vegetation, refer to **Section 3.6**, Terrestrial Resources and Wetlands. For additional analysis related to sandbar building, refer to **Section 3.4**, Geomorphology/Sediment, and **Section 3.14**, Recreation.

**Non-Bypass Alternative**

Under the Non-Bypass Alternative, the high-volume flows proposed would increase the striping of vegetation along the river, reducing the extent of bank armoring. The effects on water levels within the Colorado River under this alternative would be most intense near Glen Canyon Dam, with the influence of high- and low-volume flows on river water levels decreasing farther downriver. In general, the Non-Bypass Alternative would allow for an increase in native riparian vegetation compared with the No Action Alternative, especially in the western Grand Canyon (Yackulic et al. 2024, chap. 7). Based on modeling associated with sandbar building, this alternative would result in sandbars that are smaller than under the No Action Alternative (Yackulic et al. 2024, chap. 3) but larger than those anticipated under the action alternatives without flow spikes. Overall, landscape character along the Colorado River under this alternative would be similar to that under the No Action Alternative except for smaller anticipated sandbars and increased native riparian vegetation, especially in the western Grand Canyon area. For additional analysis related to riparian vegetation, refer to **Section 3.6**, Terrestrial Resources and Wetlands. For additional analysis related to sandbar building, refer to **Section 3.4**, Geomorphology/Sediment, and **Section 3.14**, Recreation.

**Cumulative Effects**

The effects of the LTEMP SEIS alternatives on landscape character are negligible to small, based on potential change to riparian vegetation (**Section 3.6**) and the river's sandbars (**Section 3.4**), and are not expected to contribute significantly to cumulative effects along the Colorado River corridor. Therefore, no cumulative effects on landscape character are anticipated. All proposed flow options would operate within the spatial and temporal bounds and under the assumptions of the existing analysis conducted in the 2016 LTEMP FEIS. Therefore, no cumulative effects on landscape character are anticipated beyond those included in the 2016 LTEMP FEIS.

***Summary***

Existing trends of increasing bank armoring and a narrowing lower riparian zone will continue to affect the area's landscape character under the No Action Alternative, with beneficial effects on sandbar building and sediment export occurring when HFE releases are conducted. Under the Cool Mix Alternative and Cold Shock Alternative, impacts on landscape character associated with changes in riparian vegetation would be similar to those under the No Action Alternative, with smaller sandbars associated with more spring HFEs compared with the No Action Alternative. Where increased flow regimes have been proposed under the Cool Mix with Flow Spike, Cold Shock with Flow Spike, and Non-Bypass Alternatives, sandbars are expected to be larger than those under alternatives without flow spikes, but smaller than those anticipated under the No Action Alternative, with minimal changes to riparian vegetation. The Non-Bypass Alternative would facilitate a marginal increase in native riparian vegetation compared with the No Action Alternative, especially in the western Grand Canyon area. The proposed alternatives would likely have few long-term beneficial impacts on landscape character, as—while some plant species could experience temporary, positive impacts from high-flow disturbance events and access to higher water tables during summer months—steady flow conditions are necessary for germination success rates. The addition of the 1-year accounting window under all action alternatives would result in more spring HFEs, which, based on modeling, would likely result in smaller sandbars compared with the No Action Alternative.

# 3.11 Water Quality

## 3.11.1 Affected Environment

Inflows from the Upper Colorado River Basin dictate the system's water quality. Water quality includes, but is not limited to, chemical properties, nutrient levels, temperature, and bacteria.

***Lake Powell Water Quality***

Lake Powell is stratified into vertical layers with different thermal, chemical, and biological processes. For this SEIS, the focus is mainly on the vertical stratification near Glen Canyon Dam, which acts as the release point for water into the Colorado River (Reclamation and NPS 2016).

**Temperature**

Lake Powell is thermally stratified—that is, arranged into layers with distinct temperatures and chemical characteristics—during the spring, summer, and early fall. Generally, Lake Powell's epilimnion, or uppermost layer from the reservoir surface to a depth of about 60 feet, depending on the season and location, ranges from 25°C to 30°C (77°F to 86°F) in the summer and may drop to 6°C to 10°C (42.8°F to 50°F) in the winter. Lake Powell's hypolimnion, or deeper layer beginning from a depth of about 180 feet below the surface of the reservoir, ranges from 6°C to 9°C (42.8°F to 48.2°F) (DOI 2016a). 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 (DOI 2016a). Full turnover does not occur every year, but partial turnover does.

The penstocks are 15 feet in diameter with a centerline elevation of 3,470 feet. Up until recently, the penstock intakes have aligned with the top of the cooler hypolimnion layer with temperatures around 10°C to 12.2°C (50°F to 54°F). The river outlet works are located at an elevation of 3,374 feet and typically fall within the lower hypolimnion layer with temperatures around 6.1°C to 8.9°C (43°F to 48°F). Due to the lower lake elevation, the warm epilimnion layer is currently found closer to the penstocks, which means that water released through the penstocks is warmer than historical values (GCDAMP 2023). Ongoing drought and aridification have led to continued and increased warming throughout the reservoir, particularly during the spring, summer, and early fall months.

**Salinity and Conductivity**

Historically, salinity has been a concern for the Colorado River Basin (USGS 2021). Salinity causes economic and environmental damage in agricultural, municipal, and industrial industries.

Salinity and conductivity are stratified with temperatures. The lower, cooler waters tend to have higher salinity and conductivity values (Boehrer and Schultze 2008). Releases from lower elevations in Lake Powell through the river outlet works are cooler and more saline compared with releases from higher elevations through the Glen Canyon Dam penstocks (DOI 2016a).

**Dissolved Oxygen**

DO can vary within the reservoir due to variations in inflows, inflow water temperatures, seasonal reservoir circulation, and biological processes. In years of high inflows and when the reservoir elevations are low, flows cut through deltaic sediments, resuspending organic matter and nutrients that contribute to both chemical and biological oxygen demand as the inflow water passes down through the reservoir water column. The resulting plumes of low-oxygen water drive water column concentrations lower. When deltaic sediments and organic matter are not resuspended, oxygen demand is decreased and DO concentrations remain higher. Generally, Lake Powell DO concentrations are at their highest in the spring to early summer when inflows are well oxygenated and wind-induced mixing is high.

Historic low elevations in Lake Powell during the spring of 2023, combined with a larger than average spring inflow, set up a low dissolved oxygen event in the reservoir. These events resulted in likely record low dissolved oxygen in dam releases (with a minimum of approximately 1.8 milligrams per liter [mg/L] in early October) and a record 116 days where dissolved oxygen concentrations in releases remained below 5 mg/L (data after June 1 have not been processed for rigorous quality assurance) (USGS 2024c).

Low DO concentrations move through the reservoir and closer to the dam during the summer into the fall because of organic matter decomposition and chemical reactions that consume oxygen. DO gradually increases in the winter because of the higher oxygen-carrying capacity of cold water and the natural mixing processes that occur during turnover. Releases using the river outlet tubes are made from depths beneath the powerplant intakes. The release waters tend to have lower temperatures, higher salinity, and lower oxygen levels than the water discharged from the dam during normal operations.

Other chemical and biological processes within Lake Powell can vary depending on inflow, precipitation, and other environmental conditions (DOI 2016).

### *Colorado River Water Quality*

Apart from DO, the water quality of the Colorado River below the dam is highly defined by the water quality of Lake Powell, particularly at the elevations of the penstocks and river outlet works. Typically, the water discharged from the dam is characterized as cold, clear, below saturation in DO, and low in nutrients. However, due to the recent drought conditions and aridification, the discharged water is released from higher in the water column. Once the discharged water has been released, the chemical and physical properties are affected by ambient meteorological conditions, primary production and respiration from the aquatic environment, aeration from rapids, and inputs from other tributary sources and overland flow (DOI 2016a). The processes affecting the water quality of releases are complex and explained in detail below.

There are minimal inflows from the dam to Lees Ferry, resulting in minor changes in water quality through this stretch. At Lees Ferry, the Paria River joins the Colorado River, which influences water quality in the Colorado River. Typically, these inflows contain warmer, nutrient-rich water that mixes with the Colorado River. During flood events, these inflows can bring large amounts of sediment and organic material. Several other minor tributaries can have different physiochemical properties; however, their mean flows are low enough that their contribution to water quality is minor (DOI 2016a).

When HFE releases have been conducted, a large, temporary change in water quality below Glen Canyon Dam has been observed. The excess discharge is typically derived from the river outlet works, meaning the water is cooler and more saline. The increased discharge from a river outlet work creates aeration at the outlet and increases DO. There can be minor increases in turbidity with the excess flows and additional scouring of the riverbed and banks below the dam; however, the stretch of the river below the dam has already experienced significant scouring since the construction of the dam (USGS 2018). See **Section 3.4**, Geomorphology/Sediment, for additional information on sediment resources.

#### Temperature

Following the completion of Glen Canyon Dam, temperatures in the Glen Canyon Dam tailwaters stabilized and ranged from 7.2°C to 12.2°C (45°F to 54°F) annually. Since the early 2000s, drought conditions, aridification, and lower water levels in Lake Powell have led to a general warming of water temperatures in the Colorado River below the dam (Reclamation and NPS 2016).

Temperatures in the Colorado River in the Grand Canyon are highly variable over space and time and are primarily controlled by the discharge and temperature released from Glen Canyon Dam and solar radiation dynamics along the river corridor (Mihalevich et al. 2020). As water moves farther away from Glen Canyon Dam (e.g., below river mile 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°C (1.8°F) for every 30 miles traveled downstream during warmer months of the year under specific discharge and meteorological conditions. Some variation in lateral warming also occurs, with warmer temperatures along the shoreline and cooler water in the deep, fast-moving areas (DOI 2016a). Warming is greatest from June through August (DOI 2016a).

**Salinity and Conductivity**

The construction of Glen Canyon Dam has significantly altered the downstream transport of total dissolved solids (TDS) since river impoundment. Lake Powell retains about 10 percent of TDS loaded to the system via calcite precipitation (Deemer et al. 2020). Salinity below the dam typically ranges from 300 to 600 mg/L for TDS. Slight seasonal variation has been found in salinity and conductivity levels below the dam. However, releases from lower elevations in Lake Powell contain cooler and more saline water (Reclamation and NPS 2016).

**Dissolved Oxygen**

Current DO levels in Lake Powell and the Glen Canyon Dam tailwaters are lower compared with historical levels owing to a combination of low reservoir elevations and high inflows in recent years. Resuspended sediments at the inflow areas cause low DO plumes because that suspended sediment creates high biological and chemical oxygen demand (i.e., bacteria and other biota consuming oxygen, and chemical reactions consuming oxygen). This problem is exacerbated whenever large sediment inputs occur, especially when sediment erodes from the reservoir banks in the springtime and during low lake elevations when more bed-cutting and bank erosion occur.

Under low lake elevations, the residency time in Lake Powell is shorter for the low DO plumes, and the low DO water appears at Glen Canyon Dam sooner than it would under higher starting lake elevations. The DO concentrations in Lake Powell do not typically correlate with DO concentrations in the Colorado River because the low DO condition resolves downstream of Lee Ferry as the water is reaerated through whitewater action (Hall et al. 2012). The Colorado River DO increases approximately 1 mg/L between Glen Canyon Dam and Lees Ferry. This approximation can vary between negligible reoxygenation and approximately 3 mg/L increases during very low oxygen releases during daylight hours (GCMRC 2023a).

DO levels below the dam vary throughout the year; levels as low as 2.2 mg/L have been observed in the summer and fall. Levels have risen as high as 9 to 10 mg/L in the spring. Lower values have been observed in the forebay (GCMRC 2023a). 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 (that is, less than 5 mg/L) have become more common due to the age of the reservoir and the greater volume of deltaic sediment available to be remobilized.

As the reservoir water level decreases, warmer, well-oxygenated waters exist closer to the penstocks, and 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 HFE releases, it becomes well-aerated and contains greater DO concentrations (Reclamation and NPS 2016).

## 3.11.2 Environmental Consequences

### *Methodology*

This section describes the methods used to determine the potential effects on water quality associated with the alternatives.

**Temperature and Conductivity**

Temperature exerts a major influence on biological and chemical processes. For example, the temperature of dam releases affects the aquatic ecosystems and fish population dynamics in downstream river segments. Further, the salinity of waters both within Lake Powell and dam releases are of interest to the Colorado River Basin Salinity Control Program.

Hydrologic traces generated by CRSS provide a range of inflow, outflow, and reservoir elevations that could uniquely influence water quality conditions within Lake Powell. To anticipate the potential water quality impacts associated with different hydrologies and management practices within Lake Powell and in downstream receiving waters, the CE-QUAL-W2 Lake Powell water quality model was applied to predict outflow temperature and TDS. Salinity is the measure of the amount of dissolved salt in water, whereas TDS measures all dissolved solids in a water sample. TDS and salinity are similar, as TDS estimates the level of salt within a water sample, so TDS was used in the CE-QUAL-W2 model as a proxy for salinity. While CE-QUAL-W2 has a DO module (Cole and Wells 2021), recent modeling results suggest the need for its recalibration to improve performance under low water levels and with the aging of the reservoir.

To understand the drivers of water quality change in Lake Powell, a 2D hydrodynamic model has been developed using CE-QUAL-W2 (Williams 2007). 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. Lake Powell modeling for this SEIS uses updated bathymetric information (Jones and Root 2020) to simulate temperature and TDS within the reservoir.

In adapting the model as developed by Dibble et al. (2021) for calculations of downriver warming of water released from Glen Cayon Dam from monthly to daily timestep, the signed error (bias) did not change. While the root mean squared error increased, the daily timestep provides more information on timing of when temperatures would exceed a target threshold. There is good agreement between the observed and modeled daily temperatures, though there is higher error compared with an evaluation of mean monthly temperatures. They both display similar biases, but the fit, expressed in root mean squared error, is better with the monthly data. The higher variability of daily temperatures (as compared with monthly temperatures) contributes to the greater root mean squared error when the model moves from monthly to daily timesteps in the Dibble model. There is also an increase in error moving downstream, reflecting the influence of local meteorology on water temperature. In addition (as discussed in the supplemental materials [S2] of Dibble et al. 2021), the time of year affects the error as well.

All traces from all operational alternatives were evaluated in CE-QUAL-W2, resulting in 300 model runs. The simulation period for all models was between September 11, 2023, and October 1, 2027. Models were initialized on September 11, 2023, because it is the date of the most recently processed lake-wide water quality profiles at the time of this evaluation.

**Dissolved Oxygen**

A long-term record of DO profiles from the reservoir forebay (site name LPCR0024; Deemer et al. 2023) was used to model and predict DO concentration within a 10-meter (33-foot) envelope of the penstock depth for the 180 hydrological traces generated as part of the SEIS. While the Lake Powell CE-QUAL-W2 does have a DO module (Williams 2007), recent observations suggest 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 to 2022) were used to calculate yearly mean late-summer/early fall DO concentrations in six 10-meter (33-foot) layers of the Lake Powell water column that represent the heights from which water could be drawn through the penstocks under the various SEIS hydrological traces. The six layers are as follows: 20 feet to less than 53 feet, 53 feet to less than 85 feet, 85 feet to less than 118 feet, 118 feet to less than 151 feet, 151 feet to less than 184 feet, and 184 feet to less than 217 feet.

**Impact Analysis Area**

The impact analysis area is Glen Canyon Dam and the Colorado River down to the inlet of Lake Mead.

**Assumptions**

- Change in water temperature would be expected across the analysis area.
- The action alternatives would lead to an alteration of flows.
- A minor shift in water chemistry would occur due to water being drawn from a different layer in Lake Powell.
- Temperature and flow ranges would remain within existing and historical management, leading to minor impacts from previous assessments.

**Salinity and Temperature Assumptions**

Testing of the new Lake Powell water quality model was carried out over a 12-year simulation period. This relatively long duration was used to evaluate the influence of modeling assumptions, such as the use of constant bathymetry and the omission of ephemeral tributary sources. This is important when modeling future climate change, hydrologic conditions, or both. For this simulation, a combination of measured and modeled input data was used following the methods described by Mihalevich (2022). Reclamation's hourly release data from Glen Canyon Dam penstocks and river outlet works were utilized. Sub-hourly water quality data measured below Glen Canyon Dam near Page, Arizona (gage #09379901), were used to evaluate model predictions.

The results of the long-term model test show good agreement between observed and predicted release temperatures from Glen Canyon Dam with a root mean squared error of 0.79°C (33.42°F). The distribution of temperature residuals (not shown, calculated as model minus observed) is normal and centered around zero, indicating that the predictions are free of long-term systematic bias. Predictions of specific conductance from Glen Canyon Dam also agree with the measured patterns and magnitudes below the dam, resulting in a root mean squared error of 36.71 microsiemens per centimeter. The distribution of specific conductance residuals was normal and skewed slightly positive (with a mean error of 16.65 microsiemens per centimeter), suggesting that model predictions tend to be higher than observations. This is consistent with the salinity retention that can occur in Lake Powell because of calcite precipitation, but that is not modeled within CE-QUAL-W2 (Deemer et al. 2020).

**Dissolved Oxygen Assumptions**

Linear models were built to predict these water-layer-specific DO concentrations as a function of minimum reservoir elevation in that year, the volume of the spring inflow (calculated as the inflow from April to July), and the years since the reservoir was filled. This model was based on the best model for predicting whole-metalimnion mean DO in the late summer and fall (Deemer 2023). No LTEMP hydrologic trace resulted in minimum spring reservoir elevations of less than 3,490 feet, so the only river outlet work releases predicted were those associated with high-flow events, flow spikes, cool mix treatments, or cold shock treatments. For the days when any amount of river outlet work spill was used, a daily average DO concentration of 8 mg/L was assigned.

A weighted average DO concentration (August to November) was calculated by assigning modeled penstock DO concentrations for days without river outlet work releases and 8 mg/L DO for days with river outlet work releases. Additionally, 8 mg/L DO concentrations were estimated, regardless of the river outlet works' spill rate, based on the aeration that has been observed when water is spilled through the river outlet works (Hueftle and Stevens 2001; Vernieu 2010).

River outlet work releases of 425 cubic meters per second during the 2008 HFE release resulted in supersaturated DO concentrations (12.6 mg/L) below the dam (Vernieu 2010); therefore, 8 mg/L DO was considered a conservative estimate for partial river outlet work spills. Future work to constrain the relationship between the bypass spill rate and reaeration would help more accurately model outflow DO concentrations resulting from a 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.

**Impact Indicators**

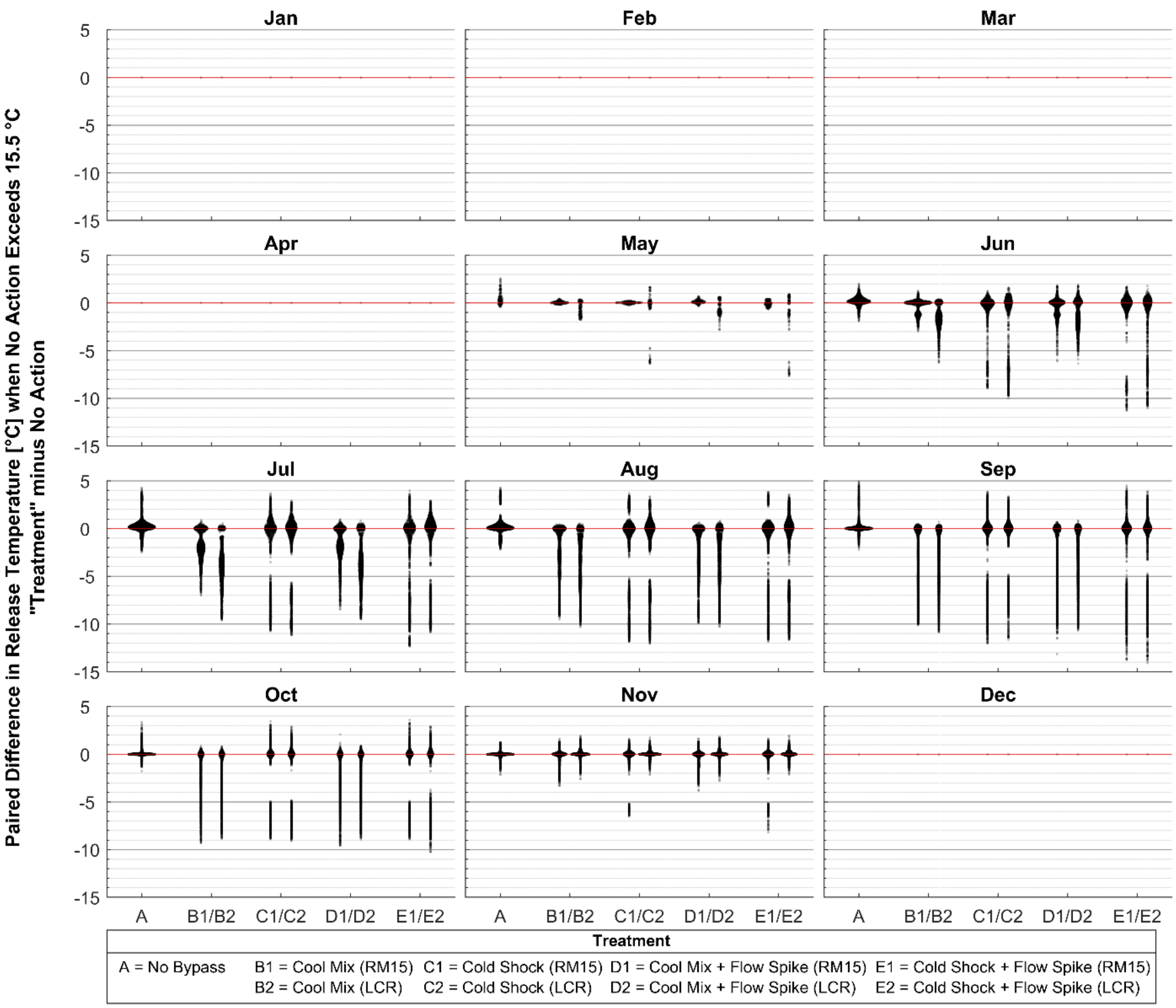
- Temperature
- Salinity
- DO

### *Issue 1: How would flow alterations impact temperature?*

**No Action Alternative**

Under the No Action Alternative, Glen Canyon Dam operations would remain unchanged. Therefore, water would continue to be discharged primarily through the penstocks, as described in the 2016 LTEMP FEIS. The water discharged from the penstocks would remain warm, leading to warmer water in the Colorado River downstream of the dam. Temperature would continue to warm in line with trends described in the affected environment, as seen in **Figure 3-47**.

**Figure 3-47**
**Swarm Charts Showing the Monthly Distribution of Predicted Glen Canyon Dam Release Temperature for All Scenarios and Traces over the Simulation Period***




Source: USGS 2024b
*Red horizontal lines indicate the means of each distribution. Widths of each distribution indicate the relative frequency of occurrence.

## Cool Mix Alternative

Under the Cool Mix Alternative, adding more bypass through cool mix operations would result in a decreased total release temperature during summer periods when bypass would be utilized, as shown in **Figure 3-47**, when compared with the No Action Alternative. Under the Cool Mix Alternative, the temperature would remain cooler over a longer duration when compared with the Cold Shock Alternative and Cold Shock with Flow Spike Alternative.

#### Cool Mix with Flow Spike Alternative

Under the Cool Mix with Flow Spike Alternative, adding more bypass through cool mix operations would result in a decreased total release temperature during summer periods when bypass would be utilized, as shown in **Figure 3-47**, when compared with the No Action Alternative. Like the Cool Mix Alternative, through cool mix operations, the temperature would remain cooler over a longer duration when compared with the Cold Shock Alternative and Cold Shock with Flow Spike Alternative. Under this alternative, the flow spike would further reduce the release temperature; however, this change would be minimal.

#### Cold Shock Alternative

Under the Cold Shock Alternative, similar to the Cool Mix Alternative, adding more bypass through cold shock operations would result in a decreased total release temperature during summer periods when bypass would be utilized, as shown in **Figure 3-47**, when compared with the No Action Alternative. However, the duration of cold releases under the Cold Shock Alternative would be more effective at reducing the total release temperature than the Cool Mix Alternative.

#### Cold Shock with Flow Spike Alternative

Under the Cold Shock with Flow Spike Alternative, similar to the Cool Mix Alternative, adding more bypass through cold shock operations would result in a decreased total release temperature during summer periods when bypass would be utilized, as shown in **Figure 3-47**, when compared with the No Action Alternative. Like the Cold Shock Alternative, the duration of cold releases under the Cold Shock with Flow Spike Alternative would be more effective at reducing the total release temperature than under the cool mix operations. Under this alternative, the flow spike would further reduce the release temperature; however, this change would be minimal.

#### Non-Bypass Alternative

Impacts on temperature under the Non-Bypass Alternative would be similar to those under the No Action Alternative, as shown in **Figure 3-47**, since the Non-Bypass Alternative would not involve the use of Glen Canyon Dam's bypass system and would instead focus on changes in release volumes. The Non-Bypass Alternative would have slightly lower temperatures compared to the No Action; however, these temperatures would not be cool enough to impact smallmouth bass spawning (see **Section 3.5**, Aquatic Resources, for more information.)

#### Cumulative Effects

Impacts on temperature from the cold-water alternatives would be temporary and would not have permanent, significant impacts on Lake Powell or the Colorado River. All proposed flow options would operate within the spatial and temporal bounds and under the assumptions of the existing analysis conducted in the 2016 LTEMP FEIS. There would be no cumulative impacts on temperature beyond those included in the 2016 LTEMP FEIS.

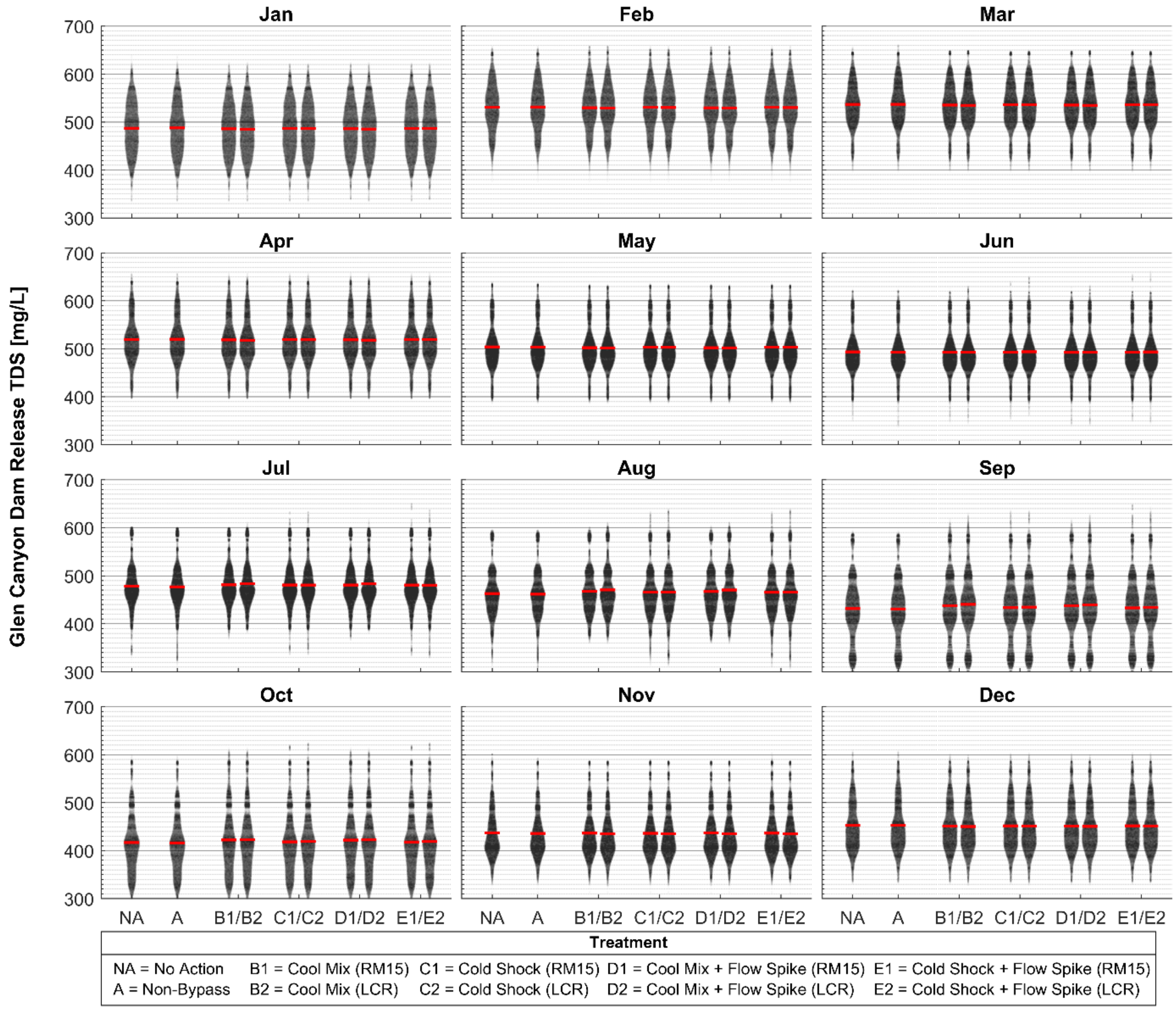
### *Issue 2: How would flow alterations impact salinity?*

#### Impacts Common to All Alternatives

Under all alternatives, any increase in salinity would have negligible impacts on biological systems and would meet the Colorado River Salinity Criteria.

As shown in **Figure 3-48**, salinity would not exceed 720 mg/L under any alternatives.

**Figure 3-48**
**Swarm Charts Showing the Monthly Distribution of Predicted Glen Canyon Dam Release Salinity* for All Scenarios and Traces over the Simulation Period****




Source: USGS 2024b
**The red horizontal lines indicate the means of each distribution. The widths of each distribution indicate the relative frequency of occurrence.

## No Action Alternative

Under the No Action Alternative, Glen Canyon Dam operations would remain unchanged. Therefore, water would continue to be discharged primarily through the penstocks, as described in the 2016 LTEMP FEIS. The warmer water discharged from the penstocks would continue to produce a negligible increase in salinity.

**Cool Mix Alternative**

Under the Cool Mix Alternative, there would be an increase in salinity when compared with the No Action Alternative, as shown in **Figure 3-48**. While there would be an increase, salinity would remain lower than the early spring salinity concentration peaks, so the increase would be minimal.

**Cool Mix with Flow Spike Alternative**

Under the Cool Mix with Flow Spike Alternative, there would be an increase in salinity related to the cool mix operations when compared with the No Action Alternative. There would also be a further increase in salinity due to the flow spike operations, as shown in **Figure 3-48**. While there would be an increase, salinity would remain lower than the early spring salinity concentration peaks, so the increase would be minimal.

**Cold Shock Alternative**

Under the Cold Shock Alternative, there would be an increase in salinity when compared with the No Action Alternative, as shown in **Figure 3-48**. This increase in salinity would also be greater than the Cool Mix Alternative. While there would be an increase, salinity would remain lower than the early spring salinity concentration peaks, so the increase would be minimal.

**Cold Shock with Flow Spike Alternative**

Under the Cold Shock with Flow Spike Alternative, there would be an increase in salinity related to the cold shock operations when compared with the No Action Alternative. This increase in salinity would also be greater than the Cool Mix Alternative. There would also be a further increase in salinity due to the flow spike operations, as shown in **Figure 3-48**. While there would be an increase, salinity would remain lower than the early spring salinity concentration peaks, so the increase would be minimal.

**Non-Bypass Alternative**

Impacts on salinity under the Non-Bypass Alternative would be similar to those under the No Action Alternative, as shown in **Figure 3-48**. This alternative would be similar to the No Action Alternative since the Non-Bypass Alternative would not involve the use of Glen Canyon Dam's bypass system and would instead focus on changes in release volumes.

**Cumulative Effects**

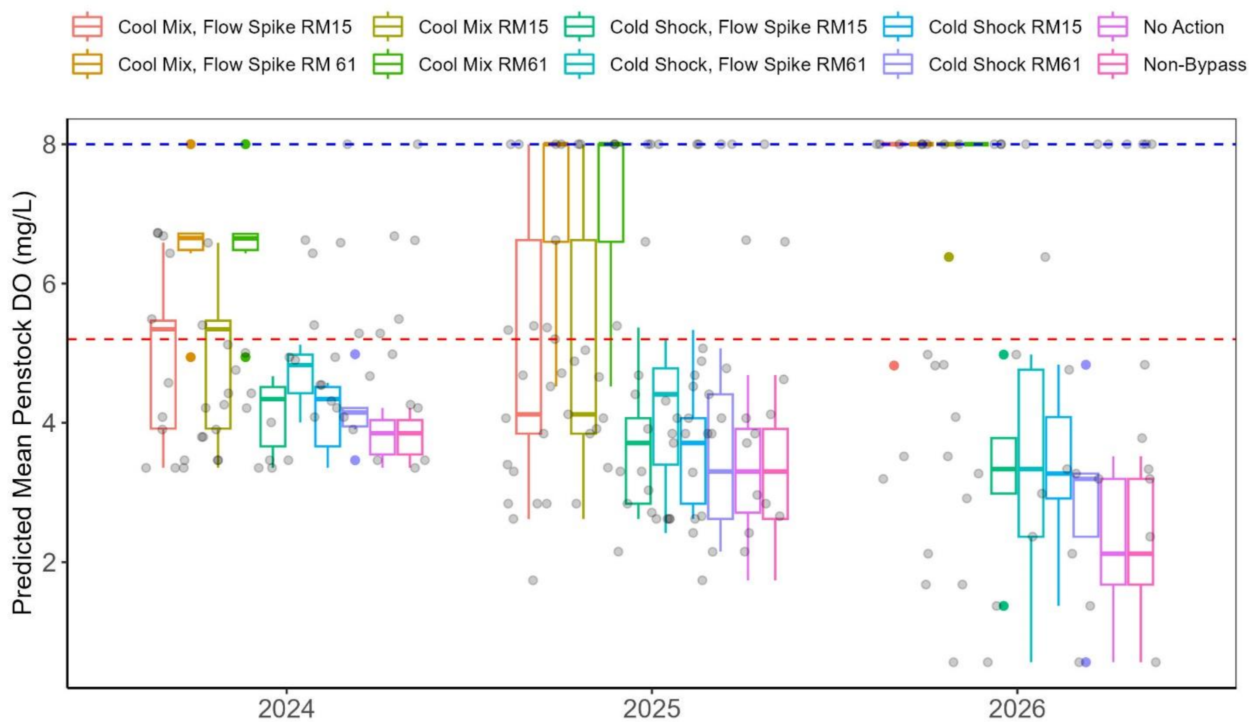
Impacts on salinity from all action alternatives would be temporary and would not have permanent, significant impacts on Lake Powell or the Colorado River. All proposed flow options would operate within the spatial and temporal bounds and under the assumptions of the existing analysis conducted in the 2016 LTEMP FEIS. There would be no cumulative impacts on salinity beyond those included in the 2016 LTEMP FEIS.

### *Issue 3: How would flow alterations impact DO?*

#### Impacts Common to All Alternatives

As shown in **Figure 3-49**, in years under which an experiment was implemented, the DO concentration would differ across alternatives; however, given that DO concentrations would vary more strongly across years rather than between alternatives, the management actions associated with the action alternatives would have a smaller impact on DO concentrations than other contributors to the reservoir and reservoir management dynamics. A stronger contributor to impacts on DO would be reservoir inflows and the resulting reservoir elevations.

**Figure 3-49**
**Predictions of Mean August to October DO Concentrations in Glen Canyon Dam Outflows for Prediction Years 2024 to 2026***




Source: GCMRC 2024a
*Unique colors are used for each alternative. Each point represents 1 year for a total of 30 points per box whisker (30 historical reconstructions). The dashed blue line demarcates 8 mg/L, which was the modeled concentration for traces where any amount of bypass spill was implemented, which was 25 traces. The dashed red line demarcates 5.2 mg/L, which is a threshold below which oxygen concentrations are stressful to trout. Output displayed only includes years under which an experiment was implemented.

**No Action Alternative**

Under the No Action Alternative, Glen Canyon Dam operations would remain unchanged. Therefore, water would continue to be discharged primarily through the penstocks, as described in the 2016 LTEMP FEIS. The water discharged from the penstocks would remain warm, leading to warmer water in the Colorado River downstream of the dam. This warmer water would continue to produce releases with a lower concentration of DO. As shown in **Figure 3-50**, the likelihood of low DO releases, where summertime mean DO would be less than 5.2 mg/L or the threshold below which oxygen concentrations are stressful to trout, was 100 percent of the years.

**Cool Mix Alternative**

Under the Cool Mix Alternative in years under which an experiment was implemented, low DO events, where summertime mean DO would be less than 5.2 mg/L or the threshold below which oxygen concentrations are stressful to trout, would be less probable than under the No Action Alternative and would likely occur during 8 to 32 percent of years. This is shown in **Figure 3-49** and **Figure 3-50**. Sub-alternatives that target the Little Colorado River (river mile 61), which has a likelihood of 11 percent of years, would lead to fewer years with low DO events than the sub-alternative that targets river mile 15, which has a likelihood of 32 percent of years. These differences across sub-alternatives would be more pronounced in some years than others, as shown in **Figure 3-49**.

**Cool Mix with Flow Spike Alternative**

Under the Cool Mix with Flow Spike Alternative in years under which an experiment was implemented, the impacts on DO would be similar to the Cool Mix Alternative, under which low DO events (with summertime mean DO of less than 5.2 mg/L ) would be likely to occur during 8–36 percent of years, as seen in **Figure 3-50**. Therefore, low DO events would be less probable under the Cool Mix with Flow Spike Alternative than under the No Action Alternative.

**Cold Shock Alternative**

Under the Cold Shock Alternative in the years under which an experiment was implemented, the impacts on DO would be similar to those under the No Action Alternative. Low DO events (with summertime mean DO of less than 5.2 mg/L) would be likely to occur during 96–100 percent of years, as shown in **Figure 3-50**.

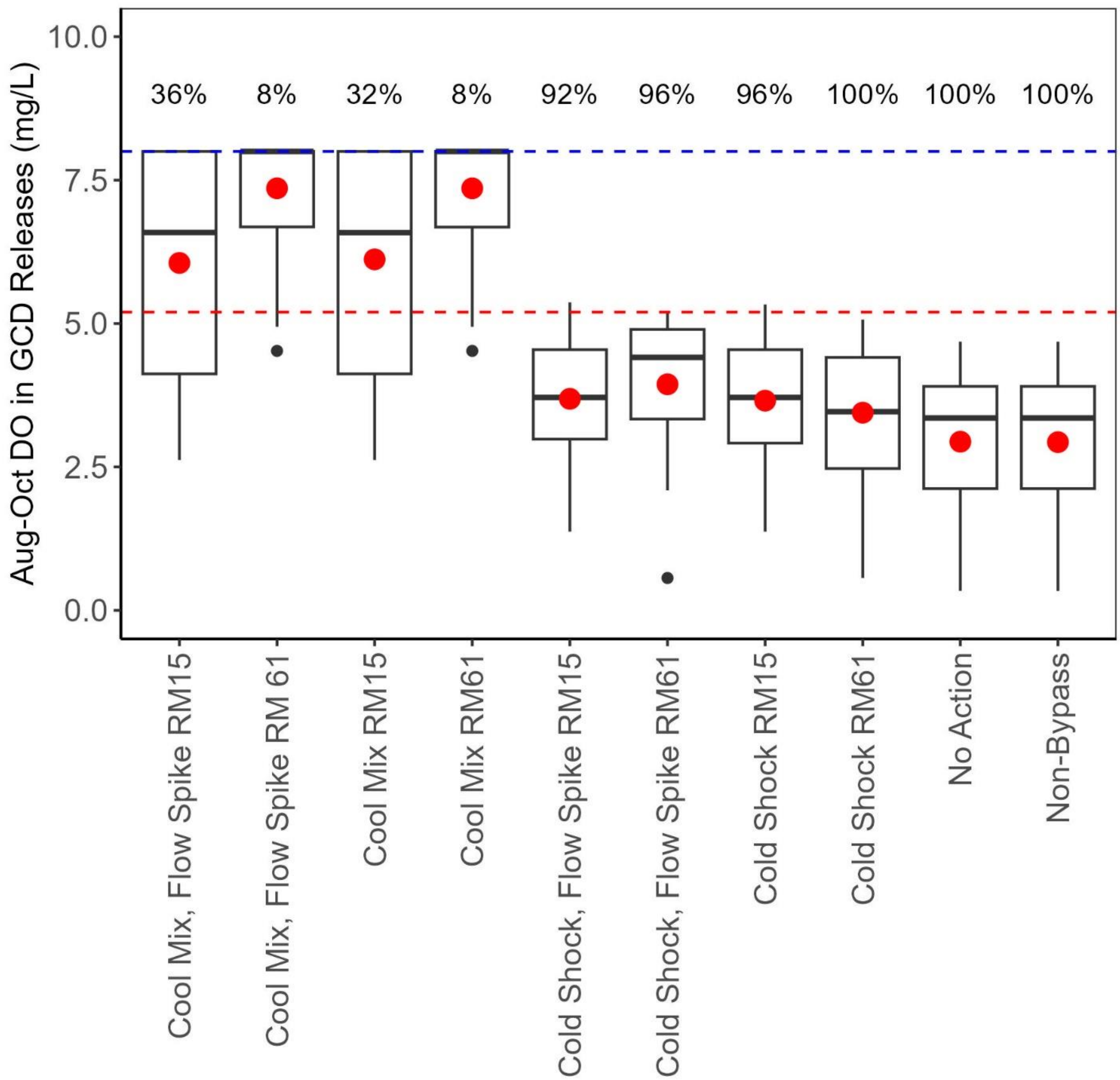
**Cold Shock with Flow Spike Alternative**

Under the Cold Shock with Flow Spike Alternative in years under which an experiment was implemented, the impacts on DO would be similar to those under the No Action Alternative and Cold Shock Alternative. Low DO events (with summertime mean DO of less than 5.2 mg/L) would be likely to occur during 92–96 percent of years, as shown in **Figure 3-50**.

**Non-Bypass Alternative**

Impacts on DO under the Non-Bypass Alternative would be similar to those under the No Action Alternative, as shown in **Figure 3-50**. This alternative would be similar to the No Action Alternative since the Non-Bypass Alternative would not involve the use of Glen Canyon Dam's bypass system and would instead focus on changes in release volumes.

**Figure 3-50**
**Mean August to October DO Concentrations in Glen Canyon Dam Outflows***




Source: GCMRC 2024a

*The figure addresses the entire prediction time frame under six alternatives (and sub-alternatives). Red dots indicate the mean release concentration across years and traces. Each point represents 1 year for a given hydrologic trace for a total of 150 points per box whisker (30 historical reconstructions and 5 prediction years). The dashed blue line demarcates 8 mg/L, which was the modeled concentration for traces where any amount of bypass spill was implemented, which was 25 traces. The dashed red line demarcates 5.2 mg/L, which is a threshold below which oxygen concentrations are stressful to trout. The percentage of trace/year combinations where the average DO is below 5.2 mg/L is annotated above each scenario. Output displayed only includes years under which an experiment was implemented.

**Cumulative Effects**

Impacts on DO from all action alternatives would be temporary and would not have permanent, significant impacts on Lake Powell or the Colorado River. All proposed flow options would operate within the spatial and temporal bounds and under the assumptions of the existing analysis conducted in the 2016 LTEMP FEIS. There would be no cumulative impacts on DO beyond those included in the 2016 LTEMP FEIS.

***Summary***

The No Action Alternative and the Non-Bypass Alternative would result in similar impacts on temperature. When compared with the No Action Alternative and the Non-Bypass Alternative, adding more bypass through cool mix or cold shock operations would result in a decreased total release temperature during summer periods when bypass would be utilized. The cold shock alternatives would be more effective at reducing the release temperature than the cool mix alternatives. However, the duration of cold releases would last only as long as the use of the bypass, whereas cool mix operations would result in temperatures remaining cooler over a longer duration. The flow spike would add to the decrease in temperature under the cool mix and cold shock operations, but the change would be minimal.

There would be an increase in salinity related to the flow spikes and the cool mix and cold shock operations; of these, the cold shock would have a greater increase in salinity. However, salinity would remain lower than the early spring salinity concentration peaks. While utilizing bypass would increase the salinity concentration at times, the annual average concentration for all traces and for each management alternative would not be significantly different.

Across all alternatives, 74 percent of the years by trace combinations (that is, 1,007 out of 1,500 traces) would likely have mean DO concentrations of less than 5 mg/L in the late summer and early fall. Low DO releases would be less likely under the Cool Mix and Cool Mix with Flow Spike Alternatives compared with the No Action, Cold Shock, and Cold Shock with Flow Spike Alternatives. Differences in the sub-alternatives would be more pronounced during some years than others.

# 3.12 Cultural Resources

Overall conditions for cultural resources today remain similar to those described in the 2016 LTEMP FEIS. Changes from the 2016 LTEMP FEIS include a more specific analysis area and the availability of more recent cultural resources data. Both changes are discussed below.

Much of the following discussion is condensed from Section 3.8, Cultural Resources, and Section 4.8, Cultural Resources, in the 2016 LTEMP FEIS (DOI 2016a). As defined in the 2016 LTEMP FEIS, cultural resources are:

> “. . . typically categorized as archaeological resources, historic [buildings and structures] and prehistoric structures, cultural landscapes, traditional cultural [places], ethnographic resources, and museum collections. Many natural resources, such as

> plants and plant gathering areas, water sources, minerals, animals, and other ecological resources, are also considered cultural resources, as they have been integral to the identity of Tribes in various ways. For some Tribal people, archaeological resources are considered to be markers left by their ancestors, the embodiment of those who came before and are imbued with the spirits of the ancestors. They represent a physical link to the past. The physical attributes of cultural resources are often nonrenewable, especially archaeological sites, which often represent ancestral homes for the park's traditionally associated Tribes." (DOI 2016a, 3-144)

Of the many laws, regulations, executive orders, and policies concerning cultural resources, the most pertinent to this project is the National Historic Preservation Act (NHPA; 54 United States Code 470x–6), as amended, and its implementing regulations (36 CFR 800). The NHPA and its implementing regulations require federal agencies to take into account the effects of their undertakings (federal undertakings or federally permitted or funded undertakings) on historic properties. Historic properties are defined in 36 CFR 800.16(l) as any district, site, building, structure, or object included in or eligible for inclusion in the National Register of Historic Places (NRHP). As such, they are a subset of cultural resources.

The regulations establish a process for consultation with the State Historic Preservation Officer (SHPO) and/or Tribal Historic Preservation Officer (THPO), interested Tribes, the Advisory Council on Historic Preservation, and other interested parties regarding an undertaking's effect on historic properties. If a project has the potential to affect historic properties, the federal agency must, in consultation with the SHPO or THPO and other interested parties, establish the area of potential effect (APE); identify historic properties within the undertaking's APE; assess what, if any, effects the undertaking may have on historic properties in the APE; and attempt to resolve adverse effects through avoidance, minimization, or mitigation of the adverse effects.

The LTEMP programmatic agreement (PA) was executed in September 2017 (Reclamation 2017) as the means of resolving any adverse effects of LTEMP actions through the stipulations therein. In addition, Reclamation is developing a MOA under the LTEMP PA regarding nonnative fish control and flow actions under Glen Canyon Dam's operations that would replace the existing MOAs.

The following analysis indicates there may be adverse effects from the proposed changes discussed in this SEIS with regard to Tribal values associated with protecting life in the Colorado River (see **Section 3.13**, Tribal Resources). The existing LTEMP PA includes provisions for new experiments and methods to resolve concerns and adverse effects on Tribal values and historic properties; consequently, Reclamation does not anticipate amending the existing PA.

### *Analysis Area*

Per the LTEMP PA, the APE for the LTEMP undertaking consists of "the area of direct and indirect effects on the character or use of historic properties on the Colorado River Corridor in the Canyons from Glen Canyon Dam to the western boundary of GCNP, including direct or indirect effects that may be caused to historic properties by the Undertaking from rim-to-rim of the Canyons" (Reclamation 2017). The analysis area for the 2016 LTEMP FEIS consisted of a larger area than the APE; it encompassed Lake Powell, Glen Canyon Dam, and the Colorado River to Lake Mead (DOI 2016a, 3-147).

The analysis area for direct and indirect impacts of this SEIS includes the Colorado River below Glen Canyon Dam to the inlet of Lake Mead.

Potential impacts on cultural resources were described as follows in the 2016 LTEMP FEIS:

> There are a number of ways in which dam operations may affect cultural resources, including the periodicity of inundation and exposure, changing vegetation cover, streambank erosion, slumping, and influencing the availability of sediment. Direct and repeated inundation/exposure may affect resources such as the Spencer Steamboat, which is in the active channel . . . , or Pumpkin Springs, a TCP along the bank that is subject to inundation during high flows (e.g., equalization flows and HFEs). Streambank erosion, slumping, flow-related deposition, and indirect effects of deposition may affect cultural resources contained within terrace contexts in proximity to inundated areas. Fine sand or sediment can be blown from flow-deposited source areas and deposited on cultural sites (East et al. 2016). . . . The effects of deposition or erosion may be negative or positive depending on the nature of the site. One important recent finding is that sandbars created by high-flow events at Glen Canyon Dam can provide sources of windblown sand that can cover archaeological sites (East et al. 2016) as well as anneal, or reverse, the formation of gullies (Sankey and Draut 2014). In this context, changes in dam operations can affect erosion rates on archaeological sites (East et al. 2016, Collins et al. 2016). In addition, bank deposition and aeolian transport of sediment can affect the character of other types of TCPs. The activities of research and monitoring may also have the potential to negatively affect the character-defining elements of archaeological sites and TCPs. (DOI 2016a, 3-147)

#### *Data Gathering Methods*

A Class I cultural resources record search was conducted for the SEIS analysis area. Sources checked include AZSITE, an online database maintained by the Arizona State Museum (ASM), the Archaeological Records Office at ASM, the BLM Kingman Field Office, and the Arizona Department of Transportation Portal. Digital records were requested from the BLM (Arizona Strip Field Office and Parashant Office), NPS (GCNP, GCNRA, and LMNRA), and the US Forest Service (Kaibab National Forest). The Arizona and National Registers of Historic Places were also checked. In addition, historic-age topographic maps, General Land Office maps, and historic-age aerial photographs were consulted, and resources were digitized.

Resources important to Tribes, such as TCPs and ecological resources, including those resources from the Class I records search, will be discussed in greater detail in **Section 3.13**, Tribal Resources.

### 3.12.1 Affected Environment

The history and importance of Glen, Marble, and Grand Canyons to humans span thousands of years and continue into the present day. The following is a summary of human history and the associated cultural resources from a Western viewpoint, as condensed from the 2016 LTEMP FEIS, Section 3.8.2, Description of Cultural Resources and Site Types (DOI 2016a, 3-149–3-156). Western archaeologists divide the human history of the canyons into six broad periods: Paleoindian, Archaic, Formative, Late Prehistoric, Protohistoric, and Historic. Information provided by the Zuni on the Zuni concept of time, which begins with their emergence in the Grand Canyon, can be found below in **Section 3.13**, Tribal Resources. Many Indigenous peoples, such as the Zuni, also view archaeological sites as sacred places where ancestors lived and continue to live (see **Section 3.13**, Tribal Resources).

### *Archaeological Resources*

Archaeological resources span all six time periods mentioned above and are the physical manifestations of human life or activities on the landscape and environment. Previous research along the Colorado River began in the 19th century, and these efforts continue today. Archaeological sites can be attributed to the Paleoindian through the Historic periods, and several different site types have been documented along the canyons.

The Paleoindian period spans the time of the earliest occupation of the Americas, from about 10,000 to 6,000 before the Common Era (BCE). Evidence of Paleoindian occupation is seen in distinctive spear points used to hunt large mammals such as mammoths. In GCNRA, six Paleoindian spear points from the Clovis, Folsom, and Plano complexes have been found (five in the northernmost part of the recreation area and one west of Lees Ferry). A fragmentary Clovis point and a partial Folsom point have been found in GCNP.

The Archaic period (6,000–500 BCE) was characterized by mobile hunter-gatherers who used smaller projectile points on darts to hunt game and one-hand manos and grinding slabs to process plant resources. Later sites also contain evidence of the beginning of plant cultivation. Sites include hunting blinds, lithic scatters at meadow edges and waterholes, temporary camps, rock art, and split-twig figurine caches. In GCNP, the Archaic period is characterized by the Split Twig Figurine Complete in the eastern Grand Canyon and Grand Canyon Polychrome pictographs in the western Grand Canyon. In GCNRA, there is also a distinctive petroglyph style called the Glen Canyon Linear Style.

The beginning of the Formative period (500 BCE–700 Common Era [CE]) is also known as the Basketmaker period due to the peoples' extensive use of baskets, sandals, and textiles. During this period, the use of the bow and arrow and the production of pottery were new innovations, and people became more sedentary as crop cultivation became more common. Within the Grand Canyon these early sites are concentrated in the western Grand Canyon.

In the later Formative period (700–1300 CE), Ancestral Puebloans emerged. During this time, people relied more heavily on agriculture and constructed distinctive masonry structures and apartment-like dwellings (pueblos). Most sites in GCNRA and GCNP are Puebloan; modern Puebloans are among the descendants of these ancestral peoples.

At the end of the Formative period, the climate became cooler and drier, and Ancestral Puebloans moved out of the canyons during the Late Prehistoric period (1250–1540 CE). However, they retained their ties to the canyons and returned to the canyons for resources, ceremonies, and other purposes. Less sedentary groups, such as the ancestral Pai and Southern Paiute, expanded into the area from the west. Sites associated with these groups consist of camps with brush structures and roasting pits.

During the Protohistoric period (1540–1776 CE), Spanish explorers looking for gold and other resources and seeking to convert Indigenous peoples to Christianity traveled the Southwest; however, the Glen Canyon area did not experience much of an impact because of its remoteness. At this time, the Navajo (Diné), Pai, and Southern Paiute were the main groups in the area.

#### *Historic-Era Resources*

The Historic period (1776–1970s CE) began with the arrival of the Domínguez-Escalante Expedition in 1776 at what is now Lees Ferry along the Colorado River and Fr. Francsico Garces expedition up the Lower Colorado River and then overland to the western Grand Canyon area. Other Spanish and then American expeditions, such as the Powell expedition and the Stanton expedition, visited the Colorado River area in the 18th and 19th centuries. More European and American settlers moved into the Colorado River corridor, putting pressure on Indigenous groups in the 19th century. Indigenous groups moved into smaller territories and more remote areas.

The Hualapai stayed in the western Grand Canyon area, and the Southern Paiute lived in the western and northern Grand Canyon area. The Havasupai lived in the Grand Canyon. The Diné lived along the south, east, and north rims of and within the canyons. Native American archaeological sites from this period contain a mix of Indigenous and non-Native artifacts.

Eventually, all the Tribes were forced or coerced onto reservations and out of their much larger traditional territories. The traditional territory of the Havasupai included the Grand Canyon and areas to the south of the canyon. Under pressure from ranchers and miners in the 19th century, the Havasupai's land on the plateau was taken from them, and they were forced to live in the canyon year-round. The US government established a reservation in the Grand Canyon for the Hualapai in 1880 to encourage them to remain in the canyon. Like the Havasupai, the Hualapai experienced pressure on their traditional territory from Euro-American miners and settlers, including the construction of the Beale Wagon Road through their territory in 1857. The pressure eventually led to the Hualapai fighting back during the Hualapai War of 1865–1869. The Hualapai lost and were forced to move to Parker and La Paz. In 1883, the Hualapai Reservation was established, and they were allowed to return to a fraction of their original territory.

Conflicts between the Diné and the army resulted in a campaign to remove the Diné to New Mexico, and they began the "Long Walk" to New Mexico in 1864. Hundreds of Diné died under the harsh conditions of the forced march; those that survived were held by the US government until 1868. When they returned, the Diné found that much of their territory was no longer theirs, which led to conflicts into the 1900s. In addition, in 1893, the Grand Canyon Reserve was established, leading the US government to evict them from the reserve. Eventually, however, their reservation was extended to the canyon.

The Southern Paiute were devastated by European disease and then, after the 1850s, were affected by cattle ranching by the Latter-day Saints. The cattle degraded much of the resources the Southern Paiute depended on. In an attempt to resolve this issue, the US sent them to the Moapa Reservation in Nevada; however, the Kaibab Paiute refused to leave. Under pressure from the creation of reserves and national parks on the Arizona Strip, the Kaibab Paiute were settled on a small reservation at Moccasin and Pipe Springs. More acreage was given to them in 1917 in northern Arizona.

European and American archaeological sites show evidence of travel, mining, ranching, sheepherding, recreation, and dam construction. Lees Ferry is a river ferry crossing that was settled by John D. Lee in the late 19th century. It is listed on the NRHP as part of the Lees Ferry and Lonely Dell Ranch Historic District. The remains of the Charles H. Spencer steamboat, which was supposed to transport coal but was abandoned at Lees Ferry, are within the district.

### *Cultural Landscapes*

Cultural landscapes are settings that humans have created in the natural world and consist of both natural and constructed elements. To Indigenous peoples, the river corridor is a cultural landscape where they have lived for millennia (DOI 2016a, 3-156). All aspects of the natural world, such as plants, animals, and land formations, are important to that landscape. Evidence of past activities that have shaped that landscape can be seen in ancestral trails and habitations, fields, and prayer objects enshrined in travertine and salt. The Grand Canyon has 16 documented cultural landscapes, including the canyon itself and the Cross Canyon Corridor, which encompasses the major trails between the North and South Rims in the inner canyon. Tribal perspectives on cultural landscapes are summarized in **Section 3.13**, Tribal Resources.

Lees Ferry is a cultural landscape representing 130 years of Euro-American cultural use. It encompasses the NRHP-listed Lees Ferry and Lonely Dell Ranch Historic District. Here, the Colorado River is not bound by canyon walls; it was the only place within 400 miles that could be accessed by wagon. Historical use of the area as a farm and ferry crossing can be seen in historic buildings and the district, a cemetery, an orchard, and other trees, fields, trails, and dugways. Today, river runners' access, camping, and USGS gaging stations demonstrate the continued use of the Lees Ferry landscape (DOI 2016a, 3-155).

### *Traditional Cultural Places and Ethnographic Resources*

A TCP is "a building, structure, object, site, or district that may be eligible for inclusion in the National Register for its significance to a living community because of its association with cultural beliefs, customs, or practices that are rooted in the community's history and that are important in maintaining the community's cultural identity" (NPS 2022c, 10).

American Indian peoples consider Glen Canyon (as well as the Grand Canyon) and its vicinity to be of traditional and sacred importance; this is discussed in more detail in **Section 3.13**, Tribal Resources. GCNP has over 500 documented ethnographic resources within the park, including the river and specific locations within the river. Because these resources are sensitive from a Tribal perspective, the full number and nature of them are and will remain unknown to the agencies.

### *Class I Results*

The Class I records search demonstrated that 436 previous projects have surveyed approximately 60,463 acres, or 3.3 percent, of the analysis area for cultural resources; these were primarily archaeological resources (Tremblay et al. 2024). Of these, 82.8 percent—or 361 of these surveys—were conducted more than 20 years ago. Only 25 surveys were conducted in the last 10 years. These 25 surveys encompass a total of 4,546 acres, or 0.2 percent, of the analysis area.

Previous projects included both block and linear surveys in support of numerous state, federal, municipal, and private development projects. These projects are associated with public utilities, such as gas pipelines, fiber-optic lines, and transmission lines; road and highway construction; mining operations; and numerous development projects, land and timber transfers, and environmental impact reports on federal and state lands within the analysis area.

#### Archaeological Sites

The records search identified a total of 3,776 archaeological sites (Tremblay et al. 2024). Of the 3,776 archaeological sites, 2,931 can be temporally affiliated with the prehistoric era, 50 are ethnohistoric, 375 are historic, 260 are multicomponent sites, and 160 could not be assigned to a temporal component. Across all sites, only three are listed on the NRHP. These consist of one prehistoric pueblo (Tusayan Ruins; AZ C:13:21[ASM]) and two historic-era properties—Grandview Mine (AZ C:13:11[ASM]) and Charles H. Spencer Steamboat (3.249.SHPO). For all other sites, 3,023 have been determined eligible for the NRHP, with an additional 94 recommended eligible. Seven sites have been determined ineligible, 34 have been recommended ineligible, and 615 are unevaluated. All resources in GCNP are eligible for the NRHP. **Table 3-37** presents the archaeological sites within the analysis area by temporal affiliation and NRHP-eligibility status.

**Table 3-37**
**Archaeological Sites in the Analysis Area**

| Temporal Affiliation | Number | NRHP Listed | Determined | | Recommended | | Unevaluated |
|---|---|---|---|---|---|---|---|
| | | | *Eligible* | *Ineligible* | *Eligible* | *Ineligible* | |
| Prehistoric | 2,931 | 1 | 2,305 | 3 | 83 | 34 | 505 |
| Ethnohistoric | 50 | — | 48 | — | — | — | 2 |
| Historic | 375 | 2 | 337 | 4 | 5 | — | 27 |
| Multicomponent | 260 | — | 226 | — | 6 | — | 28 |
| Unknown | 160 | — | 107 | — | — | — | 53 |
| **Total** | **3,776** | **3** | **3,023** | **7** | **94** | **34** | **615** |

Source: Tremblay et al. 2024

Of the 2,931 single-component prehistoric archaeological sites in the analysis area, 1,057 could only be associated generally with nonspecific Indigenous cultures, which may be pre- or post-contact with Euro-Americans. For the remaining sites, 2 are associated with Paleoindian occupations, 104 are associated with Archaic peoples, 15 are Basketmaker, 1,534 are Ancestral Puebloan, 183 are Cohonina, 3 are Payatan, and 33 are Cerbat (**Table 3-38**). The types of sites identified vary in function and consist of limited-activity artifact scatters; long- and short-term habitations; resource processing and lithic reduction locales; agricultural, storage, and water management features; trails;

petroglyphs and pictographs; and special-use sites. **Table 3-38** provides a summary of the prehistoric site functions and cultural affiliations within the analysis area.

## Table 3-38
## Prehistoric Sites in the Analysis Area by Function and Cultural Affiliation

| Site Function | Number* | Paleo-Indian | Archaic | Basket-maker | Ancestral Puebloan | Cohonina | Patayan | Cerbat | Indigenous** |
|---|---|---|---|---|---|---|---|---|---|
| Limited activity | 337 | — | 15 | 2 | 128 | 17 | — | — | 75 |
| Habitation | 824 | — | 4 | 1 | 678 | 37 | 1 | 9 | 94 |
| Temporary habitation/camp | 462 | — | 22 | 1 | 232 | 33 | 1 | 8 | 165 |
| Resource procurement/ processing | 561 | — | 12 | 3 | 149 | 71 | — | 14 | 312 |
| Agricultural | 130 | — | 1 | 1 | 98 | 2 | — | — | 28 |
| Lithic reduction | 177 | 2 | 17 | 1 | 22 | 4 | — | — | 133 |
| Storage/cache | 127 | — | — | — | 96 | 1 | — | — | 30 |
| Ceremonial/special use | 69 | — | 13 | — | 27 | 8 | — | 1 | 20 |
| Petroglyphs/pictographs | 161 | — | 16 | 6 | 66 | 1 | — | — | 72 |
| Water management | 6 | — | — | — | 2 | — | — | — | 4 |
| Transportation (trails) | 2 | — | — | — | 1 | — | — | — | 1 |
| Unknown | 73 | — | 4 | — | 35 | 9 | 1 | 1 | 23 |
| **Total** | **2,931** | **2** | **104** | **15** | **1,534** | **183** | **3** | **33** | **1,057** |

Source: Tremblay et al. 2024
* Numbers may not add up precisely because sites may have more than one cultural or temporal component.
** Only associated generally with nonspecific Indigenous cultures

Of the 50 single-component ethnohistoric sites in the analysis area, 8 could only be generally assigned to nonspecific Indigenous cultures. The remaining sites are associated with Havasupai (3 sites), Hopi (4 sites), Navajo (3 sites), Pai (8 sites), and Southern Paiute (24 sites) peoples and cultures. Site functions are similar to the subset of prehistoric-era sites, though with fewer types represented (**Table 3-39**). Temporary habitations (16 sites) and resource processing/procurement sites (16 sites) are the most abundant ethnohistoric sites in the analysis area.

## Table 3-39
## Ethnohistoric Sites in the Analysis Area by Function and Cultural Affiliation

| Site Function | N | Havasupai | Hopi | Navajo | Pai | Southern Paiute | INDG* |
|---|---|---|---|---|---|---|---|
| Habitation | 8 | 1 | — | 1 | 1 | 1 | 4 |
| Temporary habitation/camp | 16 | 1 | 2 | — | 5 | 8 | — |
| Resource procurement/ processing | 16 | — | 2 | — | 1 | 12 | 1 |
| Agricultural | 3 | — | — | — | — | 2 | 1 |
| Storage/cache | 1 | — | — | 1 | — | — | — |
| Ceremonial/special use | 3 | 1 | — | 1 | — | — | 1 |
| Petroglyphs/pictographs | 3 | — | — | — | 1 | 1 | 1 |
| **Total** | **50** | **3** | **4** | **3** | **8** | **24** | **8** |

Source: Tremblay et al. 2024
* Only associated generally with nonspecific Indigenous cultures

A total of 375 single-component historic-era sites are in the analysis area. These sites are largely attributed to Euro-Americans (316 sites); however, sites from Indigenous groups consisting of the Havasupai, Hualapai, Hopi, Navajo, and Southern Paiute are also present (**Table 3-40**). Additionally, 316 sites could only be generally associated with nonspecific Indigenous peoples, and 7 are of unknown cultural affiliation.

Historic-era sites in the analysis area are dominated by temporary camps (72 sites) but also include structural features associated with Euro-American mining claims and ventures from the early 1900s to the 1960s (**Table 3-40**). Sites with corrals, fences, stock tanks, storage facilities, and other features attest to the extent of Euro-American and contemporary American Indian ranching activities and agriculture in the analysis area. Additionally, sites associated with the construction of the dams, GCNP, and national recreation areas are also present, including several utilities and water management features and numerous transportation features, such as ferry crossings.

**Table 3-40**
**Historic-Era Sites in the Analysis Area by Function and Cultural Affiliation**

| Site Function | Number | Havasupai | Hualapai | Hopi | Navajo | Southern Paiute | Indigenous* | Euro-American | Unknown |
|---|---|---|---|---|---|---|---|---|---|
| Limited activity | 69 | — | — | — | 1 | — | 1 | 67 | — |
| Habitation | 29 | 5 | — | — | 1 | — | 3 | 20 | — |
| Temporary habitation/camp | 72 | 2 | 1 | 2 | 1 | — | 8 | 54 | 4 |
| Resource procurement/ processing | 8 | — | — | — | 2 | 2 | 3 | 1 | — |
| Agricultural | 2 | — | — | — | — | — | — | 2 | — |
| Storage/cache | 3 | — | — | — | 1 | — | 1 | 1 | — |
| Ceremonial/special use | 35 | 4 | — | — | 4 | — | 4 | 23 | — |
| Petroglyphs/pictographs | 6 | 1 | — | — | 1 | 1 | — | 3 | — |
| Water management | 5 | — | — | — | — | — | — | 5 | — |
| Waste management (refuse piles) | 13 | — | — | — | — | — | — | 13 | — |
| Transportation | 28 | — | — | — | — | — | — | 28 | — |
| Utility | 3 | — | — | — | — | — | — | 3 | — |
| Livestock/ranching | 33 | — | — | — | 1 | — | 1 | 30 | 1 |
| Mining | 43 | — | — | — | — | — | — | 43 | — |
| Government | 4 | — | — | — | — | — | — | 4 | — |
| Military | 1 | — | — | — | — | — | — | 1 | — |
| Unknown | 21 | — | — | — | — | — | 1 | 18 | 2 |
| **Total** | **375** | **12** | **1** | **2** | **12** | **3** | **22** | **316** | **7** |

Source: Tremblay et al. 2024
* Only associated generally with nonspecific Indigenous cultures

A total of 260 multicomponent sites are also present in the analysis area. Nearly all of these (258 sites) include a prehistoric component. In addition, 85 have ethnohistoric components, and 176 have historic-era components. Cultural affiliations for the multicomponent sites were variable, with individual components representing Prehistoric Archaic (8 sites), Basketmaker (3 sites), Ancestral Puebloan (161 sites), Cohonina (17 sites), and Cerbat (1 site) peoples; ethnohistoric and historic-era components attributed to Havasupai (5 sites), Hopi (20 sites), Navajo (8 sites), Pai (20 sites), and Southern Paiute (54 sites) peoples; and 139 Euro-American historic-era components. An additional

73 individual components from these sites are associated only with indeterminate Indigenous cultures (across all 3 temporal categories).

**Built Environment Resources**

Built environment resources in the analysis area south of Glen Canyon Dam include the Lees Ferry and Lonely Dell Historic District, two cabins at the Upper Ferry Crossing, portions of the Escalante Route of the Old Spanish Trail, and multiple hiking trails.

**Mapped Resources**

Resources found on the historic topographic maps, General Land Office maps, and aerial photographs include buildings, corrals, fences, mining features, roads, water tanks, utility lines, trails, campgrounds, bridges, ranches, ruins and cliff dwellings, towers, wells, and other features.

### *USGS Glen Canyon Dam Operations Study*

A study conducted by the USGS demonstrated that flow changes from the operation of Glen Canyon Dam since 1963 have changed the amount of sediment and riparian vegetation along the Colorado River through GCNP, which has led to a decrease in the amount of wind-borne sand protecting sites (Sankey et al. 2023). The wind-borne sediment helps protect sites from erosion, which may impact a site's physical integrity by incremental accumulation of sand over long periods of time. By examining aerial imagery, the USGS concluded that the number of sites along the river that have "the highest likelihood of receiving wind-blown sand from fluvial sand bars…decreased over each monitoring interval, from 98 in 1973 to only 4 in 2021-22" (Sankey et al. 2023, 10). The change is generally the result of the increase in vegetation on the sand bars, which prevents the transport of sand. The vegetation increase can be attributed to the lack of floods, which would have normally occurred seasonally along the river prior to the construction of the dam (Sankey et al. 2023).

## 3.12.2 Environmental Consequences

### *Methodology*

Changes in flow could have direct, indirect, and cumulative impacts on cultural resources. Specifically, impacts could occur on historic properties that would alter the integrity of the characteristics that make the properties eligible for listing in the NRHP. The impacts considered in Glen Canyon in the 2016 LTEMP FEIS consisted of direct impacts from changes to terraces from flow effects and on the stability of the NRHP-listed Spencer Steamboat, indirect effects from visitors' time off the river, and cumulative effects.

Glen Canyon Dam flow effects can be seen most prominently in the reach below the dam because there is less sediment in this reach to buffer the effects, and cultural resources are found close to the river below the dam (DOI 2016a, 4.236). In addition, visitor effects on cultural resources may occur when people camp or hike at stops during river trips; these effects are most likely in the summer when most people use the river for recreational purposes (see **Section 3.14**, Recreation).

**Impact Analysis Area**

The impact analysis area is the same as for the 2016 LTEMP FEIS' APE. It stretches from rim to rim of the Grand Canyon from Glen Canyon Dam to the inlet into Lake Mead.

**Assumptions**

The analysis assumptions include the following:

- The data available from the 2016 LTEMP FEIS and from the Class I records search are adequate for the analysis.
- Resources within 66 feet (20 meters) of the river are most likely to be impacted by changes in flows.
- Sediment availability is a good predictor of the potential aeolian transport of sediment to cover sites.

**Impact Indicators**

The impact indicators for cultural resources include:

- Changes in Glen Canyon Dam flow that were not analyzed in the 2016 LTEMP FEIS
- Number and types of archaeological sites and built environmental resources that may be impacted by changes in water flow from inundation, erosion, or exposure to elements and visitation
- Amounts of sediment available daily for aeolian transport

Modeling of daily available sediment for aeolian transport to archaeological sites for each alternative was conducted by the GCMRC (Yackulic et al. 2024, chap. 5). The modeling did not take into account, however, the effects of HFE releases on rebuilding sandbar size, which would increase the amount of available sediment for aeolian transport. The GCMRC is currently developing a combined model to incorporate the sand routing, sandbar volumes, and aeolian transport models to more accurately demonstrate what the potential effects would be on archaeological sites; however, this model is not yet available for this analysis. When available, data from this combined model could be incorporated into the planning and implementation processes for the selected alternative. In addition, impacts from the different indicators could be separate, combined, or cumulative depending on the location of the sandbars and resources within the canyon.

### *Issue 1: How would flow alterations at Glen Canyon Dam impact archaeological sites and built environment resources in the Grand Canyon?*

**No Action Alternative**

Under the No Action Alternative, Reclamation would not change Glen Canyon Dam's current operations. No new impacts on terraces in Glen Canyon, where archaeological sites are located, would occur beyond those impacts expected from current dam operations. No impacts on petroglyphs or pictographs would occur because no petroglyph or pictograph sites are below the water level reached by the HFE releases. No change would occur from the current amount of time people spend stopped during river trips; therefore, no change would occur to the potential that these people could impact historic properties. Impacts on archaeological sites and built environment resources would be the same as those analyzed in the 2016 LTEMP FEIS for the dam's current operations (DOI 2016a, 4.248).

**Cool Mix Alternative**

Impacts under the Cool Mix Alternative would be the same as those impacts described for the No Action Alternative. Flows under the Cool Mix Alternative would be within the range of permitted flows under the 2016 LTEMP FEIS; no flows would be outside those analyzed for the 2016 LTEMP FEIS. Changes to temporary impacts not already analyzed under the 2016 LTEMP FEIS are not expected. Therefore, Reclamation would not anticipate additional impacts on the historic properties beyond those impacts analyzed for the 2016 LTEMP FEIS.

**Cool Mix with Flow Spike Alternative**

Impacts under the Cool Mix with Flow Spike Alternative would be the same as those impacts described for the No Action Alternative.

**Cold Shock Alternative**

Impacts under the Cold Shock Alternative would be the same as those impacts described for the No Action Alternative.

**Cold Shock with Flow Spike Alternative**

Impacts under the Cold Shock with Flow Spike Alternative would be the same as those impacts described for the No Action Alternative.

**Non-Bypass Alternative**

Based on available data, the impacts under the Non-Bypass Alternative could result in the exposure of archaeological sites during low flow events, should there be any, that are outside those analyzed in the 2016 LTEMP FEIS. Exposure could lead to damage or disturbance from wave action, wet/dry effects, and increased visitation. Adverse effects on historic properties would be resolved through the stipulations of the LTEMP PA. Reclamation does not know of any prehistoric archaeological sites under the present levels of the Colorado River, but the potential is there.

**Cumulative Effects**

None of the cold-water alternatives would contribute to cumulative impacts on historic properties. No additional impacts, other than those impacts analyzed in the 2016 LTEMP FEIS, would be anticipated under the cold-water alternatives. Cumulative impacts under the 2016 LTEMP FEIS, which include erosion of terraces and effects from visitor traffic, are considered negligible for the cold-water alternatives (DOI 2016a, Table 4-17.2). The Non-Bypass Alternative low flows are outside those analyzed in the 2016 LTEMP FEIS and may result in the exposure of cultural resources; however, adverse effects on cultural resources would be resolved under the LTEMP PA and, therefore, would not contribute to cumulative effects.

### *Issue 2: How would flow alterations at Glen Canyon Dam impact sediment availability in the Grand Canyon?*

**No Action Alternative**

Under the No Action Alternative, HFE releases would not change from current conditions, as discussed above in **Section 3.4**, Geomorphology/Sediment. If drought conditions continue, the No Action Alternative could result in the continued trend of fewer and smaller HFE releases, which would result in less sand bar volume (see **Figure 3-27**, **Figure 3-30**, and **Figure 3-31** in **Section 3.4**).

**Cool Mix Alternative**

Under the Cool Mix Alternative, fewer and shorter fall HFE releases and more and longer spring HFE releases are expected (see **Figure 3-27** and **Figure 3-28**). Sand bar growth would be smaller than under the No Action Alternative (Yackulic et al. 2024, chap. 5); however, the amount of sediment available daily for aeolian transport is predicted to be similar to that under the No Action Alternative (Yackulic et al. 2024, chap. 5).

**Cool Mix with Flow Spike Alternative**

Under the Cool Mix with Flow Spike Alternative, HFE releases would be similar to those under the Cool Mix Alternative, but some HFE releases may be of shorter duration. There may be more sand bar growth than under the alternatives without flow spikes, but daily available sediment would be similar to that under the No Action Alternative.

**Cold Shock Alternative**

Impacts under the Cold Shock Alternative would be the same as those under the Cool Mix Alternative.

**Cold Shock with Flow Spike Alternative**

Impacts under the Cold Shock with Flow Spike Alternative would be the same as those under the Cool Mix with Flow Spike Alternative.

**Non-Bypass Alternative**

Initial impacts under the Non-Bypass Alternative would be similar to those described under the Cool Mix and Cold Shock Alternatives. HFE probabilities and durations would fall between those of the Cool Mix and the Cool Mix with Flow Spike Alternatives (see **Figure 3-27** and **Figure 3-28**), and sandbar development may be smaller than under the Cool Mix with Flow Spike Alternative. According to Yackulic et al. (2024, chap. 5), daily available sediment for aeolian transport would be roughly the same as under the other alternatives; however, as discussed in **Section 3.4**, Geomorphology/Sediment, the Non-Bypass Alternative would eventually result in the greatest loss of sandbar volume due to erosion and slow sandbar recovery. Although sandbar volume would be initially similar to the that under the No Action Alternative, after 2025 both higher and lower fluctuations would result in erosion and lower sandbar growth (see **Figure 3-33**).

**Cumulative Effects**

Sediment availability for aeolian transport is predicted to be similar across all alternatives, including the No Action Alternative; however, HFE releases needed for sandbar building would vary between the alternatives. In addition, the Non-Bypass Alternative could result in lower sandbar volume and, therefore, less sediment available for aeolian transport than the other alternatives, contributing more significantly to cumulative effects. Changes to sandbar volume and the effects of windblown sediment on archaeological sites would vary by location.

***Summary***

Impacts on archaeological sites and built environment resources would be the same under the No Action and cold-water alternatives. Under the Non-Bypass Alternative, resources may be exposed during low flow events. The alternatives with flow spikes would result in more sand bar growth than the other alternatives, and the Non-Bypass Alternative would result in less sand bar growth. The amount of daily exposed sand available for aeolian transport to protect sites would be similar for all alternatives (Yackulic et al. 2024, chap. 5).

## 3.13 Tribal Resources

The affected environment for Tribal resources remains the same as described in the 2016 LTEMP FEIS (DOI 2016a), with the exception of additional information collected for the pending Class I records search discussed above in **Section 3.12**, Cultural Resources. The following discussion relies on Section 3.9, Tribal Resources, and Section 4.9, Tribal Resources, in the 2016 LTEMP FEIS and presents information from the Class I cultural resources record search. The analysis area for Tribal resources is the same as that for cultural resources (see **Section 3.12**, Cultural Resources); it stretches from Glen Canyon Dam to the inflow into Lake Mead. Reclamation reaffirms its responsibilities to the Tribes under the Council on Environmental Quality (CEQ) memorandum titled "Memorandum on Indigenous Traditional Ecological Knowledge and Federal Decision Making" (CEQ 2021) and will work to incorporate traditional ecological knowledge as it becomes available.

For the current project, Reclamation is consulting with the Tribal signatories to the PA, which include the Havasupai Tribe, Hopi Tribe, Hualapai Tribe, Navajo Nation, Pueblo of Zuni, and Southern Paiute Consortium. See **Section 3.12**, Cultural Resources, for a discussion of the current agreement documents in place or being developed. The following analysis indicates there may be adverse effects from the proposed alternatives discussed in this SEIS with regard to Tribal values associated with protecting life in the Colorado River. The existing LTEMP PA includes provisions for new experiments and methods to resolve concerns and adverse effects on Tribal values and historic properties; consequently, Reclamation does not anticipate amending the existing PA.

The focus of this SEIS is on the Colorado River below Glen Canyon Dam to Lake Mead. The Glen Canyon, Marble Canyon, and Grand Canyon cannot be separated in some cases for Tribes; therefore, the three canyons are referred to as the Canyons in this section.

## 3.13.1 Affected Environment

From time immemorial, the Canyons and the Colorado River have been sacred places for American Indian communities. The Colorado River features prominently in the cosmology and culture of American Indians in the Southwest (DOI 2016a, 3-156–3-157). The Havasupai Tribe, Hopi Tribe, Hualapai Tribe, Navajo Nation, Pueblo of Zuni, and Southern Paiute Consortium all have strong cultural ties to the Colorado River and identify the Colorado River and the Canyons as a "property of traditional religious and cultural importance to an Indian Tribe" (40 CFR 800.16(i)(1)), that is, a TCP. For the Tribes, the Colorado River and the Canyons are living, sentient entities. They are sacred spaces, the home 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 land and the living world, including the Colorado River and the Canyons.

As an act of stewardship, several Tribes have submitted documentation of the Colorado River and the Canyons as TCPs (Hopi CPO 2001; Coulam 2011; Dongoske 2011; Maldanado 2011). For the Hopi Tribe, the Canyons are places of their ancestors; they emerged in the Grand Canyon, and several of their clans lived in the Canyons during their migration period. Archaeological sites in the Canyons are the footprints of the ancestral Hopi peoples (Hisatsinom) and still are the ancestors' homes today. The Canyons as a whole are sacred to the Hopi Tribe (DOI 2016a, 3-158–3-159). The Hualapai Tribe considers the Colorado River region as a single great cultural landscape with the river as the backbone (Ha'yiđađa) (DOI 2016a, 3-159–3-162).

For the Navajo Nation, the Colorado and Little Colorado Rivers are deities, and their confluence is associated with Changing Woman (DOI 2016a, 3-162–3-164). Glen and Marble Canyons are home to many other deities who gave ceremonial and resource knowledge to the Navajo Nation. Traditional narratives of the Southern Paiute Consortium, which includes the Kaibab Band of Paiute and the Paiute Indian Tribe of Utah, recount that they were the original inhabitants of the area along the Colorado River and are responsible for its protection (DOI 2016a, 3-167–3-168). The Colorado River corridor and its resources are among their most vital natural resources.

The Colorado River is also sacred to the Zuni people (DOI 2016a, 3-164–3-167). After their emergence into this world, the Zuni people traveled along the Colorado and Little Colorado Rivers on their journey to the Middle Place. The Zuni still maintain strong ties to the area, and Zuni beliefs and practices are intertwined with the ecosystem of the Canyons. The Zuni have a familial relationship with animals (including fish), soils and rocks, vegetation, and water. All aspects of the environment and the Zuni universe are interconnected and kept in balance through traditional practices.

The Zuni consider archaeological sites as living places where the spirits of their ancestors continue to reside. The Zuni refer to the places as Ino:de Heshoda:we. They are indelibly associated with historic events that have made and continue to make significant contributions to the broad pattern of Zuni history and cultural identity. These ancestral places are physical evidence that the Zuni ancestors resided (and continue to reside) in and traveled extensively throughout the Grand Canyon to collect what they needed to survive and to initiate the journeys to find the Middle Place. These ancestral places act as nodes of intersection and reactivation that tie the entire Zuni sacred geography together.

To the Zuni archaeological sites can be described by the following:

> Rather than isolated, standalone, or temporally distinct "archaeological" structures, aspects of integrity of *Ino:de Heshoda:we* are first and foremost defined by how these ancestral places are able to connect to, calibrate, and direct Zuni practices of movement, pause, and return in relationship to ancestral movements, migrations, pauses, and creations. Likewise, instead of linear temporal periodizations or blocks of time gone past, the traditional religious and cultural importance and historical significance of *Ino:de Heshoda:we* are defined by how Zuni practices of movement, pause, and return work to (en)fold the past, present, and future at these places through interactions with the ancestors who continue to dwell with/in their spaces. At *Ino:de Heshoda:we*, past and present enfold in and through Zuni mo(ve)ments of communal pause-as Zuni offerings, prayers, songs, rituals, ceremonies, collections, and/or knowledge recovery; so, too, do these present mo(ve)ments enfold the future through information reactivation and enhanced capacities for collective continuance in and through communication with and learning from the ancestors dwelling within their structured spaces. For these reasons and in these ways, viable futures for traditional Zuni identities and practice intimately and indelibly depend on the integrity of *Ino:de Heshoda:we* as tangible reservoirs of Zuni history and human environment relationships, relational life/way lessons and processes, and navigational and calibrating landmarks through their intimate and expressive functions as intensive and concentrated information zones of the traditional cultural land/waterscape and the total environment. (Kucate 2024)

### *Class I Results*

This document cannot adequately convey the deep ties that each Tribe, individually, has to the Canyons and Colorado River. Words are insufficient to express that connection. Each Tribe is a sovereign government with deep and ongoing ties to the welfare of the area on many levels. Reclamation recognizes those ties and provides the means and opportunities for the Tribes to monitor the Colorado River’s health on an annual basis.

The Class I literature search reinforced the importance of the Colorado River and the Canyons, especially the Grand Canyon, to multiple Tribes (Tremblay et al. 2024). TCP and ethnographic documentation has demonstrated the multiple sacred locations, traditional use areas, and traditional resources within the Canyons.

The Havasupai live in the Grand Canyon and identify themselves as Havasu *'Baaja* (People of the Blue-Green Water) for their home near Havasu Falls. Several important landscape formations and resource locations, such as salt deposits, are found within the canyon.

The Hualapai (*Hwal 'baia* or *"*Ponderosa People”) live along the south rim of the Grand Canyon. Resources they have identified as TCPs include archaeological sites and the Hualapai origin site. The Tribe has identified multiple plant resources, traditional use areas, sacred places, mineral resources, animals, water sources, and others.

For the Hopi, the Grand Canyon is holy ground. The Hopi Tribe has documented the Grand Canyon as a TCP that includes archaeological sites, the Hopi Salt Mine, Lees Ferry, shrines, the Hopi origin place (*Sipapun*i), and multiple other sacred and important places.

The Navajo Nation Reservation shares a border with the Colorado River's south bank along Marble Canyon. The Tribe identifies the river as their origin place. As discussed above, the Colorado and Little Colorado Rivers are holy entities, and the Canyons are home to many Navajo deities. Resources important to the Navajo include trails, mineral sources, plant resources, and wildlife in the Canyons.

The Southern Paiute used the Grand Canyon's north rim. In the 19th century, some Southern Paiute people lived with the Hualapai when members of the Church of Jesus Christ of Latter-Day Saints grabbed Paiute lands. Places used by Southern Paiutes include *Parovu* (crossing, in Paiute) upstream of Lees Ferry, *Pari* (intersection of rivers, in Paiute), Lees Ferry at the confluence of the Paria and Colorado Rivers, and trails from the river.

The Ute have ties to the Canyons, but they are not as well documented as other groups. Petroglyphs in the Canyons are known to the Ute to be ancient.

Western Apache oral history tells of a place of emergence north of the Little Colorado River where they lived. The Apache used the Grand Canyon's south rim for resources. For the Apache, the canyon is a holy place associated with a deity, and it must be protected.

As discussed above, the Zuni regard the Colorado River and the Canyons as sacred. The Zuni experience spiritual harm when there are negative impacts on the Grand Canyon. In addition, the Zuni provided the following text regarding the Zuni Chaco Heritage Historic District, which encompasses the LTEMP SEIS analysis area:

> To *A:shiwi*, Chaco Canyon is known as *Heshoda Bitsulliya/Ki:whihtsi Bitsulliya* and in the name *K'yakwe: A:mossi*, or "House of Puebloan High Priests." The greater *A:shiwi* Chaco traditional cultural land/waterscape is simultaneously a dynamic and diverse and inter-functional and unified geographical area densely lined and dotted with multiple intensive zones of historic significance and ongoing traditional religious and cultural importance. The interconnected and interrelated layers and dimensions of multiple intensive middle zones of the district both circularly and circuitously pivot—in space and time—on *Heshoda Bitsulliya/Ki:whihtsi Bitsulliya*, Chaco Canyon, while always connecting and radiating to and from the spatial anchors of *Idiwana'a*, the Zuni Pueblo, and *Chimik´yana´kya dey´a* and *Kuhnin A´l´akk´wa*, the Grand Canyon. The connective umbilical tissues and relations of *Heshoda Bitsulliya/Ki:whihtsi Bitsulliya* are vast for *A:shiwi* and can be topographically diagrammed and understood to extend at least from Kuhnin *A´l´akk´wa*, Grand Canyon, in Arizona to the west to Shiba:bulim´a, Bandelier National Monument, in New Mexico to the east. The historic district's northern reach extends at a minimum to the areas of Abajo (Blue) Mountains and Montezuma Canyon in southeast Utah and Alkali Canyon in southwest Colorado, and its southern reach to the area of *K'y"k'yali an Yalanne*, or

> Eagle Peak, in the central western region of New Mexico. Each of these intensive center or middle spatial zones that help diagram the outlines of the greater *A:shiwi* Chaco traditional cultural land/waterscape and historic district connect and convey three delineable "time periods" that are simultaneously layered and intersecting in their discernability. (Curti et al. 2023, Executive Summary)

Further context was then provided by the Zuni during the LTEMP Draft SEIS comment period:

> The greater Zuni Chaco Heritage Historic District is simultaneously a dynamic and diverse and inter functional and unified geographical area densely lined and dotted with multiple intensive zones of historical significance and ongoing traditional religious and cultural importance. The interconnected and interrelated layers and dimensions of multiple intensive middle zones of the district both circularly and circuitously pivot-in space and time-on *Heshoda Bitsulliya/Ki:whihtsi Bitsullya*, Chaco Canyon, while always connecting and radiating to and from the spatial anchors of *Idiwana 'a*, the Zuni Pueblo, and *Chimik'yana'kya dey 'a* (place of emergence) and *Kuhnin A 'l'akk'wa* (Grand Canyon). The spatial forms and surficial constellations of Chaco Canyon convey deep time and deep space Zuni understandings of the multi-dimensional cosmos, and take on wider communal layers of social, historical, geographical, and ceremonial significance as *K'yakwe: A:mossi*, or "House of Puebloan High Priests." Diagramming the socio-spatial and spatiotemporal dimensions and layers of the greater Zuni Chaco Heritage Historic District requires accounting for the deep time and deep space lessons, historical, environmental, and ecological insights, and verbally conveyed cartographies of Zuni *chimiky'ana'kona* and Ino:de hena:we storytelling traditions. These deep time and deep space re-countings demonstrate that just as Zuni history is embodied and conveyed in and by specific geographies, these specific geographies are often readily identifiable in and as concentrated spatial zones of intensive significance that Zuni people remain deeply connected to through topological practices of oral tradition, ceremony, and everyday encounters. These spatial zones often depend on living socio-spatial relationships among the human, non-human, and more-than-human for their integrity, health, and well-being, and find expression through various tangible resources, elements, and forms that may be characterized as objects, sites, structures, buildings, and/or districts. These include intensive zones of the land/waterscape that have given names and *Ino:de Heshoda:we*, or ancient homes, waterbodies and waterways such as springs, seeps, rivers, and lakes, *Adeshkwi:we* ("Shrines") and *delashinnawe* ("Sacred Old Places/Shrines of the World"), flora, fauna, and geological mineral gathering, hunting, and collection areas, each of which indelibly involve ongoing associations to the maintenance of Zuni traditional religious and cultural practices and identities, the recovery and reactivation of ancestral histories and geographies, and the overall health and wellbeing of Zuni people, the Zuni Tribe, and countless non-human and more-than-human Zuni relatives.
>
> The formation, maintenance, and practice of these Zuni people-place, society-space, and human-environment relationships with the greater Zuni Chaco Heritage Historic

District-and the historical contexts and events and geographical planes and processes of significance that they embody, convey, live, and reactivate-can be delineated and diagrammed under three general “time periods” of Zuni socio-spatial and spatiotemporal formation, aggregation, and assemblage.

- From the event of Zuni emergence in *Chimik 'yana'kya dey 'a* and *Kuhnin A'l 'akk'wa* in time immemorial to the initial movement to and pause at *Heshoda Bitsulliya/Ki:whihtsi Bitsulliya* on the northern route in search of Idiwan'a. Archaeologists identify the time of this pause as most intensively occurring between ca. 800 and 1150 C.E.
- From the subsequent movement of Zuni ancestors from *Kuhnin A'l'akk'wa* along the northern migration route to the initial pause at *Heshoda Bitsulliya/Ki:whihtsi Bitsulliya* between ca. 800 and 1150 C.E. and the resumed journey to find *Idiwan'a*. Archaeologists suggest that the most intensive aggregation of Zuni people finding *Idiwan'a* occurred between ca. 900 and 1300 C.E.
- From the ongoing and cyclical continuum of spatiotemporal and socio-spatial practice that enfolds the event of emergence in time immemorial, journeys to find *Idiwan'a*, and subsequent obligations to return to, pause at, and steward and recover knowledge with and throughout the diversity of resources, elements, and the intensive spatial zones of multiple middles that help form, comprise, and sustain the integrity of the greater Chaco historic district and land/waterscape in and as the emerging ever-present.

These time periods are simultaneously layered and intersecting as they exist in assemblage with the greater Zuni Chaco Heritage Historic District, are dependent upon the integrity of its traditional religious and cultural land/waterscape for their maintenance and perseverance, and always involve processes of movement, pause, and return with this diverse and dynamic land/waterscape as it topologically and topographically connects Zuni of the present with those of the past and future.

Overall, the traditional cultural land/waterscape that defines the greater Chaco area for Zuni is comprised of numerous contributing resources, elements, and spatially distinct yet intimately interconnected spatial middle zones of multi-layered, multi-dimensional, and inter-functional past, present, and future significance that render it a unified historic district of *A:shiwi A:wan Dehwa:we*. As a vast yet interconnected and interfunctional intensive spatial zone comprised of multiple intensive tangible middles, the greater Zuni Chaco Heritage Historic District provides the material basis for the origins, traditional histories and sacred geographies, and current collective identity and traditional practices of the Zuni people and the Zuni Tribe. For Zuni, the integrity of the greater Zuni Chaco Heritage Historic District-like so many temporal layers and spatial dimensions of its traditional religious and cultural importance-is most directly identified, calibrated, and navigated through processes of dynamic continuity, and what deep time and deep space processes of continuity have

> done-and are doing-and for what and for whom; Zunis "add on to what they already have so that if one looks beyond the superficial trappings of Western society, one finds a stable Zuni cultural core." (Kucate 2024)

No effects on Indian trust assets were identified from the proposed alternatives; therefore, these are not considered further.

## 3.13.2 Environmental Consequences

### *Methodology*

During consultation for the 2016 LTEMP FEIS, seven themes of concern to Tribes were identified and analyzed in the 2016 LTEMP FEIS (DOI 2016a):

- Increase the health of the ecosystem in the Canyons
- Protect and preserve sites of cultural importance
- Preserve and enhance respect for life in the Canyons
- Preserve and enhance the sacred integrity of the Canyons
- Maintain and enhance healthy stewardship opportunities
- Maintain and enhance economic opportunities
- Maintain Tribal water rights and supply

The most pertinent theme for this SEIS—preserve and enhance respect for life in the Canyons—is derived from Section 4.9.3 of the 2016 LTEMP FEIS, which states:

> For those Tribes that hold the Canyons to be a sacred space, the plant and animal life are integral elements without which its sacredness would not be complete. The Zuni, in particular, have established a lasting familial relationship with all aquatic life in the Colorado River and the other water sources in the Canyons (Dongoske 2011). . . . The killing of fish in proximity to sacred places of emergence is considered desecration, and would have an adverse effect on the Grand Canyon as a Zuni TCP. In addition, Pueblo of Zuni have identified significant social and psychological effects to their community during mechanical removal periods. (DOI 2016a, 4.256)

Through scoping comments, the Hopi Tribe, the Navajo Nation, the Colorado River Indian Tribes, and the Pueblo of Zuni have expressed concerns to the Department regarding the sanctity of life; they oppose lethal management actions. In general, the Tribes emphasized the importance of being good stewards over the entire environment and respecting the life found therein. As an example, the Hopi Tribe has expressed concern regarding the mechanical removal of large numbers of trout and trout management flows, while also expressing an understanding of the need to effectively manage nonnative populations, if necessary, to prevent the extinction of humpback chub. The Navajo Nation looks to restore "to the extent practicable, ecological patterns and processes within their range of natural variability, including the natural abundance, diversity, and genetic and ecological integrity of the plant and animal species native to those ecosystems" following Diné Natural Law.[33]

**Impact Analysis Area**

The impact analysis area is the same as for the 2016 LTEMP FEIS APE. It stretches from rim to rim of the Grand Canyon from Glen Canyon Dam to the inlet into Lake Mead.

**Assumptions**

No impacts on water deliveries or Indian trust assets are anticipated.

**Impact Indicators**

The impact indicators for Tribal resources include:

- Characteristics of TCPs that may be altered by changes in flows, including the taking of life
- Number and types of cultural resources that may be impacted by changes in water flow from inundation, erosion, or exposure to elements and visitation
- Changes in habitats and vegetation due to flow changes

### *Issue 1: How would flow alterations for fish management at Glen Canyon Dam impact TCPs in the Grand Canyon?*

The Tribes hold the Canyons sacred. Rather than interventions, they prefer nature to take its course regarding fish management (DOI 2016a, 4.257). In particular, the Pueblo of Zuni has expressed that the taking of life has an adverse impact on the TCP and is culturally offensive. Such actions have corresponding highly negative effects within the Pueblo of Zuni; thus, they have far-reaching consequences beyond the Colorado River itself.

**No Action Alternative**

Under the No Action Alternative, Reclamation would not change Glen Canyon Dam's current operations. Effects on TCPs would not be different from those effects analyzed in the 2016 LTEMP FEIS, which may include management activities to prevent further spread of nonnative fish.

**Cool Mix Alternative**

The Cool Mix Alternative is meant to disrupt spawning before it occurs, which means there would be no direct taking of life.

**Cool Mix with Flow Spike Alternative**

Impacts under the Cool Mix with Flow Spike Alternative, such as some fish mortality, could occur in backwater or margin habitats if fish are moved off nests.

**Cold Shock Alternative**

The Cold Shock Alternative could result in the mortality of eggs or larval fish.

[33] Diné Bi Beenahaz'áanii (1 N.N.C. §§ 201–206), recognized by the Navajo Nation Council in 2002.

**Cold Shock with Flow Spike Alternative**

Impacts on fish under the Cold Shock with Flow Spike Alternative would be the same as for the Cold Shock Alternative.

**Non-Bypass Alternative**

Under the Non-Bypass Alternative, impacts on fish would be greater than under the other alternatives. Under the Non-Bypass Alternative, the flows would be intended to reduce the survival of smallmouth bass eggs and fry through desiccation of eggs, abandonment of nests, and impacts on fry.

**Cumulative Effects**

Cumulative impacts on Tribal values would occur if Reclamation chooses flow options with expected mortality. The Zuni, in particular, have linked fish mortality in the Canyons with adverse physical, mental, and psychological effects within the Zuni Pueblo. Consequently, additional mortality would have negative cumulative impacts on the Zuni. Because the action alternatives could result in the taking of life within the Canyons, they would have an adverse impact on the Zuni culture and TCPs, if Reclamation implements the flow options with expected fish mortality. The PA includes procedures for consultation to resolve any adverse effects on the TCPs. Because several alternatives would result in the additional taking of life within the Canyons more than the present conditions under the LTEMP dam operations, however, they could contribute to negative cumulative impacts on the Zuni culture and TCPs.

Other reasonable and foreseeable projects include the Interim Guidelines SEIS, the Colorado River Post-2026 Operations NEPA effort, a proposed thermal fish barrier, and proposed riparian restoration along the river. These projects are not expected to contribute to cumulative impacts on Tribal values; however, each project will undergo a separate NEPA analysis to disclose the potential impacts.

### *Issue 2: How would flow alterations at Glen Canyon Dam impact archaeological sites and sacred sites in the Grand Canyon?*

**No Action Alternative**

As described in **Section 3.12**, Cultural Resources, Reclamation would not change Glen Canyon Dam's current operation under the No Action Alternative. No additional impacts beyond those analyzed in the 2016 LTEMP FEIS would occur.

**Cool Mix Alternative**

Impacts under the Cool Mix Alternative would be the same as those impacts described for the No Action Alternative.

**Cool Mix with Flow Spike Alternative**

Impacts under the Cool Mix with Flow Spike Alternative would be the same as those impacts described for the No Action Alternative.

**Cold Shock Alternative**
Impacts under the Cold Shock Alternative would be the same as those impacts described for the No Action Alternative.

**Cold Shock with Flow Spike Alternative**
Impacts under the Cold Shock with Flow Spike Alternative would be the same as those impacts described for the No Action Alternative.

**Non-Bypass Alternative**
The low flows proposed under the Non-Bypass Alternative are outside those analyzed in the 2016 LTEMP FEIS and may lead to the exposure of archaeological sites and sacred sites. Any adverse effects on archaeological sites or sacred sites that are historic properties would be resolved under the LTEMP PA. Reclamation does not know of any prehistoric archaeological sites under the present levels of the Colorado River, but the potential is there.

**Cumulative Effects**
Any potential impacts on archaeological sites or sacred sites from the cold-water alternatives fall within those previously analyzed in the 2016 LTEMP FEIS. None of the cold-water alternatives would contribute to cumulative impacts on archaeological sites or sacred sites in the Grand Canyon. No additional impacts, other than those impacts analyzed in the 2016 LTEMP FEIS, would be anticipated under the cold-water alternatives (DOI 2016a, Table 4-17.2). The Non-Bypass Alternative may result in the exposure of archaeological sites or sacred sites; however, any adverse effects on archaeological sites or sacred sites that are historic properties would be resolved under the LTEMP PA.

### *Issue 3: How would flow alterations at Glen Canyon Dam impact vegetation within riparian habitats within the Grand Canyon?*

**No Action Alternative**
Reclamation would continue Glen Canyon Dam's current operations as described in the 2016 LTEMP FEIS under the No Action Alternative. Changes to riparian vegetation communities would follow the current trends under drought conditions and aridification. More details of impacts on riparian vegetation can be found in **Section 3.6**, Terrestrial Resources and Wetlands.

**Cool Mix Alternative**
The difference in impacts on riparian vegetation communities would be minor under the Cool Mix Alternative.

**Cool Mix with Flow Spike Alternative**
Under the Cool Mix with Flow Spike Alternative, impacts on riparian vegetation would range from no change in Marble Canyon to a small increase in vegetation cover in the Grand Canyon. Impacts would be the same as those impacts described for the Cool Mix Alternative.

**Cold Shock Alternative**
Impacts under the Cold Shock Alternative would be the same as those impacts described for the Cool Mix with Flow Spike Alternative.

**Cold Shock with Flow Spike Alternative**
Impacts under the Cold Shock with Flow Spike Alternative would be the same as those impacts described for the Cool Mix with Flow Spike Alternative.

**Non-Bypass Alternative**
Under the Non-Bypass Alternative, impacts on riparian vegetation would range from a small increase in vegetation cover in Marble Canyon to a small decrease in vegetation cover in the Grand Canyon.

**Cumulative Effects**
Changes to riparian vegetation under any of the alternatives would be minor. No alternative would contribute to cumulative impacts on riparian vegetation community sites in the Grand Canyon. No additional impacts, other than those impacts analyzed in the 2016 LTEMP FEIS, would be anticipated under the alternatives (DOI 2016a, Table 4-17.2).

#### *Summary*
The No Action Alternative and the Cool Mix Alternative are not expected to result in the taking of the life of fish. The Cool Mix with Flow Spike Alternative, the Cold Shock Alternative, the Cold Shock with Flow Spike Alternative, and the Non-Bypass Alternative could result in fish mortality of different intensities. Cool water flows are intended to disrupt spawning and would have the least impact on life. The Non-Bypass Alternative would have the greatest impact on life.

Impacts on archaeological sites and sacred sites in the Grand Canyon would be the same under the cold-water alternatives, and overall impacts on riparian vegetation would be minor. Under the Non-Bypass Alternative, low flow may lead to the exposure of archaeological sites and sacred sites. As noted previously in this document, the existing LTEMP PA includes provisions for new experiments and methods to resolve concerns and adverse effects on Tribal values and historic properties; consequently, Reclamation does not anticipate amending the existing PA.

## 3.14 Recreation

### 3.14.1 Affected Environment
The description of recreational resources in this section focuses on resources and activities found in the Colorado River corridor, from below Glen Canyon Dam downstream to Lake Mead (the recreation analysis area). Recreational resources of concern include the Blue Ribbon rainbow trout fishery, boating (such as kayaking, rafting, and canoeing) from Glen Canyon Dam to Lees Ferry, whitewater boating through the Grand Canyon, and camping opportunities throughout the recreation analysis area. Smallmouth bass recreational fisheries in reservoirs are not targeted by the project and will not be impacted by proposed flows; therefore, they are not addressed further in this analysis. Recreation's economics are discussed in **Section 3.15**, Socioeconomics.

#### *Glen Canyon Reach of the Colorado River in the Glen Canyon National Recreation Area*
The Glen Canyon reach of the Colorado River is an approximately 16-mile segment of the river between Glen Canyon Dam and Lees Ferry, Arizona. Recreational activities of concern in this area

include rainbow trout fishing, day rafting, boating (including motorized and nonmotorized boating and rafting), and camping.

**Fishing in the Glen Canyon Reach**

The Glen Canyon reach of the Colorado River supports a Blue Ribbon recreational rainbow trout fishery that attracts local, national, and international anglers. Most fishing is done from boats or with the assistance of boat access, often provided by guide services. Some anglers also fish by wading or from the shore. Fish in all waters within the GCNRA and GCNP are managed by the NPS, in coordination with the AZGFD and the Service. The condition of the fishery within the GCNRA can be affected by the operations of Glen Canyon Dam, which is operated by Reclamation.

Dam operations and fishery management may affect the size and quality of the rainbow trout fishery and the angler experience. Since the completion of the dam and the introduction of rainbow trout shortly afterward, the high quality of the rainbow trout fishery has been supported by reliable flows of cold water ranging from 6.7°C to 15.6°C (44°F to 60°F). Recent drought conditions and aridification have resulted in warming water temperatures and reduced DO levels below Glen Canyon Dam, which could negatively impact rainbow trout energetics and survival (Rogers 2015; Korman et al. 2022).

Trout population dynamics have also shifted in the last decade, with brown trout now occupying a greater percentage (approximately 15 percent compared with 2 to 3 percent prior to 2014) of the trout population at Lees Ferry (Strogen 2021). This has the potential to reduce young age classes of rainbow trout at Lees Ferry. The NPS currently utilizes an incentivized harvest program to encourage anglers to remove brown trout in the Lees Ferry reach. The program has had more participation each year since 2016; however, the number of participants is still low, though the number of brown trout removed by this small number of anglers has increased greatly and is showing reductions in the population. Fishing in the remainder of this analysis refers to the rainbow trout fishery.

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 8,874 anglers used the rainbow trout fishery in 2020; of these, 5,363 were boat anglers and 3,511 were walk-in anglers (Rogowski and Boyer 2021).

The quality of the fishing experience in the Glen Canyon reach has been studied to identify which characteristics of fishing in the area are most important to participants. Studies conducted in 1987 and 2000 suggest that anglers prefer flows between 8,000 and 15,000 cfs, with the 1987 study further identifying a preference for steady, unfluctuating flows (Bishop et al. 1987; Stewart et al. 2000). High water levels, as well as rapid changes in water levels, directly affect the safety of wading anglers who could potentially be swept away by the river current. The 1995 Glen Canyon Dam Environmental Impact Statement (Reclamation 1995) included a reference to three drownings that were possibly related to river stage or stage change and noted that high flows (30,000 cfs or more) reduced the safety of wading in the river. After the adoption of the Modified Low Fluctuating Flow operating protocol in 1996, ramping rates were restricted, which has likely reduced the level of this risk, as has the reduction of normal high flows to 25,000 cfs. Most anglers elect not to fish in the Glen Canyon reach during HFE releases.

### Day Rafting, Boating, and Camping in the Glen Canyon Reach

In addition to fishing, the Glen Canyon reach supports other recreational activities, including camping and recreational boating. The NPS estimated that 26,000 commercial angler and water-based recreational visits occurred in the area in 2021 (NPS 2022a). As water temperatures have increased in the Glen Canyon reach in the past decade, private recreational uses such as swimming and paddle boarding have also become popular.[34]

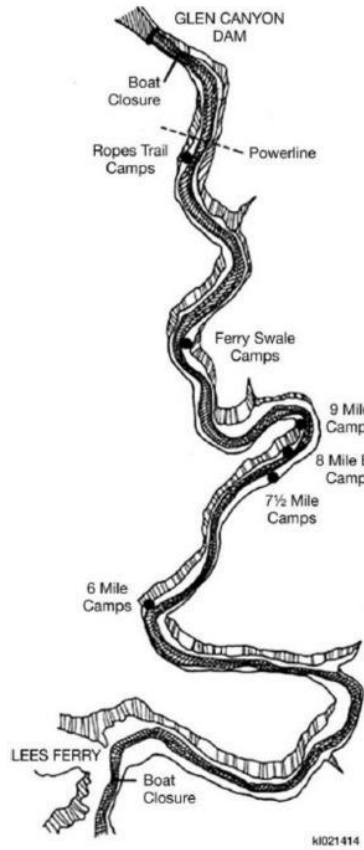
The NPS facilities at Lees Ferry consist of a boat launch ramp, campground, restroom, interpretive facilities, and hiking trails. The NPS launching facility provides the main access for trips going through the Grand Canyon and for anglers and other boaters heading upstream into the Glen Canyon reach. Aside from the courtesy dock next to the launch ramp, facilities in this area are not directly affected by river fluctuations.

There are six designated, boat-accessible-only camping areas upstream of the Lees Ferry launching facility. These areas are located on sediment terraces and beaches. **Figure 3-51** shows the general location of the six designated campsite areas. Releases of 40,000 to 45,000 cfs can create steep banks in some portions of the river, which makes access more difficult from boats to the upper sediment terraces. Eventually, most steep areas are eroded by use, restoring easy access to the terraces; however, in some locations, the banks have been steepened to such a degree that visitor access is adversely affected (DOI 2016a).

The NPS authorizes one commercial recreational river rafting concessionaire to operate in the Glen Canyon reach. The concessionaire's most popular service is a half-day guided trip that originates at Glen Canyon Dam. Trips occur in most months, but most trips occur in the summer. The concessionaire provided 2,099 trips in 2022 that serviced 41,677 passengers (**Table 3-41**). Releases of 40,000 cfs or greater create operational issues for the rafting concessionaire, including cessation of operations and the need to move mooring docks and rafts to other locations.

[34] Zoom call between Lucas Bair, Economist, USGS, and Noelle Crowley, Environmental Planner, EMPS, on January 13, 2023.

## Figure 3-51
## Designated Campsite Areas in the Glen Canyon Reach




Source: Reclamation 2011a
Map showing designated sites on the Colorado River between Glen Canyon Dam and Lees Ferry. Boat closures are indicated by cables across the river.

## Table 3-41
## Commercial River Rafting Annual Visitation for the Glen Canyon Reach of the Colorado River

| Year | Total Number of Raft Trips | Total Number of Passengers |
|---|---:|---:|
| 2022 | 2,099 | 41,677 |
| 2021* | 257 | 4,670 |
| 2020* | 149 | 1,620 |
| 2019 | 1,691 | 30,839 |
| 2018 | 2,105 | 41,659 |

Source: NPS 2022b
*Lower visitation in 2020 and 2021 compared with previous years is likely attributed to the COVID-19 pandemic.

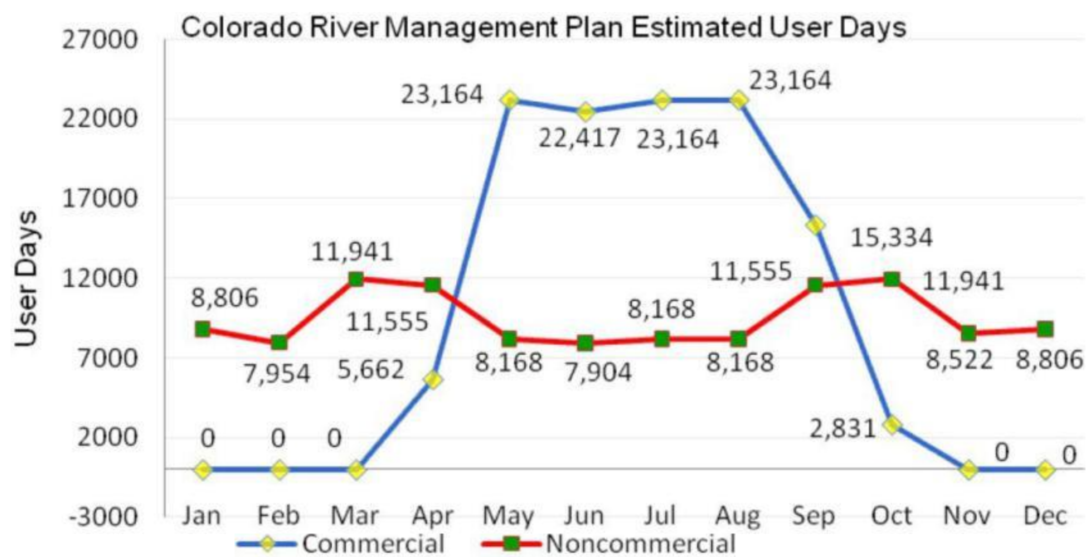
### *The Colorado River in Grand Canyon National Park*

**Boating in Grand Canyon National Park**

Boating in the reach below Lees Ferry and through the Grand Canyon is internationally renowned. The NPS manages most of the reach from Glen Canyon Dam to Lake Mead, except where it is bordered on the east by the Navajo Indian Reservation and on the south by the Hualapai Indian Reservation.

Use is regulated by GCNP staff under the Colorado River Management Plan (NPS 2006a) with a lottery system. The 2006 Colorado River Management Plan for boating through GCNP governs use in both the reach from Lees Ferry (river mile 0) to Diamond Creek (river mile 226) and the reach from Diamond Creek to Lake Mead (river mile 277). Higher-use months for commercial operations extend from May through September, but there is relatively consistent use throughout the year for noncommercial boating. **Figure 3-52** shows the expected maximum amount of use allowed by the Colorado River Management Plan, as measured in user days.

**Figure 3-52**
**Anticipated Annual Boating Use in the Grand Canyon by Month**




Sources: NPS 2006; Reclamation 2011a
Estimated annual boating use in the Grand Canyon, 2006

The Colorado River Management Plan (NPS 2006a, Table 2 and Table 3) allows up to approximately 1,100 total yearly launches (598 commercial trips and 504 noncommercial trips). Up to 24,567 boaters could be accommodated annually if all trips were taken and all were filled to capacity (NPS 2016). Historically, this has not occurred.

The Colorado River corridor borders Tribal lands for nearly half the distance from the put-in at Lees Ferry to the last takeout at Pearce Ferry. The Navajo Indian Reservation borders GCNP along the eastern bank of the Colorado River from near Lees Ferry to the confluence with the Little Colorado River at river mile 61. The Hualapai Indian Reservation borders the river corridor for approximately

108 miles from upstream of National Canyon (river mile 167) to approximately river mile 274. The Hualapai Indian Reservation offers camping, fishing, hiking, and big game hunting opportunities. Hualapai River Runners offers rafting trips on the Colorado River between Diamond Creek and Pearce Ferry. The NPS coordinates with Tribal neighbors to address resource management and visitor use concerns along shared boundaries. Access permits from the Navajo Nation, Havasupai Tribe, and/or Hualapai Tribe are required from each respective Tribe to access and recreate on Tribal lands.

River flow levels and fluctuations are important for whitewater boaters (Bishop et al. 1987; Shelby et al. 1992; Hall and Shelby 2000; Stewart et al. 2000; Roberts and Bieri 2001). Commercial and private whitewater trip leaders have reported that flows below 10,000 cfs and above about 45,000 cfs are considered unsatisfactory; flows between 20,000 and 26,000 cfs are considered optimum (Shelby et al. 1992; Bishop et al. 1987). Flows of 8,000 to 9,000 cfs have been identified by commercial guides as the minimum level necessary to safely run the river with passengers (Bishop et al. 1987; Stewart et al. 2000).

**Boating Facilities**

No boating facilities are within GCNP. Development along the Colorado River within the park is limited to the development at Phantom Ranch (river mile 88) and Pipe Creek (river mile 89.5). Other focal points include the launch ramp at Lees Ferry (within the GCNRA), the helipad near Whitmore Wash (river mile 187) on the Hualapai Indian Reservation, the road access and minor structures operated by the Hualapai Tribe at Diamond Creek (river mile 226), and the tourist area near Quartermaster Canyon (river mile 260).

Camping between Glen Canyon Dam and Lake Mead occurs in GCNP on undeveloped beaches (sandbars) along the Colorado River. The number of available campsites and the amount of campsite area at any particular time are affected by the river flow (that is, fewer campsites are available at higher flows, and vice versa). Because of their singular importance in supporting river use, there have been numerous campsite inventories over the years. The NPS reported in the Colorado River Management Plan that there are more than 200 regularly used camping beaches in the GCNP planning area. The number and usability of campsites vary from year to year based on several factors, including flow regimes, vegetation changes, erosion from tributary flooding, wind, or recreation use, or closure of sites to protect sensitive resources (NPS 2006a). The primary factors identified in campsite loss were riparian vegetation growth and sandbar erosion.

The diminishing availability of campable area, particularly in some of the narrower reaches of the river corridor, is an important issue for managers and recreational river runners. Over the long term, eddy-sandbar size can only be increased if (1) adequate sediments are available for deposition, (2) high-flow deposition is substantial, (3) high flows occur frequently, and (4) erosion that occurs between high flows is less than the deposition. Thus, the net effect of high flows in building eddy sandbars results from the magnitude and frequency of high flows and the deposition they cause. Erosion ensues rapidly after each high flow, and the rate of erosion declines thereafter but persists. The longer the time period between HFE releases, the more erosion occurs (Melis 2011).

The average annual release volume from Glen Canyon Dam was 9.1 maf from 2007 to 2019 and 8.1 maf from 2020 to 2022. The recent years of low release volumes have allowed accumulation of sand on the riverbed; sand was not redistributed to camping beaches from 2019 through 2022 due to a lack of HFE releases. From 2012 to 2018, there were more frequent HFE releases, which, on average, built more sandbars and beaches in Marble and Grand Canyons. The lack of HFE releases from 2019 through 2022 has resulted in greater erosion than deposition on the high-elevation sandbars, due to erosive flows in the main channel and gullying from side channels with no rebuilding. Also, the lack of HFE releases has contributed to more vegetation encroachment since 2018 (USGS 2023).

Of the 275 campsites referenced in Section 3.12.1.1 of the 2007 FEIS, 195 sites are still classified as "camps" (Kearsley 2023). Sixty-eight sites have been classified as "non-camps" due to sand erosion, vegetation overgrowth, or both. The condition of two sites could not be assessed during the float-by survey conducted in November 2022 as part of the NPS Colorado River Management Plan monitoring trip, due to the methodology used. Ten campsites were not evaluated (Kearsley 2023).

High fluctuations, ranging from 3,000 to 25,000 cfs per day, have been noted as contributing to issues related to the selection of campsites, time allowed at attractions, mooring and tending of boats, transiting major rapids, and trip scheduling (Bishop et al. 1987).

## 3.14.2 Environmental Consequences

### *Methodology*

This section examines the potential effects of the No Action Alternative and action alternatives on recreation within the analysis area. Reclamation's CRMMS modeling results were used to develop potential releases and flow rates for the alternatives. The results of these analyses are used throughout this section.

**Impact Analysis Area**

The impact analysis area for recreation extends from Glen Canyon Dam to the inlet of Lake Mead.

**Assumptions**

- The analysis assumes that the demand for recreational opportunities will either remain constant or increase over time, forming the basis for evaluating impacts on activities such as fishing, whitewater boating, and camping.
- The analysis assumes 8,000 cfs to be the minimum level necessary to safely run the river with passengers (Bishop et al. 1987; Stewart et al. 2000).
- Given that dam operations often substantially exceed the 8,000 cfs reference threshold, the modeled sandbar volumes do not necessarily represent usable sand (for example, for camping). This caveat is particularly important when considering some traces that result in elevated discharges (that is, sustained monthly releases at 20,000 cfs or more).
- Additional assumptions related to modeling are considered in the analysis, contributing to the accuracy and reliability of the hydrologic models used to anticipate impacts resulting from various actions.

The assumptions outlined in **Chapter 2** of the analysis, broadly categorized as general assumptions, influence the overall understanding and context of these environmental consequences.

**Impact Indicators**

- Flow fluctuations and changes in water levels
- Whitewater boating flows
- Sedimentation and erosion
- Water temperatures
- Rainbow trout water temperature thresholds

**Impacts Common to All Action Alternatives**

Under all action alternatives, the volume of water discharged during the flow actions is the factor that would have the greatest potential to impact recreation. Impacts on recreation would be temporary because flow actions would be implemented for a limited time. Generally, alternatives with more sediment-triggered HFE releases are expected to result in a greater campsite area in the Grand Canyon, although flow and fluctuation levels, as well as vegetation control, will affect the maintenance of the campsite area.

### *Issue 1: How would flow fluctuations affect recreational opportunities, including fishing, boating, and camping?*

**No Action Alternative**

Under the No Action Alternative, Reclamation would not make any changes to the operations of Glen Canyon Dam. Therefore, water would continue to be released as described in the 2016 LTEMP FEIS (DOI 2016a).

*Impacts on Fishing in the Glen Canyon Reach*

Under the No Action Alternative, anglers would continue to have the same level of access as under current conditions, with angler access continuing to be restricted during the implementation of HFE releases. Therefore, there would likely be no change to angler satisfaction as a result of short-term flow levels and daily fluctuations. In the long term, drought conditions and aridification could result in increasingly warm water temperatures, which could lead to deteriorating conditions for rainbow trout. This could negatively impact the fishery and angler satisfaction.

*Impacts on Boating and Camping in the Glen Canyon Reach*

The Glen Canyon reach hosts a large number of day rafters who use the pontoon-raft concessionaire that departs from near Glen Canyon Dam and travels to Lees Ferry (**Section 3.13.1**). Impacts on rafting use are related to the occurrence of HFE releases, which result in lost visitor recreational opportunities and lost revenue for the rafting concessionaire. The variables influencing the level of impact are the number of HFE releases and the time of year in which the releases occur. Spring HFE releases have a greater impact than fall HFE releases because visitor use is higher in the spring months. Under the No Action Alternative, HFE releases would continue to be implemented as under current conditions and would be more likely to occur in the fall months, reducing impacts on the concessionaire and recreational boaters in this reach.

The camping facilities in the Glen Canyon reach are generally located above the high-water level of normal dam operations; however, HFE releases could affect these campsites through erosion of terraces, combined with an absence of sediment sources in the Glen Canyon reach for possible deposition and rebuilding of terraces. Under the No Action Alternative, these impacts would continue during the implementation of HFE releases.

*Impacts on Boating in the Grand Canyon*

River flow levels and fluctuations are important for whitewater boaters. The minimum daily flow levels under the No Action Alternative are considered only minimally adequate for Grand Canyon boating. Morning flows would increase to 8,000 cfs from the overnight minimums of 5,000 cfs. However, these desired flow increases may be delayed to downstream rapids due to flow transit times. Such concerns would arise only in low-volume months, however, when minimum flow limits would be applied. Flows on most days under the No Action Alternative would exceed these limits.

Extended low flows of 5,000 cfs would adversely affect navigability and trip management because of a greater risk of boating incidents. In September 2023, the NPS received several reports of boating incidents, including several life-threatening injuries to boaters and damaged equipment across all types of watercraft, when flows were reduced to 5,000 cfs after trips had launched. Commercial and private whitewater trip leaders have reported a preference for steady flows in the 20,000–26,000 cfs range (Bishop et al. 1987); thus, there would likely be greater perceived value to rafters when flows are within this range. While this is the preferred range, the historical and projected volume range under the No Action Alternative may not align with these preferences, potentially leading to a long-term decline in optimal conditions for rafting. The exact impacts on recreation would continue to depend on water availability for releases.

**Cool Mix Alternative**

*Impacts on Fishing in the Glen Canyon Reach*

The Cool Mix Alternative would reduce water temperatures, aiming for a target temperature of 15.5°C (60°F). This would benefit the rainbow trout fishery in the short term because rainbow trout are a cold-water species that thrive in colder water temperatures. The long-term benefits could improve water quality and enhance the rainbow trout fishery, which would likely result in higher angler satisfaction in the long term than under the No Action Alternative. More information on the impacts of water temperature and rainbow trout are described in **Section 3.5**, Aquatic Resources, and **Section 3.11**, Water Quality.

Under the Cool Mix Alternative, total discharge volumes would be approximately the same as those under the No Action Alternative; therefore, the impacts on fishing in the Glen Canyon reach resulting from the volume of water discharged would be the same as described under the No Action Alternative.

*Impacts on Boating and Camping in the Glen Canyon Reach*

Under the Cool Mix Alternative, total discharge volumes would be approximately the same as those under the No Action Alternative; therefore, the impacts on rafting and camping in the Glen Canyon

Reach resulting from the volume of water discharged would be the same as described under the No Action Alternative.

*Impacts on Boating in Grand Canyon National Park*
Under the Cool Mix Alternative, total discharge volumes would be approximately the same as those under the No Action Alternative; therefore, the impacts on whitewater boating in the Grand Canyon would be similar to those described under the No Action Alternative.

**Cool Mix with Flow Spike Alternative**

*Impacts on Fishing in the Glen Canyon Reach*
Similar to the Cool Mix Alternative, the Cool Mix with Flow Spike Alternative would reduce water temperatures, benefiting the rainbow trout fishery in the short term. However, the inclusion of flow spikes between May and July would temporarily reduce catchability during peak months since high water levels and rapidly changes in water levels directly affect angler safety. ,This may reduce angler satisfaction in the short term. However, the long-term benefits to the rainbow trout fishery could improve water quality and enhance the rainbow trout fishery, which would likely result in higher angler satisfaction in the long term than under the No Action Alternative. More information on the impacts of the alternatives on rainbow trout is described in **Section 3.5**, Aquatic Resources, and **Section 3.11**, Water Quality.

*Impacts on Boating and Camping in the Glen Canyon Reach*
The Cool Mix with Flow Spike Alternative would produce flows during implementation of up to three 8-hour flow spikes between late May and mid-July that would temporarily disrupt boating within the Glen Canyon reach. Impacts on recreational boating and the rafting concessionaire during the implementation of flow spikes would be increased compared with the No Action Alternative. Flow spikes could additionally result in increased erosion of the campsites and terraces in this reach compared with the No Action Alternative.

*Impacts on Boating in Grand Canyon National Park*
The Cool Mix with Flow Spike Alternative would implement up to three 8-hour flow spikes between May and mid-July if sufficient water were available; during these spikes, impacts on whitewater boating in the Grand Canyon would be similar to those from HFE releases. The volume of water released during flow spikes would be greater than during typical operations; however, volumes would still be within the range analyzed in the 2016 LTEMP FEIS. Flows under this alternative, including spikes, could improve boater navigability but could temporarily limit beach usability for camping during the spikes' implementation.

**Cold Shock Alternative**

*Impacts on Fishing in the Glen Canyon Reach*
Although adult and juvenile rainbow trout are less susceptible to cold shocks than warmwater species, recently hatched fry and early juveniles could be negatively impacted by the sudden decrease in temperature, especially in the Glen Canyon reach, if cold shock releases occur between January and June. The catchability of trout would be dramatically reduced during the implementation of cold shocks, which are planned to occur on weekends when fishing is most popular. This would

negatively impact short-term angler satisfaction; however, it would most likely not have negative impacts in the long term. Overall, the Cold Shock Alternative would reduce water temperatures, which would likely benefit the rainbow trout fishery in the long term.

Under the Cold Shock Alternative, total discharge volumes from the dam would be approximately the same as those under the No Action Alternative; therefore, the impacts on fishing in the Glen Canyon reach resulting from the volume of water discharged would be similar to those described under the No Action Alternative.

*Impacts on Boating and Camping in the Glen Canyon Reach*
Total discharge volumes under the Cold Shock Alternative would be approximately the same as those under the No Action Alternative; therefore, the impacts on boating and camping in the Glen Canyon reach would be similar to those described under the No Action Alternative.

*Impacts on Boating in Grand Canyon National Park*
Total discharge volumes under the Cold Shock Alternative would be approximately the same as those under the No Action Alternative; therefore, impacts on whitewater boating in the Grand Canyon would be similar to those described under the No Action Alternative.

**Cold Shock with Flow Spike Alternative**

*Impacts on Fishing in the Glen Canyon Reach*
Impacts on the rainbow trout fishery resulting from implementation of cold shocks would be similar to those described under the Cold Shock Alternative. The inclusion of flow spikes between May and mid-July could disrupt fishing during peak months, further reducing angler satisfaction in the short term. The impacts of flow spikes on the rainbow trout fishery would be similar to those described above under the Cool Mix with Flow Spike Alternative.

*Impacts on Boating and Camping in the Glen Canyon Reach*
The Cold Shock with Flow Spike Alternative would produce flows during implementation of up to three 8-hour flow spikes that would temporarily disrupt boating within the Glen Canyon reach. Impacts on recreational boating and the rafting concessionaire during the implementation of flow spikes would be similar to those described under the Cool Mix with Flow Spike Alternative. Flow spikes could additionally result in increased erosion of the campsites and terraces in this reach compared with the No Action Alternative.

*Impacts on Boating in Grand Canyon National Park*
The Cold Shock with Flow Spike Alternative would implement flow spikes between late May and mid-July if sufficient water is available. The volume of water released during flow spikes would be greater than typical operations; however, release volumes would be within the range analyzed in the 2016 LTEMP FEIS. The flows, including spikes, might improve boater navigability but could temporarily limit beach usability for camping during the spikes' implementation.

### Non-Bypass Alternative

*Impacts on Fishing in the Glen Canyon Reach*

Under the Non-Bypass Alternative, high flows are not anticipated to affect adult rainbow trout; however, they would likely displace young and juvenile rainbow trout and expose these fish to starvation and predation, or possibly displace them downstream to population centers of native fish where the displaced young and juvenile rainbow trout could become prey for the native species. If weekend flows of 2,000 cfs occurred between January and March, they could negatively affect eggs and fry through desiccation and displacement of juveniles, leading to reduced survival from predation or starvation. Adult rainbow trout would not be as negatively affected; this is because the larger fish are able to shift habitats during dramatic flow changes. Reducing the overall rainbow trout population could negatively affect the rainbow trout fishery, particularly when combined with existing adverse effects of additional high water temperatures, low DO, additional predation, and other recent poor health indicators.

Rapid changes in water levels would directly affect the safety of wading anglers; therefore, angler satisfaction would likely decrease during implementation of high-fluctuation releases. This alternative is also less likely to benefit the rainbow trout fishery by reducing water temperatures, compared with the cold-water alternatives. Modeling results also suggest that the smallmouth bass population would be expected to grow in all years other than 2024 at river mile 15 and in all years (2024–2027) at river mile 61; therefore, this alternative may not be effective at controlling reproduction and recruitment of smallmouth bass and other warmwater species. This could result in long-term impacts on the rainbow trout fishery from increased predation from warmwater predators.

*Impacts on Boating and Camping in the Glen Canyon Reach*

Under the Non-Bypass Alternative, the minimum flows of 2,000 cfs would limit or eliminate the ability of boats to navigate freely within the Glen Canyon reach. This would adversely impact boating and the rafting concessionaire's operations compared with all other alternatives. These impacts would be temporary given the short-term duration of the low-flow release, but they would occur more frequently than with the HFE releases or flow spikes under the other alternatives.

*Impacts on Boating in Grand Canyon National Park*

Under the Non-Bypass Alternative, on a weekly basis, flows would drop to a minimum of 2,000 cfs followed by a rapid increase to approximately 27,300 cfs over an approximate 8-hour window overnight. The minimum flows of 2,000 cfs would be below the safe whitewater boating minimum of 8,000 cfs and would adversely affect whitewater boating opportunities in the Grand Canyon and the ability of Hualapai River Runners to provide boating trips, compared with under all other alternatives. These minimum flows would be unnavigable for some types of boats, and they would adversely affect navigability and trip management in GCNP because of a greater risk of boating incidents. In September 2023, the NPS received several reports of boating incidents, including several life-threatening injuries to boaters and damaged equipment across all types of watercraft, when flows were reduced to 5,000 cfs after trips had launched.

Impacts would be temporary, but they would occur more frequently than the impacts from HFE releases or flow spikes under the other alternatives. Also, the impacts would be experienced for a period extending beyond the nighttime implementation period because of the delay that it takes outflow water at Glen Canyon Dam to reach rapids and campsites downstream. Impacts would be greatest near Glen Canyon Dam and diminish farther downstream.

**Cumulative Effects**

Most Action Alternatives would result in a reduction of navigation concerns (except for the Non-Bypass Alternative and No Action Alternative) and improved long-term conditions for the rainbow trout fishery. Except for the Non-Bypass Alternative's effects on boating, camping, and the rainbow trout fishery in the Glen Canyon reach and whitewater boating and camping in the Grand Canyon, all alternatives' contribution to cumulative effects would be negligible compared with the effects of past, present, and reasonably foreseeable future actions.

### *Issue 2: How would sedimentation resulting from flow fluctuations change camping opportunities in the Glen Canyon reach and Grand Canyon?*

**No Action Alternative**

Under the No Action Alternative, Reclamation would not make any changes to the operations of Glen Canyon Dam. Therefore, water would continue to be released as described in the 2016 LTEMP FEIS (DOI 2016a). HFE releases would continue to affect campsites in the Glen Canyon reach through erosion of terraces combined with an absence of sediment sources in the Glen Canyon reach for possible deposition and rebuilding of terraces. This effect would be exacerbated with higher fluctuation levels. Conversely, sediment-triggered HFE releases could result in greater campsite area within the Grand Canyon, although flow and fluctuation levels, as well as vegetation control, would affect the maintenance of the campsite areas.

**Alternatives without Flow Spikes**

Under the Cool Mix and Cold Shock Alternatives, HFE releases would be triggered and implemented according to a 1-year sediment accounting period. Compared with the No Action Alternative, the alternatives without flow spikes would result in a slightly higher mass balance on average because the average HFE release duration would be slightly shorter under the 1-year sediment accounting period (see **Section 3.4.2**). Therefore, impacts on camping opportunities in the Glen Canyon reach and Grand Canyon would be similar to those described under the No Action Alternative, but to a slightly greater extent due to the shorter, but more frequent, duration of spring HFE releases.

**Alternatives with Flow Spikes**

Under the Cool Mix with Flow Spike and Cold Shock with Flow Spike Alternatives, HFE releases would be triggered and implemented according to a 1-year sediment accounting period. Compared with the No Action Alternative and alternatives without flow spikes, the elevated flows associated with flow spikes would contribute to increased erosion of campsites in the Glen Canyon reach and the Grand Canyon, likely decreasing campsite access and availability. Furthermore, if a flow spike occurred outside the sediment accounting period, it would increase sediment export, thereby decreasing the amount of available sand to perform an HFE release. This would further reduce sandbar size, as HFE releases are the only mechanism for providing substantial deposition of high-elevation sandbars.

**Non-Bypass Alternative**
Of all alternatives, the Non-Bypass Alternative would cause the greatest reduction in mass balance of sand. Modeled Non-Bypass Alternative fluctuations would result in a 196 percent increase in sand export in the months in which they occur, relative to the No Action Alternative.[35] These fluctuations would substantially erode sand that has accumulated in the channel, and could preclude the opportunity to conduct an HFE release, which would further reduce sandbar size as described under Alternatives with Flow Spikes. Therefore, camping opportunities in the Glen Canyon reach and the Grand Canyon would be reduced compared with all other alternatives.

**Cumulative Effects**
The action alternatives are expected to reduce or only modestly improve sediment conditions to varying degrees. They also are overall more likely to decrease camping areas within the Glen Canyon reach and the Grand Canyon. The action alternatives would likely contribute to cumulative impacts on camping resources within these areas.

### *Summary*
**No Action Alternative**: Under the No Action Alternative, Glen Canyon Dam operations would remain unchanged, following the guidelines set in the 2016 LTEMP FEIS. In the Glen Canyon reach, implementation of HFE releases would continue to result in reduced short-term angler satisfaction, lost rafting visitor opportunities to the concessionaire, and increased erosion of campsites on terraces. In the Grand Canyon, daytime flows would continue to be above the safe whitewater boating minimum of 8,000 cfs, with good river conditions (between 20,000 and 26,000 cfs) occurring most of the time. Sediment-triggered HFE releases would result in a potential increase in camping area in the Grand Canyon.

**Cool Mix Alternative:** Under the Cool Mix Alternative, reduced water temperatures would improve water quality for rainbow trout, which would likely increase angler satisfaction in the short and long term. Impacts on boating, the rafting concessionaire, camping in the Glen Canyon reach, and whitewater boating and camping in the Grand Canyon would be similar to those described under the No Action Alternative.

**Cool Mix with Flow Spike Alternative:** Under the Cool Mix with Flow Spike Alternative, benefits to the rainbow trout fishery resulting from reduced water temperatures would be the same as described under the Cool Mix Alternative. Flow spikes would reduce catchability during the peak fishing months, thereby reducing angler satisfaction in the short term. Flow spikes would also temporarily disrupt boating in the Glen Canyon reach and the ability of the rafting concessionaire to operate, as well as contribute to increased erosion of campsites, compared with the No Action Alternative. Flow spikes would likely improve whitewater boating conditions in the Grand Canyon but could temporarily limit beach usability for camping during implementation. In the long term,

[35] Gerard Salter, PhD, hydrologist, personal communication, April 1, 2024

flow spikes could contribute to increased sand export in the lead up to HFE implementation, which would reduce campsite availability in the Grand Canyon.

**Cold Shock Alternative:** Under the Cold Shock Alternative, cold shocks would likely have adverse impacts on fry and early juveniles, which could decrease angler satisfaction in the short term; however, cooler water temperatures would likely improve water quality for rainbow trout in the long term, thereby increasing angler satisfaction in the long term. Impacts on boating, the rafting concessionaire, and camping in the Glen Canyon reach and whitewater boating and camping in the Grand Canyon would be similar to those described under the No Action Alternative.

**Cold Shock with Flow Spike Alternative:** Under the Cold Shock with Flow Spike Alternative, short-term reduced angler satisfaction similar to that described under the Cold Shock Alternative could occur. Flow spikes would reduce catchability during the peak fishing months, thereby reducing angler satisfaction in the short term. Flow spikes would also temporarily disrupt boating in the Glen Canyon reach and the ability of the rafting concessionaire to operate. Compared with the No Action Alternative, flow spikes under this alternative also would contribute to increasing erosion of campsites. Flow spikes would likely improve whitewater boating conditions in the Grand Canyon but could temporarily limit beach usability for camping during implementation. In the long term, flow spikes could contribute to increased sand export in the lead up to HFE implementation, which would reduce campsite availability in the Grand Canyon.

**Non-Bypass Alternative**: Under the Non-Bypass Alternative, fry and juveniles would be negatively affected by both the high and low flows. The rapid fluctuations in water levels could also disrupt fishing during the flows' implementation. Compared with the cold-water alternatives, the Non-Bypass Alternative would also be less likely to benefit the rainbow trout fishery by reducing water temperatures. The low flows under the Non-Bypass Alternative could limit the ability of boats to freely navigate in the Glen Canyon reach, which would adversely impact boating and the rafting concessionaire in the short term compared with all other alternatives. In the Grand Canyon, minimum flows would be below the safe whitewater minimum, which would adversely affect whitewater boating by reducing or preventing navigability and increasing the likelihood of safety incidents.

## 3.15 Socioeconomics

### 3.15.1 Affected Environment

This section provides a brief socioeconomic background for two regions of influence as defined in the 2016 LTEMP FEIS: (1) the six-county region in which most recreation in the Grand Canyon area occurs, and (2) a seven-state region in which power from the Glen Canyon Powerplant is marketed.

#### *Recreation Expenditures Analysis Area*

The six-county recreation analysis area consists of Coconino and Mohave counties in Arizona and Garfield, Kane, San Juan, and Washington counties in Utah. This analysis area includes the GCNRA and GCNP, as well as various surrounding cities.

### Population

Population growth is a factor that can drive recreational demand. **Table 3-42** presents recent and projected populations for the six-county recreation analysis area and for the states of Arizona and Utah as a whole. All counties in the analysis area, with the exception of Washington County, Utah, are anticipated to experience population growth rates below those of the state levels by 2040. The highest rate of population growth is anticipated in Washington County, Utah (85.2 percent), and the lowest rate of growth is anticipated in Garfield County, Utah (2.1 percent).

**Table 3-42**
**Population in the Recreational Expenditures Analysis Area**

| Location | Historical Population | | Projected Population | | Projected Change 2020 to 2040 | |
|---|---|---|---|---|---|---|
| | 2010 | 2020 | 2030 | 2040 | Total Change | Percentage Change |
| Coconino County, Arizona | 134,421 | 145,101 | 155,200 | 159,600 | 14,499 | 10.0 |
| Mohave County, Arizona | 200,186 | 213,269 | 251,300 | 270,600 | 57,331 | 26.9 |
| Garfield County, Utah | 5,176 | 5,184 | 5,017 | 5,294 | 110 | 2.1 |
| Kane County, Utah | 7,113 | 7,692 | 8,834 | 9,769 | 2,077 | 27.0 |
| San Juan County, Utah | 14,715 | 14,541 | 14,712 | 16,186 | 1,645 | 11.3 |
| Washington County, Utah | 13,435 | 182,111 | 265,865 | 337,326 | 155,215 | 85.2 |
| Arizona | 6,392,017 | 7,151,502 | 8,313,800 | 9,206,900 | 2,055,398 | 28.7 |
| Utah | 2,772,667 | 3,284,823 | 3,879,161 | 4,440,560 | 1,155,737 | 35.2 |

Sources: US Census Bureau 2022a; Arizona Commerce Authority 2022; Kem C. Gardner Policy Institute 2022

### Income

Total personal income in the analysis area in 2022 was highest for Washington County, Utah, at $10 billion; the lowest was in Garfield County at $0.29 billion (**Table 3-43**). The fastest average annual rate of growth for income from 2010 to 2022 was in Washington County, Utah (8.8 percent), and the lowest rate of growth for personal income was in San Juan County, Utah (4.0 percent). For per capita income, the highest income in 2022 was in Coconino County, Arizona ($58,993), and the lowest was in San Juan County, Utah ($35,597). The rate of average annual growth in per capita income from 2010 to 2022 was highest in Coconino County, Arizona, and Garfield County, Utah (5.8 percent for both counties), and lowest in San Juan County, Utah (4.3 percent). Per capita incomes for all counties, with the exception of Coconino County, were lower than the respective state averages in 2022. In Coconino County, per capita income ($58,993) was slightly above that for the state of Arizona ($58,442).

**Table 3-43**
**Income in the Recreational Expenditures Analysis Area**

| Location | 2010 | 2022 | Average Annual Growth Rate 2010–2022 |
|---|---|---|---|
| **Coconino County, Arizona** | | | |
| Income (billions $) | 4.7 | 8.5 | 6.9% |
| Per capita income ($) | 34,531 | 58,993 | 5.8% |
| **Mohave County, Arizona** | | | |
| Income (billions $) | 5.2 | 9.9 | 5.5% |
| Per capita income ($) | 25,864 | 44,645 | 4.7% |
| **Garfield County, Utah** | | | |
| Income (billions $) | 0.15 | 0.29 | 5.9% |
| Per capita income ($) | 28,447 | 55,775 | 5.8% |
| **Kane County, Utah** | | | |
| Income (billions $) | 0.22 | 0.42 | 5.7% |
| Per capita income ($) | 29,894 | 51,164 | 4.6% |
| **San Juan County, Utah** | | | |
| Income (billions $) | 0.32 | 0.51 | 4.0% |
| Per capita income ($) | 21,574 | 35,597 | 4.3% |
| **Washington County, Utah** | | | |
| Income (billions $) | 3.6 | 10.0 | 8.8% |
| Per capita income ($) | 26,218 | 50,746 | 5.7% |
| **Arizona** | | | |
| Income (billions $) | 216.2 | 430.1 | 5.9% |
| Per capita income ($) | 33,774 | 58,442 | 4.7% |
| **Utah** | | | |
| Income (billions $) | 88.9 | 201.0 | 7.0% |
| Per capita income ($) | 32,038 | 59,457 | 5.3% |

Source: US Department of Commerce, Bureau of Economic Analysis 2022

### Employment

Employment by sector for the most recent available data is examined in **Table 3-44**. Farm employment represented an equal or greater share of total employment compared with the state level for all analysis area counties, with the exception of Washington County, Utah. Notably, farm employment represented 10.5 percent of employment in San Juan County, Utah, and 7.4 percent in Garfield County, Utah, compared with a state average of 0.9 percent.

## Table 3-44
## Employment by Industry, 2022

| Industry | Coconino County, Arizona | Mohave County, Arizona | Garfield County, Utah | Kane County, Utah | San Juan County, Utah | Washington County, Utah | Arizona | Utah |
|---|---|---|---|---|---|---|---|---|
| | Jobs/percentage of total jobs by county or state | | | | | | | |
| Total employment | 88,910 | 81,675 | 3,907 | 6,101 | 6,836 | 124,640 | 4,287,595 | 2,367,996 |
| Farm | 2,088 | 479 | 289 | 169 | 715 | 557 | 27,735 | 21,081 |
| | 2.3% | 0.6% | 7.4% | 2.8% | 10.5% | 0.4% | 0.6% | 0.9% |
| Non-Farm | 86,822 | 81,196 | 3,618 | 5,932 | 6,121 | 124,083 | 4,259,860 | 2,346,915 |
| | 97.7% | 99.4% | 92.6% | 97.2% | 89.5% | 99.6% | 99.4% | 99.1% |
| Forestry, fishing, and related | 254 | (D) | (D) | (D) | 88 | 184 | 14,280 | 4,704 |
| | 0.3% | (D) | (D) | (D) | 1.3% | 0.1% | 0.3% | 0.2% |
| Mining | 178 | 469 | (D) | (D) | 331 | 776 | 20,295 | 13,730 |
| | 0.2% | 0.6% | (D) | (D) | 4.8% | 0.6% | 5.0% | 0.6% |
| Utilities | 196 | 418 | 34 | (D) | (D) | 258 | 12,818 | 5,064 |
| | 0.2% | 0.5% | 0.9% | (D) | (D) | 0.2% | 0.3% | 0.2% |
| Construction | 4,086 | 6,958 | 148 | 332 | 345 | 12,535 | 270,022 | 166,041 |
| | 4.6% | 8.5% | 3.8% | 5.4% | 5.0% | 10.1% | 6.3% | 7.0% |
| Manufacturing | 3,852 | 3,561 | 64 | (D) | 112 | 4,739 | 204,725 | 160,756 |
| | 4.2% | 4.4% | 1.6% | (D) | 1.6% | 3.8% | 4.8% | 6.8% |
| Wholesale trade | 1,412 | 1,827 | 44 | 47 | (D) | 2,495 | 126,540 | 65,904 |
| | 1.6% | 2.2% | 1.1% | 0.8% | (D) | 2.0% | 3.0% | 2.8% |
| Retail trade | 8,866 | 12,436 | 300 | 587 | 440 | 14,923 | 422,975 | 235,054 |
| | 10.0% | 15.2% | 7.7% | 9.6% | 6.4% | 12.0% | 9.9% | 9.9% |
| Transportation and warehousing | 2,709 | 3,254 | 61 | (D) | (D) | 6,249 | 240,127 | 105,686 |
| | 3.0% | 4.0% | 1.6% | (D) | (D) | 5.0% | 5.6% | 4.5% |
| Information | 791 | 769 | 156 | 47 | (D) | 1,351 | 66,692 | 54,369 |
| | 0.9% | 0.9% | 4.0% | 0.8% | (D) | 1.1% | 1.6% | 2.3% |
| Finance and insurance | 2,295 | 3,078 | 74 | 117 | 151 | 7,884 | 309,879 | 174,506 |
| | 2.6% | 3.8% | 1.9% | 1.9% | 2.2% | 6.3% | 7.2% | 7.4% |

| Industry | Coconino County, Arizona | Mohave County, Arizona | Garfield County, Utah | Kane County, Utah | San Juan County, Utah | Washington County, Utah | Arizona | Utah |
|---|---|---|---|---|---|---|---|---|
| | Jobs/percentage of total jobs by county or state | | | | | | | |
| Real estate and rental and leasing | 4,777 | 5,693 | 177 | 584 | (D) | 10,778 | 272,879 | 154,826 |
| | 5.4% | 7.0% | 4.5% | 9.6% | (D) | 8.6% | 6.4% | 6.5% |
| Professional and technical services | 4,012 | 3,643 | (D) | 219 | 167 | 7,458 | 289,301 | 194,639 |
| | 4.5% | 4.5% | (D) | 3.6% | 2.4% | 6.0% | 6.7% | 8.2% |
| Management of companies | 597 | 295 | 35 | 39 | (D) | 1,344 | 53,464 | 36,775 |
| | 0.7% | 0.4% | 0.9% | 0.6% | (D) | 1.1% | 1.2% | 1.6% |
| Administrative and waste services | 2,948 | 4,424 | (D) | 234 | (D) | 5,798 | 322,974 | 12,1592 |
| | 3.8% | 5.4% | (D) | 3.8% | (D) | 4.7% | 7.5% | 5.1% |
| Educational services | 1,280 | 887 | (D) | 31 | 167 | 1,985 | 92,109 | 77,750 |
| | 1.4% | 1.1% | (D) | 0.5% | 2.4% | 1.6% | 2.1% | 3.3% |
| Health care and social assistance | 9.792 | 9,709 | (D) | 201 | 919 | 14,038 | 476,659 | 193,936 |
| | 11.0% | 11.9% | (D) | 3.3% | 13.4% | 11.3% | 11.1% | 8.2% |
| Arts, entertainment, and recreation | 3,260 | (D) | 64 | 369 | (D) | 2,939 | 85,991 | 51,311 |
| | 3.7% | (D) | 1.6% | 6.0% | (D) | 2.4% | 2.0% | 2.2% |
| Accommodation and food services | 14,645 | 8,557 | 1,127 | 1,208 | (D) | 10,709 | 317,706 | 145,448 |
| | 16.5% | 10.5% | 28.8% | 19.8% | (D) | 8.7% | 7.4% | 6.1% |
| Other services | 3,774 | 5,424 | 150 | 727 | (D) | 6,910 | 214,742 | 111,237 |
| | 4.2% | 6.6% | 3.8% | 11.9% | (D) | 5.5% | 5.0% | 4.7% |
| Government | 17,098 | 8,539 | 560 | 783 | 1,687 | 10,730 | 445,732 | 273,587 |
| | 19.2% | 10.5% | 14.3% | 12.8% | 24.7% | 8.6% | 10.4% | 11.6% |

Source: US Department of Commerce, Bureau of Economic Analysis 2022
Note: (D) Data not shown by the Bureau of Economic Analysis to avoid disclosure of confidential information; estimates are included in higher-level totals.

Within the service sector, accommodation and food services represented a higher percentage of jobs for all counites as compared with the respective state averages for Arizona and Utah (7.4 and 6.1 percent, respectively). In particular, this sector represented 28.8 percent of total employment in Garfield County, Utah, and 19.8 percent of employment in Kane County, Utah. All area counties, with the exception of Washington County, Utah, also had higher shares of jobs in government compared with the state averages. In particular, government jobs were 24.7 percent of total employment in San Juan County, Utah, and 19.2 percent of employment in Coconino County, Arizona, compared with 10.4 percent and 11.6 percent in Arizona and Utah, respectively.

**Unemployment**

At the county level, the unemployment rate in 2012 was highest in Mohave County, Arizona (11.0 percent), and lowest in Kane County, Utah (5.9 percent). In 2022, the unemployment rate was highest in Garfield County, Utah (5.9 percent), and remained lowest in Kane County as well as in Washington County, Utah (both 2.5 percent). For all counties examined, unemployment rates were higher in 2012 than in 2022. In 2022, both Arizona counties had a higher unemployment rate than the state unemployment rate, while all Utah counties, with the exception of Garfield County, had lower unemployment rates than the state. See **Table 3-45**.

It should be noted that data presented in this discussion include annual averages for the most recent reporting periods. Data, including the 2020 time frame, may differ from historical trends due to the widespread economic effects of the recession brought about by the 2020 global COVID-19 pandemic. This event affected local and regional economies in the analysis area through severe short-term changes to employment and industrial output; the effects of this are still ongoing and not evenly distributed across industries.

**Table 3-45**
**Annual Unemployment Trends in the Recreational Expenditures Analysis Area**

| Location | 2012 (%) | 2022 (%) |
|---|---:|---:|
| Coconino County, Arizona | 8.6 | 4.3 |
| Mohave County, Arizona | 11.0 | 4.5 |
| Garfield County, Utah | 8.4 | 5.9 |
| Kane County, Utah | 5.9 | 2.5 |
| San Juan County, Utah | 7.8 | 4.4 |
| Washington County, Utah | 6.1 | 2.5 |
| Arizona | 8.3 | 3.8 |
| Utah | 2.3 | 4.8 |

Source: US Department of Labor, Bureau of Labor Statistics 2023

**Recreation Spending and Valuation**

Recreational resources of concern in the socioeconomics recreation analysis area include fishing and boating (such as kayaking, rafting, and canoeing) from Glen Canyon Dam to Lees Ferry and through the Grand Canyon. Recreation is discussed in **Section 3.14**. Visitors to Lees Ferry and the Grand Canyon spend large sums of money in the region purchasing gas, food and drink, lodging, guide services, and outdoor equipment when visiting the region. These expenditures impact the regional economy through direct effects, indirect effects, and induced effects. Direct effects represent a change in the final demand for the affected industries caused by the change in spending. Indirect effects are the changes in interindustry purchases as industries respond to the new demands of the directly affected industries. Induced effects are the changes in spending from households as their income increases or decreases due to the changes in production (Reclamation 2011a).

Bair et al. (2016) estimated the annual value of fishing at Lees Ferry to be $2.7 million at 2014 visitation levels. Demand for fishing was affected by the season, with per-trip values of $210 in the summer, $237 in the spring, $261 in the fall, and $399 in the winter (Bair et al. 2016).

The annual regional economic activity generated from visitors in 2021 was estimated at approximately $372 million for GCNRA and $1.01 billion for GCNP (NPS 2022d). A portion of this activity is related to rafting and fishing.

As noted in **Section 3.14.1**, the NPS authorizes one commercial recreational river rafting concessionaire to operate in the Glen Canyon reach. This commercial activity directly and indirectly supports jobs and income in the region. It also may provide additional benefits for recreationists' visitor experience.

The value of recreation can also be assessed based on the quality of the recreational experience. This value represents not just the amount of money spent in the local or regional economy but also the value that potential users assign to the opportunity to use a resource. One method of measuring nonmarket value is the use of a stated preference valuation technique. One version of this is contingent valuation (CV), which is a means of eliciting the maximum dollar amount an individual would be willing to pay for a resource of a specified quantity and quality. CV methods use surveys to ascertain value by asking people about their willingness to pay for a carefully specified change in environmental amenities.

Neher et al. (2017) estimated the willingness to pay per private whitewater trip by boat through the Grand Canyon under varying flows. The willingness to pay was estimated at $628 for flows of 5,000 cfs, $1,226 for flows of 13,000 cfs, $1,382 for flows of 22,000 cfs, and $1,094 for flows of 40,000 cfs, which suggests a preference for flows between 13,000 and 22,000 cfs (Neher et al. 2017).

### Nonuse Values

Nonmarket values can also be assessed for nonuse values. Nonuse values are values that may be placed on the status of the natural or physical environment by nonusers (or individuals who may never visit or otherwise use a natural resource that might still be affected by changes in its status or quality). Nonusers may assign a nonuse or passive-use economic value to a resource.

CV surveys have been applied widely in the published economics literature to estimate passive-use values associated with preserving river and lake resources. Loomis (2014) concluded that research on this subject is limited and that additional research may be warranted. The National Research Council (2005) has concluded that the results of studies using CV methods are of high quality; however, the results and findings of studies relating to the Colorado River corridor are considerably outdated. Other studies have emphasized the need for additional or updated research on the sources and magnitudes of values associated with operational goals (see additional information in National Research Council 1999).

To address these concerns, the NPS conducted a survey to determine nonuse values associated with the impacts of each of the six action alternatives examined in the 2016 LTEMP FEIS on the endangered humpback chub, sandbars in the Grand Canyon, and populations of large trout in Glen Canyon. This study found that for every 1 percent increase in humpback chub population, the marginal willingness to pay increased by $1.95, and for every 1 percent increase in sandbar protection, the willingness to pay increased by $1.58, based on a national sample. Additional details of this study and background literature are included in DOI 2016a and Duffield et al. 2016.

In addition, Loomis (2014) concluded that there is a theoretical basis for nonmarket values associated with hydropower and water. He used the example of how people can place value on maintaining the ranching and farming way of life associated with western rural communities as irrigated agriculture landscapes are correlated with open space. In addition, people may place value on the existence and well-being of farming communities. Nonmarket values associated with hydropower and water resources may also exist to the extent that hydropower and developed water assist in the maintenance of some Tribal values and social well-being, such as support for irrigated agriculture and livestock. Specific studies examining tribal non-market values, are not, however, available to determine the relative importance of  values supported by developed water uses, and those that may be impacted by such uses (e.g. visual setting, subsistence fishing and hunting).

Additional studies support the importance of the nonmarket, nonuse associated with hydropower generation of Glen Canyon Dam. A 2016 study found that the median household value for retaining the current pattern of Glen Canyon Dam operations (that is, hydropower generation) would be nearly $20 per year (Jenkins-Smith et al. 2016).

#### ***The Seven-State Region of Influence***

WAPA markets wholesale CRSP Act power to preference entities (WAPA, n.d.), serving approximately 5.8 million retail customers in Arizona, Colorado, Nebraska, Nevada, New Mexico, Utah, and Wyoming. The current socioeconomic conditions within the seven-state region of influence (the area where electricity from Glen Canyon Dam is marketed) are described below.

### Population

The total population in the seven-state region was almost 24 million in 2020, which is an increase from 21.3 million in 2010 (**Table 3-46**). Population in the region is concentrated in Arizona and Colorado, which, at 12.9 million people, had almost 54 percent of the total regional population in 2020. The regional population is projected to reach 26.9 million in 2030 and 30.0 million in 2040.

**Table 3-46**
**Population in the Seven-State Region of Influence**

| Location | Historical Population | | Projected Population | | Projected Change 2020 to 2040 | |
|---|---|---|---|---|---|---|
| | 2010 | 2020 | 2030 | 2040 | Total Change | Percentage Change |
| Arizona | 6,392,017 | 7,151,502 | 8,284,861 | 9,247,212 | 2,095,710 | 29.3 |
| Colorado | 5,029,196 | 5,773,714 | 6,416,216 | 7,692,907 | 1,919,193 | 33.2 |
| Nebraska | 1,826,341 | 1,961,504 | 2,053,788 | 2,164,420 | 202,916 | 10.3 |

| Location | Historical Population | | Projected Population | | Projected Change 2020 to 2040 | |
|---|---|---|---|---|---|---|
| | 2010 | 2020 | 2030 | 2040 | Total Change | Percentage Change |
| Nevada | 2,700,551 | 3,104,614 | 3,535,890 | 3,723,046 | 618,432 | 19.9 |
| New Mexico | 2,059,179 | 2,117,522 | 2,136,414 | 2,132,755 | 15,233 | 0.7 |
| Utah | 2,763,885 | 3,271,616 | 3,879,161 | 4,440,560 | 1,168,944 | 35.7 |
| Wyoming | 563,626 | 575,851 | 597,260 | 614,820 | 38,969 | 6.8 |
| **Total** | **21,334,795** | **23,956,323** | **26,903,590** | **30,015,720** | **6,059,397** | **25.3** |

Sources: US Census Bureau 2022a; Arizona Office of Economic Opportunity 2022; Colorado Department of Local Affairs 2022; Drozd and Deichert 2015; Lawton 2022; University of New Mexico 2022; Kem C. Gardner Policy Institute 2022; Wyoming Department of Administration and Information 2019

### Income

Arizona and Colorado generated almost 55 percent of the income in the seven-state region, together producing almost $815 billion in 2021 (**Table 3-47**). From 2010 to 2021, personal income grew across the seven-state region, with higher growth rates in Colorado (9.1 percent), Nevada (7.9 percent), and Utah (9.9 percent). Per capita income rose over the same period at a rate of 5.4 percent, increasing from $37,998 to $60,515. In 2021, per capita incomes were higher in Colorado ($70,706), Nebraska ($61,205), and Wyoming ($69,666) than the average for the region as a whole ($60,515).

Median household incomes (the income level at which half of all households earn more and half earn less) over the period from 2018 to 2022 varied between $58,722 in New Mexico to $87,598 in Colorado (US Census Bureau 2023d). Median household income in the United States was $75,149 over the same period.

**Table 3-47**
**Total and Per Capita Income in the Seven-State Region of Influence**

| Location | 2010 | 2021 | Average Annual Growth Rate 2010–2021 |
|---|---|---|---|
| **Arizona** | | | |
| Income (billions of 2020$) | 216.9 | 403.7 | 7.8% |
| Per capita income (2020$) | 33,876 | 55,487 | 5.8% |
| **Colorado** | | | |
| Income (billions of 2020$) | 205.9 | 410.9 | 9.1% |
| Per capita income (2020$) | 40,790 | 70,706 | 6.7% |
| **Nebraska** | | | |
| Income (billions of 2020$) | 75.5 | 120.2 | 5.4% |
| Per capita income (2020$) | 41,248 | 61,205 | 4.4% |
| **Nevada** | | | |
| Income (billions of 2020$) | 101.3 | 189.3 | 7.9% |
| Per capita income (2020$) | 37,494 | 60,213 | 5.5% |

| Location | 2010 | 2021 | Average Annual Growth Rate 2010–2021 |
|---|---|---|---|
| **New Mexico** | | | |
| Income (billions of 2020$) | 69.6 | 106.4 | 4.8% |
| Per capita income (2020$) | 33,710 | 50,311 | 4.5% |
| **Utah** | | | |
| Income (billions of 2020$) | 89.4 | 187.0 | 9.9% |
| Per capita income (2020$) | 32,218 | 56,019 | 6.7% |
| **Wyoming** | | | |
| Income (billions of 2020$) | 26.3 | 40.3 | 4.8% |
| Per capita income (2020$) | 46,649 | 69,666 | 4.5% |
| **Total** | | | |
| Income (billions of 2020$) | 785.0 | 1,458 | 7.8% |
| Per capita income (2020$) | 37,998 | 60,515 | 5.4% |

Source: US Department of Commerce, Bureau of Economic Analysis 2022

**Employment**

In 2020, more than 49 percent of all employment in the seven-state power marketing service territory (that is, 6.5 million jobs out of a total of 13.1 million) was concentrated in Arizona and Colorado (**Table 3-48**). Employment figures showed 401,871 jobs in Wyoming, 1.1 million in New Mexico, 1.3 million in Nebraska, and 1.8 million in Nevada; each remaining state supported over 2 million jobs. From 2012 to 2020, annual employment growth rates were higher in Arizona and Colorado (13.4 percent) than elsewhere in the seven-state region, with rates in Nevada (2.1 percent), New Mexico (0.0 percent), Wyoming (0.2 percent), Utah (3.1 percent), and Nebraska (0.5 percent) lower than the average rate of 5.0 percent.

In 2021, the service sector provided the highest percentage of employment in the seven-state region at almost 73 percent, followed by government (11.9 percent). Within the service sector, health care and social assistance had the highest percentage of jobs (11.2 percent of total jobs), see **Table 3-49**. Smaller employment shares were held by retail trade (9.5 percent), professional and technical services (7.3 percent), and accommodation and food services (6.8 percent). Within the region, the distribution of employment across sectors varied somewhat compared with the region as a whole. Nebraska and Wyoming had a higher percentage of employment in agriculture (4.0 percent in Nebraska and 3.5 percent in Wyoming) than the region as a whole (1.3 percent); these states had lower shares of employment in services compared with the region as a whole. Service sector employment in Nevada (79.2 percent), Arizona (76.4 percent), and New Mexico (73.5 percent) was higher than in the region as a whole (72.5 percent). Nebraska (7.8 percent), Utah (7.0 percent), and New Mexico (6.5 percent) had larger-than-average shares of manufacturing sector employment, while mining was a more significant employer in Wyoming (4.6 percent) than elsewhere in the region.

**Table 3-48**
**Employment in the Seven-State Region of Influence**

| Location | 2012 | 2020 | Average Annual Growth Rate 2012–2020 (%) |
|---|---|---|---|
| Arizona | 1,276,249 | 2,644,781 | 13.4 |
| Colorado | 3,262,925 | 3,821,923 | 13.4 |
| Nebraska | 1,251,258 | 1,305,987 | 0.5 |
| Nevada | 1,519,198 | 1,770,936 | 2.1 |
| New Mexico | 1,067,211 | 1,069,680 | 0.0 |
| Utah | 1,706,060 | 2,135,409 | 3.1 |
| Wyoming | 396,704 | 401,871 | 0.2 |
| Total | 10,479,605 | 13,150,587 | 5.0 |

Source: US Census Bureau 2022b

## Table 3-49
## Employment in the Seven-State Region of Influence by Industry, 2021

| Industry | Arizona | | Colorado | | Nebraska | | Nevada | | New Mexico | | Utah | | Wyoming | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jobs | % | Jobs | % | Jobs | % | Jobs | % | Jobs | % | Jobs | % | Jobs | % | Jobs | % |
| **Total employment** | **4,055,932** | **—** | **4,945,819** | **—** | **1,330,296** | **—** | **1,875,709** | **—** | **201,142,600** | **—** | **2,229,147** | **—** | **409,176** | **—** | **215,988,679** | **—** |
| **Non-services/ government-related industries** | **509,941** | **12.6** | **540,904** | **10.9** | **253,011** | **19.0** | **212,324** | **11.3** | **29,194,100** | **14.5** | **349,489** | **15.7** | **78,697** | **19.2** | **31,138,466** | **14.4** |
| Farm | 29,309 | 0.7 | 47,988 | 1.0 | 53,669 | 4.0 | 5,028 | 0.3 | 2,588,000 | 1.3 | 20,552 | 0.9 | 14,277 | 3.5 | 2,758,823 | 1.3 |
| Forestry and agricultural services | 13,832 | 0.3 | 13,423 | 0.3 | 10,929 | 0.8 | 1,937 | 0.1 | 927,600 | 0.5 | 4,358 | 0.2 | 3,323 | 0.8 | 975,402 | 0.5 |
| Mining | 17,894 | 0.4 | 37,994 | 0.8 | 2,340 | 0.2 | 18,132 | 1.0 | 923,600 | 0.5 | 11,812 | 0.5 | 18,824 | 4.6 | 1,030,596 | 0.5 |
| Construction | 253,184 | 6.2 | 276,197 | 5.6 | 82,748 | 6.2 | 120,249 | 6.4 | 11,673,300 | 5.8 | 156,909 | 7.0 | 29,989 | 7.3 | 12,592,576 | 5.8 |
| Manufacturing | 195,722 | 4.8 | 165,302 | 3.3 | 103,325 | 7.8 | 66,978 | 3.6 | 13,081,600 | 6.5 | 155,858 | 7.0 | 12,284 | 3.0 | 13,781,069 | 6.4 |
| **Services-related industries** | **3,099,749** | **76.4** | **2,895,813** | **58.6** | **904,077** | **68.0** | **1,486,244** | **79.2** | **147,900,500** | **73.5** | **1,608,824** | **72.2** | **256,568** | **62.7** | **156,665,531** | **72.5** |
| Utilities | 12,720 | 0.3 | 9,401 | 0.2 | 1,287 | 0.1 | 4,526 | 0.2 | 598,200 | 0.3 | 5,036 | 0.2 | 2,551 | 0.6 | 633,721 | 0.3 |
| Wholesale trade | 115,142 | 2.8 | 120,434 | 2.4 | 42,323 | 3.2 | 43,982 | 2.3 | 6,309,900 | 3.1 | 61,996 | 2.8 | 8,547 | 2.1 | 6,702,324 | 3.1 |
| Retail trade | 413,565 | 10.2 | 341,676 | 6.9 | 130,940 | 9.8 | 185,306 | 9.9 | 19,120,800 | 9.5 | 227,274 | 10.2 | 39,259 | 10.0 | 20,458,820 | 9.5 |
| Transportation and warehousing | 224,294 | 5.5 | 181,227 | 3.7 | 70,099 | 5.3 | 137,427 | 7.3 | 10,403,700 | 5.2 | 97,325 | 4.4 | 16,124 | 3.9 | 11,130,196 | 5.2 |
| Information | 59,769 | 1.5 | 89,824 | 1.8 | 20,268 | 1.5 | 21,137 | 1.1 | 3,414,000 | 1.7 | 46,605 | 2.1 | 4,197 | 1.0 | 3,655,800 | 1.7 |
| Finance and insurance | 290,236 | 7.2 | 251,294 | 5.1 | 87,581 | 6.6 | 103,909 | 5.5 | 11,721,200 | 5.8 | 159,236 | 7.1 | 26,587 | 6.5 | 12,640,043 | 5.9 |
| Real estate and rental and leasing | 234,832 | 5.8 | 238,959 | 4.8 | 56,945 | 4.3 | 110,419 | 5.9 | 10,100,700 | 5.0 | 131,835 | 5.9 | 27,667 | 6.8 | 10,901,357 | 5.1 |
| Professional and technical services | 269,961 | 6.7 | 381,312 | 7.7 | 67,787 | 5.1 | 109,638 | 5.9 | 14,812,500 | 7.4 | 177,495 | 8.0 | 19,159 | 4.7 | 15,837,852 | 7.3 |

| Industry | Arizona | | Colorado | | Nebraska | | Nevada | | New Mexico | | Utah | | Wyoming | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jobs | % | Jobs | % | Jobs | % | Jobs | % | Jobs | % | Jobs | % | Jobs | % | Jobs | % |
| Management of companies | 44,165 | 1.1 | 52,152 | 1.1 | 21,111 | 1.6 | 32,573 | 1.7 | 2,754,000 | 1.4 | 33,989 | 1.5 | 2,192 | 0.5 | 2,940,182 | 1.4 |
| Administrative and waste services | 313,831 | 7.7 | 211,660 | 4.3 | 65,274 | 4.9 | 132,423 | 7.1 | 12,426,500 | 6.2 | 118,472 | 5.3 | 14,540 | 3.6 | 13,282,700 | 6.2 |
| Educational services | 85,070 | 2.1 | 77,829 | 1.6 | 23,642 | 1.8 | 21,845 | 1.2 | 4,684,400 | 2.3 | 75,217 | 3.4 | 4,106 | 1.0 | 4,972,109 | 2.3 |
| Health care and social assistance | 459,980 | 11.3 | 359,593 | 7.3 | 145,717 | 11.0 | 160,792 | 8.6 | 22,880,500 | 11.4 | 185,491 | 8.3 | 30,657 | 7.5 | 24,222,730 | 11.2 |
| Arts, entertainment, and recreation | 81,541 | 2.0 | 100,129 | 2.0 | 24,070 | 1.8 | 55,322 | 3.0 | 4,157,100 | 2.1 | 48,191 | 2.2 | 8,233 | 2.0 | 4,474,586 | 2.1 |
| Accommoda-tion and food services | 293,749 | 7.2 | 281,218 | 5.7 | 79,624 | 6.0 | 276,961 | 14.8 | 13,554,000 | 6.7 | 135,066 | 6.1 | 35,231 | 8.6 | 14,655,849 | 6.8 |
| Other services | 200,894 | 5.0 | 199,105 | 4.0 | 67,409 | 5.1 | 89,984 | 4.8 | 10,963,000 | 5.5 | 105,596 | 4.7 | 17,518 | 4.3 | 11,643,506 | 5.4 |
| **Government** | **446,242** | **11.0** | **509,102** | **10.3** | **173,208** | **13.0** | **177,141** | **9.4** | **24,048,000** | **12.0** | **270,834** | **12.2** | **73,911** | **18.1** | **25,698,438** | **11.9** |

Source: US Department of Commerce, Bureau of Economic Analysis 2022

**Unemployment**

In 2022, unemployment was lower in Utah (2.1 percent), Nebraska (2.4 percent), Wyoming (3.5 percent), and Colorado (3.6 percent) than the rest of the United States (3.7 percent); while Arizona (3.9 percent), Nevada (4.6 percent), and New Mexico (4.3 percent) were higher than the rest of the United States. (**Table 3-50**).

**Table 3-50**
**Unemployment Rates in the Seven-State Region of Influence, 2022**

| Location | Unemployment Rate (%) |
|---|---|
| Arizona | 3.9 |
| Colorado | 3.6 |
| Nebraska | 2.4 |
| Nevada | 4.6 |
| New Mexico | 4.3 |
| Utah | 2.1 |
| Wyoming | 3.5 |
| United States | 3.7 |

Source: US Department of Labor, Bureau of Labor Statistics 2022

## 3.15.2 Environmental Consequences

### *Methodology*

**Recreational Use Values and Economic Contributions**

Estimation of the use values associated with potential changes in recreational resources under each alternative used a benefits transfer method. This method involved applying existing use value data or estimates for a particular time period, site, level of resource quality, or combination thereof at an original or study site to a policy site for which data are not available. The benefits transfer method involved choosing study and policy sites with similar socioeconomic and environmental characteristics, similar recreational activities, and similar ranges of changes in recreational quality. Additional details for this approach are included in DOI 2016a.

The net economic value of recreation was estimated for Glen Canyon (from Glen Canyon Dam to Lees Ferry), Upper Grand Canyon (from Lees Ferry to Diamond Creek), and Lower Grand Canyon (from Diamond Creek to Lake Mead) based on the GCRec_Full utility program[36] output. This program uses the mean monthly release from Glen Canyon Dam and the presence or absence of daily fluctuations exceeding 10,000 cfs per day during the month to predict the economic value of day-use rafting and fishing in Glen Canyon and the economic value of commercial and private whitewater boating in the Upper Grand Canyon. These calculations are repeated for each month in

[36] The GCRec_Full utility model uses the recreation value relationships for Glen Canyon and Upper Grand Canyon estimated by Bishop et al. (1987). See Reclamation 2017, Appendix L for additional information.

the period of analysis and for each hydrologic trace. This information is provided along with qualitative information about the recreational experience by alternative.

Based on the recreation section analysis, it is not anticipated that a substantial change in recreation visitation will occur by alternative. As a result, no analysis of regional economic contributions is included in this SEIS. This is because the economic contribution analysis is based on a change in visitation levels and the associated direct spending. Information on potential impacts on the existing concessionaire and related economic contributions are discussed qualitatively.

**Environmental Nonuse Values**

Economists have long recognized that wildlife species, especially rare, threatened, and endangered species, have economic value beyond just viewing. This is supported by a series of legal decisions and technical analyses. For example, in assessing damages in natural resource damage assessment cases, the Department includes "passive-use values"—that is, existence values provided to nonusers of the species—as a compensable value in addition to any use value. The term "passive values" is interchangeable with the term "nonuse values." This is consistent with well-established economic theory showing that people derive value from passive use or nonuse as well as active uses of resources (Krutilla 1967). Nonuse value data can help provide additional information about the value of resources when direct economic contribution data are not available. Environmental nonuse value is examined based on the CV study prepared for the 2016 LTEMP FEIS, as well as information from existing literature (for example, Loomis 2014).

Potential changes to the sandbar size and humpback chub protection by alternative, as analyzed in **Section 3.8**, Threatened and Endangered Species, and **Section 3.4**, Geomorphology/Sediment, were examined utilizing modeled willingness to pay data. The analysis is presented in a qualitative format due to a lack of quantitative input information for humpback chub population size changes and other environmental factors.

**Hydropower Economic Impacts**

Discussion of impacts from hydropower generation changes on the economic value of electric energy are addressed in **Section 3.3.2**, Energy and Power economic impacts. Additional information on power marketing, including wholesale and retail rates, is included in the 2016 LTEMP FEIS and incorporated by reference (DOI 2016a).

### *Impact Analysis Area*

The impact analysis area consists of two separate areas, the six-county recreation analysis area and the seven-state hydropower analysis area, as defined in **Section 3.15.1**, Affected Environment.

### *Assumptions*

Under all alternatives, the NPS sets the number of whitewater boating trips in the Grand Canyon, and demand exceeds available permits. It is, therefore, not anticipated that the number of boat trips and associated recreational spending associated with this use would vary by alternative. No further analysis is provided for recreation's economic contributions due to the lack of change in direct spending across alternatives.

### *Impact Indicators*

- Net recreation value for whitewater boaters and anglers in the Colorado River
- Nonuse environmental value

### *Issue 1: How would management decisions affect recreational use values?*

**No Action Alternative**

Under the No Action Alternative, Reclamation would not make any changes to Glen Canyon Dam's operations. Therefore, water would continue to be released, as described in the 2016 LTEMP FEIS (DOI 2016a). As noted in **Section 3.14**, Recreation, anglers, boaters, and campers would continue to have the same level of access to recreation. Under the No Action Alternative, HFE releases would continue to be implemented the same as under current conditions; also, the HFE releases would be more likely to occur in the fall months, thereby limiting impacts on the concessionaire and recreational boaters in the Glen Canyon reach, because the greatest expenditures on recreation occur in the spring and summer. The exact impacts on recreation in the Grand Canyon reach would continue to depend on water availability for releases. Access for anglers would continue to be disrupted by HFE releases. As a result, no change would occur in the short term to the recreational experience and associated value.

In the long term, drought conditions and aridification could result in increasingly warm water temperatures that could lead to deteriorating conditions for rainbow trout, which could negatively impact the fishery and angler satisfaction and value associated with this use. The exact impacts on recreation and the associated value would, however, continue to depend on water availability for releases.

In terms of the estimated net value for boaters and anglers, the net value for the 50-month analysis period was calculated at $367.76 million for whitewater boaters and $18.94 million for anglers.

**Cool Mix Alternative**

As detailed in **Section 3.14**, Recreation, a long-term reduction in water temperature could improve water quality and enhance the rainbow trout fishery, which would likely result in higher angler satisfaction than under the No Action Alternative in the long term. Impacts on fishing, as well as whitewater boating, in the Glen Canyon and Grand Canyon reaches resulting from the volume of water discharged would be the same as described under the No Action Alternative. Compared with the No Action Alternative, this would result in minimal changes to the net value for anglers and whitewater boaters for all reaches (**Table 3-51**).

**Table 3-51**
**Total Mean Net Economic Value for 50-Month Analysis Period**
**($ Million Net Present Value, 2023)**

| | Glen Canyon Reach | | | | Lower Grand Canyon Reach | | | |
|---|---|---|---|---|---|---|---|---|
| | Whitewater Boaters | | Anglers | | Whitewater Boaters | | Anglers | |
| | Value ($) | Change from No Action (%) | Value ($) | Change from No Action (%) | Value ($) | Change from No Action (%) | Value ($) | Change from No Action (%) |
| Cool Mix Alternative | 359.83 | -1.9 | 18.96 | 0.1 | 367.6 | 0.2 | 18.96 | 0.1 |
| Cool Mix with Flow Spike Alternative | 367.6 | 0.0 | 22.80 | 20.0 | 367.6 | 0.2 | 18.96 | 0.1 |
| Cold Shock Alternative | 367.6 | 0.2 | 18.96 | 0.1 | 367.6 | 0.2 | 18.96 | 0.1 |
| Cold Shock with Flow Spike Alternative | 367.6 | 0.2 | 18.96 | 0.1 | 367.6 | 0.2 | 18.96 | 0.1 |
| Non-Bypass Alternative | 367.6 | 0.2 | 18.96 | 0.1 | 367.6 | 0.2 | 18.96 | 0.1 |

Source: USGS and Reclamation 2023
Note: The USGS worked in conjunction with Reclamation's model results for the operating period from October 2024 to December 2027. The data presented are the average net value out of 30 modeled traces.

### Cool Mix with Flow Spike Alternative

As discussed in **Section 3.14**, Recreation, under the Cool Mix with Flow Spike Alternative, the inclusion of flow spikes between May and July could reduce angler satisfaction in the short term, thereby impacting the net value for this use. However, improved water quality could enhance the rainbow trout fishery, which would likely result in higher angler satisfaction in the long term compared with the No Action Alternative.

Impacts on recreational boating and the rafting concessionaire during the implementation of the flow options could include increased temporary disruptions, especially in the Glen Canyon reach, impacting the net value for this use in the short term; long-term impacts would be minimal.

Estimates for the net value for anglers include a 20.0 percent increase in value in the Glen Canyon reach and minimal increase in the Lower Grand Canyon reach **(Table 3-51)**. A minimal change would occur for the whitewater boating value.

### Cold Shock Alternative

Under the Cold Shock Alternative, as detailed in **Section 3.14**, Recreation, some long-term increases in angler satisfaction would likely occur due to the reduced water temperature for the Glen Canyon reach.

Compared with the No Action Alternative, boating would have minimal changes in terms of satisfaction and value (**Table 3-51**).

### Cold Shock with Flow Spike Alternative

Impacts on the rainbow trout fishery resulting from the implementation of cold shocks would be similar to those impacts described under the Cold Shock Alternative. The inclusion of flow spikes between May and July could disrupt fishing during peak months, potentially reducing angler satisfaction in the short term. The impacts of flow spikes on the rainbow trout fishery would be similar to those impacts described under the previous alternatives, including the Flow Spike Alternative.

Impacts on recreational boating and the rafting concessionaire during the implementation of flow spikes would be similar to those described under the Cool Mix with Flow Spike Alternative. Flow spikes may cause erosion or deposition of sandbars along camping areas, depending on the volume of the flow released.

The Cold Shock with Flow Spike Alternative would affect a relatively small portion of the Colorado River used by boaters in the Grand Canyon. Impacts on boater navigability and beach usability would be limited.

Impacts on the angler and boating net economic value would be the same as that described in the Cold Shock Alternative (**Table 3-51**).

**Non-Bypass Alternative**

Under the Non-Bypass Alternative, some short-term impacts could occur for angler satisfaction; however, minimal changes are anticipated long term to angler satisfaction, as discussed in **Section 3.14**, Recreation.

The high and low fluctuations of water under the Non-Bypass Alternative could impact the boater experience in both the Glen Canyon and Grand Canyon reaches. This alternative may negatively affect the boating experience in the Glen Canyon reach, as unpredictability could pose challenges for boaters navigating through the area. The minimum flows of 2,000 cfs would limit the ability of boats to navigate freely in the Glen Canyon reach. This would adversely impact boating and the rafting concessionaire's operations compared with all other alternatives. These impacts would be temporary due to the short-term duration of the low-flow releases. While overall changes to visitation numbers may not occur, whitewater boating opportunities in GCNP could have temporary limitations, and Hualapai River Runners' ability to provide boating trips could be impacted.

**Cumulative Effects**

Impacts on recreation from the alternatives would be temporary in nature and would have minimal impacts on the use value associated with whitewater boating recreation in the recreation analysis area. Some impact improvements could occur to angler satisfaction and the associated net value, particularly in the Glen Canyon reach. There would be no cumulative impacts on recreation beyond those impacts included in the 2016 LTEMP FEIS.

### *Issue 2: How would management decisions affect environmental nonuse values?*

**No Action Alternative**

Under the No Action Alternative, operations of Glen Canyon Dam would not change. Although population levels of humpback chub are likely the highest since the construction of Glen Canyon Dam, invasions of nonnative species, especially smallmouth bass, could lead to the decline of some population centers of native fish species, such as near the mouth of the Little Colorado River. See

**Section 3.8**, Threatened and Endangered Species, for additional details. As a result, nonmarket values associated with the humpback chub may decrease in the long term. This includes a reduction in the nonuse value associated with the preservation of species, as discussed in the methods section.

Other nonmarket values may also be impacted in the long term. HFE releases could continue to impact sandbar development and the associated values, as discussed in the 2016 LTEMP FEIS (DOI 2016a). Nonmarket values may differ for different groups. Based on Jones et al. (2016), respondents who are supportive of hydropower, concerned about the health effects of air pollution, and concerned about ways of life for tribal communities and rural western communities are more likely to support the continuation of current patterns of dam operations and assign a higher value to this operation. Additionally, current CRSP customers are more likely to support the continuation of dam operations. This is because they are more likely to receive the benefits of Glen Canyon Dam hydropower and are, therefore, more likely to be personally affected by the economic viability of communities that receive reliable and low-cost hydropower (Jones et al. 2016).

**Cool Mix Alternative**

Under the Cool Mix Alternative, nonmarket values associated with humpback chub are not likely to be negatively affected. The presumed distributions of this species remain about the same and are expected to persist under this alternative.

In terms of sandbars and the associated values, sandbar volume would continue to increase, albeit in smaller, more frequent increases relative to the No Action Alternative; this would result in the potential for slight increases in the associated nonmarket value. **Section 3.4**, Geomorphology/Sediment, provides additional details.

For values associated with climate change, nonmarket values would be impacted by an increase in carbon emissions due to the need to secure alternative power sources. This alternative represents the greatest level of increased emissions, as modeled in **Section 3.17**, Climate Change. Similarly, this alternative represents the greatest potential for other values associated with rural ranching and farmers, or other area residents who may value continued current operations of the dam.

**Cool Mix Alternative with Flow Spike**

Impacts on the values associated with the humpback chub from the Cool Mix Alternative with Flow Spike would be the same as described above. The addition of flow spikes would result in potential short-term impacts on larvae and juvenile humpback chub, but no population-level impacts are anticipated. As a result, the associated values would be maintained.

Modeling predicts that sandbar formation at the Little Colorado River under both the Cool Mix and Cold Shock Flow Spike Alternatives would eventually surpass sandbar formation under the alternatives that do not include flow spikes. As a result, values associated with sandbars would be increased compared with the No Action Alternative. As discussed, values associated with continued current operations of the dam could be impacted under this alternative. For values associated with climate change, $CO_2$e emissions would be reduced slightly compared with the Cool Mix Alternative but elevated above the No Action Alternative.

**Cold Shock Alternative**

Under the Cold Shock Alternative, potential impacts would occur for values associated with the humpback chub. The level of impact depends on the extent and timing of the cold shock, which is also discussed in **Section 3.8**, Threatened and Endangered Species.

Sandbar volume would continue to increase, albeit in smaller, more frequent increases relative to the No Action Alternative. This increase would support increased values compared with the No Action Alternative.

Compared with the No Action Alternative, increased carbon emissions would occur; this is due to the need to secure alternative sources of energy due to reduced hydropower production. However, these increases under the Cold Shock Alternative would be lower than those increases described in the Cool Mix Alternative, as discussed in **Section 3.17**, Climate Change. Likewise, impacts on the people who value continued dam operations would occur, but at a lower level than under the Cool Mix Alternative.

**Cold Shock with Flow Spike Alternative**

Under the Cold Shock with Flow Spike Alternative, the use of cold shock events could reduce the growth and survival of young humpback chub and razorback sucker. However, the effect is not expected to be a population-level effect; therefore, impacts on the associated values would be minimal.

As discussed in the Cool Mix with Flow Spike Alternative, modeling predicts that sandbar formation at the Little Colorado River under the flow spike alternatives would eventually surpass the sandbar formation under the alternatives that do not include flow spikes. As a result, values associated with sandbars would be increased compared with the No Action Alternative. As discussed, values associated with continued current operations of the dam could be impacted under this alternative. Emissions under the Cool Mix with Flow Spike Alternative would be slightly lower than those described in the Cool Mix Alternative, as discussed in **Section 3.17**, Climate Change; however, they would still be elevated above the No Action Alternative, impacting associated nonmarket values.

**Non-Bypass Alternative**

Under the Non-Bypass Alternative, there is the potential for short-term impacts on humpback chub juveniles from flow changes, such as exposure to predators; however, the effect of these high flows is expected to be minimal. Trends in sandbar building under the Non-Bypass Alternative would be similar to those produced under the cold-water alternatives. The Non-Bypass Alternative would generally produce the second-smallest sandbars, slightly surpassing volumes that would be generated under the alternatives without flow spikes. As a result, some reductions in associated values are anticipated compared with the No Action Alternative.

No change is anticipated to carbon emissions or values associated with continued dam operations under this alternative; this is because hydropower operations would continue as they would under the No Action Alternative.

**Cumulative Effects**

Cumulative effects of these flow alternatives on threatened and endangered fish would likely be temporary and beneficial overall, with minimal changes to the values associated with the humpback chub. For sandbars, minimal changes could occur to associated values, with impacts dependent on the timing and duration of the flow spikes.

Under all action alternatives, with the exception of the Non-Bypass Alternative, values associated with continued hydropower and dam operations in the current setting (for example, those reliant on hydropower) would potentially be impacted due to changes to these conditions.

# 3.16 Environmental Justice

## 3.16.1 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, formally requires federal agencies to incorporate environmental justice as part of their missions. Specifically, it directs them to address, as appropriate, any disproportionately and adverse human health or environmental effects of their actions, programs, or policies on minority and low-income populations. Executive Order 14096, Revitalizing Our Nation's Commitment to Environmental Justice for All (88 *Federal Register* 25251), was enacted on April 21, 2023, to complement Executive Order 12989. Reclamation is waiting on additional guidance on how to implement Executive Order 14096, until then Reclamation will continue to implement Executive Order 12898.

This analysis consists of two steps: (1) screening of populations within the analysis area to identify the presence of communities for further environmental justice consideration, and (2) review of impacts to determine the potential for disproportionate adverse impacts on these communities.

As in the 2016 LTEMP FEIS, the environmental justice analysis area is defined by those counties that may be affected by changes in the operation of hydropower facilities and/or changes in hydropower costs. The environmental justice analysis area consists of 11 counties: Apache, Coconino, Mojave, and Navajo counties in Arizona; Cibola, McKinley, and San Juan counties in New Mexico; and Kane, San Juan, Garfield, and Washington counties in Utah.

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:

- Minority populations—Guidance from the Council on Environmental Quality (CEQ) in 1997 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 a threshold of 110 percent of the total minority population percentage of the geographic reference area to determine whether the minority population of the affected area is meaningfully greater than the minority population percentage in the appropriate unit of geographic analysis. For Arizona, New Mexico, and Utah, 110 percent of the total minority population is 51.7 percent, 70.8 percent, and 25.5 percent, respectively.

- Low-income populations—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.
- Tribal populations—Federally recognized Tribes are often considered environmental justice populations in and of themselves. When possible, they are included in the analysis as separate minority populations.
- Indigenous populations—For this analysis, additional screening was utilized to review US Census Bureau data for Indigenous populations (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. For this analysis, populations are considered to meet the criteria for environmental justice consideration when (1) 50 percent of the population is Indigenous, or (2) any geographic area of analysis has an Indigenous population percentage equal to or higher than the reference area.

**Table 3-52** provides an overview of the environmental justice screening results for the 11-county environmental justice analysis area.

All 11 analysis area counties (4 Arizona counties, 3 New Mexico counties, and 4 Utah counties) are identified as environmental justice communities, based on the criteria described above. As such, the analysis area has 11 environmental justice populations at the county level. Further, Coconino County, Arizona, and San Juan, Garfield, and Kane counties, Utah, are identified as environmental justice communities based on both indicators of Indigenous and low-income populations. Apache and Navajo counties, Arizona; Cibola and McKinley counties, New Mexico; and San Juan County, Utah, are identified as environmental justice communities based on all three indicators of minority, Indigenous, and low-income populations. See **Table 3-52** for more information; details for each indicator are provided below.

Additional information is also provided below in the discussion on Tribal populations with the potential to be affected by the proposed management.

**Table 3-52**
**Analysis Area Environmental Justice Screening Results (2022)**

| 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 | 47.0 (51.7) | 5.9 | 30.8 | — |
| New Mexico | 64.4 (70.8) | 11.5 | 38.8 | — |
| Utah | 23.2 (25.5) | 2.1 | 23.9 | — |
| Apache County, Arizona | 81.8* | 74.5* | 57.9* | Yes |
| Coconino County, Arizona | 47.0 | 28.1* | 36.0* | Yes |
| Mohave County, Arizona | 24.5 | 3.7 | 37.8* | Yes |
| Navajo County, Arizona | 58.1* | 45.6* | 49.6* | Yes |
| Cibola County, New Mexico | 81.9* | 44.7* | 51.2* | Yes |
| McKinley County, New Mexico | 92.0* | 80.6* | 59.0* | Yes |
| San Juan County, New Mexico | 63.8 | 42.2* | 49.2* | Yes |
| Garfield County, Utah | 11.7 | 3.0* | 36.3* | Yes |
| Kane County, Utah | 8.8 | 2.3* | 32.4* | Yes |
| San Juan County, Utah | 56.2* | 48.7* | 43.1* | Yes |
| Washington County, Utah | 17.2 | 2.0 | 26.4* | Yes |

Sources: US Census Bureau 2023a, 2023b, 2023c
*Meets the criteria for environmental justice community of concern.

### *Minority Population*

In Arizona, Apache and Navajo counties had total minority populations that exceeded the meaningfully greater threshold of 51.7 percent (81.8 percent and 58.1 percent, respectively). McKinley and Cibola counties, New Mexico, had total minority populations (92.0 and 81.9 percent, respectively) that exceeded the meaningfully greater threshold of 70.8 percent. However, it is important to note that all three New Mexico counties had total minority populations well above 50 percent, ranging from 58.1 percent to 92.0 percent. One of the four Utah counties within the environmental justice analysis area, San Juan County, had a total minority population (56.2 percent) that exceeded the meaningfully greater threshold of 25.5 percent and is considered an environmental justice community. Compared with the state and other counties within the analysis area, Garfield, Kane, and Washington counties, Utah, had smaller total minority populations, ranging from 8.8 to 17.2 percent.

Overall, five counties in the analysis area had total minority populations that met the criteria for consideration as environmental justice communities.

To provide environmental justice population data at a finer geographic scale, Census Bureau data were gathered at the census tract level. **Map 3-1** displays the minority populations at the census tract level.

### *Indigenous Population*

In Arizona, all counties, excluding Mohave County, had Indigenous populations exceeding the state average Indigenous population (5.9 percent). In New Mexico, all counties had Indigenous populations exceeding the state average Indigenous population (11.5 percent). Cibola, McKinely, and San Juan counties, New Mexico, had Indigenous populations exceeding the state average by over 30 percent. The Indigenous population was highest in McKinley County, New Mexico (80.6 percent). In Utah, all counties, excluding Washington County, had Indigenous populations exceeding the state average (2.1 percent), and the Indigenous population in San Juan County was notably higher than the other Utah analysis area counties. **Map 3-2** displays the Indigenous populations at the census tract level.

Overall, nine counties had total Indigenous populations that met the criteria for consideration as environmental justice communities.

It should be noted that the information above pertains to those counties that met or exceeded thresholds for total Indigenous populations. Additional Tribal populations at the Tribe and reservation levels are identified in the *Tribal Populations* section below.

### *Low-Income Population*

All 11 counties in the analysis area had low-income populations that exceeded their respective state averages (Arizona: 30.8 percent; New Mexico: 38.8 percent; and Utah: 23.9 percent). As such, all counties had low-income populations that met the criteria for consideration as environmental justice communities. The total low-income population ranged from 26.4 percent in Washington County, Utah, to 59.0 percent in McKinley County, New Mexico. **Map 3-3** displays low-income populations at the census tract level.

### *Tribal Populations*

As described above, two counties had Indigenous populations that did not exceed their respective state averages. In Mohave County, Arizona, the total Indigenous population was 3.7 percent in 2022, falling below the state average of 5.9 percent. While the meaningfully greater criteria for Indigenous populations were not met at the county level, it is important to note that the county overlaps the Kaibab, Fort Mohave, and Hualapai Indian Reservations. Reservations meet the criteria for further consideration as environmental justice populations. Similarly, in Washington County, Utah, the total Indigenous population was 2.0 percent in 2022, falling below the state average of 2.1 percent.

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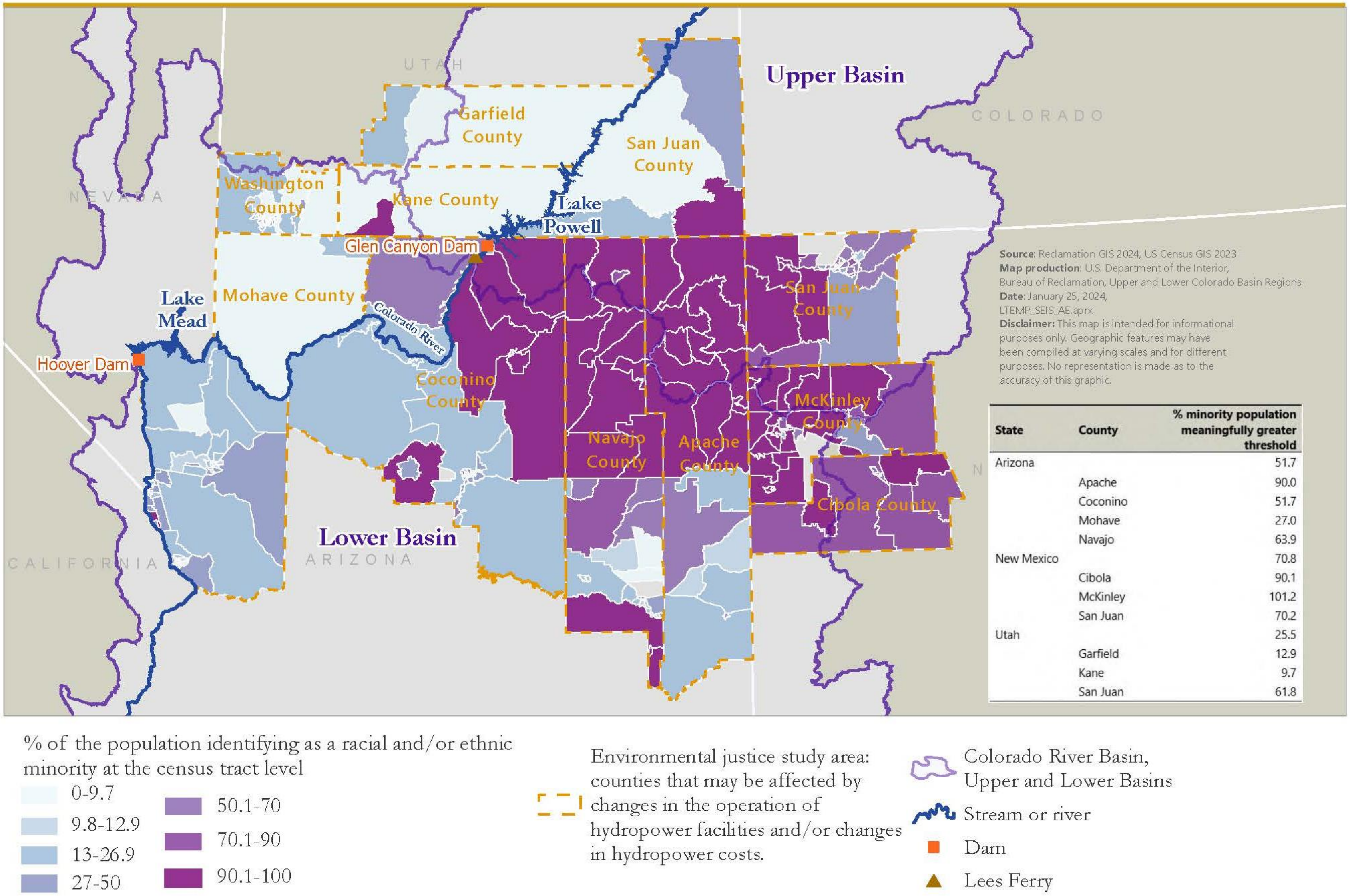
## Map 3-1: Minority Populations for Environmental Justice Consideration




| State | County | % minority population meaningfully greater threshold |
|---|---|---|
| Arizona | | 51.7 |
| | Apache | 90.0 |
| | Coconino | 51.7 |
| | Mohave | 27.0 |
| | Navajo | 63.9 |
| New Mexico | | 70.8 |
| | Cibola | 90.1 |
| | McKinley | 101.2 |
| | San Juan | 70.2 |
| Utah | | 25.5 |
| | Garfield | 12.9 |
| | Kane | 9.7 |
| | San Juan | 61.8 |

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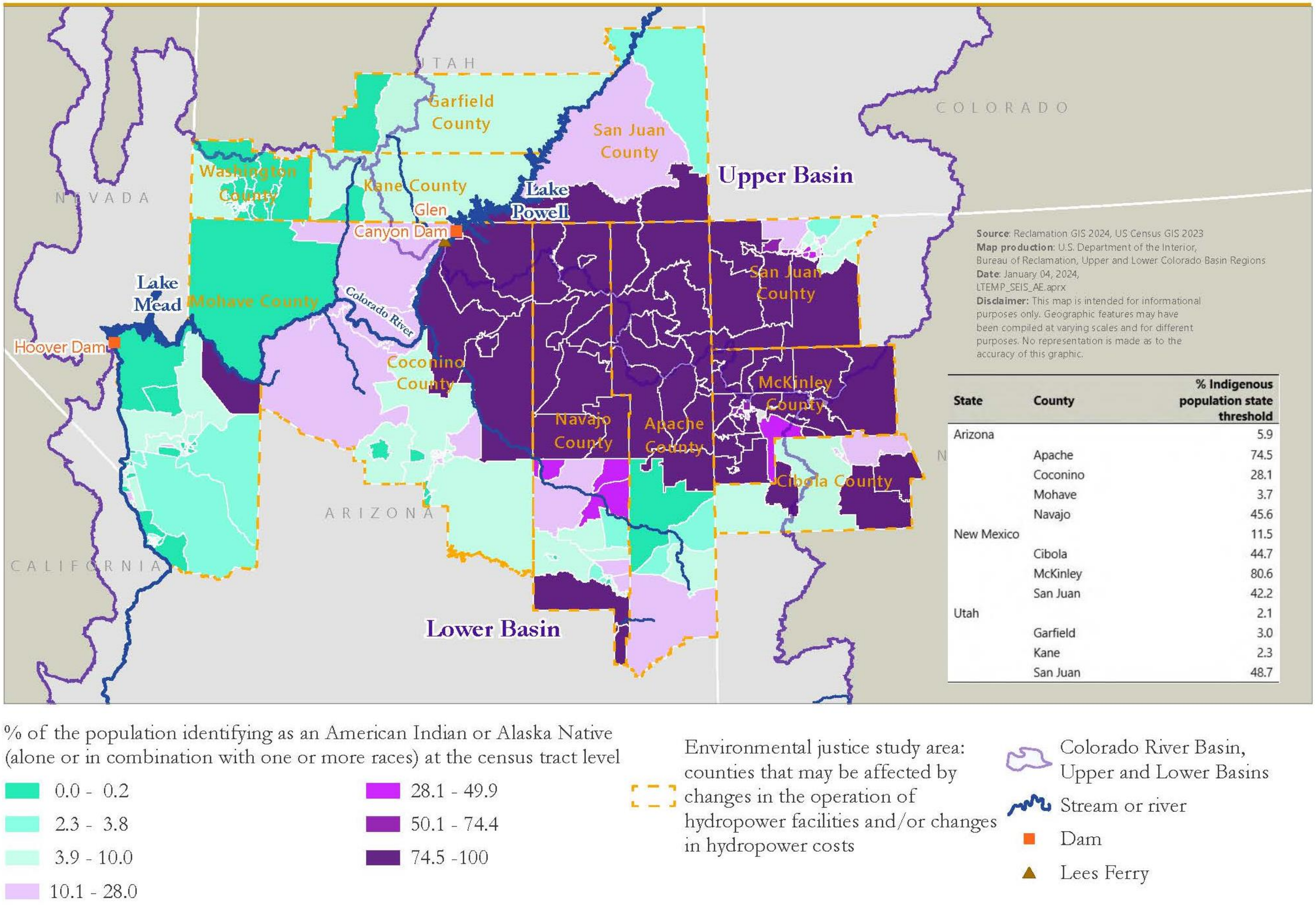
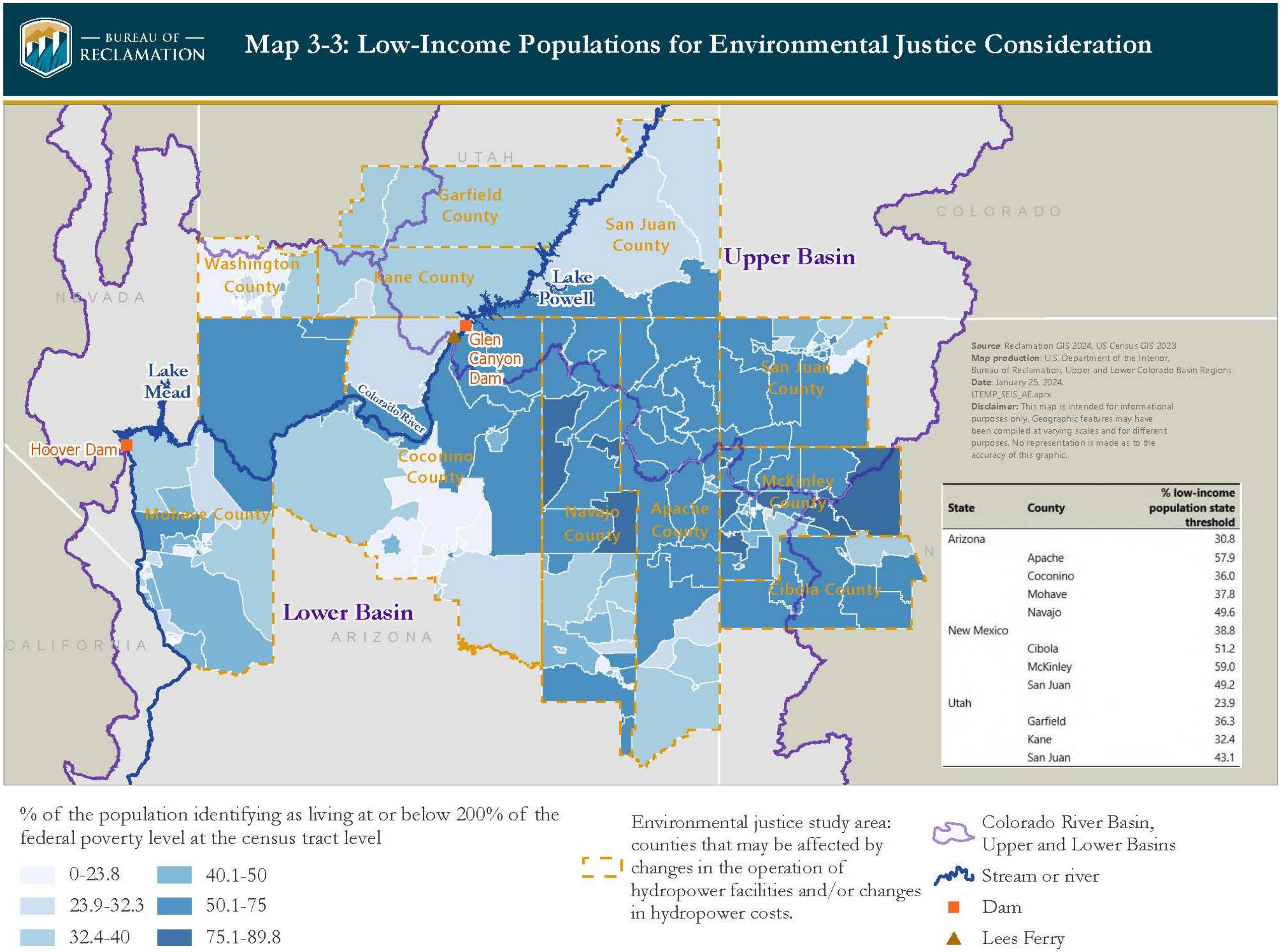
## Map 3-2: Indigenous Populations for Environmental Justice Consideration




| State | County | % Indigenous population state threshold |
|---|---|---|
| Arizona | | 5.9 |
| | Apache | 74.5 |
| | Coconino | 28.1 |
| | Mohave | 3.7 |
| | Navajo | 45.6 |
| New Mexico | | 11.5 |
| | Cibola | 44.7 |
| | McKinley | 80.6 |
| | San Juan | 42.2 |
| Utah | | 2.1 |
| | Garfield | 3.0 |
| | Kane | 2.3 |
| | San Juan | 48.7 |

## Map 3-3: Low-Income Populations for Environmental Justice Consideration




| State | County | % low-income population state threshold |
|---|---|---|
| Arizona | | 30.8 |
| | Apache | 57.9 |
| | Coconino | 36.0 |
| | Mohave | 37.8 |
| | Navajo | 49.6 |
| New Mexico | | 38.8 |
| | Cibola | 51.2 |
| | McKinley | 59.0 |
| | San Juan | 49.2 |
| Utah | | 23.9 |
| | Garfield | 36.3 |
| | Kane | 32.4 |
| | San Juan | 43.1 |

However, a portion of the Paiute Indian Reservation is in western Washington County and would be considered an environmental justice population for further consideration.

Apache and Coconino, Arizona; Cibola County, New Mexico; and Kane County, Utah, had Indigenous populations that exceeded environmental justice thresholds. Within these counties, there are Hopi Tribe, Havasupai Tribe, Hualapai Tribe, Navajo Nation, Pueblo of Zuni, and Southern Paiute Consortium Tribal reservation and off-reservation trust lands. As described in **Section 3.13.1**, the Havasupai Tribe, Hopi Tribe, Hualapai Tribe, Navajo Nation, Pueblo of Zuni, and Southern Paiute Consortium all have strong cultural ties to the Colorado River. **Section 3.12** and **Section 3.13** provide more detailed information on cultural and Tribal resources.

Additionally, Tribal members receive hydropower from WAPA, including hydropower from Glen Canyon Dam. Glen Canyon Dam is one component of a larger hydropower system and is included with other powerplants for marketing purposes. Capacity and energy from Glen Canyon Dam are bundled and marketed by WAPA as the Salt Lake City Area Integrated Projects (SLCA/IP) to consumers across Arizona, Colorado, Nebraska, New Mexico, Nevada, Utah, and Wyoming.

In the 2016 LTEMP FEIS, Tribal populations with the potential to be affected by project management include those who receive annual SLCA/IP allocations. The 2016 LTEMP FEIS (DOI 2016a, Appendix K, Attachment 12) provides a comprehensive list of the annual SLCA/IP allocations to American Indian Tribes and benefit information. The Tribes/Tribal entities identified are also listed below:

- Ak-Chin Indian Community
- BIA Colorado River Agency
- San Carlos Irrigation Project
- Alamo Navajo Chapter
- Canoncito Navajo Chapter
- Cocopah Indian Tribe
- Colorado River Indian Tribes
- Confederated Tribes of the Goshute Reservation
- Duckwater Shoshone Tribe
- Ely Shoshone Tribe
- Fort Mojave Indian Tribe
- Fort McDowell Yavapai Nation Gila River Indian Community
- Havasupai Tribe
- Hopi Tribe
- Hualapai Tribe
- Jicarilla Apache Tribe
- Las Vegas Paiute Tribe
- Mescalero Apache Tribe
- Nambe Pueblo
- Navajo Agricultural Products Industries
- Navajo Tribal Utility Authority
- Paiute Indian Tribe of Utah
- Pascua Yaqui Tribe
- Picuris Pueblo
- Pueblo De Cochiti
- Pueblo of Acoma
- Pueblo of Isleta
- Pueblo of Jemez
- Pueblo of Laguna
- Pueblo of Pojoaque
- Pueblo of San Felipe
- Pueblo of San Ildefonso
- Pueblo of San Juan
- Pueblo of Sandia
- Pueblo of Santa Clara

- Pueblo of Santa Domingo
- Pueblo of Taos
- Pueblo of Tesuque
- Pueblo of Zia
- Pueblo of Zuni
- Quechan Indian Tribe
- Ramah Navajo Chapter
- Salt River Pima-Maricopa Indian Community
- San Carlos Apache Tribe
- Santa Ana Pueblo
- Skull Valley Band of Goshute Indians
- Southern Ute Indian Tribe
- Tohono O'odham Utility Authority
- Tonto Apache Tribe
- Ute Indian Tribe
- Ute Mountain Ute Tribe
- White Mountain Apache Tribe
- Wind River Reservation
- Yavapai Apache Nation
- Yavapai Prescott Indian Tribe
- Yomba Shoshone Tribe

Tribes receive a significant portion of their electricity from WAPA. When originally allocated in 2022, WAPA anticipated serving about 55.7 percent of total Tribal electric use in the summer season and 58.8 percent in the winter season to the 57 Tribes or Tribal entities currently receiving an allocation of power from SLCA/IP, which includes power from Glen Canyon Dam. Over the past 20 years, Tribal load growth and reductions in hydropower due to drought have reduced that original percentage.

Ten Tribes or Tribal entities operate their own electric utilities and receive power directly from WAPA. Power received directly from WAPA tends to be lower cost than power from other resources. A reduction in WAPA power allocation, therefore, would translate into higher costs for Tribal utilities, unless other compensation was provided.

The remaining 47 Tribes have a benefit crediting arrangement. In a benefit crediting arrangement, the Tribe's electric service supplier takes delivery of the SLCA/IP allocation and in return gives an economic benefit or a payment to the Tribe. In other words, for Tribal customers without utility status, WAPA enters into third-party arrangements with the Tribe and another utility that can receive delivery of the power. Ideally, arrangements are made with public power utilities in areas that receive an allocation of power from WAPA, such as a rural electric cooperate or municipality (however, exceptions apply for various reasons). Under benefit crediting agreements, the traditional utility receives WAPA power on behalf of the Tribe; subsequently, the utility receives the benefit of the power and transfers the economic benefit of federal hydropower to the Tribe.

### 3.16.2 Environmental Consequences

The analysis of potential environmental justice impacts follows guidelines described in the CEQ's Environmental Justice Guidance under the National Environmental Policy Act (CEQ 1997). To comply with Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (59 *Federal Register* 7629, February 11, 1994), Executive Order 14096 Revitalizing Our Nation's Commitment to Environmental Justice for All (88 *Federal Register* 25251, April 21, 2023), the CEQ (1997) instructs agencies to determine whether minority or low-income populations might be affected by a proposed action and, if so, whether there might be disproportionate and adverse human health or environmental effects on them. The analysis method has three parts: (1) a description of the geographic distribution of low-income and minority populations in the affected area; (2) an assessment to determine whether the impacts of changes in operation would produce impacts that are adverse; and (3) if impacts are adverse, a determination as to whether these impacts would disproportionately affect minority and low-income populations.

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 the potential for disproportionate adverse impacts on identified environmental justice communities. The environmental consequences analysis also incorporates information by reference from the 2016 LTEMP FEIS and the SMB EA (Reclamation 2023b), where applicable.

#### Impact Analysis Area

The impact analysis area is the same as that described in **Section 3.16.1**. The analysis of environmental justice issues considered impacts within the 11-county environmental justice analysis area in which disproportionate and adverse human health and environmental effects on minority and low-income populations may occur (including Apache, Coconino, Mohave, and Navajo counties in Arizona; Cibola, McKinley, and San Juan counties in New Mexico; and Garfield, Kane, San Juan, and Washington counties in Utah).

Other potential impacts related to environmental justice include changes in Tribal electricity retail rates and impacts on Tribal resources and values. Using CEQ guidelines, the impact assessment determined whether each alternative would produce impacts that are adverse. If impacts were adverse, a determination was made as to whether these impacts would disproportionately affect minority and low-income populations by comparing the proximity of locations where any adverse impacts are expected with the location of low-income and minority populations. If impacts are not adverse, there can be no disproportionate impacts on minority and low-income populations.

#### Assumptions

- Information to determine exactly which facilities at which replacement generation would occur is not available. All replacement generation would occur in the WECC region.

#### Impact Indicators

- Disproportionate and adverse human health or environmental impacts

### *Issue 1: How would changes in hydropower generation affect environmental justice communities?*

#### No Action Alternative

As described in **Sections 3.3.2** and **3.15.2**, no changes would be made to Glen Canyon Dam operations under the No Action Alternative. Power generation would continue, similar to historical levels, with slight variations dependent on water availability and the constraints outlined in the 2016 LTEMP FEIS. Revenue from energy sales would also continue to be generated similar to historical levels, with slight variations dependent on consumer demands, generation levels, and the constraints outlined in the 2016 LTEMP FEIS.

As described in **Section 3.9.2**, the existing air quality conditions would continue for communities near Glen Canyon Dam, including environmental justice communities, and there would be no change in emissions of criteria pollutants due to changes at the Glen Canyon Dam facility.

Under the No Action Alternative, there would be no disproportionate adverse impacts on minority or low-income populations.

**Impacts Common to the Cold-Water Alternatives**

Compared with current conditions, all four cold-water alternatives would include passing more water through the river outlet works where energy is not generated. Each flow scenario studied would reduce the energy generation and increase the amount of replacement energy required to meet demand in the interconnected transmission and distribution system. Under all cold-water alternatives, there is the potential for direct, indirect, and cumulative impacts on environmental justice communities as a result of changes to Glen Canyon Dam operations. These include financial impacts, an accelerated potential for financial impacts on environmental justice communities, changes to air quality through air emissions from replacement power, changes to Tribal resources, changes to regional economic activity related to recreation, and changes to use and nonuse values (refer to **Sections 3.3**, **3.9**, **3.13**, and **3.15**).

As described in **Section 3.3.2**, changes in operation at Glen Canyon Dam would reduce available generating capacity at Glen Canyon Dam to varying degrees under all cold-water alternatives. Bypassing water around the generators would result in a reduction in power generation and a financial impact to the Basin Fund; because WAPA purchases replacement power to cover the lost generation during experimental releases under the GCPA. Since the passage of the GCPA, WAPA has accounted for the financial impacts of experimental releases at Glen Canyon Dam as nonreimbursable expenses and constructive returns to the Treasury. More detailed information is provided in **Section 3.3.1**.

Therefore, under the alternatives with bypass that require replacement power purchases, WAPA would purchase replacement power on the market to ensure customers, including Tribes, receive power and energy as if the bypass had not occurred. While the financial impacts from the cold-water alternatives would vary, depending on the reduction in the amount of power generated and the cost to purchase power from replacement sources, environmental justice communities would not experience direct financial impacts. The Basin Fund would incur the financial impacts, with no financial impacts anticipated to environmental justice communities. It is anticipated that in 2024, customers, including Tribes with benefit crediting contracts, would receive their power as if no bypass had occurred. Further, a reduction in WAPA power from Glen Canyon Dam output would not impact the benefit crediting agreements in 2024.

If the Basin Fund were to reach a level at which there were insufficient funds for WAPA to purchase replacement power through 2027, there is the potential for customers to experience direct financial impacts resulting from the cold-water alternatives. The potential for this to occur depends on several factors and cannot be quantified. Such factors that would impact the potential for the Basin Fund to reach a level in which funds were insufficient include, but are not limited to, the current balance of the Basin Fund at the time of bypass, the frequency of implementing bypass experiments, the timing and duration of the bypass, unanticipated Basin Fund expenses, and variations in economic conditions. While quantifying the potential for this scenario to occur is not possible, because the potential for this scenario to occur is partly dependent on the availability of funds via the Basin Fund, the alternatives are compared by the degree to which they would increase or decrease the potential time frame for reaching a critical level in the Basin Fund.

Reclamation would use adaptive management to minimize the potential for the Basin Fund to reach a level at which direct financial impacts on consumers would occur (see **Section 2.2**.). The status of the Basin Fund would be considered during implementation, as described in **Section 2.2**. As noted in **Section 2.3.1**, Planning and Implementation, Reclamation will analyze and consider impacts on environmental justice communities and Tribal concerns during the planning and implementation process in future years.

Further, impacts on environmental justice communities resulting from reduced power generation and the resulting financial impacts in future years would also depend on the degree to which environmental justice populations within the analysis area rely on power generation from Glen Canyon Dam and the associated revenue. As noted in the 2016 LTEMP FEIS, the amount of power sold by WAPA to customer utilities varies considerably (DOI 2016a, 4-383). Potential impacts would be experienced to a different degree by some utility groups. For instance, utility groups that are allocated a large fraction of their generation resources from the Salt Lake City Area Integrated Projects include Tribal utilities and other small utilities (DOI 2016a, 4-383).

Environmental justice communities, including Tribal communities, may have less capacity to compensate for impacts resulting from changes to Glen Canyon Dam operations. More detailed information can be found in Appendix K of the 2016 LTEMP FEIS, as well as in **Section 3.3**.

As described in **Section 3.9.2**, reductions in hydropower generation from Glen Canyon Dam resulting from proposed flow alterations would result in air quality impacts due to the need for replacement power using generation sources with greater air emissions. Replacement power would most likely be provided from natural gas powerplants, with a smaller portion supplied by coal-fired powerplants. Renewable generation such as wind, solar, or other sustainable sources may also be used for replacement power. Specific impacts on environmental justice communities would depend on the replacement energy source, location of emissions, and proximity to environmental justice communities.

The Plexos modeling results provide additional analysis on replacement power, such as the types of generation facilities (solar, natural gas, coal, etc.). However, information on exactly which facilities would be used would be determined on a case-by-case basis and depend on specific generation availability at the time of bypass; see **Section 3.3** for additional information. Because potential air quality impacts are anticipated to be negligible, environmental justice communities would not experience disproportionate adverse air quality impacts.

**Impacts Common to All Action Alternatives**

All action alternatives would involve changes to Glen Canyon Dam operations to disrupt smallmouth bass spawning. As described in **Section 3.13.2**, the action alternatives would result in negligible impacts on Tribal resources, including TCPs and cultural resources. However, under all action alternatives, there could be smallmouth bass mortality and/or deterrence of smallmouth bass spawning. Fish mortality would disproportionally impact Tribal populations (for instance, the Pueblo of Zuni hold the Canyons sacred and view fish mortality as an adverse impact on the TCP [the Colorado River]). Overall, potential impacts on Tribal resources are not anticipated to result in disproportionate, adverse impacts on environmental justice communities.

As described in **Section 3.13.2** and **Section 3.14.2**, all action alternatives would contribute to the prevention of smallmouth bass establishment below Glen Canyon Dam, thereby contributing to the protection of native fish populations. Additionally, under all action alternatives, cold water below Glen Canyon Dam during and after releases would benefit rainbow trout populations and temporarily restore ecological processes toward pre-drought conditions. All communities, including environmental justice communities, could benefit from the aforementioned impacts. None of the action alternatives are anticipated to affect the regional economy resulting from boating in the Grand Canyon; as a result, there would be no subsequent impacts on environmental justice communities.

Potential impacts on environmental justice communities that differ among the action alternatives are discussed below.

**Cool Mix Alternative**

As discussed in *Impacts Common to the Cold-Water Alternatives*, due to WAPA's purchase of replacement power on the market, under the Cool Mix Alternative, customers would receive their power as if no bypass had occurred, including Tribes with benefit crediting agreements in 2024. Compared with the other action alternatives, the Cool Mix Alternative would result in the most impacts on power generation. Because financial impacts are directly correlated with impacts from power generation, the Cool Mix Alternative would result in financial impacts due to the loss in economic value of electric energy. Of the action alternatives, the Cool Mix Alternative would result in the most financial impacts (see **Section 3.3.2**). A reduction in power generation capacity would need to be replaced by purchases and generation from other sources. Because WAPA would purchase replacement power to cover the lost generation to firm energy contracts during experimental releases, these financial impacts would be to the Basin Fund. Therefore, environmental justice communities, including Tribes, are not anticipated to be impacted.

As noted in **Section 3.3.2**, replacement energy sources needed to cover decreases in power generation, ultimately leading to decreased funds available in the Basin Fund, could result in an increased potential for direct financial impacts on customers in future years. As a result, the Cool Mix Alternative could accelerate the potential for direct financial impacts on environmental justice communities in future years, should the Basin Fund reach a critically low point. Reclamation would use adaptive management to minimize the potential for the Basin Fund to reach a level at which direct financial impacts on consumers would occur. Additionally, Reclamation will analyze and consider impacts on environmental justice communities and Tribal concerns during the planning and implementation process. The Cool Mix Alternative would result in the most impacts on the Basin Fund, which could contribute to an increased risk for potential impacts on environmental justice communities.

The Cool Mix Alternative would result in the greatest increase in air emissions and other criteria pollutants compared with the No Action Alternative. As such, potential air quality impacts on environmental justice communities would be greater under the Cool Mix Alternative than under the No Action Alternative.

As described in **Section 3.5**, under the Cool Mix Alternative, reduced water temperatures would improve water quality for rainbow trout, which would likely increase angler satisfaction in the short and long term. Impacts on boating, the rafting concessionaire, and camping in the Glen Canyon reach, as well as whitewater boating and camping in the Grand Canyon, would be similar to those described under the No Action Alternative. As a result, there would be no recreational impacts on environmental justice communities.

### Cool Mix with Flow Spike Alternative

Impacts on environmental justice communities would be similar to those discussed under the Cool Mix Alternative. As described in **Section 3.3**, the Cool Mix with Flow Spike Alternative would result in the second-most impacts on power generation and the second-most financial impacts. Because WAPA would purchase replacement power to cover the lost generation to firm energy contracts during experimental releases, these financial impacts would be to the Basin Fund. Therefore, environmental justice communities, including Tribes, are not anticipated to be impacted.

However, the Cool Mix with Flow Spike Alternative could accelerate the potential for direct financial impacts on environmental justice communities in future years, should the Basin Fund reach a critically low point. Reclamation would use adaptive management to minimize the potential for the Basin Fund to reach a level at which direct financial impacts on consumers would occur. Additionally, Reclamation will analyze and consider impacts on environmental justice communities and Tribal concerns during the planning and implementation process. The Cool Mix with Flow Spike Alternative would result in the second-most impacts on the Basin Fund, which could contribute to an increased risk for potential financial impacts on environmental justice communities.

Additionally, while flow spikes would benefit rainbow trout populations, they may reduce the quality of recreational experiences in terms of fishing access. For environmental justice communities, impacts on fishing access could be experienced differently. For instance, a low-income community could be less able to adjust to access issues that require them to travel farther or utilize more financial resources to maintain access.

### Cold Shock Alternative

As described in **Section 3.3**, the Cold Shock Alternative would have the third-most impacts on modeled power generation and would result in the third-most financial impacts on the Basin Fund due to WAPA's purchase of replacement power to cover lost generation during experimental releases. It is anticipated that in 2024, customers, including Tribes with benefit crediting contracts, would receive their power as if no bypass had occurred. As such, environmental justice communities, including Tribes, are not anticipated to be impacted.

However, the Cold Shock Alternative could accelerate the potential for direct financial impacts on environmental justice communities in future years, should the Basin Fund reach a critically low point. Reclamation would use adaptive management to minimize the potential for the Basin Fund to reach a level at which direct financial impacts on consumers would occur. Additionally, Reclamation will analyze and consider impacts on environmental justice communities and Tribal concerns during the planning and implementation process in future years. As stated above, the Cold Shock Alternative would result in the third-most impacts on the Basin Fund; this could contribute to an increased risk for potential financial impacts on environmental justice communities.

#### Cold Shock with Flow Spike Alternative

As described in **Section 3.3**, the Cold Shock with Flow Spike Alternative would have the least impacts on power generation out of all the cold-water alternatives. Compared with the other cold-water alternatives, the Cold Shock with Flow Spike Alternative would result in the least financial impacts on the Basin Fund due to WAPA's purchase of replacement power to cover lost generation during experimental releases. It is anticipated that in 2024, customers, including Tribes with benefit crediting contracts, would receive their power as if no bypass had occurred. As such, environmental justice communities, including Tribes, are not anticipated to be impacted.

However, the Cold Shock with Flow Spike Alternative could accelerate the potential for direct financial impacts on environmental justice communities in future years, should the Basin Fund reach a critically low point. Reclamation would use adaptive management to minimize the potential for the Basin Fund to reach a level at which direct financial impacts on consumers would occur. Additionally, Reclamation will analyze and consider impacts on environmental justice communities and Tribal concerns during the planning and implementation process in future years. The Cold Shock with Flow Spike Alternative would have the second-fewest impacts on the Basin Fund, which could contribute to the increased risk for potential financial impacts on environmental justice communities.

Short-term impacts on environmental justice communities as a result of changes to fishing access would be the same as those described under the Cool Mix with Flow Spike Alternative.

#### Non-Bypass Alternative

Compared with the all other alternatives, impacts on recreation would be greatest under the Non-Bypass Alternative; however, this alternative would result in the fewest impacts on hydropower generation and the economic value of electric energy. This is because the Non-Bypass Alternative explores a hydropower flow option that does not involve the use of Glen Canyon Dam's bypass system and instead focuses on changes in release volumes to disturb smallmouth bass spawning. Because the bypass system would not be used, there would be changes in release volume. Under this alternative, there would be an estimated economic value gain for electric energy of around $0.97 million compared to the No Action Alternative.

Compared with the action alternatives, the Non-Bypass Alternative would result in the fewest potential financial impacts on environmental justice communities. All communities, including environmental justice communities, could potentially experience economic benefits under this alternative. However, the estimated economic value gain for electric energy would be a minimal change from the No Action Alternative.

As described in **Section 3.9.2**, under the Non-Bypass Alternative, the total LTEMP-related average air emissions would be reduced over the 5-year project timeline. Therefore, under this alternative, there is a potential for improved air quality. All communities, including environmental justice communities, could benefit from potential air emissions reductions. Under the Non-Bypass Alternative, there would be no disproportionate impacts on environmental justice communities.

As described in **Section 3.13.2**, the Non-Bypass Alternative would have the greatest potential impacts on fish and subsequent impacts on life. Some Tribal populations, such as the Pueblo of Zuni, experience adverse physical, mental, and psychological effects associated with fish mortalities and disruption to the fish life cycle. As a result, the Non-Bypass Alternative would result in the greatest potential for disproportionate impacts on some Tribal populations from fish mortality.

As described in **Section 3.5.2**, the Non-Bypass Alternative would be less likely to benefit the rainbow trout fishery by reducing water temperatures, compared with the cold-water alternatives. The low flows under this alternative would result in short-term impacts on boating, whitewater boating, and rafting access. Therefore, this alternative would result in the most potential for recreational impacts on environmental justice communities.

**Cumulative Effects**

As described in **Section 3.13.1**, cumulative impacts on Tribal values would occur under the alternatives that disrupt spawning or result in fish mortality. The Pueblo of Zuni, in particular, have linked fish mortality in the Canyons with adverse physical, mental, and psychological effects within the Pueblo of Zuni. Because the action alternatives could result in the taking of life within the Canyons, the Pueblo of Zuni indicated that the action alternatives would have an adverse impact on the Pueblo of Zuni culture and TCPs if Reclamation implements the flow options with expected fish mortality (see **Section 3.13.2**).

To assess whether environmental justice populations are particularly vulnerable and, as a result, likely to experience disproportionate adverse impacts in terms of resources and resource uses, it is helpful to consider sensitivity and exposure to potential impacts. Environmental justice populations, including Tribal populations, may be impacted in ways the general population is not. As noted above, the Pueblo of Zuni have the potential to be affected by changes to flow operations. Further, because of the cultural and spiritual connection to life within the Canyons, the magnitude of impacts is increased for the Pueblo of Zuni, resulting in increased sensitivity to potential fish mortality.

Therefore, cumulative disproportionate, adverse impacts on environmental justice communities, such as the Pueblo of Zuni, would occur under the action alternatives.

Additionally, socioeconomic and environmental trends independent of this SEIS will contribute to cumulative effects. Electricity generation and human health in the Southwest are inextricably linked to water resources. In the Southwest, severe drought, aridification, wildfires, and temperatures have increased and are anticipated to continue to increase, and the area will remain vulnerable to water shortages and changes in hydrologic conditions. Trends of population growth have affected—and will continue to affect—the demand for electricity. Environmental justice communities, including Tribal communities, 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 (EPA 2017; USGCRP 2018; CDC 2021).

Potential impacts from the action alternatives would contribute to the cumulative effects of and be compounded by other state and federal projects related to water resources in the Lower and Upper Colorado River Basin, including those in the environmental justice analysis area. For example, in 2024, Reclamation published the Interim Guidelines SEIS. The environmental justice analysis area for this SEIS and the Interim Guidelines SEIS overlap. The Interim Guidelines SEIS noted the potential for impacts on environmental justice communities associated with potential water shortages from annual release volumes (Reclamation 2024d). The modeled water shortages analyzed in the Interim Guidelines SEIS are separate from this SEIS because LTEMP only analyzes sub-annual releases, as discussed in **Section 1.8**. However, it is important to consider that changes in hydropower generation from the action alternatives are a component of the existing and potential future challenges related to Colorado River water resources that exist for environmental justice communities in the Southwest, including within the environmental justice analysis area.

### *Summary*

Under all cold-water alternatives, there is the potential for direct, indirect, and cumulative impacts on environmental justice communities as a result of changes to Glen Canyon Dam operations and reduced energy generation. For the cold-water alternatives, these include some potential for direct financial impacts on power customers through 2027, changes to air quality from replacement power sources, changes to Tribal resources, changes to regional economic activity related to recreation, and changes to use and nonuse values (see **Sections 3.3**, **3.9**, **3.13**, and **3.15**). For the Non-Bypass Alternative, potential direct, indirect, and cumulative impacts on environmental justice communities as a result of changes to Glen Canyon Dam operations would include changes to Tribal resources, potential air emissions reductions, increased power generation, potential gains in the economic value of electric energy, changes to regional economic activity related to recreation, and changes to use and nonuse values.

Because all 11 counties in the environmental justice analysis area meet one or more criteria for consideration as environmental justice populations, the action alternatives would impact environmental justice populations. Impacts on environmental justice communities would vary depending on capacity and revenue loss. No impacts are anticipated in 2024, and Reclamation will analyze and consider impacts during the planning and implementation process.

Changes in river and reservoir recreational visitation might disproportionately impact low-income and minority populations, including Tribal communities, in the environmental justice analysis area. Temporary changes in access to culturally important Tribal resources and other areas of significance to Tribes may also impact Tribal members.

Overall, for the majority of resources and resource uses, impacts on minority, low-income, and Indigenous populations are not anticipated to be disproportionately adverse.

# 3.17 Climate Change

## 3.17.1 Affected Environment

Changes in operations at Glen Canyon Dam may have the potential to alter GHG emissions from other sources of electricity, which can produce different levels of GHGs compared with hydroelectric power. Glen Canyon Dam Powerplant reduces carbon dioxide ($CO_2$) emissions by about 1.4 to 3.5 million metric tons in an average year compared with fossil fuel powered generation sources (DOI 2016a, Section 3.16), equating to about 0.1 to 0.3 percent of the 11-state total emissions (EPA 2023a).

The project area is within the Lower Colorado River Basin, where climatic conditions are driven by topography. Higher elevations are characterized by cold winters, cool summers, and abundant precipitation as snowfall, while lower elevations are characterized by mild winters, hot summers, and low rainfall (DOI 2016a, Section 3.1.3). The arid Lower Colorado River Basin experiences episodes of intense drought and precipitation. Mid- to late summers (July–September) are marked by late-afternoon thunderstorms of the North American monsoon season, supplying 30 to 50 percent of annual precipitation. Elevation dramatically shapes the amount of precipitation and its relative contribution to runoff, with 85 percent of annual runoff coming from the 15 percent of the Basin's area that is in the mountain headwaters (Kunkel et al. 2022).

Climate change is having serious consequences on the region's scarce water supplies. Higher temperatures have resulted in the region's aridification. Aridification describes a period of transition and an evolving baseline to an increasingly water-scarce environment, characterized by extreme events such as droughts and floods (Colorado River Research Group 2018). Snowpack at high elevations plays a critical role in supplying water for lower arid regions. Warming temperatures have led to decreases in snowpack, earlier snowmelt, higher-elevation snow lines, more winter rain events, increased peak winter river flows, and reduced summer flows. Earlier spring snowmelt and higher temperatures during the summer can increase the number of forest fires. Impurities in snow, such as dust or soot, enhance solar radiation absorption and melting rates. Sources of dust deposited on snowpack in the high mountains likely include nearby lands where soil-disturbing activities[37] have made the land susceptible to wind erosion; dust from the deserts of the Colorado Plateau carried by prevailing westerlies; and, to some extent, dust from other southwestern deserts (USGCRP 2023).

Climate change refers to the change in the state of the climate, as determined by changes in its properties (for example, temperature or precipitation) that persist for an extended period (IPCC 2021). Humans are estimated to have caused approximately 1.1°C (1.8°F) of global warming above preindustrial levels. At the current rate of warming, the temperature increase is likely to reach 1.5°C (2.7°F) in the near term (2024–2040). Observed increases in GHG concentrations since around

[37] Activities such as exploration and development of energy resources, off-road vehicle use, agriculture, and grazing serve to destabilize soils, making them more susceptible to wind erosion (Duniway et al. 2019).

1750 are unequivocally caused by human activities (IPCC 2021). GHGs trap absorbed radiation and result in warming of the atmosphere. The principal GHGs that enter the atmosphere due to human activities, including fossil fuel power generation, include $CO_2$, $CH_4$, nitrous oxide ($N_2O$), and other trace gases.

In 2021, Reclamation updated the climate and hydrology projections across the West using approaches that align with previous Intergovernmental Panel on Climate Change reports (IPCC 2011, 2018) and new techniques, data, and analyses. Under scenarios with higher GHG concentrations, increases in temperature are more severe (warmer) than in scenarios with lower GHG concentrations. In both the higher and lower scenarios, average temperatures are projected to increase across the West, and annual precipitation is projected to decline in the Southwest (Reclamation 2021b).

## 3.17.2 Environmental Consequences

### *Methodology*

The analysis of GHG emissions and climate change was conducted based on the latest CEQ guidance (which improves transparency in reporting impacts). This guidance recommends that the NEPA analyses incorporate a quantitative climate change analysis in planning and environmental review processes, as appropriate, including the reporting of GHG emissions and the social cost of GHGs to disclose climate impacts (CEQ 2023).

Potential impacts on climate change associated with dam operations were compared in terms of GHG emissions for each alternative relative to emissions for the No Action Alternative. Glen Canyon Dam operations do not generate GHG emissions, but dam operations can indirectly affect climate change, regionally and globally, through varying contributions to the total mix of power generation in the region, which also includes coal-fired, natural gas-fired, hydroelectric, nuclear, and renewable generation sources. Similar to air emission factors, average GHG emission factors over the life of Glen Canyon Dam were assumed to present a reasonable approximation. Over time, older and higher-emitting facilities will be replaced by new zero- or lower-emission sources, and emissions-reduction equipment on existing facilities will be upgraded.

To compute total GHG emissions under the alternatives, emissions were estimated using the methodology outlined in **Section 3.9**, Air Quality, for estimating air emissions, which used both the WECC eGRID composite (all generation source types) emission factors, as well as the WECC eGRID emission factors specific to coal power generation sources (coal power generation emission factors were used to represent the highest emissions scenario). Composite electric generation GHG emission factors from the WECC region for 2021 were calculated to be 723.38 lb/MWh for $CO_2$, 0.057 lb/MWh for $CH_4$, and 0.008 lb/MWh for $N_2O$. Coal power generation emission factors from the WECC region for 2021 were calculated to be 2,293 lb/MWh for $CO_2$, 0.254 lb/MWh for $CH_4$, and 0.037 lb/MWh for $N_2O$.

To compare various GHGs' heat-trapping impacts and estimate their total effect on climate change, a measure used is $CO_2e$, which is defined as the ratio of heat trapped by one unit mass of the GHG to that of one unit mass of $CO_2$ over a specific time period. This analysis uses the conversion factors from the Intergovernmental Panel on Climate Change Sixth Assessment Report ($CO_2$ equals 1 for both 100- and 20-year time frames; $CH_4$ equals 29.8 for a 100-year time frame and 82.5 for a 20-year time frame; and $N_2O$ equals 273 for both 100- and 20-year time frames) (IPCC 2021). To provide a familiar comparison of GHGs generated, the 20-year $CO_2e$ value for both emission scenarios under each alternative was entered into the EPA Greenhouse Gas Equivalencies Calculator (EPA 2024) to calculate the number of gasoline-powered passenger vehicles and the number of natural gas-fired powerplants that would generate equivalent annual emissions.

### Impact Analysis Area

Emissions of GHGs ($CO_2$, $CH_4$, and $N_2O$) are considered on a regional 11-state area; replacement power generation facilities may be located anywhere in the region. While climate change is a global issue, impacts on GHG emissions resulting from the proposed alternatives would occur within this region.

### Assumptions

- The local climate would follow existing trends.
- The reservoir level would not change significantly under any proposed alternative.
- Power replacement would be 1:1 (that is, 1 MWh of generation lost from Glen Canyon Dam would be replaced by 1 MWh from another facility).
- Information to determine exactly which facilities at which replacement generation would occur is not available. All replacement generation would occur in the WECC region. Additional information on replacement power can be found in the Plexos modeling report (Veselka et al., forthcoming).
- The average GHG emissions per MWh from power generation on the regional grid will not change significantly during the temporal extent of the smallmouth bass flow experiments.

### Impact Indicators

- Change in the expected amount of power produced in MWh and the GHG emissions produced to generate an equivalent amount of replacement power from other generation types

## *Issue 1: How would flow alterations at the Glen Canyon Dam affect climate change through changes to GHG emissions?*

### No Action Alternative

Under the No Action Alternative, the existing level of hydropower generation would continue at its current level; therefore, as shown in **Table 3-53**, there would be zero emissions of additional GHGs from other power generation sources under this alternative.

**Table 3-53**
**No Action Alternative GHG Emissions**

| GHGs | Grid Generation Average Emissions Scenario | Coal Generation Average Emissions Scenario |
|---|---:|---:|
| $CH_4$ (metric tons) | 0.00 | 0.00 |
| $N_2O$ (metric tons) | 0.00 | 0.00 |
| $CO_2$(metric tons) | 0.00 | 0.00 |
| 100-year $CO_2e$ (metric tons) | 0.00 | 0.00 |
| 20-year $CO_2e$ (metric tons) | 0.00 | 0.00 |
| Percentage of 11-state region's total annual emissions 100-year $CO_2e$ | 0.0000 | 0.0000 |
| Percentage of 11-state region's total annual emissions 20-year $CO_2e$ | 0.0000 | 0.0000 |

Sources: EPA 2023b; EMPS staff calculations

### Cool Mix Alternative

*River mile 61*

Under the Cool Mix Alternative (river mile 61), a 1.58 percent reduction in total 5-year hydropower generation would result in an increase in GHG emissions from other sources of power generation. As shown in **Table 3-54**, this reduction would be equal to 75,801.88 metric tons of $CO_2e$ for the 100-year time horizon and 76,126.76 metric tons of $CO_2e$ for the 20-year time horizon, for the composite grid generation emissions scenario, representing 0.0039 percent of the 11-state region's total annual emissions. This is approximately equivalent to the annual $CO_2e$ emissions of 18,118 gasoline-powered passenger vehicles or 0.20 natural gas-fired powerplants. For the coal generation emissions scenario, this alternative would result in an increase of 240,806.36 metric tons of $CO_2e$ for the 100-year time horizon and 242,271.63 metric tons of $CO_2e$ for the 20-year time horizon, which would represent 0.0122 percent of the 11-state region's total annual emissions. This is approximately equivalent to the annual $CO_2e$ emissions of 57,661 passenger vehicles or 0.65 natural gas-fired powerplants.

**Table 3-54**
**Cool Mix Alternative at Little Colorado River (River Mile 61)**

| GHGs | Grid Generation Average Emissions Scenario | Coal Generation Average Emissions Scenario |
|---|---:|---:|
| $CH_4$ (metric tons) | 5.94 | 26.48 |
| $N_2O$ (metric tons) | 0.83 | 3.86 |
| $CO_2$ (metric tons) | 75,408.88 | 239,034.19 |
| 100-year $CO_2e$ (metric tons) | 75,801.88 | 240,806.36 |
| 20-year $CO_2e$ (metric tons) | 76,126.76 | 242,271.63 |
| Percentage of 11-state region's total annual emissions 100-year $CO_2e$ | 0.0039 | 0.0122 |
| Percentage of 11-state region's total annual emissions 20-year $CO_2e$ | 0.0039 | 0.0122 |

Sources: EPA 2023b; EMPS staff calculations

*River mile 15*

Under the Cool Mix Alternative (river mile 15), a 1.00 percent reduction in hydropower generation would result in an increase in GHG emissions from other sources of power generation. As shown in **Table 3-55**, this reduction would be equal to 47,863.29 metric tons of $CO_2e$ for the 100-year time horizon and 48,068.43 metric tons of $CO_2e$ for the 20-year time horizon, for the composite grid generation emissions scenario, representing 0.0024 percent of the 11-state region's total annual emissions. This is approximately equivalent to the annual $CO_2e$ emissions of 11,440 gasoline-powered passenger vehicles or 0.13 natural gas-fired powerplants. For the coal generation emissions scenario, this alternative would result in an increase of 152,051.44 metric tons of $CO_2e$ for the 100-year time horizon and 152,976.65 metric tons of $CO_2e$ for the 20-year time horizon, which would represent 0.0077 percent of the 11-state region's total annual emissions. This is approximately equivalent to the annual $CO_2e$ emissions of 36,409 gasoline-powered passenger vehicles or 0.41 natural gas-fired powerplants.

**Table 3-55**
**Cool Mix Alternative at River Mile 15**

| GHGs | Grid Generation Average Emissions Scenario | Coal Generation Average Emissions Scenario |
|---|---|---|
| $CH_4$ (metric tons) | 3.75 | 16.72 |
| $N_2O$ (metric tons) | 0.53 | 2.44 |
| $CO_2$ (metric tons) | 47,615.14 | 150,932.45 |
| 100-year $CO_2e$ (metric tons) | 47,863.29 | 152,051.44 |
| 20-year $CO_2e$ (metric tons) | 48,068.43 | 152,976.65 |
| Percentage of 11-state region's total annual emissions 100-year $CO_2e$ | 0.0024 | 0.0077 |
| Percentage of 11-state region's total annual emissions 20-year $CO_2e$ | 0.0024 | 0.0077 |

Sources: EPA 2023b; EMPS staff calculations

**Cool Mix with Flow Spike Alternative**

*River mile 61*

Under the Cool Mix with Flow Spike Alternative at Little Colorado River, a 1.41 percent reduction in hydropower generation would result in an increase in GHG emissions from other sources of power generation. As shown in **Table 3-56,** this alternative would result in an increase of 67,618.14 metric tons of $CO_2e$ for the 100-year time horizon and 67,907.94 metric tons of $CO_2e$ for the 20-year time horizon, for the composite grid generation emissions scenario, representing 0.0034 percent of the 11-state region's total annual emissions. This is approximately equivalent to the annual $CO_2e$ emissions of 16,162 gasoline-powered passenger vehicles or 0.18 natural gas-fired powerplants. For the coal generation emissions scenario, this alternative would result in an increase of 214,808.35 metric tons of $CO_2e$ for the 100-year time horizon and 216,115.43 metric tons of $CO_2e$ for the 20-year time horizon, which would represent 0.0109 percent of the 11-state region's total annual emissions. This is approximately equivalent to the annual $CO_2e$ emissions of 51,436 gasoline-powered passenger vehicles or 0.58 natural gas-fired powerplants.

**Table 3-56**
**Cool Mix with Flow Spike Alternative at Little Colorado River (River Mile 61)**

| GHGs | Grid Generation Average Emissions Scenario | Coal Generation Average Emissions Scenario |
|---|---|---|
| $CH_4$ (metric tons) | 5.30 | 23.62 |
| $N_2O$ (metric tons) | 0.74 | 3.44 |
| $CO_2$ (metric tons) | 67,267.56 | 213,227.51 |
| 100-year $CO_2e$ (metric tons) | 67,618.14 | 214,808.35 |
| 20-year $CO_2e$ (metric tons) | 67,907.94 | 216,115.43 |
| Percentage of 11-state region's total annual emissions 100-year $CO_2e$ | 0.0034 | 0.0109 |
| Percentage of 11-state region's total annual emissions 20-year $CO_2e$ | 0.0034 | 0.0109 |

Sources: EPA 2023b; EMPS staff calculations

*River mile 15*

Under the Cool Mix with Flow Spike Alternative at river mile 15, a 0.96 percent reduction in hydropower generation would result in an increase in GHG emissions from other sources of power generation. As shown in **Table 3-57**, this alternative would result in an increase of 46,141.58 metric tons of $CO_2e$ for the 100-year time horizon and 46,339.34 metric tons of $CO_2e$ for the 20-year time horizon, for the composite grid generation emissions scenario, representing 0.0023 percent of the 11-state region's total annual emissions. This is approximately equivalent to the annual $CO_2e$ emissions of 11,029 gasoline-powered passenger vehicles or 0.12 natural gas-fired powerplants. For the coal generation emissions scenario, this alternative would result in an increase of 146,581.93 metric tons of $CO_2e$ for the 100-year time horizon and 147,473.86 metric tons of $CO_2e$ for the 20-year time horizon, which would represent 0.0075 percent of the 11-state region's total annual emissions. This is approximately equivalent to the annual $CO_2e$ emissions of 35,099 gasoline-powered passenger vehicles or 0.39 natural gas-fired powerplants.

**Table 3-57**
**Cool Mix with Flow Spike Alternative at River Mile 15**

| GHGs | Grid Generation Average Emissions Scenario | Coal Generation Average Emissions Scenario |
|---|---|---|
| $CH_4$ (metric tons) | 3.62 | 16.12 |
| $N_2O$ (metric tons) | 0.51 | 2.35 |
| $CO_2$ (metric tons) | 45,902.35 | 145,503.19 |
| 100-year $CO_2e$ (metric tons) | 46,141.58 | 146,581.93 |
| 20-year $CO_2e$ (metric tons) | 46,339.34 | 147,473.86 |
| Percentage of 11-state region's total annual emissions 100-year $CO_2e$ | 0.0023 | 0.0075 |
| Percentage of 11-state region's total annual emissions 20-year $CO_2e$ | 0.0023 | 0.0075 |

Sources: EPA 2023b; EMPS staff calculations

### Cold Shock Alternative

*River mile 61*

Under the Cold Shock Alternative at Little Colorado River (river mile 61), a 0.71 percent reduction in hydropower generation would result in an increase in GHG emissions from other sources of power generation. As shown in **Table 3-58**, this alternative would result in an increase of 33,925.66 metric tons of $CO_2e$ for the 100-year time horizon and 34,071.07 metric tons of $CO_2e$ for the 20-year time horizon, for the composite grid generation emissions scenario, representing 0.0017 percent of the 11-state region's total annual emissions. This is approximately equivalent to the annual $CO_2e$ emissions of 8,109 gasoline-powered passenger vehicles or 0.09 natural gas-fired powerplants. For the coal generation emissions scenario, this alternative would result in an increase of 107,774.57 metric tons of $CO_2e$ for the 100-year time horizon and 108,430.37 metric tons of $CO_2e$ for the 20-year time horizon, which would represent 0.0055 percent of the 11-state region's total annual emissions. This is approximately equivalent to the annual $CO_2e$ emissions of 25,807 gasoline-powered passenger vehicles or 0.29 natural gas-fired powerplants.

**Table 3-58**
**Cold Shock Alternative at Little Colorado River (River Mile 61)**

| GHGs | Grid Generation Average Emissions Scenario | Coal Generation Average Emissions Scenario |
|---|---|---|
| $CH_4$ (metric tons) | 2.66 | 11.85 |
| $N_2O$ (metric tons) | 0.37 | 1.73 |
| $CO_2$ (metric tons) | 33,749.77 | 106,981.43 |
| 100-year $CO_2e$ (metric tons) | 33,925.66 | 107,774.57 |
| 20-year $CO_2e$ (metric tons) | 34,071.07 | 108,430.37 |
| Percentage of 11-state region's total annual emissions 100-year $CO_2e$ | 0.0017 | 0.0055 |
| Percentage of 11-state region's total annual emissions 20-year $CO_2e$ | 0.0017 | 0.0055 |

Sources: EPA 2023b; EMPS staff calculations

*River mile 15*

Under the Cold Shock Alternative at river mile 15, a 0.48 percent reduction in hydropower generation would result in an increase in GHG emissions from other sources of power generation. As shown in **Table 3-59**, this alternative would result in an increase of 23,104.60 metric tons of $CO_2e$ for the 100-year time horizon and 23,203.62 metric tons of $CO_2e$ for the 20-year time horizon, for the composite grid generation emissions scenario, representing 0.0012 percent of the 11-state region's total annual emissions. This is approximately equivalent to the annual $CO_2e$ emissions of 5,523 gasoline-powered passenger vehicles or 0.06 natural gas-fired powerplants. For the coal generation emissions scenario, this alternative would result in an increase of 73,398.36 metric tons of $CO_2e$ for the 100-year time horizon and 73,844.98 metric tons of $CO_2e$ for the 20-year time horizon, which would represent 0.0037 percent of the 11-state region's total annual emissions. This is approximately equivalent to the annual $CO_2e$ emissions of 17,575 gasoline-powered passenger vehicles or 0.20 natural gas-fired powerplants.

**Table 3-59**
**Cold Shock Alternative at River Mile 15**

| GHGs | Grid Generation Average Emissions Scenario | Coal Generation Average Emissions Scenario |
|---|---:|---:|
| $CH_4$ (metric tons) | 1.81 | 8.07 |
| $N_2O$ (metric tons) | 0.25 | 1.18 |
| $CO_2$ (metric tons) | 22,984.81 | 72,858.20 |
| 100-year $CO_2e$ (metric tons) | 23,104.60 | 73,398.36 |
| 20-year $CO_2e$ (metric tons) | 23,203.62 | 73,844.98 |
| Percentage of 11-state region's total annual emissions 100-year $CO_2e$ | 0.0012 | 0.0037 |
| Percentage of 11-state region's total annual emissions 20-year $CO_2e$ | 0.0012 | 0.0037 |

Source: EPA 2023b; EMPS staff calculations

### Cold Shock with Flow Spike Alternative

*River mile 61*

Under the Cold Shock with Flow Spike Alternative at Little Colorado River (river mile 61), a 0.57 percent reduction in hydropower generation would result in an increase in GHG emissions from other sources of power generation. As shown in **Table 3-60**, this alternative would result in an increase of 27,408.88 metric tons of $CO_2e$ for the 100-year time horizon and 27,526.35 metric tons of $CO_2e$ for the 20-year time horizon, for the composite grid generation emissions scenario, representing 0.0014 percent of the 11-state region's total annual emissions. This is approximately equivalent to the annual $CO_2e$ emissions of 6,551 gasoline-powered passenger vehicles or 0.07 natural gas-fired powerplants. For the coal generation emissions scenario, this alternative would result in an increase of 87,072.15 metric tons of $CO_2e$ for the 100-year time horizon and 87,601.97 metric tons of $CO_2e$ for the 20-year time horizon, which would represent 0.0044 percent of the 11-state region's total annual emissions. This is approximately equivalent to the annual $CO_2e$ emissions of 20,849 gasoline-powered passenger vehicles or 0.23 natural gas-fired powerplants.

**Table 3-60**
**Cold Shock with Flow Spike Alternative at Little Colorado River (River Mile 61)**

| GHGs | Grid Generation Average Emissions Scenario | Coal Generation Average Emissions Scenario |
|---|---:|---:|
| $CH_4$ (metric tons) | 2.15 | 9.57 |
| $N_2O$ (metric tons) | 0.30 | 1.39 |
| $CO_2$ (metric tons) | 27,266.78 | 86,431.36 |
| 100-year $CO_2e$ (metric tons) | 27,408.88 | 87,072.15 |
| 20-year $CO_2e$ (metric tons) | 27,526.35 | 87,601.97 |
| Percentage of 11-state region's total annual emissions 100-year $CO_2e$ | 0.0014 | 0.0044 |
| Percentage of 11-state region's total annual emissions 20-year $CO_2e$ | 0.0014 | 0.0044 |

Sources: EPA 2023b; EMPS staff calculations

*River mile 15*

Under the Cold Shock with Flow Spike Alternative at river mile 15, a 0.45 percent reduction in hydropower generation would result in an increase in GHG emissions from other sources of power generation. As shown in **Table 3-61**, this alternative would result in an increase of 21,455.78 metric tons of $CO_2e$ for the 100-year time horizon and 21,547.73 metric tons of $CO_2e$ for the 20-year time horizon, for the composite grid generation emissions scenario, representing 0.0011 percent of the 11-state region's total annual emissions. This is approximately equivalent to the annual $CO_2e$ emissions of 5,128 gasoline-powered passenger vehicles or 0.06 natural gas-fired powerplants. For the coal generation emissions scenario, this alternative would result in an increase of 68,160.41 metric tons of $CO_2e$ for the 100-year time horizon and 68,575.16 metric tons of $CO_2e$ for the 20-year time horizon, which would represent 0.0035 percent of the 11-state region's total annual emissions. This is approximately equivalent to the annual $CO_2e$ emissions of 16,321 gasoline-powered passenger vehicles or 0.18 natural gas-fired powerplants.

**Table 3-61**
**Cold Shock with Flow Spike Alternative at River Mile 15**

| GHGs | Grid Generation Average Emissions Scenario | Coal Generation Average Emissions Scenario |
|---|---:|---:|
| $CH_4$ (metric tons) | 1.68 | 7.49 |
| $N_2O$ (metric tons) | 0.24 | 1.09 |
| $CO_2$ (metric tons) | 21,344.54 | 67,658.80 |
| 100-year $CO_2e$ (metric tons) | 21,455.78 | 68,160.41 |
| 20-year $CO_2e$ (metric tons) | 21,547.73 | 68,575.16 |
| Percentage of 11-state region's total annual emissions 100-year $CO_2e$ | 0.0011 | 0.0035 |
| Percentage of 11-state region's total annual emissions 20-year $CO_2e$ | 0.0011 | 0.0035 |

Sources: EPA 2023b; EMPS staff calculations

**Non-Bypass Alternative**

Under the Non-Bypass Alternative, the implementation of HFE releases routed through the generation facility would result in a 0.29 percent increase in hydropower generation compared with the No Action Alternative. An increase in hydropower generation could reduce power generation from GHG-emitting sources. As presented in **Table 3-62**, in the composite grid generation emissions scenario, there would be a potential reduction of 13,769.42 metric tons of $CO_2e$ for the 100-year time horizon and 13,828.43 metric tons of $CO_2e$ for the 20-year time horizon, representing 0.0007 percent of the 11-state region's total annual emissions. This is a reduction approximately equivalent to the annual $CO_2e$ emissions of 3,291 gasoline-powered passenger vehicles or 0.04 natural gas-fired powerplants. For the coal generation emissions scenario, this alternative would result in a reduction of 43,742.49 metric tons of $CO_2e$ for the 100-year time horizon and 44,008.66 metric tons of $CO_2e$ for the 20-year time horizon, representing 0.0022 percent of the 11-state region's total annual emissions. This is a reduction approximately equivalent to the annual $CO_2e$ emissions of 10,474 gasoline-powered passenger vehicles or 0.12 natural gas-fired powerplants.

**Table 3-62**
**Non-Bypass Alternative**

| GHGs | Grid Generation Average Emissions Scenario | Coal Generation Average Emissions Scenario |
|---|---|---|
| $CH_4$ (metric tons) | -1.08 | -4.81 |
| $N_2O$ (metric tons) | -0.15 | -0.70 |
| $CO_2$ (metric tons) | -13,698.03 | -43,420.58 |
| 100-year $CO_2e$ (metric tons) | -13,769.42 | -43,742.49 |
| 20-year $CO_2e$ (metric tons) | -13,828.43 | -44,008.66 |
| Percentage of 11-state region's total annual emissions 100-year $CO_2e$ | -0.0007 | -0.0022 |
| Percentage of 11-state region's total annual emissions 20-year $CO_2e$ | -0.0007 | -0.0022 |

Sources: EPA 2023b; EMPS staff calculation

### Cumulative Effects

In this analysis, the potential impacts on climate change associated with dam operations have been discussed in terms of indirect impacts from other power generation sources in the power grid; therefore, the climate change impacts are cumulative in nature. Past, present, and reasonably foreseeable future actions that would result in GHG emissions would contribute to cumulative impacts under each alternative. Among the action alternatives, the Cool Mix Alternative at Little Colorado River (river mile 61) would result in the highest cumulative climate change impacts, followed by the Cool Mix with Flow Spike Alternative at Little Colorado River. The Non-Bypass Alternative would result in the smallest cumulative climate change impacts. Under the Non-Bypass Alternative, a potential reduction in GHG emissions would countervail contributions to GHG emissions from past, present, and reasonably foreseeable future actions to result in the smallest cumulative impacts on climate change. Over time, older and higher GHG-emitting facilities will likely be retired, and their generation capacity will be replaced by new zero- or lower-emission sources. All these trends are expected to result in a reduction in average grid GHG emissions over time. Under all Alternatives the Glen Canyon Dam Facility would continue to generate hydropower which has lower GHG emissions compared with fossil fuel powered generation sources.

### *Summary*

Potential impacts on climate change associated with dam operations were compared in terms of GHG emissions for each alternative relative to emissions for the No Action Alternative. While Glen Canyon Dam operations do not generate GHG emissions, dam operations can indirectly affect climate change, regionally and globally, through varying contributions to the total power generation in the region which includes sources that emit GHGs.

The Cool Mix Alternative at Little Colorado River (river mile 61) would have the most significant impact on the regional generation of GHGs and climate change. All of the Action Alternatives, except the Non-Bypass Alternative, would result in increased GHG emissions compared with the No Action Alternative. The Non-Bypass Alternative could potentially result in a reduction in regional GHG emissions.

All the action alternatives, except the Non-Bypass Alternative, would result in increased regional GHG emissions from electricity generation, which would contribute cumulatively to climate change impacts along with other sources of GHGs.

# 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 Final SEIS included project scoping, consultation, and coordination with Tribes, federal and state 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. This approach also included incorporating public comments received during the SMB EA.

A variety of informational materials to educate and inform audiences about the environmental assessment process related to the smallmouth bass populations below Glen Canyon Dam and related issues were employed. The existing GCDAMP website was updated and maintained for this SEIS. It contains project documents, points of contact, scoping materials, and the project schedule. Reclamation used an electronic mailing list 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.

In response to these changing conditions, the Secretary of the Interior's acting designee to the AMWG directed Reclamation in August 2022 to identify and analyze operational alternatives at Glen Canyon Dam to disrupt the spawning of smallmouth bass and other warmwater nonnative fish that pass through the dam. As directed, Reclamation prepared the SMB EA. Reclamation published a Notice of Intent to prepare an SEIS in the *Federal Register* on October 4, 2023. A 30-day scoping comment period was held from October 4, 2023, to November 3, 2023. Reclamation notified interested parties of the NOI and scoping comment period through an email notification to the project mailing list on October 5, 2023. The email consisted of the NOI and information on two public webinars.

Reclamation held two virtual public webinars during the scoping period. One meeting was held on October 18, 2023, from 5:00 p.m. to 6:30 p.m. mountain daylight time, and 37 people attended. The second virtual public meeting was held on October 20, 2023, from 11:00 a.m. to 12:30 p.m. mountain daylight time, and 60 people attended. The webinars included an opening statement, a presentation that summarized the NOI, a range of hydrologic and operational scenarios that informed people about the SEIS analysis, an overview of potential alternatives being considered in the SEIS, information on the SEIS process schedule, and a question-and-answer session. The webinars were recorded and published on the GCDAMP website.

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.

The Draft SEIS was available for public review on the project website. Reclamation held three virtual public meetings to provide opportunities to learn more about the project, provide analysis, speak with Reclamation managers and resource specialists, and ask questions. **Appendix A** includes additional information on the public comment period. Public comments were accepted for 45 calendar days following the EPA's publication of the Notice of Availability in the *Federal Register*. Comments were provided by email to LTEMPSEIS@usbr.gov or by mail to Bureau of Reclamation, Attn.: LTEMP SEIS Project Manager, 125 South State Street, Suite 800, Salt Lake City, Utah 84138.

## 4.3 Cooperating Agency Involvement

In compliance with NEPA and its implementing regulations, Reclamation worked with 16 cooperating agencies in the preparation of this SEIS. As described in **Chapter 1**, cooperating agencies included the BIA, NPS, Service, WAPA, State of Nevada, AZGFD, Salt River Project, UAMPS, Upper Colorado River Commission, Colorado River Board of California, Havasupai Tribe, Hopi Tribe, Hualapai Tribe, Kaibab Band of Paiute Indians, Navajo Nation, and Pueblo of Zuni. In developing the Final SEIS, Reclamation hosted 12 cooperating agency virtual meetings to obtain data, information, resource analyses, and review of internal documents. Additionally, individual agencies provided specific assistance, including the following:

- The Service has jurisdiction by law and special expertise with respect to the ESA, biological resources within the analysis area, and the Service's administration of several wildlife refuges in the analysis area. The Service provided resource expertise and worked closely with Reclamation in developing a biological assessment to support consultation under Section 7 of the ESA.
- Given its jurisdiction of NPS units within the Basin and administration of recreation on Lake Powell and Lake Mead, the NPS provided data and analysis of potential impacts on resources under its management.
- WAPA provided models for Glen Canyon Dam to aid in resource-specific modeling. WAPA also provided hydroelectric modeling to assess impacts on power generation and revenue across the major generation facilities in the Upper Basin.

While not a cooperating agency, the USGS contributed expertise and resource modeling support based on their role as the science and monitoring provider to the GCDAMP.

## 4.4 Tribal Consultation and Coordination

For purposes of this NEPA process, Reclamation is consulting and coordinating with Tribes who participated in the 2016 LTEMP FEIS. These include the Havasupai Tribe of the Havasupai Reservation, Arizona; Hopi Tribe; Hualapai Tribe; Kaibab Band of Paiute Indians; Navajo Nation; and Pueblo of Zuni. Representatives of various Tribes also attended the scoping meetings in October 2023. Two Tribes provided Reclamation with written comments during the scoping process. Several Tribes are also cooperating agencies.

### 4.4.1 Summary of Tribal Consultation and Coordination

Formal Tribal consultation began on November 8, 2023, with a letter from the Upper Colorado Basin Regional Director. Informal consultation with representatives of the Tribes has occurred throughout the process via monthly calls, coordination meetings, LTEMP PA meetings, formal and informal phone calls, and emails. Reclamation has received signed cooperating agency letters from all but one of the Tribes invited to be cooperating agencies.

## 4.5 ESA Section 7 Consultation

In 2016, the Service finalized ESA Section 7 consultation for the 2016 LTEMP FEIS due to impacts on the threatened and endangered species. Reclamation began early interagency coordination with the Service in January 2023 while writing the SMB EA. The SMB EA contained alternatives similar to those in the LTEMP SEIS, but this SEIS includes a non-bypass flow option not considered in the SMB EA. Early cooperation through meetings and letter exchanges with the Service on this LTEMP SEIS began in July 2023, and is ongoing.

Reclamation determined the effects of the Cool Mix Alternative on threatened and endangered species fall within the parameters analyzed in the 2016 LTEMP Biological Opinion and do not likely require additional consultation. The other alternatives may require additional effects analysis under the Section 7 consultation process. Reclamation will continue to coordinate with the Service to determine the necessary ESA coverage for alternatives not analyzed under the 2016 LTEMP Biological Opinion, more information will be provided in the ROD.

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# List of Preparers

The Final SEIS was prepared by Reclamation with resource modeling and analysis support from the Service, BIA, NPS, WAPA, State of Nevada, AZGFD, Havasupai Tribe, Hopi Tribe, Hualapai Tribe, Kaibab Band of Paiute Indians Tribe, Navajo Nation, Pueblo of Zuni, Salt River Project, UAMPS, Upper Colorado River Commission, and Colorado River Board of California. The following 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 Final 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.

**alluvium**—Sedimentary material transported and deposited by the action of flowing water.

**ambient**—Surrounding natural conditions (or environment) in a given place and time.

**amphibian**—A vertebrate animal that has a life stage in water and a life stage on land. Examples include salamanders, frogs, and toads.

**annual flow-weighted average concentration**—A weighted average of monthly total dissolved solids (TDS) concentrations for a year, where the weight for each month is based on the relative flow for each month.

**backwater**—A relatively small, generally shallow area of a river with little or no current.

**baseload**—Minimum load in a power system over a given period of time.

**Basin States**—In accordance with the Colorado River Compact of 1922, those parts of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming within and from which waters drain naturally into the Colorado River. These seven states are referred to as the Basin States. *See also* Colorado River Compact of 1922.

**biological assessment (BA)**—A document identifying the likely effects of a proposed federal action on threatened and endangered species. To facilitate compliance with Section 7(a)(2) of the Endangered Species Act (ESA), federal agencies must prepare a BA pursuant to Section 7(c)(1) of the ESA. *See also* Endangered Species Act.

**biological opinion (BO)**—A document stating the opinion of the United States Fish and Wildlife Service (Service) or the National Marine Fisheries Service, or both, 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. *See also* river outlet works.

**capacity**—The maximum amount of energy that can be instantaneously produced.

**catch**—At a recreational fishery, refers to the number of fish captured, whether they are kept or released.

**channel (watercourse)**—An open conduit either naturally or artificially created that periodically or continuously contains moving water, or that forms a connecting link between two bodies of water. Some terms used to describe natural channels are river, creek, run, branch, and tributary. Natural channels may be single or braided. Two terms used to describe artificial channels are canal and floodway.

***Cladophora***—Filamentous green alga important to the food chain in the Colorado River downstream of Glen Canyon Dam.

**Colorado River Basin (Basin)**—The drainage area of the Colorado River system. The Basin occupies an area of approximately 250,000 square miles in the southwestern United States and 3,500 square miles in northwestern Mexico. The Colorado River Compact of 1922 divided the Colorado River system into two subbasins: the Upper Basin and the Lower Basin. It also divided the seven states within the Basin into the Upper Division and the Lower Division. Upper Division States include Colorado, New Mexico, Utah, and Wyoming; Lower Division States include Arizona, California, and Nevada. Additionally, 30 federally recognized Tribes are in the Basin.

**Colorado River Basin Salinity Control Program**—The organization dedicated to controlling Colorado River salinity; it consists of representatives of the seven Basin States.

**Colorado River Compact of 1922**—The agreement concerning the apportionment of the use of the waters of the Colorado River Basin, dated November 24, 1922, and executed by commissioners for Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming. On June 25, 1929, it was approved and proclaimed effective by Herbert Hoover, the president of the United States and representative of the United States for purposes of the compact.

**Colorado River Simulation System (CRSS)**—An operational model of the Colorado River Basin based on a monthly time step.

**Colorado River system**—The portion of the Colorado River and its tributaries within the United States as defined in the Colorado River Compact of 1922.

**compact**—The Colorado River Compact of 1922.

**compact point**—The reference point designated by the Colorado River Compact of 1922 as dividing the Colorado River Basin into two subbasins, the Upper Basin and the Lower Basin. The compact point is Lee Ferry, Arizona. *See also* Lee Ferry Compact Point.

**conductivity**—A measure of water's ability to pass an electrical current.

**Consolidated Decree**—A decree entered by the United States Supreme Court on March 27, 2006, in the case of *Arizona v. California,* 547 US 150 (2006), incorporating all applicable provisions of the earlier-issued decisions and decrees in the matter. The Supreme Court reached a decision in the case of *Arizona v. California* in 1963 and implemented this decision in a 1964 decree, which was supplemented over time after its adoption.

**contractors**—Those who hold entitlements to Colorado River water. Contractors consist of the federal government, states, Indian Tribes, and various public and private entities that are recognized under the Consolidated Decree, hold a Section 5 Contract with the Secretary, or have a Secretarial Reservation of water. *See also* Consolidated Decree.

**conveyance loss**—Water that is lost in transit from a pipe, canal, conduit, or ditch by leakage or evaporation. If the water is lost due to leakage, it may be considered return flow if it percolates to an aquifer and is available for reuse. If the water evaporates, it is considered consumptive use.

**cooperating agency**—With respect to the National Environmental Policy Act of 1969, as amended (NEPA) process, an agency that has jurisdiction by law or special expertise concerning an aspect of a proposed federal action and that is requested by the lead agency to participate in the preparation of an environmental impact statement (EIS).

**covered species**—Those species addressed in the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) for which conservation measures would be implemented and for which authorization for "take" is being requested under Section 10 of the ESA. *See also* take.

**criteria**—Standards used for making a determination.

**critical habitat**—Specific areas with physical or biological features essential to the conservation of a listed species and that may require special management considerations or protection. These areas have been legally designated via *Federal Register* notices.

**cubic foot per second (cfs)**—A measure of water flow equal to 1 cubic foot of water passing a point on the stream in 1 second of time.

**cultural resource**—A building, site, district, structure, or object significant in history, architecture, archaeology, culture, or science.

**delta sediment**—Deposit formed at the mouth of the Colorado River and other rivers where they enter Lake Powell or Lake Mead.

**debris flow**—Large deposit of sediment into a tributary caused by slope failures on tributary canyons.

**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. Deposition 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 supplemental environmental impact statement (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 DO 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.

**duration tier**—The possible HFE durations determined in modeling, measured in increments of 12 hours. Duration tiers include 12, 24, 36, 48, 60, 72, 96, 144, 192, and 250 hours.

**ecosystem**—Complex system composed of a community of fauna and flora and that system's chemical and physical environments.

**electric power system**—Physically connected facilities for electricity generation, transmission, and distribution that are operated as a unit under one control.

**electrical demand**—Energy requirement placed upon a utility's generation at a given instant or averaged over any designated period of time.

**endangered species**—A species or subspecies whose survival is in danger of extinction throughout all or a significant portion of its range.

**Endangered Species Act of 1973 (ESA)**—As amended, an act that obligated the government to protect all animal and plant species threatened with extinction and promoted the protection of critical habitats (16 US Code 1531–1544). Under Section 9, the ESA provides for the prohibition of "take" of any fish or wildlife species listed as threatened or endangered under the ESA unless specifically authorized by regulation. *See also* take.

**energy**—What is produced by power plants; measured in kilowatt hours.

**fan-eddy complex**—The controlling geomorphic feature in the Colorado River for sediment deposition; debris fans partially block tributaries that cause the formation of rapids and edits.

**epilimnion**—Thermal layering of water in lakes and streams. *See also* stratification.

**firm energy or power**—Uninterruptible 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.

**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.

**high-flow experiment (HFE)**—Special release from Glen Canyon Dam that involves the full power-plant capacity (30,000 cfs) and the four by-pass valves (15,000 cfs). HFE releases are performed under sediment-enriches conditions in order to benefit downstream resources; this includes maintaining and rebuilding sandbars and beaches in downstream reaches.

**historic property**—Any district, site, building, structure, or object listed on or eligible for listing on the National Register of Historic Places (36 Code of Federal Regulations 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.

**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 Code of Federal Regulations 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 and water, and human-made modifications. These factors give the area a distinctive quality that distinguishes it from its immediate surroundings.

**Law of the River**—As applied to the Colorado River, a body of documents the Secretary uses to carry out the responsibility to manage the mainstream waters of the Lower Basin pursuant to applicable federal law. The Secretary is vested with this responsibility. This collective set of documents comprising numerous operating criteria, regulations, and administrative decisions included in federal and state statues, interstate compacts, court decisions and decrees, an international treaty, and contracts with the Secretary apportions the Colorado River waters and regulates the use and management of the Colorado River among the seven Basin States and Mexico.

**lead agency**—An agency initiating and overseeing the preparation of an EIS. For this SEIS, Reclamation is the lead agency for compliance with NEPA.

**Lee Ferry Compact Point**—Identified the reference point that marks the division between the two subbasins—the Upper Basin and the Lower Basin—created by the division of the Colorado River Basin in the Colorado River Compact of 1922. This reference point is in the mainstream Colorado River in Arizona, 1 mile below the confluence of the Colorado River with the Paria River.

**Lees Ferry Gaging Station**—The site of the United States Geological Survey 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.

**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.

**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 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 the Nation's 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.

**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 that is a descriptive measure that splits ranked data into 100 parts, or hundredths. For example, the 10th percentile is the value that splits the data in such a way that 10 percent of the values are less than or equal to the 10th percentile.

**piscivorous**—Habitually feeding on fish.

**$PM_{10}$ (PM10)**—Particulate matter (PM) (dust particles) standard that includes particles with a diameter of 10 micrometers or less.

**power**—Electrical capacity generated, transferred, or used.

**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 2024 is equal to the number of modeled elevations greater than 1,180 feet msl in June 2024, divided by the total number of modeled elevations in June 2024.

**public involvement**—Process of obtaining citizen input into each stage of development of planning documents. Public involvement is required as a major input into any EIS.

**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.

**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.

**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.

**revenue—**The total income generated by a business or organization from its primary activities, such as sales of goods or services. It is a crucial financial metric, representing the money earned before deducting expenses.

**riffle**—A stretch of choppy water caused by an underlying rock shoal or sandbar.

**rill**—A small grove, furrow, or channel in soil made by water flowing down over its surface; a small stream.

**riparian**—Of, on, or pertaining to the bank of a river, pond, or lake.

**river mile**—Numbered along the Colorado River from north to south starting with river mile -15 at Glen Canyon Dam, river mile 0 at Lees Ferry, and river 61 for the confluence with the Little Colorado River. Note that river miles upstream of Lees Ferry are denoted as negative (for example, the slough at river mile -12).

**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.

**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 take that is "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 accounting period**—periods over which sand inputs and exports are measured to evaluate whether conditions have been met to trigger an HFE release, which occurs during an HFE implementation window. Currently, two HFE implementation windows occur (1) from October 1 to November 30, during the fall sediment accounting period; and (2) from March 2 to April 30 during the spring sediment accounting period.

**sediment load**—Mass of sediment passing through a stream.

**seepage**—Relatively slow movement of water through a medium, such as sand.

**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.

**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* 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.

**tailwater**—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 US Code 1531[18]).

**thermocline**—The zone of maximum change in temperature in a waterbody, separating upper (epilimnetic) from lower (hypolimnetic) zones.

**threatened species**—A species or subspecies that is likely to become endangered in the foreseeable future.

**total dissolved solids (TDS)**—Dissolved materials in the water, including ions such as potassium, sodium, chloride, carbonate, sulfate, calcium, and magnesium. In many instances, the term "TDS" is used to reflect salinity, since these ions are typically in the form of salts.

**traces** —Multiple time series of forecasted streamflow used in hydrologic modeling. Multiple traces are sometimes referred to as an ensemble.

**traditional cultural place**—A type of historic property that is rooted in a community's history and important to that community's cultural identity.

**tributary**—River or stream flowing into a larger river or stream.

**turbidity**—Cloudiness of water, measured by how deeply light can penetrate into the water column from the surface.

**turbine**—A rotary mechanical device that uses water flow to turn and convert it into useful energy.

**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.

**waters of the United States**—In accordance with the Clean Water Act, (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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# Index

# Appendix A. Response to Public Comments

## A.1 Introduction

This appendix describes the public comment process on the Draft Supplemental Environmental Impact Statement (Draft SEIS) for the Glen Canyon Dam Long-Term Experimental and Management Plan Project (LTEMP; the project). It also includes responses to public comments.

## A.2 Draft SEIS Public Involvement

On February 9, 2024, the Notice of Availability of the Draft SEIS was published in the *Federal Register*.[38] The *Federal Register* notice also announced a 45-day public comment period ending on March 25, 2024, and three virtual public comment webinars.

### A.2.1 Advertising of the Notice of Availability and Public Meetings

The Bureau of Reclamation (Reclamation) informed interested parties of the Notice of Availability through a press release and email notification to the project mailing list (277 recipients) on February 7, 2024 (**Table A-1**).

**Table A-1**
**Revised Draft SEIS Public Comment Period Notification Methods and Publication Dates**

| Notification Item | Method and Date |
|---|---|
| Press release | Reclamation News and Multimedia website,[39] February 7, 2024 |
| Email notification | Project mailing list, February 7, 2024 |
| Notice of Availability | *Federal Register*, February 9, 2024 |

Three virtual public webinars were conducted during the public comment period. **Table A-2** summarizes the dates, times, and meeting attendance of the webinars. The webinars consisted of an overview of the project background, an overview of the revised Draft SEIS, alternatives being considered in the SEIS, and an overview of the impacts analysis in the revised Draft SEIS.
The webinars also included opportunities for the public to ask clarifying questions about the project. The webinars were recorded and published on the project website.[40]

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[38] https://www.federalregister.gov/documents/2024/02/09/2024-02676/environmental-impact-statements-notice-of-availability
[39] https://www.usbr.gov/uc/progact/amp/index.html#project
[40] https://www.usbr.gov/uc/progact/amp/index.html#project

**Table A-2**
**Public Meeting Dates, Locations, and Attendance**

| Meeting Format | Meeting Date | Meeting Time | Number of Attendees |
|---|---|---|---|
| Virtual (Zoom) webinar | Friday, February 16, 2024 | 10:00 a.m. to 11:30 a.m. Mountain standard time | 32 |
| Virtual (Zoom) webinar | Tuesday, February 20, 2024 | 5:30 p.m. to 7:00 p.m. Mountain standard time | 25 |
| Virtual (Zoom) webinar | Thursday, February 22, 2024 | 12:00 p.m. to 1:30 p.m. Mountain standard time | 25 |

### A.2.2 Public Engagement Website

Reclamation provided an interactive web page providing information on the project background and a summary of the Draft SEIS purpose and need, alternatives, and analyses for review during the public comment period. The web page also included related documents and directions on how to submit a public comment.

### A.2.3 Opportunities for Public Comments

Public comments were accepted during the comment period via email at LTEMPSEIS@usbr.gov and by mail addressed to Bureau of Reclamation, Attn: LTEMP SEIS Project Manager, 125 South State Street, Suite 800, Salt Lake City, UT 84138.

## A.3 Comment Collection and Analysis

### A.3.1 Comment Processing

Reclamation used an electronic comment analysis and reporting database to manage the comment submittals. Comments received included unique submittals, one form letter submittal, form plus submittals, and form copy submittals.[41]

Names, contact information, and letter text for all respondents were entered into the database. Each database entry was considered a submittal and assigned a unique number. The sender type was captured to indicate the entity from which it was received (that is, an individual, government, Tribe, or organization). Submittals containing only a person's name and any address information were categorized as having been received from an individual. Comments from businesses, nongovernmental organizations, and corporations or associations were categorized as an organization. Submittals from elected officials; local, state, or federal agencies; and cities and towns were categorized as government or Tribe, depending on their affiliation. Submittals from water management agencies, water and irrigation districts, water service providers, and electric service providers were categorized as government submissions due to the senders' governmental and quasi-

[41] Unique letters are submittals with unique content. Form letters are submittals from multiple entities or individuals containing identical or similar content; form plus letters are submittals that have additional unique content in addition to the form letter content; and form copy letters are submittals that have additional unique content in addition to the form letter content. Duplicate submittals are duplicates of a unique letter.

governmental status (for example, the Maricopa Water District, Salt River Project, or Southern Nevada Water Authority).

After the submittals were entered into the database, Reclamation reviewed each unique submittal to identify specific comments. A coding structure was developed to help thematically sort comments in the database into logical topics representing substantive issues and concerns for the Final SEIS. Outputs from the database consist of tallies of the total number of submittals and comments received, sorting and reporting comments by a topic or issue, and sender affiliations.

All public comments received are retained in the project's administrative record.

### A.3.2 Substantive Comments

Reclamation uses the comment analysis process to identify substantive public comments, which formed the basis for many revisions between the publication of the revised Draft SEIS and the Final SEIS.

In general, substantive comments do one or more of the following:

- Question, with a reasoned basis related to the analysis, the accuracy of information in the revised Draft SEIS.
- Question, with a reasoned basis related to the analysis, the adequacy of, methodology for, or assumptions used for the analysis.
- Present new information relevant to the analysis.
- Present reasonable alternatives other than those analyzed in the revised Draft SEIS.
- Present issues for analysis other than those analyzed in the revised Draft SEIS.
- Cause changes or revisions in one or more of the alternatives.

## A.4 Summary of Comment Submittals

Reclamation received 66 letter submissions (unique, form, form copy, form plus, and duplicate letters) during the public scoping period. Of the 66 letters, 50 were unique letters, 1 was a form letter, 12 were copies of the form letter, 2 were form plus letters (form letters with additional content), and 1 was a duplicate letter (**Table A-3**). **Table A-4** provides information on the affiliation of letter submissions and the number of senders. **Table A-5** lists the specific Tribes, governmental agencies, organizations, and joint entities that submitted letters during the public comment period.

From the 66 letter submittals, 673 comments were identified (see **Section A.5**). **Table A-6** lists the coding structure themes, description of themes, the number of comments coded to each theme, and the percentage of those codes out of the total comments. **Section A.5** provides all substantive public comments and Reclamation's responses.

**Table A-3**
**Submittals by Type**

| Type | Number of Submittals | Percentage of Total Submittals |
|---|---|---|
| Unique | 50 | 76 |
| Form copy | 12 | 19 |
| Form plus | 2 | 3 |
| Duplicate | 1 | 1 |
| Form | 1 | 1 |
| **Total** | **66** | **100** |

**Table A-4**
**Summary of Sender Affiliation Type**

| Affiliation | Number of Senders |
|---|---|
| Organizations | 37 |
| Government | 29 |
| Individuals | 17 |
| Tribes | 2 |
| **Total** | **85** |

Note: The total number of senders (85) does not equal the total number of letter submittals (66), as more than one sender may be affiliated with a submittal.

**Table A-5**
**Sender Affiliations**

| | |
|---|---|
| **Tribes** | |
| Colorado River Indian Tribes | Zuni Tribe of the Zuni Indian Reservation |
| **Governments** | |
| Arizona Electric Power | Maricopa Water District |
| Arizona Game and Fish Department | Navajo Tribal Utility Authority |
| Central Arizona Project | National Park Service |
| City of Manti, Utah | Roosevelt Irrigation District |
| City of Nephi, Utah | Salt River Project |
| City of Oak, Utah | Southern Nevada Water Authority |
| City of Price, Utah | United States Environmental Protection Agency, Region 9 |
| City of Provo, Utah | Town of Levan, Utah |
| City of Salem, Utah | United States Fish and Wildlife Service |
| City of Spanish Fork, Utah | Upper Colorado River Commission |
| City of St. George, Utah | Utah Municipal Power Agency |
| Colorado River Commission of Nevada | Washington City Power |
| Electrical District Number Seven | Western Area Power Administration |
| Heber Light and Power | Wyoming Municipal Power Agency |
| Logan City Light and Power | — |
| **Organizations** | |
| American Whitewater | Grand Canyon River Guides Inc |
| Adaptive Management Workgroup Recreational Fishing Representatives | Grand Canyon River Outfitters Association |
| Blue Ribbon Coalition | Grand Canyon Trust |
| Center for Biological Diversity | Grand Canyon Wildlands Council |
| Colorado River Energy Distributors Association | National Parks Conservation Association |
| Colorado River Keeper | Utah Associated Municipal Power Systems |
| **Joint Entity Submissions** | |
| Adaptive Management Workgroup representatives from Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming; Southern Nevada Water Authority | Colorado Rural Electric Association, Grand Canyon State Electric Cooperation Association, Nebraska Rural Electric Association, New Mexico Rural Electric Cooperative Association, Utah Rural Electric Cooperative Association, and Wyoming Rural Electric Association |
| Adaptive Management Workgroup representatives from Colorado, New Mexico, Utah, and Wyoming | Recreational Fishing Adaptive Management Workgroup representatives and alternative representatives |
| Arizona Municipal Power Users' Association, Arizona Power Authority, Grand Canyon State Electric Cooperation Association, and Irrigation and Electrical Districts' Association of Arizona | Center for Biological Diversity; Great Basin Water Network; Living Rivers and Colorado Riverkeeper; and Sierra Club, Grand Canyon Chapter |

**Table A-6**
**Comment Coding Summary**

| Theme | Description | Number of Comments | Percentage of Total Comments |
|---|---|---|---|
| Aquatic Resources | Comments coded to this theme included concerns regarding aquatic organisms; the aquatic food base; native fish; nonnative and invasive species; nonnative fish species; nonnative fish control activities and the effects of flow conditions; food web dynamics; and inadequate analyses, new data sources, and mitigation. | 152 | 23 |
| Energy and Power | Comments coded to this theme included concerns regarding Glen Canyon Dam and the Glen Canyon Powerplant's power operations; power marketing; power scheduling; the capacity reserve; generation and generation impacts; the transmission system; and inadequate analyses, new data sources, and mitigation. | 89 | 13 |
| Editorial | Comments coded to this theme identified typos or mistakes in the Draft SEIS, including map revisions; literature cited; preparers; incorrect references and in-text citations; and grammar, punctuation errors, and so forth. | 51 | 8 |
| Inadequate Range of Alternatives | Comments coded to this theme included concerns regarding an inadequate range of alternatives and concerns that Reclamation has rushed the analysis process and included alternatives focusing on flow alternatives. Commenters provided various alternative suggestions, such as slough modifications, physical barriers, alternatives that could disrupt the establishment of smallmouth bass below Glen Canyon Dam, nonflow options, and others. | 50 | 7 |
| Cultural and Tribal Resources | Comments coded to this theme included concerns regarding cultural resources and archaeological resources and sites; cultural landscapes; Class I records and results; built environmental resources; mapped resources; previously submerged or not currently submerged archaeological sites and archaeological sites along the river; ethnographic resources; traditional cultural properties; historic places and sacred sites; access to sacred sites; Native American concerns and traditional uses; Indian trust assets; Tribal water rights and supply; the Reclamation programmatic agreement; indirect impacts, physical impacts, and nonphysical impacts on cultural sites; and inadequate analyses, new data sources, and mitigation. | 37 | 5 |

| Theme | Description | Number of Comments | Percentage of Total Comments |
|---|---|---|---|
| General Assumptions Common to All Alternatives | This theme includes comments on the assumptions for the smallmouth bass alternatives, Glen Canyon operational and regulatory constraints, high-flow implementation modeling details, smallmouth bass modeling, hydropower, and comments about general assumptions for the alternatives. | 32 | 5 |
| Scope of the Analysis | Comments coded to this theme included concerns regarding what areas are and are not in the project area, such as Lake Mead and Lake Powell; this theme also included comments with a general discussion of the analysis area. | 30 | 5 |
| Socioeconomics | Comments coded to this theme included concerns regarding socioeconomic impacts on environmental justice communities; recreational expenditures, spending, valuation, use values, and economic contributions; environmental nonuse values; hydropower economic impacts; the population; and funding sources. | 28 | 4 |
| Recreation | Comments coded to this theme included concerns regarding sport fishing, reservoir boating, river and whitewater boating, and shoreline public use. | 24 | 4 |
| Wildlife | Comments coded to this theme included concerns regarding terrestrial wildlife; invertebrates, insects, amphibians, reptiles, birds, mammals, pollinators, and terrestrial insects; federally listed and special status species; wildlife habitat, wildlife movement, corridors, and population; and inadequate analyses, new data sources, and mitigation. | 22 | 3 |
| Alternatives – Non-Bypass | Comments coded to this theme included concerns regarding this alternative specifically; shoreline stability, loss of sediment, and disruptions to smallmouth bass; smallmouth bass populations at the confluence of the Little Colorado River; and humpback chub congregations at river mile 30. | 20 | 3 |
| Water Quality | Comments coded to this theme included concerns regarding salinity; water chemistry; water temperature; conductivity; temperature constraints on native and nonnative fish; sediment; high-flow events; sand deposition and erosion; sand dredging projects related to water quality, such as visibility; nutrients and algae; dissolved oxygen; metal concentrations; and inadequate analyses, new data sources, and mitigation. | 17 | 3 |

| Theme | Description | Number of Comments | Percentage of Total Comments |
|---|---|---|---|
| Geomorphology and Sediment | Comments coded to this theme included concerns regarding salinity sediment concentrations, erosion, disposition, and suspension; sediment accounting periods; high-flow experiments and accounting windows; sediment-enriched flows; sandbars and beaches; sand mass balances and beach building metrics; sandbar modeling; and inadequate analyses and mitigation. | 16 | 3 |
| Hydrology | Comments coded to this theme included concerns regarding surface water elevations; sloughs; hydrologic models; hydrologic traces; release volumes; technical information on how to run the models and what information goes into the model scenarios; and inadequate analyses, new data sources, and mitigation. | 13 | 2 |
| Public Involvement | Comments coded to this theme included concerns regarding public involvement and decision-making opportunities. It also included suggestions to revise the analyses and reissue the Draft SEIS for public comment and broaden the makeup of stakeholders, including representatives of the recreation industry and Tribal nations that have previously been excluded from the decision-making process. This theme also included a request to extend the drafting and analyses development timeline to allow for sufficient time to analyze the project's impacts. | 10 | 2 |
| Agency Cooperation (General) | Comments coded to this theme included requests from cooperators to be included in the National Environmental Policy Act planning processes; requests to include stakeholders in future policy considerations; requests for Reclamation to create a process or schedule consistent with the existing LTEMP communication and consultation processes to provide stakeholders sufficient time to review and provide feedback on the Draft SEIS; and requests for stakeholders to have sufficient time to plan for experimental flows, including potential grid stabilization or replacement purchase power activities. | 9 | 1 |
| Purpose and Need | Comments coded to this theme included requests to expand the purpose and need, and general concerns over the purpose and need. | 9 | 1 |
| Policy and Governance | Comments coded to this theme included concerns regarding relationships to policies, plans, and programs; agency planning regulations or federal laws (such as the Grand Canyon Protection Act); and other Reclamation National Environmental Policy Act documents (the Post 26 Guidelines, Interim Guidelines SEIS, LTEMP Record of Decision, etc.). | 9 | 1 |

| Theme | Description | Number of Comments | Percentage of Total Comments |
|---|---|---|---|
| Consultation and Coordination (Tribal and National Historic Preservation Act Section 106) | Comments coded to this theme included concerns regarding Section 106 consultation; Tribal coordination and outreach; Tribal involvement, such as government-to-government consultation; and general comments related to Tribal input. | 6 | 1 |
| Proposed Action | Comments coded to this theme included suggested revisions to the Proposed Action section (Section 1.3) of the Draft SEIS. It also included concerns regarding funding, personnel, and resources in place to assure the ability to collect systemwide data and quickly analyze that data to determine whether the chosen action is effective or whether refinements are needed to the management plan. This theme also included concerns that the Draft SEIS evaluates two proposed actions separately, yet neither action is informed by the potential impacts of the other on the resources and the impacts on other experiments. | 6 | 1 |
| Consultation and Coordination (Biology and Endangered Species Act) | Comments coded to this theme included concerns regarding Endangered Species Act Section 7 consultation and compliance. | 5 | 1 |
| Alternatives Considered but Eliminated from Detailed Analysis | Comments coded to this theme included concerns regarding various alternatives considered but eliminated from detailed analysis in the Draft SEIS. | 4 | 1 |
| Cumulative Impacts | Comments coded to this theme included concerns regarding cumulative impacts related to high-flow experiments and beach building. They also included comments regarding the analysis of impacts if potential implementation of both proposed actions occurs and comments regarding the lack of analysis of the alternatives' combined effects. | 4 | 1 |
| Data | Comments coded to this theme included new data sources and requests to revise the Draft SEIS using the best available data. | 4 | 1 |
| Environmental Justice | Comments coded to this theme included concerns regarding environmental justice communities; comments also suggested revisions to the environmental justice section (Section 3.16) of the Draft SEIS. | 4 | 1 |

| Theme | Description | Number of Comments | Percentage of Total Comments |
|---|---|---|---|
| Air Quality, Climate Change, and Greenhouse Gases | Comments coded to this theme included concerns regarding emissions, pollutants, carbon-free power, renewable energy, and renewable energy credits. | 3 | <1 |
| Attention | Comments coded to this theme included requests to be added to the project mailing list and in-person government-to-government consultation. | 3 | <1 |
| Visual Resources | Comments coded to this theme included concerns regarding the landscape character and suggestions for revisions to the visual resources section (Section 3.10) of the Draft SEIS. | 3 | <1 |
| Alternatives – Cool Mix | Comments coded to this theme included concerns regarding power production in relation to this alterative and requested that assumptions under this alternative be applied to all bypass alternatives. | 2 | <1 |
| Alternatives – No Action | Comments coded to this theme encouraged Reclamation to choose the No Action Alternative and recommended that Reclamation reframe the impacts under the No Action Alternative to better align with the proposed actions. | 2 | <1 |
| Alternatives – Cold Shock with Flow Spikes | Comments coded to this theme included concerns regarding consistency of the timing of flow spikes, and they requested clarity about the intent of flow spikes in regard to temperature and velocity. | 2 | <1 |
| 2016 LTEMP EIS | Comments coded to this theme expressed general concerns over the inadequacy of the analysis in the 2016 LTEMP EIS. | 2 | <1 |
| Out of scope | Commended coded to this theme were out of scope for the project, such as suggested planning efforts for threatened and endangered fish, suggestions that the Lower Colorado River be made into a no-visitation area, and suggested planning efforts. | 2 | <1 |
| Alternatives – Cold Shock | The comment coded to this theme expressed concerns over the effectiveness of the implementation of cold-water flow options. | 1 | <1 |
| Alternatives – Cool Mix with Flow Spikes | The comment coded to this theme states support for this alternative being the preferred alternative. | 1 | <1 |
| Terrestrial Resources and Wetlands | The comment coded to this theme expressed concerns over noxious weeds (Tamarisk). | 1 | <1 |
| **Total** | **—** | **673** | **100** |

## A.5 Public Comments and Responses

**Table A-7** includes all letter submittal numbers and sender information. **Table A-8** includes all substantive comments identified during the comment analysis process and provides responses to the comments.

**Table A-7**
**Submittal Letter Number and Sender**

| Letter Number | Organization | Sender Name |
|---|---|---|
| 1 | Individual | Bruce McElya |
| 3 | City of Manti, Utah | Alfred Bigelow |
| 4 | Recreational Fishing Adaptive Management Workgroup representative | Jim Strogen |
| 5 | Recreational Fishing Adaptive Management Workgroup representative | Jim Strogen |
| 6 | City of Provo, Utah | Michelle Kaufusi |
| 9 | Arizona Municipal Power Users' Association, Arizona Power Authority, Grand Canyon State Electric Cooperation Association, and Irrigation and Electrical Districts' Association of Arizona | Dave Lock, Ed Gerak, Jordy Fuentes, Russell Smoldon |
| 10 | Individual | Ronald Stearns |
| 11 | City of Spanish Fork, Utah | Mike Mendenhall |
| 12 | United States Environmental Protection Agency, Region 9 | Jean Prijatel |
| 13 | Navajo Tribal Utility Authority | Walter Haase |
| 14 | Wyoming Municipal Power Agency | Rosemary Henry |
| 15 | Utah Municipal Power Agency | Kevin Garlick |
| 16 | Pueblo of Zuni of the Zuni Indian Reservation | Arden Kucate |
| 17 | United States Fish and Wildlife Service | Amy Lueders |
| 18 | Grand Canyon Trust | Jen Pelz |
| 19 | Roosevelt Irrigation District | Donovan Neese |
| 20 | Electrical District Number Seven | R.D. Justice |
| 21 | Western Area Power Administration | Rodney Bailey |
| 22 | Recreational Fishing Adaptive Management Workgroup representatives and alternative representatives | Bill Davis, Bill Persons, Jim Strogen, Rod Buchanan |
| 23 | Center for Biological Diversity; Great Basin Water Network; Living Rivers and Colorado Riverkeeper; and Sierra Club, Grand Canyon Chapter | John Weisheit, Kyle Roerink, Sandy Bahr, Taylor McKinnon |
| 24 | Utah Associated Municipal Power Systems | Mike Squires |
| 25 | CREDA | Leslie James |
| 26 | City of Price, Utah | Nick Tatton |
| 28 | Town of Levan, Utah | Bruce Rowley |
| 29 | Salt River Project | Angie Bond-Simpson |
| 30 | Grand Canyon River Outfitters Association | John Dillon |
| 31 | BlueRibbon Coalition | Ben Burr |
| 32 | City of Oak, Utah | David Steele |

| Letter Number | Organization | Sender Name |
|---|---|---|
| 33 | Colorado Rural Electric Association, Grand Canyon State Electric Cooperation Association, Nebraska Rural Electric Association, New Mexico Rural Electric Cooperative Association, Utah Rural Electric Cooperative Association, and Wyoming Rural Electric Association | Charise Swanson, Dave Lock, Kent Singer, Nathaniel Johnson, Rick Nelson, Shawn Taylor |
| 34 | Grand Canyon Wildlands Council | Kelly Burke, Larry Stevens |
| 35 | Colorado River Indian Tribes | Amelia Flores |
| 36 | National Parks Conservation Association | Sanober Mirza |
| 37 | Arizona Game and Fish Department | Ginger Ritter |
| 38 | Grand Canyon River Guides | Ben Reeder, David Brown, Lynn Hamilton |
| 39 | Washington City Power | Rick Hansen |
| 40 | Maricopa Water District | Glen Vorterms |
| 41 | Colorado River Commission of Nevada | Eric Witkoski |
| 42 | Adaptive Management Workgroup representatives from Colorado, New Mexico, Utah, and Wyoming | Ali Effati, Amy Haas, Charlie Ferrantelli, Michelle Garrison |
| 43 | Adaptive Management Workgroup representatives from Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming; Southern Nevada Water Authority | Ali Effati, Amy Haas, Charlie Ferrantelli, Clint Chandler, Colby Pellegrino, Jessica Neuwerth, Michelle Garrison, Sara Price |
| 44 | Arizona Electric Power | David Fitzgerald |
| 45 | American Whitewater | Hattie Johnson, Kestrel Kunz |
| 46 | City of Salem, Utah | Kurt Christensen |
| 47 | Heber Light and Power | Jason Norlen |
| 48 | Central Arizona Project | Brenda Burman |
| 49 | City of Nephi, Utah | Justin Seely |
| 50 | National Park Service | Kate Hammond |
| 51 | Logan City Light and Power | Mark Montgomery |
| 52 | Upper Colorado River Commission | Charles Cullom |
| 53 | City of St. George, Utah | Michelle Randall |
| 54 | Town of Levan, Utah | Bruce Rowley |
| 55 | Form Letter 1 | Ray Young |
| 56 | Form Letter 1 | Roy Bond |
| 57 | Form Letter 1 | Victor Petersen |
| 58 | Form Letter 1 | Shelly Wayne |
| 59 | Form Letter 1 | Charles Kirkland |
| 60 | Form Letter 1 | Chris Memmott |
| 61 | Form Letter 1 | Michael Mastrangelo |
| 62 | Form Letter 1 | Edward Gevrekian |
| 63 | Form Letter 1 | Daniel Childs |
| 64 | Form Letter 1 | Casey Thiel |
| 65 | Form Letter 1 | Tina Ciombor |
| 66 | Form Letter 1 | Robert Munson |
| 67 | Form Letter 1 | Robert Burns |
| 68 | Form Letter 1 | Lawrence Calkins |
| 69 | Form Letter 1 | Kelley Hart |

**Table A-8**
**Substantive Comments Received during the Public Comment Period and Bureau of Reclamation's Response**

| Letter Number | Letter Comment Number | Comment Code | Comment | Response |
|---|---|---|---|---|
| 1 | 2 | ALTRANGE - Inadequate Range of Alternatives | Concerning water flow changes in order to mitigate the bass/chub conflict. Why not just string nets at the mouth of the LCR to keep other mature fish out? Monkeying around with an entire river eco system by changing water flows for one scenario is inappropriate. Nets would also deny river traffic into the LCR. It isn't currently allowed but people still do so on a regular basis. Nets would stop that as well. Nets would also deny mature chubs into the main channel. It would be a fair trade since they can't breed out there anyway. | Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. These efforts are out of scope for this NEPA effort. |
| 1 | 1 | OOS - Out of Scope | LCR should be made into a no visitation area to river runners until the chubs are at peace again. | Thank you for your comment. Managing visitation to the Little Colorado River is outside the scope of the LTEMP SEIS, which focuses on analyzing flow options at Glen Canyon Dam to address nonnative, invasive smallmouth bass and other warmwater nonnative species below the dam. |
| 3 | 1 | ALTRANGE - Inadequate Range of Alternatives | Although Reclamation has well intention in drafting the SEIS, it has been rushed and lacks a thorough and comprehensive examination of other alternatives other than use of the bypass tubes. Maintaining a higher elevation in Lake Powell should have been examined. | The management of Lake Powell reservoir elevations, including maintaining a higher elevation, is outside the scope of this SEIS. |
| 3 | 5 | SOC - Socioeconomics | By contract with Western Area Power Administration (W APA), we receive over 20% of our power resources from these federal facilities. Any cost increases or power reductions have a significant impact on our community. This clean and renewable hydroelectric energy supports our efforts to meet our carbon-free and renewable goals in the community. Over the past years, we have been impacted by drought conditions in the upper Colorado basin leading to lower energy production and higher costs. | The LTEMP SEIS evaluates the potential impacts of the proposed alternatives on hydropower generation, reliability, and associated economic impacts in the region. Reclamation does not anticipate any impacts on customer costs in 2024 and will consider impacts on customers in the planning and implementation process. Your input regarding the impacts of drought conditions on energy production and costs is also noted and has been taken into consideration in our analysis. |
| 3 | 4 | SOC - Socioeconomics | The DSEIS acknowledges that power generated through Glen Canyon Dam would need to be replaced and lays that responsibility onto W APA for solutions. However, it does not address and considers the scarcity in energy generation faced by utilities. We express serious concerns regarding the draft SEIS's failure to sufficiently analyze the impact that the flow options will have on hydropower production and the risk that reduced hydropower production may have on the ability for utilities to provide power to the Utah region during the summer. Currently the energy market is being strained and a further reduction of hydroelectric generation will add to constraint energy market with scarcity and higher prices. The DSEIS fails to reflect impacts in our market area and only examines the Palo Verde trading hub. | The LTEMP SEIS evaluates the potential impacts of the proposed alternatives on hydropower generation, reliability, and associated economic impacts in the region. Reclamation recognizes the importance of these factors and has carefully considered them in the analysis. Reclamation will also consider them in the planning and implementation process. Past, present, and reasonably foreseeable future actions regarding utilities in the region have been taken into consideration in the cumulative impacts section. |
| 3 | 2 | SOC - Socioeconomics | We strongly urge further studies to avoid reduction of hydropower generation and the impact to reliability and affordability in the region. | The LTEMP SEIS evaluates the potential impacts of the proposed alternatives on hydropower generation, reliability, and associated economic impacts in the region. We recognize the importance of these factors and have carefully considered them in our analysis and in the planning and implementation process. |
| 4 | 1 | HYDROLOGY - Hydrology | On page 2-3, the reference to river mile 15 as well as to the slough really means cooling to 15.5 C a full 15 miles downstream of LF to assure that the slough and other places in the LF reach where SMB have been collected do receive adequately cold water to inhibit spawning and growth, correct? | The five action alternatives have different temperatures and flow targets. The Cool Mix Alternatives aim to maintain a river temperature of 15.5°C. You are correct that the reference to river mile 15 equates to cooling the river temperature from the dam downstream to river mile 15. This was done just for modeling purposes; actual implementation will be decided during the planning and implementation process. |

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| 5 | 2 | ALTNODTAIL - Alternatives - Considered but Eliminated from Detailed Analysis | I am in search of anticipated wording regarding the change in adherence to the current HFE accounting window in the SEIS. This is what I found. HFE Protocol Evaluation: The evaluation of the HFE protocol will consider factors such as the absence of fall HFE releases in certain years, despite sediment triggers being met; sediment transport in low-release and low-elevation years; use of best available science for sediment accounting; and the need to improve the protocol to utilize the best available science. (1-8) * Modifications to HFE Protocol: The SEIS will explore potential modifications to the HFE protocol in light of the latest scientific findings and insights, including adjustments to sediment accounting periods and HFE implementation windows. (1-8) 2.11.1 HFE Only Alternative The HFE Only Alternative describes a set of actions aimed at better implementation of HFE releases, as outlined by the LTEMP ROD, utilizing best available science for sediment accounting. This alternative would change both the sediment accounting windows and HFE implementation periods with the goal of implementing HFE releases at a frequency and magnitude originally projected in the LTEMP ROD. This alternative did not meet the purpose and need because it did not address the issue of smallmouth bass. (2-19) Does this really mean that the modifications to the HFE accounting window have been dropped from the SEIS? Or can you point me to another section of the document that discusses this? | The SEIS does explore potential modifications to the High Flow Experiment (HFE) protocol, including adjustments to sediment accounting periods and HFE implementation windows, as outlined in Section 2.3, Common to All Action Alternatives. These changes consist of adjusting the semiannual sediment accounting period to an annual period with the option for a spring or fall HFE release, or both. These adjustments are aimed at optimizing the best available science when implementing HFE protocols, without changing the duration or magnitude of HFE releases as outlined in the LTEMP Final Environmental Impact Statement (FEIS).<br><br>The HFE Only Alternative, described in Section 2.11.1, focuses on better implementation of HFE releases, using best available science for sediment accounting. However, this alternative did not meet the purpose and need of the SEIS because it did not address the issue of smallmouth bass. |
| 6 | 2 | ALTRANGE - Inadequate Range of Alternatives | Although Reclamation has well intention in drafting the SEIS, it has been rushed and lacks a thorough and comprehensive examination of other alternatives other than use of the bypass tubes. Maintaining a higher elevation in Lake Powell should have been examined. | While we appreciate your feedback, the management of Lake Powell reservoir elevations, including maintaining a higher elevation, is outside the scope of this SEIS, which focuses on analyzing flow options at Glen Canyon Dam to address threats of nonnative, invasive smallmouth bass and other warmwater nonnative species below the dam. The SEIS has considered a reasonable range of alternatives beyond the use of bypass tubes to address this issue. |
| 6 | 1 | SOC - Socioeconomics | The DSEIS acknowledges that power generated through Glen Canyon Dam would need to be replaced and lays that responsibility onto WAPA for solutions. However, it does not address and consider the scarcity in energy generation faced by utilities. We express serious concerns regarding the draft SEIS's failure to sufficiently analyze the impact that the flow options will have on hydropower production and the risk that reduced hydropower production may have on the ability for utilities to provide power to the Utah region during the summer. Currently the energy market is being strained and a further reduction of hydroelectric generation will add to constraint energy market with scarcity and higher prices. The DSEIS fails to reflect impacts in our market area and only examines the Palo Verde trading hub. | The SEIS evaluates the potential impacts of flow options on hydropower production and recognizes the importance of ensuring a reliable and affordable power supply to the region. We have taken into consideration your concerns regarding the potential impacts on the energy market in your area. Your input will be valuable as we continue to refine our analysis. |
| 6 | 3 | SOC - Socioeconomics | We strongly urge further studies to avoid reduction of hydropower generation and the impact to reliability and affordability in the region. | The LTEMP SEIS evaluates the potential impacts of the proposed alternatives on hydropower generation, reliability, and associated economic impacts in the region. We recognize the importance of these factors and have carefully considered them in our analysis. We will also consider them in the planning and implementation process. |
| 9 | 15 | AIRCCGHG - Air Quality, Climate Change, Greenhouse Gases | Air quality is very specific to pollution sources, airflow, topography, and precipitation. While the utilization of the WECC 11 State grid average emissions factor of pollutants for replacement power is rational, comparing the increased pollution on a percentage basis based on this regional area minimizes the true increase in tons. A more comprehendible comparison would be to equate the increased tons of pollutants to vehicles on the road. For example, the increase of 33,750 Metric Tons of $CO_2$ (Table 3-60) is roughly equivalent to 6,275 gas power cars on the road. | The use of the Western Electricity Coordinating Council (WECC) 11 state grid average emissions factor for replacement power in the SEIS is a rational approach. Your suggestion to provide a more comprehensible comparison by equating the increased tons of carbon dioxide ($CO_2$) to vehicles on the road is insightful and was taken into consideration for improving the clarity of the analysis in the SEIS without falling outside the scope of this project. We have added the comparative number of gas-powered cars carbon dioxide equivalent ($CO_2e$) emissions to the results in the climate change section (Section 3.17). |

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| 9 | 6 | ALTRANGE - Inadequate Range of Alternatives | As mentioned in the "Purpose and Need" section, the alternatives do not go far enough to address the nonnative, warmwater, invasive fish downstream of Glen Canyon Dam. These alternatives are missing nonflow options that could prevent entrainment through the dam and fails to address nonnative hotspots like the -12 Mile Slough. We question whether some of the flow alternatives will inundate the slough, as some of its elevation sits above the normal river channel. Certain areas, like the -12 Mile slough, should be permanently modified to eliminate a warm water area conducive to nonnative fish establishment. In our opinion, the proposed channel (mentioned during the Annual Reporting meeting) through the slough will fill with sediment after the first HFE. Permanent actions, like fish curtains and slough excavation, should ultimately be included in the LTEMP SEIS, in addition to the proposed flow alternatives. | Reclamation is pursuing additional tiered projects to address these issues with short-, mid-, and long-term timelines, including associated NEPA efforts. Efforts to deal with the slough and address fish exclusion devices are ongoing and will be incorporated into the planning and implementation process.<br><br>Your input regarding the potential inundation of the slough and the sedimentation of proposed channels is valuable, and we have taken it into consideration as we refined the SEIS analysis. These areas will be considered and analyzed during the planning and implementation process. |
| 9 | 1 | PN - Purpose and Need | As we have mentioned in the past, the "purpose" of pursuing improvements in the LTEMP should be expanded beyond only flow options to address short, mid, and long-term needs. | Reclamation and its partners have already begun efforts toward additional protections at Glen Canyon Dam. These efforts include guidance provided by the Glen Canyon Adaptive Management Program stakeholders. The guidance includes fish exclusions, slough modifications, and temperature control devices. |
| 9 | 21 | ALTASSUMP - General Assumptions Common to All Alternatives | Based on the benefits that warm water provides to the humpback chub, we feel that the benefits of cool/cold water flow alternatives are overstated, or the pros are not adequately contrasted to the cons. If the viability of the humpback chub is the main concern, alternatives that reduce HFEs and the transportation of nonnative fish downstream, instead of increasing their frequency, should be contemplated. | The goal of the cold-water alternatives is to disrupt smallmouth bass establishment, which would inherently benefit humpback chub by reducing predators in the river. Also, concerns about downstream flushing related to HFEs have not materialized in past HFEs.<br><br>Nonnative fish conveyance would be considered during the planning and implementation process for any flow spikes or HFEs. |
| 9 | 12 | SOC - Socioeconomics | Economic value, as presented in the SEIS, was confusing, inconsistent, and lacked consideration of electric grid dynamics. In reviewing the draft, the meaning of loss of economic value was not clear. What was clear was that the grid impacts due to reductions at Glen Canyon Dam were not evaluated in context of the market. Summer purchase power can exceed $300/MWh, and scarcity pricing can skyrocket costs into the thousands per MWh. | The Final SEIS has been updated to include the PLEXOS model for an additional analysis of hydropower economics and electric grid dynamics. |
| 9 | 10 | WATERQUAL - Water Quality | Figure 3-23 (page 109) is very telling in the life cycle of native fish. They benefit from warmer waters in the river. It appears that the nonnative trout are the ones who would benefit the most from cooler/colder water. (https://deeply.thenewhumanitarian.org/water/articles/2017/05/15/calls-to-rethink-the-colorado-rivers-iconic-dams-grow-louder) Therefore, how can cool/cold flows be prioritized when warmer water benefits the humpback chub? It should be especially concerning that the SEIS contemplates increased HFEs or flow spikes, which would transport nonnative fish into humpback chub populations downstream of Glen Canyon Dam. | The goal of the cold-water alternatives is to disrupt smallmouth bass establishment, which would inherently benefit humpback chub by reducing predators in the river. Additionally, we are less concerned about rainbow trout and brown trout and other cold-water predators because their populations are not as significant or impactful as smallmouth bass on humpback chub.<br><br>Nonnative fish conveyance would be considered during the planning and implementation process for any flow spikes or HFEs. |

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| 9 | 24 | GEOSEDI - Geomorphology and Sediment | HFEs have been utilized since 1996 and could be the most efficient mechanism to build beaches. However, they may also be the biggest threat to native fish because of their transport mechanism of nonnative fish downstream (page 140). As the only currently allowed mechanism to rebuild beaches, alternatives should be developed that allow for beach building without HFEs to prevent depositing nonnative fish downstream. | The best available scientific information supports the use of high flows as releases from Glen Canyon Dam at times when sediment supply is available from the Paria River or the Little Colorado River. These HFEs suspend and deposit sand at the margins of recirculating eddies to build beaches. While HFEs are typically conducted in spring or fall, the specific mechanisms of fish displacement and the optimal timing to minimize transport downstream have not been thoroughly investigated.<br><br>The decision to conduct HFEs involves a tradeoff: on THE one hand, they are essential for building sandbars necessary for riparian habitat and recreational camping; on the other hand, they may transport deleterious fish to native fish populations. Recent events, such as the cancellation of an HFE due to the presence of large numbers of green sunfish at the 3-mile slough, highlight the need for ongoing monitoring and reevaluation to balance the benefits of HFEs with the goal of reducing downstream fish transport. Additionally, concerns about downstream flushing related to HFEs have not materialized in past HFEs. |
| 9 | 11 | SOC - Socioeconomics | Hydropower is a primary authorized purpose of the CRSP Act, and it should be protected (page 2). As such, analysis of the impacts to hydropower should be performed by the subject matter experts (Western Area Power Administration). The SEIS states that economic models used by Grand Canyon Research and Monitoring Center (GCMRC) are based on standard energy economic analysis methods from (Harpman) 1999 (page 75). The energy market today is drastically different than the one from 25 years ago. The historical locational marginal price used pricing from 2020 to 2023 (page 76). These years include COVID energy prices, an outlier that skews and minimizes the impacts. The modeling was also performed for one week in the month and extrapolated over the entire month (page 76). Energy prices are highly volatile and weather dependent. This extrapolation has resulted in flawed economic modeling by GCMRC. The price comparison between the GCMRC and WAPA data translates to nearly a $30/MWh price difference (page 82). We feel that even the highest purchase power value used ($117/MWh) is insufficient to reflect the true cost of replacement power during the cool/cold flows. Therefore, we recommend that the modeling from GCRMC related to hydropower be removed. | Reclamation has worked closely with multiple cooperating agencies and stakeholders, including Western Area Power Administration (WAPA) and the Grand Canyon Monitoring and Research Center (GCMRC), to include the best available science and modeling. The Final SEIS has been updated to include the PLEXOS model, provided by WAPA, for an additional analysis of hydropower economics. PLEXOS was not available at the time of the Draft SEIS, and its inclusion enhances the analysis in the SEIS. |
| 9 | 23 | ALTASSUMP - General Assumptions Common to All Alternatives | If Reclamation insists on having a cool/cold water flow alternative, we must insist that it does not select either cool water alternative and that the alternative have sufficient guardrails as to Lake Powell elevations that preclude these experiments from being performed if the lake is above an elevation that might entrain nonnative fish. | While reservoir elevations will be considered, river temperature will be the main trigger for these experimental flows. Triggers, guardrails, and hydrology will be considered during the planning and implementation process. |
| 9 | 16 | ALTASSUMP - General Assumptions Common to All Alternatives | Modeling assumptions throughout the SEIS appear speculative or limited. Terms like "assumed..., but not confirmed" (page 102), "unproven models" (pages 151/152), "several limitations...modeling results" (pages 155 & 183), "conceptual, as opposed to predictive" (page 183), "recalibration" (page 209) and "no model exists" (page 369) call to question the information presented. Decisions based on flawed date often result in flawed decisions. | It is important to note that while some terms like "assumed" and "conceptual" are used to describe certain aspects of the analysis, these are standard practices in environmental modeling where uncertainties exist. The SEIS strives to transparently present these limitations and uncertainties to ensure that decisions are based on the best available scientific information. The SEIS has been updated accordingly. |

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| 9 | 4 | ALTRANGE - Inadequate Range of Alternatives | Nonnative, warmwater fish have been detected downstream of Glen Canyon Dam for over 20 years. Green sunfish were rotenone poisoned in 2015, and biologists have recommended that the Bureau pursue prevention of fish passage from the dam since 2016. (https://www.wired.com/story/the-fight-against-the-smallmouth-bass-invasion-of-the-grand-canyon/) While we support the concept of preventing establishment of smallmouth bass and other nonnative, warmwater, invasive fish (page 19), the issues being addressed existed in 2016 and should have been addressed in the LTEMP FEIS, or this SEIS should have included nonflow prevention methods (page 20) based on seven years of awareness that nonnative, invasive fish could impact humpback chub downstream of Glen Canyon Dam. | Reclamation acknowledges the presence of warmwater nonnative invasive species below Glen Canyon Dam. While the issues have been known for some time, only recently has evidence of spawning and population growth been identified, necessitating swift action to avoid long-term and expensive solutions. Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. |
| 9 | 9 | WATERQUAL - Water Quality | Starting in 2004, the temperature of water released through Glen Canyon Dam increased in summer and fall when lower levels in Lake Powell allowed warm surface water to be entrained in the penstocks. Warmer releases of up to 16oC were reported in late summer and fall through 2015, but the magnitude and duration of these warm water releases have varied by year. This temperature increase has enhanced the growth of Humpback Chub in Grand Canyon and allowed greater mainstem residence and possibly reproduction in western Grand Canyon (Kegerries et al. 2016; Rogowski et al. 2017). The warmer temperature may also allow for expansion of warm-water nonnative fish species. (USFW Species Status Assessment for the Humpback Chub - March 2018) | Thank you for providing this information. Your comment underscores the importance of considering these factors in the context of the LTEMP SEIS. We have incorporated this information in Section 3.5, Aquatic Resources for additional details on warming impacts on fish species. |
| 9 | 17 | TERREWET - Terrestrial Resources and Wetlands | Tamarisk, introduced by the US Department of Agriculture, reached the Grand Canyon in the late 1920s and early 1930s. While the potential to scour these invasive trees has been severely limited because of flow limitations at Glen Canyon Dam, the dam is not responsible for the impacts to beach building that Tamarisk prevent downstream of the dam because they existed before the dam. Nor are they called out in the SEIS for the impacts to aeolian transport and how they limit cultural resource protection. | Thank you for your comment. The SEIS states that there are four specific vegetation issues influenced by dam operations that the LTEMP restoration projects specifically seek to address: 1) encroachment of vegetation on sandbars, 2) a decrease in native plant species, 3) erosion of archaeological resources, and 4) narrowing and loss of plants in the old high-water zone (OHWZ). These issues are described in the 2016 LTEMP FEIS (U.S. Department of the Interior [DOI] 2016a) and have been incorporated by reference in the current SEIS. |
| 9 | 18 | ALTASSUMP - General Assumptions Common to All Alternatives | The biases expressed in the SEIS are concerning and indicative of a failed process. This is self-evident in the statement that the "Reclamation would like the flexibility to implement temperature-based flow options to target smallmouth bass" (page 27). This is further reinforced by describing the alternatives as "smallmouth bass alternatives" (page 28). | The SEIS has been updated to better clarify the statement's goal of explaining the modeling assumptions. The focus of this analysis, however, is appropriately directed at flow options to address the effects of smallmouth bass on humpback chub. |
| 9 | 20 | ENERGYPOW - Energy and Power | The inclusion of statements such as, "individuals owning property in the region around Glen Canyon Dam are considerably more likely to support continuation of dam operations" and "(t)hese people are more likely to receive the benefits of Glen Canyon Dam hydropower at their property and are, therefore, more likely to be personally affected by the economic viability of communities that receive low-cost hydropower" (Jones et al. 2016) (page 264) reflect a bias against hydropower. CRSP power is delivered over the majority of five states. Perhaps their support of hydropower is based on a comprehension of the benefits it provides, not just based on the proximity to Glen Canyon Dam. | To address this, we have revised the SEIS to ensure that it reflects this broader perspective and acknowledges the support for hydropower from all Colorado River Storage Project (CRSP) customers. This involves replacing language that specifically mentions property owners with more inclusive language that encompasses all CRSP customers, highlighting their support for hydropower based on the benefits it provides, such as reliable and low-cost electricity. |
| 9 | 19 | ALTBYPASS - Alternatives - Non-Bypass | The Non-Bypass flow alternative seems targeted by mentioning its impact to shoreline stability, but the SEIS does not mention something similar with regards to HFEs (pages 157 & 166). | The Non-Bypass Alternative results in a reduction in sand mass balance and smaller sandbars, which can impact shoreline stability. On the other hand, HFEs are implemented when adequate sediment volumes exist in the river to result in an increase in sandbar size and help stabilize shorelines. The SEIS does not specifically mention the impacts of HFEs on shoreline stability because they are designed to enhance sandbar formation and support ecosystem functions. Ecosystem functions have not been stressed much since the early inception of the protocol. |

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| 9 | 2 | ALTRANGE - Inadequate Range of Alternatives | The rush to complete this SEIS by the Summer of 2024 (Draft SEIS-page 22) is resulting in a flawed process by strictly focusing on flow alternatives. A proper and thorough evaluation of alternative prevention methods should be included in this SEIS, not in a later NEPA process, because the issues being addressed have persisted for some time, including before the finalization of the LTEMP FEIS. | Smallmouth bass represent an unacceptable risk that requires immediate action. To address the risk of establishment, Reclamation is collaborating with cooperating agencies to take advantage of the best opportunity to optimize the use of flows to disrupt the establishment of smallmouth bass. The SEIS incorporates the best available science at the time of its development, and Reclamation has updated the document to include new and improved information in the LTEMP Final SEIS. Moving forward, Reclamation will continue to incorporate the best available science in the planning and implementation process.<br><br>Additionally, while the issues have been known for some time, only recently has evidence of spawning and population growth been identified, necessitating swift action to avoid long-term and expensive solutions. Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. |
| 9 | 13 | ENERGYPOW - Energy and Power | There also seems to be a lack of understanding by those who drafted the SEIS on how the shift towards electrification is increasing demand, while supply is lagging. Resource adequacy and grid reliability are a major area of concern for FERC/NERC, but the SEIS presents a false narrative regarding new renewables eliminating the need for generation at Glen Canyon Dam (page 195). In reality, these renewables will increase the reliance on hydropower to help balance the grid. | Thank you for your comment. Reclamation appreciates your input and has considered these perspectives in the development of the Final SEIS. |
| 9 | 8 | AQUA - Aquatic Resources | Warm water downstream of Glen Canyon Dam is not a new phenomenon and is likely the reason for the improvements in the humpback chub population resulting in a downlisting (from endangered to threatened). This is acknowledged in the SEIS (page 176 & paragraph below) but impacts to humpback chub from cool/cold water are not discussed in this draft. | To address this concern, we have added a paragraph to the Distribution and Abundance section in section 3.5 of the SEIS that provides additional context on how humpback chub have persisted and even thrived in the Colorado River through Grand Canyon despite the presence of cold-water releases from Glen Canyon Dam. This paragraph highlights the species' ability to adapt to varying water temperatures and its historical movements in response to these conditions. The new change adds to the concerns about warm-water nonnative predation, which are the subject of this analysis. Additionally, the Section 3.5 of the SEIS addresses the role of warm water in the recent humpback chub population increases. |
| 9 | 7 | ALTASSUMP - General Assumptions Common to All Alternatives | We also assert that the proposed alternatives should have guardrails to ensure that these experiments are only considered when necessary. If the elevation in Lake Powell gets high enough, release temperatures through the penstocks from the hypolimnion will be cool/cold enough to prevent establishment downstream without bypass flows. | In general, implementation considerations such as these are addressed in Chapter 1. Moreover, information concerning effects on other resources, including any appropriate triggers, guardrails, and hydrology, will be considered during the planning and implementation process. Regarding temperature, the preferred alternative addresses the relationship between Lake Powell's elevation and release temperature by modeling release temps and verifying against actuals. |

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| 9 | 14 | SOC - Socioeconomics | We also find a disparate analysis of nonuse in relation to hydropower. There is an abstract reference to nonuse hydropower value (page 254) but a very descriptive comparison of nonuse values for the environment. Included later (page 261), there are very specific (if not overstated) net values of whitewater boaters and anglers but none for hydropower impacts. A true comparison between the 40+K rafters' economic value and the 4M power customers should be included in the SEIS, as should the baseline generation value that Tables 3-13 to 3-28 utilize. | A detailed discussion of hydropower-related economic impacts is included in Section 3.3 of the SEIS. It should be noted that non-use values are discussed in greater detail for recreation aspects due to a lack of specific use value data available for this resource. In contrast, for hydropower, actual use value data are available and are included, providing a more precise understanding of its economic impacts. Your feedback regarding the analysis of non-use values for hydropower and the comparison between rafters' economic value and power customers has been noted and considered in the development of the Final SEIS. |
| 9 | 25 | GEOSEDI - Geomorphology and Sediment | We continue to have concerns with the impacts of HFEs on the system, including increased erosion/wear on the bypass tubes and the potential to utilize them in high power demand months (June-August). There are conflicting statements in the SEIS regarding non-HFE years due to warmer weather and entrainment of nonnative fish (page 19). HFEs were not held during certain years because of nonnative fish being discovered downstream of Glen Canyon Dam. If HFEs were avoided because of the rationale stated, then flow spikes (similar to HFEs) should not be included in the flow alternatives. | The impacts of HFEs on the system, including increased erosion/wear on the bypass tubes and the potential for their use in high-power demand months, are valid concerns that have been noted and will be monitored during the planning and implementation process. These concerns were built into the modeling conducted for the LTEMP SEIS.<br><br>Conveyance of nonnative fish will be considered during the planning and implementation process for HFEs and flow spikes.<br><br>Additional language has been added to Chapter 1. |
| 9 | 5 | PN - Purpose and Need | We find the representation that smallmouth bass is a new problem in the "Purpose and Need" section erroneous. The purported inclusion of the "latest scientific information" for HFEs was found lacking in the document. While mentioned later in the document, the absence of inclusion that warmer water potentially benefits the humpback chub is a glaring omission in the "Purpose and Need" section. | The Purpose and Need section has been updated to reflect recent evidence of increased smallmouth bass spawning. While smallmouth bass have been detected in low numbers before, recent smallmouth bass detections have increased, highlighting the need for effective management strategies.<br><br>Reclamation has incorporated the best available science for implementing HFEs. HFEs have been conducted in various forms. Reclamation and the Adaptive Management Program have continuously collected and considered data from these HFEs, including data concerning sediment accounting windows. Please refer to the 2023 Proposal to Amend the High-Flow Experiment Protocol and Other Considerations for additional information. The proposed action includes continuation of the planning and implementation process, which will use the latest scientific information.<br><br>The Purpose and Need is appropriate as drafted concerning potential benefits to humpback chub from warmer water, as it is not required to detail every ecosystem condition that affects a listed species. There may be benefits to the humpback chub from warmer temperatures, as described in Section 3.5. However, the main concern for this analysis is the rapidly expanding smallmouth bass population and its effects on listed species. |
| 11 | 2 | ALTRANGE - Inadequate Range of Alternatives | Although Reclamation has well intention in drafting the SEIS, it has been rushed and lacks a thorough and comprehensive examination of other alternatives other than use of the bypass tubes. Maintaining a higher elevation in Lake Powell should have been examined. | The management of Lake Powell reservoir elevations, including maintaining a higher elevation, is outside the scope of this SEIS. |

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| 11 | 1 | SOC - Socioeconomics | The DSEIS acknowledges that power generated through Glen Canyon Dam would need to be replaced and lays that responsibility onto WAPA for solutions. However, it does not address and consider the scarcity in energy generation faced by utilities. We express serious concerns regarding the draft SEIS's failure to sufficiently analyze the impact that the flow options will have on hydropower production and the risk that reduced hydropower production may have on the ability for utilities to provide power to the Utah region during the summer. Currently, the energy market is being strained and a further reduction of hydroelectric generation will add to the constrained energy market with scarcity and higher prices. The DSEIS fails to reflect impacts in our market area and only examines the Palo Verde trading hub. | The SEIS evaluates the potential impacts of flow options on hydropower production and recognizes the importance of ensuring a reliable and affordable power supply to the region. We have taken your concerns into consideration regarding the potential impacts on the energy market in your area. Your input was valuable as we refined our analysis.<br><br>It is also important to note that future restrictions on flows to address Endangered Species Act (ESA) concerns could also reduce hydropower generation. The goal of this analysis is to proactively address the smallmouth bass problem to avoid potential issues with ESA-related flow restrictions in the future. |
| 13 | 4 | ENERGYPOW - Energy and Power | Further, there is not yet a CRSP rate analysis that provides a complete picture of rate impacts and any effects as to funding of Basin Fund. The DSEIS states at 3-19 that: "By bypassing the electrical generators at Glen Canyon Dam, the experiment will reduce hydropower generation. Accordingly, W AP A will be required to purchase replacement power to fulfill its contractual obligations to customers. The experiment would markedly increase the amount of nonreimbursable costs drawn from the Basin Fund and returned to the Treasury." While acknowledging impacts if the Basin Fund balance falls below $70 million, the DSEIS does not analyze in Section 3.3 the likelihood and degree of a shortfall under the $70 million level (and likelihood of triggering a cost-recovery charge, as noted in DSEIS at 3-27), or other quantitative analysis of the impacts to the Basin Fund. The DSEIS should reflect such analysis. | Reclamation is committed to incorporating the best available science into the planning and implementation process to thoroughly assess impacts on hydropower resources. The Final SEIS has been updated to include additional data reflecting this commitment. |
| 13 | 5 | EJ - Environmental Justice | Lastly, the DSEIS at 3-220 acknowledges that some tribes "operate their own electric utilities and receive power directly from W AP A. Power received directly from W AP A tends to be lower cost than other resources. A reduction in W AP A power allocation, therefore, translates into higher costs for Tribal utilities." The DSEIS continues by discussing benefit crediting arrangements and their importance to tribes. However, the DSEIS does not analyze whether reductions in GCD output will adversely impact these benefit crediting arrangements nor attempt to quantify any such impact. The DSEIS should undertake this analysis. | Thank you for your comment. Under the SEIS alternatives where the bypass for smallmouth bass is treated as an experiment, WAPA would purchase replacement power on the market to ensure that customers, including Tribes, are kept whole. This means that customers would receive their power as if no bypass had occurred, and there would be no impacts to customers, including Tribes with benefit crediting agreements. The Final SEIS has been revised to add clarification on this matter in Section 3.16 and Chapter 2. |
| 13 | 3 | ENERGYPOW - Energy and Power | Moreover, the models relied upon in the DSEIS do not include WAPA's work and should include W AP A's analysis. W AP A's work includes the March 11, 2024 W AP A Desert Southwest Region, "Impact of Reduced Glen Canyon Generation on Transmission Reliability 2024." ("W AP A Report"). The W AP A Report would help in understanding the broader picture as to transmission reliability and ability to weather impacts of reduced GCD output. Section 3.3 of the DSEIS should be revised to include analysis undertaken by W AP A, as well as the information from NREL and Argonne noted above. | The inclusion of WAPA's analysis, as well as the information from the National Renewable Energy Laboratory (NREL) and Argonne National Laboratory (Argonne), is crucial for a comprehensive understanding of transmission reliability and the ability to weather impacts of reduced Glen Canyon Dam output. In response to your feedback, Section 3.3 of the Final SEIS has been revised to include information from the WAPA analysis, along with the analyses from NREL and Argonne, to provide a more comprehensive analysis of transmission reliability. |

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| 13 | 2 | ENERGYPOW - Energy and Power | NTUA is concerned with specific transmission congestion impacts that are appearing in the models. Data generated by the National Renewable Energy Laboratory ("NREL") found congestion effects due to reduced GCD generation, including potential congestion impacts that may affect NTUA. For example, the NREL data found congestion impacts from Kayenta to Longhouse as an effect of reduced GCD generation. Analysis by Argonne National Laboratory ("Argonne") found that the reduction in generation at GCD significantly affects the transmittal of energy to Four Corners and Northern loads. | The concerns regarding specific transmission congestion impacts, as identified by the NREL and Argonne, are important considerations. To address these concerns, PLEXOS modeling, considered the best available scientific information, has been added to the Final SEIS. Additionally, the cumulative impacts section of Section 3.3.2 has been updated to reflect these findings. It is important to note that emergency operations will continue regardless of the alternative selected, and the planning and Implementation process will consider impacts to hydropower resources. Reclamation works closely with WAPA on determining operations to mitigate transmission congestion impacts. |
| 13 | 1 | ENERGYPOW - Energy and Power | Reduced and/or bypassed generation at Glen Canyon Dam ("GCD")/CRSP, as discussed in the DSEIS, has implications and potential impacts to NTUA, including the affordable delivery of electricity to the Navajo people and to counterparties. From a tribal perspective, hydropower is necessary for our Navajo people to be able to pay their electric bills. Basic necessities such as electricity, water, internet are still not adequately met on the Navajo Nation, which is unacceptable. With the risk of interruption or congestion affecting hydropower resources, such impacts will exacerbate an already serious problem. | Thank you for your comment. Because the alternatives in this SEIS are treated as experiments, WAPA would be responsible for the purchase of replacement power on the market and customers, including Tribes, would be kept whole. This means that customers would receive their power as if no bypass had occurred, and there would be no impacts to customers. This includes Tribes with benefit crediting agreements. The Final SEIS has been revised to add clarification. |
| 14 | 4 | ALTRANGE - Inadequate Range of Alternatives | Additionally, based on Reclamation's recent 24-month study, the temperature triggers may not occur this summer. Given that information, WMPA believes that other options such as physical barriers and slough modification should be considered and undertaken as soon as possible. The DSEIS should be modified to include other than flow-only actions. | Reclamation will use the best available science during the planning and implementation process.<br><br>Reclamation is pursuing additional tiered projects to address these issues with short-, mid-, and long-term timelines, including associated NEPA efforts. |
| 14 | 3 | WATERQUAL - Water Quality | Additionally, WMPA is concerned that temperature control through changing the flows from the dam are the only options considered in the current draft. The DSEIS states that "(s)pecific data on these fish have been collected but are not available or citable at this time." As temperature control is the main premise and the sole mitigation action considered in the DSEIS, WMPA is concerned that this experimental attempt at temperature control will not have the desired effect. | The SEIS analyzes a range of feasible alternatives consistent with the best available science. Reclamation is committed to considering all alternatives in the analysis.<br><br>Reclamation is pursuing additional tiered projects to address these issues with short-, mid-, and long-term timelines, including associated NEPA efforts. |
| 14 | 1 | ENERGYPOW - Energy and Power | Additionally, WMPA strongly believes that WAPA should be the federal agency to provide the hydropower and grid reliability studies for the DSEIS. While other agencies can create models, WAPA, as a grid operator, has decades of practical experience. It's important that peer-reviewed, published models, such as those used by WAPA in the original L TEMP EIS and other Reclamation NEPA processes be used in the DSEIS for clarity and consistency. WMPA also recommends that any untested experiment must include specific implementation triggers and offramps that incorporate species as well as financial and grid considerations. | Reclamation has included PLEXOS modeling in the Final SEIS for an additional analysis of impacts to hydropower and the electric grid. Triggers, guardrails, and hydrology will be considered during the planning and implementation process. |

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| 14 | 2 | ENERGYPOW - Energy and Power | Reliable electricity is essential to human life and livelihoods. From a social justice perspective, providing reliable electricity is a moral obligation. Providing reliable electricity is WMPA's highest priority. Generally, electricity is generated exactly when humans want it because electricity is expensive and relatively difficult to store. Dispatchable generation, such as hydroelectric, gas, coal, nuclear, and diesel, produce power based on when people want it. Non-dispatchable generation, such as solar and wind, produce power based on weather conditions. Dispatchable generation is vital to providing reliable electricity. WMPA is deeply concerned about the reduction of dispatchable generation from Glen Canyon Dam when the generators are bypassed. As dispatchable generation becomes more scarce, WMPA is concerned about the availability of replacement power. Also, from an environmental perspective and as noted in the DSEIS, it is likely that most of the replacement power will come from sources with more carbon emissions than hydropower. | Reclamation has added the PLEXOS modeling for an analysis of impacts to the grid and replacement energy. The planning and implementation process will consider the impacts on dispatchable generation from Glen Canyon Dam when generators are bypassed, as well as the availability of replacement power. The environmental implications, including potential increased carbon emissions from alternative power sources, were also considered in the development of the Final SEIS. |
| 14 | 7 | AQUA - Aquatic Resources | While many entities are interested in mitigating the smallmouth bass threat, the DSEIS does not state how that mitigation will be funded. It should be funded by federal non-reimbursable appropriations, not by WAPA or its customers. | Thank you for your comment. The Final SEIS has been updated accordingly. |
| 14 | 6 | AQUA - Aquatic Resources | WMPA is concerned about unintended consequences due to the desire to act quickly without considering the optimal long-term goals regarding non-native fish. The very presence of smallmouth bass in the Colorado River is an unintended consequence of stocking smallmouth bass in the river several decades ago. Now, it is easy to see this as an error, but unfortunately, people didn't understand the risk in the past. This unintended consequence also underscores WMPA's recommendation about funding mitigation, because hydropower customers didn't stock smallmouth bass in the river and should not bear the obligation to mitigate for their presence. | As you noted, smallmouth bass were stocked in Upper Basin reservoirs starting in 1967 and through the 1970s as sportfish and predators of Utah chub. Their expansion into the Yampa River of the Upper Basin in 2002 following record low flows highlights the complex nature of managing nonnative species. The release of smallmouth bass into Lake Powell by the Utah Division of Wildlife Resources in 1982 likely led to the population now present below Glen Canyon Dam.<br><br>Reclamation is committed to addressing the unintended consequences of past actions and is working to mitigate the impacts of nonnative fish on the Colorado River ecosystem. While this SEIS addresses short-term actions, the goal is to implement measures that have lasting positive effects with respect to the purpose of and need for this action. Your input on funding mitigation efforts is valuable, and we considered it as we refined the SEIS to achieve the project's goals. |
| 14 | 5 | AQUA - Aquatic Resources | WMPA is concerned that the -12 mile slough is not addressed in this draft. The slough is a spawning location for non-native fish like the green sunfish and smallmouth bass. This slough issue has been discussed for years and solutions have been proposed, but no action has been taken to mitigate this problem. WMPA strongly believes that removing this smallmouth bass spawning area is very important to the long-term success of mitigating threats from non-native fish. | Reclamation acknowledges the importance of addressing this spawning location for nonnative fish, such as the green sunfish and smallmouth bass. The -12 mile slough is described in the last paragraph of page 3-81 and the top of page 3-82 of the Draft SEIS. We have also included a statement indicating that Reclamation and the National Park Service (NPS) are in advanced planning stages for mechanically modifying the slough. While plans are progressing, it is important to note that the NPS has not yet confirmed the final implementation of these modifications. |
| 15 | 28 | AQUA - Aquatic Resources | In addition, input from the independent fisheries expert panel, experiment decision-making process and implementation, off-ramps and mitigation measures must be found. | While the Science Panel report is not available at the time of this comment period and Draft SEIS, Reclamation has indeed used the best available science during the development of the SEIS. Moving forward, Reclamation will continue to rely on the best available science during the planning and implementation process. While we could not include the findings of the Science Panel in the Draft SEIS, we have ensured that the Science Panel information was included in the Final SEIS. |

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| 15 | 14 | AQUA - Aquatic Resources | After hearing reports at AMWG and the Annual Reporting meeting, UMPA is concerned that the invasive fish species and predators of the endangered fisheries are already established downstream. There are plenty of locations of tributaries, springs, eddies, and coves with pockets of warmer water conducive for SMB, green sunfish, and non-native species to the Colorado River. Will this effort to remove or manage the SMB be successful when other attempts have failed? | Reclamation acknowledges the concern regarding the establishment of invasive fish species and predators of endangered fisheries downstream. Long-term fish monitoring in the Grand Canyon has revealed small numbers of smallmouth bass in three locations: at Lees Ferry, at the mouth of the Little Colorado River, and downstream of Diamond Creek. This monitoring is conducted annually and provides the best available scientific information for decision-making.<br><br>Monitoring the status of all fish species in the Grand Canyon is the primary responsibility of the U.S. Geological Survey's (USGS's) GCMRC and the Arizona Game and Fish Department (AZGFD). Reclamation is implementing actions that subject matter experts believe have the best chance of controlling smallmouth bass. However, there is uncertainty associated with each alternative, and success cannot be guaranteed. Your input on the effectiveness of these efforts is valuable, and we  considered it as we refined the Final SEIS. |
| 15 | 1 | ALTRANGE - Inadequate Range of Alternatives | Although Reclamation has well intention in drafting the DSEIS, it has been rushed and lacks a thorough and comprehensive examination of other alternatives other than use of the bypass tubes. | This SEIS focuses on analyzing flow options at Glen Canyon Dam to address threats of nonnative, invasive smallmouth bass and other warmwater nonnative species below the dam. The SEIS has considered a reasonable range of alternatives within this scope to address this issue. |
| 15 | 19 | ENERGYPOW - Energy and Power | Although, there are several flows with mixing of the bypass tubes being analyzed to disrupt the spawning and reproduction cycles of these invasive species, the impacts to power production may not warrant the effort if the species are already established. | Reclamation has considered impacts to hydropower while selecting a preferred alternative. The urgency of addressing the immediate threat to native species is paramount. The best available science is guiding this process to ensure that the most effective options are selected to balance many different interests in the operation of Glen Canyon Dam. |
| 15 | 13 | ENERGYPOW - Energy and Power | Another major concern is the wasteful usage of federal monies within the federal families competing to perform outside of their expertise and roles with AMP. Historically, WAPA provided the modeling of energy costs for HFE and Reclamation relied on WAPA for guiding the discussion on these critical financial and energy matters. Now due to a lack of trust between certain agencies, the SDEIS contains inadequate information provided this agency. | Reclamation is committed to fostering collaboration and trust among all agencies involved in the Adaptive Management Program. Reclamation has worked hard to ensure that the Final SEIS contains adequate information from all relevant agencies. |
| 15 | 21 | ALTASSUMP - General Assumptions Common to All Alternatives | If the Reclamation moves forward with a proposed flow to address the SMB what will the criteria for measuring success? It appears to us that there are still open discussions and debate among the experts on SMB and the benefits of the proposed flows. To the nonexpert, the proposed flow controls and justification is a based-on trial-and-error method. Without a good baseline of fishery data downstream, success could be a moving target with no clear outcomes. Any proposed flow patterns need to demonstrate clear and measurable objectives against the costs and other environmental attributes. | While there are ongoing discussions and debates among experts regarding smallmouth bass and the benefits of proposed flows, these flows are based on the best available science and are not simply trial-and-error methods. To ensure the effectiveness of proposed flow patterns, monitoring programs by the GCMRC, NPS, and AZGFD will continue to provide baseline fishery data downstream. These data will help establish clear objectives and outcomes for evaluating the success of the proposed flows against their costs and other environmental conditions. Moreover, any flow-based options will include appropriate monitoring to assess changes from baseline conditions. |

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| 15 | 7 | ENERGYPOW - Energy and Power | If the reduction of hydropower energy from using the bypass tubes is somehow transferred by WAPA onto its customers, UMPA would be thrust into an already competitive spot or day ahead market to find replacement energy. With current energy market conditions, UMPA had not been given ample time to model the impacts on its budgets. However, it is easy to conclude that the cost would be extremely high due to the lack of energy sources available in the market, especially during the summer months. | Because the alternatives in this SEIS are treated as experiments, WAPA would be responsible for the purchase of replacement power on the market, and customers would be kept whole. This means that customers would receive their power as if no bypass had occurred in 2024, and there would be no impact on customers. Potential cost impacts will be analyzed and considered during the planning and implementation process for future years. The Final SEIS has been revised to add clarification. |
| 15 | 26 | ALTNODTAIL - Alternatives - Considered but Eliminated from Detailed Analysis | In evaluating the impacts to power supply, the study should consider conducting Spring HFE during low consumptive months defined as shoulder months in the industry. There is a high likelihood of available replacement power, and costs tend to be lower. It has been reported that Spring HFEs could be beneficial to the trout fisheries and detrimental to the spawning of these evasive species if they are not established. | As part of the planning and implementation process, hydropower resources will be considered and analyzed. Reclamation will look for opportunities to minimize impacts while meeting the purpose of and need for the project. |
| 15 | 12 | ENERGYPOW - Energy and Power | In summary, to protect reliability to the grid and affordability to the customers, there must be established offramps of any experimental design flows and immediately cease the experiments if replacement power is not available in the market or if the basin fund cannot sustain those replacement costs. | Emergency operating criteria would continue as outlined in the LTEMP ROD. Reclamation will work closely with WAPA to address any necessary off-ramps due to a lack of replacement power. |
| 15 | 24 | HYDROLOGY - Hydrology | Not only should conducting an HFE consider the sediment loads in the river but should consider the elevation of the lake. Any HFE during low lake levels, even with the use of the bypass, will promote the entrainment of these evasive species through the turbine tubes. Any operations that can cause entrainment should be avoided. | HFEs are conducted based on the best available science and are part of a comprehensive strategy to manage and control smallmouth bass and other warmwater, nonnative invasive species. The decision to conduct an HFE takes into account a range of factors, including sediment loads, lake elevation, and the potential impacts on native fish populations. Triggers for HFEs are sediment based, but any decision to conduct an HFE includes consideration of other resource areas, including lake elevation, entrainment potential, and the potential impacts on native fish populations. The effects of HFE implementation on fish populations will continue to be monitored and evaluated to inform future management decisions. |
| 15 | 18 | AQUA - Aquatic Resources | SMB populations are increasing but so are the humpback chub which has been downlisted from "endangered" to "threatened." The Western Grand Canyon population of approximately 66,000 must be taken into consideration in the DSEIS risk assessment. Lake Powell elevations have also risen due to better than average hydrology in 2023, cooling the waters and lowering the risk of entrainment. Current forecasts show above average snowpack with favorable water inflows into Lake Powel. There is no reason to implement experiments right away. | Regarding the western Grand Canyon population, the temperature-based trigger accounts for current hydrology developments, which is a key aspect of the adaptive management approach. This trigger mechanism allows for responsive adjustments based on real-time conditions, ensuring that the management strategies remain effective in addressing smallmouth bass populations.<br><br>Although the Glen Canyon Dam Adaptive Management Program (GCDAMP) is an adaptive management program, the alternatives proposed in this SEIS will be implemented based on the best available options for managing and controlling smallmouth bass. The preferred alternative is being implemented under the principles of adaptive management and will continue to be evaluated in the post-2026 EIS. Continued monitoring of fish before and after implementation of the preferred alternative will provide a better understanding of the potential flow-prescribed options for controlling smallmouth bass. |

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| 15 | 9 | SOC - Socioeconomics | The drought has already impacted CRSP customers causing them to enter the energy market to replace power not supplied by WAPA. Selecting any of the flow options would cause WAPA to enter into the energy market to replace the lost power. Customers will then be competing with WAPA as a buyer in the markets. Prices will increase for all utilities in the market from the constraint of energy supplies, transmission path congestion and fuel conditions. The DSEIS has not considered the added operational constraints in the already competitive energy market. | The SEIS analyzes potential economic impacts, including hydropower generation and associated costs. Reclamation does not anticipate any impacts on customer rates in 2024. Impacts to customers will be analyzed and considered during the planning and implementation process for future years. |
| 15 | 27 | DATA - Data Sources | The DSEIS does not include critical data and analyses necessary for either the public to provide meaningful input or the Secretary of the Interior to make a fully informed decision to undertake untested experiments. Missing information includes but is not limited to impacts to (1) hydropower capacity, energy, and rates to WAPA customers including Tribal customers, (2) the impact to the electric grid for adequacy, reserves, emergencies, and reliability, (3) the physical infrastructure condition of routinely operating the bypass tubes for temperature control and impacts at Glen Canyon Dam, and (4) the Upper Colorado River Basin Fund impacted with replacement power. | The Draft SEIS is based on the best available scientific information and developed in cooperation with various agencies, including WAPA and tribal entities. It addresses the immediate threat posed by nonnative, invasive species. Additional analysis has been added to the Final SEIS to address additional impacts to hydropower resources, including PLEXOS modeling results. Please see Section 3.3 for additional information. |
| 15 | 6 | SOC - Socioeconomics | The DSEIS lacks details on the funding sources to cover the cost of replacing any lost production of hydropower energy in considering any of the bypass flow options. We know that there are insufficient funds in the basin fund supplied from power revenues from WAPA customers to cover the cost of replaced energy in the market. Reclamation should name the funding source and not simply defer this matter to WAPA. Protecting the endangered fishery below GCD is in the best interest of all the parties. However, placing the burden for funding these experimental fish flow options on the backs of the power customers is unfair. The power customer did not introduce the SMB, a non-native fish, into Lake Powell. No one expected the low elevation and entrainment of fish caused by the drought. The federal agencies should seek federal funding or use their federal budgets to address this matter if the decision to proceed with by-pass flow happens. There are several beneficial uses with GCD not being recovered and assigned through an appropriate pay structure. | The SEIS analyzes potential economic impacts, including hydropower generation and associated costs. Reclamation does not anticipate any impacts on customer rates in 2024. That is, Reclamation anticipates customers would receive their power as if no bypass had occurred in 2024, and there would be no impact on customers. The Final SEIS has been updated with additional analysis of the costs of replacement power. Reclamation will consider potential cost impacts thoroughly during the planning and implementation process. |
| 15 | 25 | ALTNODTAIL - Alternatives - Considered but Eliminated from Detailed Analysis | The impacts by droughts and low inflow of water years should be appropriately applied to protect the lake levels in managing the water flows between the two dams. The lake level is becoming a significant driver in decision for HFE and managing the evasive species. HFE should not increase the risk of reaching minimum power pool. We should avoid any HFE during low elevation for the opportunity for entrainment of these evasive species. | While we understand your concern regarding the impacts of drought and low-inflow water years on Lake Powell reservoir elevations, the management of lake levels is outside the scope of this SEIS. |
| 15 | 4 | ENERGYPOW - Energy and Power | The modeling of energy costs in the DSEIS fails to adequately examine the impacts to WAPA customers outside of the Palo Verde energy markets. WAPA customers in other regions participate in energy markets not studied and modeled in the DSEIS. Without these comprehensive efforts to better study and model these other market site results in undervaluing the impacts to the WAPA customers. UMPA request a comprehensive look at the energy markets outside of Palo Verde energy market. | We appreciate your concern about potential impacts to WAPA customers outside the Palo Verde market. Reclamation has worked closely with WAPA during this SEIS process to analyze economic impacts within the region served by Glen Canyon Dam. We carefully considered your input as we finalized the document. |
| 15 | 10 | SOC - Socioeconomics | The power customer did not introduce the SMB, a non-native fish, into Lake Powell. No one anticipated low lake elevation and entrainment of fish. The federal agencies should seek federal funding or use their federal budgets to address this matter if the decision to proceed with by-pass flow happens. We ask that the study examine the beneficiary use and pay structure of GCD caused by the impacts of the drought. There are several beneficial uses with GCD not being recovered through an appropriate pay structure. | Additional information, including the PLEXOS modeling results, has been added to the Final SEIS. Reclamation does not anticipate any impacts on customer rates in 2024. Impacts on customers will be analyzed and considered during the planning and implementation process for future years. The analysis of hydropower impacts is based on current authorities. Options that might require new authorities are beyond the scope of this NEPA analysis. |

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| 15 | 15 | AQUA - Aquatic Resources | The slough at mile maker-12 continues to be a problem and has become a nursery for these invasive fish. Why is the focus on water temperature and bypass flows when this natural hatchery for invasive fishery is allowed to exist? Several attempts to fix the slough and chemical treat the fish over the years have yielded marginal results and failed to accomplish the end goal. Chemical treatments and the taking of life are discouraged by tribal partners. Until the slough is addressed appropriately based on technical recommendations by participating partners, results from the bypass flows for SMB seems futile with little benefits. We understand that the National Park Service is proceeding with assessment of actions necessary to address the -12-mile slough. We believe that this work is more urgent. | Reclamation acknowledges the concern regarding the slough at mile marker -12 and its role as a nursery for invasive fish. The last paragraph of page 3-81 and the top of page 3-82 of the Draft SEIS describe the slough, and there is a statement indicating that Reclamation and the NPS will be mechanically modifying the slough. Reclamation has worked closely with the NPS to address the overall strategy for the slough. |
| 15 | 11 | LTEMPEIS - LTEMP EIS | Three years is a long time for this experimental flow along with the costly replacement power. With the forecast of lower lake levels in the future, we urge Reclamation to take immediately action and begin the work on a barrier device in the forebay as discussed for the long-term solution to this challenge. The prior effort is deficient by only focusing on the mixing of flows using the bypass tubes to address the SMB matter and did not seriously examine other options. A better solution must be development that does solely rely on water temperature and bypass flows. | Barrier devices would not address the population of smallmouth bass that already exists in the river below the forebay. The focus of the LTEMP SEIS is on analyzing additional flow options that align with the purpose of and need for the project. This approach follows the best available scientific information and allows for an adaptive management approach.<br><br>In addition, Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. These efforts are out of scope for this NEPA effort. |
| 15 | 8 | ENERGYPOW - Energy and Power | UMPA is concerned that the replacement power will not be clean and renewable. We value the environmental attributes of hydropower in promoting UMPA's goals and commitments toward a carbon-free energy portfolio. Replacing hydropower from a renewable source will not occur in the energy market. If power utilities already have solar and wind, these renewable sources are already economically dispatched in conjunction with CRSP power before any carbon fueled generation is operated. | Your input on the importance of clean and renewable energy sources is valuable, and we considered this aspect as we refined the SEIS to achieve the project's purpose and need. Additional information on replacement power has been added to the cumulative impacts section of Section 3.3. |
| 15 | 16 | AQUA - Aquatic Resources | UMPA is concerned that there is insufficient fishery data in many of the tributaries and springs feeding the Colorado River and providing warmer waters where existing breeding grounds offer refuge to these invasive species. More downstream assessments need to be conducted to better determine the establishment and population of the SMB and green sunfish. If these invasive species of fisheries are already established further downstream, then the proposed SMB flows being considered offer little value in protecting the endangered species. There are current statements that green sunfish already occur throughout the Grand Canyon in small numbers. Should we be concerned about the potential impacts from dispersal? This seems to suggest that there is a lack of quantitative research on green sunfish movement or dispersal in response to flows. | While more downstream assessments may be necessary to better determine the establishment and population of smallmouth bass, it is important to note that long-term fish monitoring in the Grand Canyon has revealed small numbers of smallmouth bass in three locations: at Lees Ferry, at the mouth of the Little Colorado River, and downstream of Diamond Creek. This monitoring is conducted annually and provides the best available scientific information for decision-making.<br><br>Monitoring the status of all fish species in the Grand Canyon is a primary responsibility of the GCMRC and the AZGFD. Reclamation is analyzing alternatives that subject matter experts believe have the best chance of controlling smallmouth bass. However, there is uncertainty associated with each alternative, and additional monitoring and research may be necessary to understand the potential impacts of nonnative fish dispersal from tributaries into the Colorado River mainstem.<br><br>The current monitoring programs will continue as described here. Moreover, any implementation of flow options would include appropriate data collection to assess effectiveness. |

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| 15 | 5 | ENERGYPOW - Energy and Power | UMPA urges for the removal of the current 3.3 section in DSEIS and supports the insertion of WAPA proposed 3.3 Energy and Power submitted March 15, 2024. The current modeling data is deficient and needs to be replaced with best available information from WAPA. The modeling tools used by WAPA is much more comprehensive advanced, evidenced, and qualified than those used in the DSEIS. Reclamation fast-tracked the modeling to produce the DSEIS promptly, however, it is clear that this modeling work and assessment of hydropower replacement costs should be provided within the federal family with the highest degree of science and expertise on the matter by WAPA. | Reclamation has worked closely with WAPA and integrated WAPA's findings as appropriate as we finalized the SEIS. Reclamation has included the PLEXOS modeling results in the Final SEIS to further analyze impacts to hydropower resources. Utah Municipal Power Agency's (UMPA's) input, including WAPA's proposed Section 3.3 on Energy and Power, has been carefully considered. |
| 15 | 29 | PI - Public and Stakeholder Involvement | UMPA urges Reclamation to consider that the DSEIS should be revised to include all necessary information and analyses and reissued for public comment prior to issuance of a final SEIS or record of decision. | All public comments received on the Draft SEIS were considered and responded to, and necessary information was included in the Final SEIS. The Final SEIS addressed any gaps or deficiencies identified in the Draft SEIS to ensure a thorough and transparent decision-making process. For example, the analysis of hydropower production, despite the addition of the PLEXOS model, did not significantly change the data, which indicates that the initial findings were robust. |
| 15 | 22 | ALTRANGE - Inadequate Range of Alternatives | We propose that consideration be given to maintaining an elevation in Lake Powell to prevent the entrainment of these invasive species. If lake levels are high enough, this is clearly the best method to prevent entrainment. High lake levels help with better hydropower production with lesser flows. Higher lake elevations result in low cavitation problems in using the bypass tubes. | The management of Lake Powell reservoir elevations is outside the scope of this SEIS, which focuses on analyzing flow options at Glen Canyon Dam to address the immediate threat posed by nonnative, invasive species. |
| 15 | 17 | AQUA - Aquatic Resources | We understand that WAPA has formed a panel of fishery expert to evaluate these matters and the alternatives. More expertise from outside sources to examine the threat to the humpback chub should be encouraged. We strongly urge that the findings of this panel of fishery experts be included in the final report. | While the Science Panel report was not available at the time of this comment period and Draft SEIS, Reclamation has indeed used the best available science during the development of the SEIS. Moving forward, Reclamation will continue to rely on the best available science during the planning and implementation process. While we could not include the findings of the Science Panel in the Draft SEIS, the Science Panel information has been included in the Final SEIS. |
| 15 | 20 | AQUA - Aquatic Resources | With some of the higher flow patterns, there should be a concern that the invasive species are pushed downstream further into warm water conditions and no flows regime will be able to affect nor prevent their reproductive efforts. Pushing these invasive species further downstream is contrary to all prior efforts in protecting the populations of threatened humpback chub in and around the Little Colorado River and its confluence with the Colorado River mainstem. | Continuing fish monitoring by GCMRC, the NPS, and the AZGFD is essential to understanding the distributions and abundances of fish throughout the Grand Canyon. This information will form a crucial part of the assessment of effects of high releases, such as HFEs, on fish displacement and informing future management decisions. Additionally, concerns about downstream flushing related to HFEs have not materialized in past HFEs. |
| 15 | 2 | ENERGYPOW - Energy and Power | With the efforts to move the DSEIS quickly, UMPA is concerned that there has been insufficient time by those grid operators including WAPA to model and decide the full impacts to the grid system based on the bypass alternatives. | While this is a fast-track project to address physical and biological timing constraints, Reclamation has worked closely with WAPA to ensure that the best available scientific information guides our decisions. Efforts have been made to model and understand the impacts to the grid system to the best of our ability within the project's timeline. Reclamation remains committed to addressing these concerns and has ensured that the Final SEIS reflects the most accurate and up-to-date information available. It is important to note that we are using WAPA's analysis to inform our decisions. |
| 15 | 3 | ENERGYPOW - Energy and Power | With the rapid retirement of the coal-fired base load and dispatchable facilities in the West and by adding intermittent renewable sources, the grid become more unstable and subject to disruptions and quality of service. Reducing any generation from GDC will add to this already compromised grid system. The DSEIS should consider examining the impacts to the stability of the grid and the significant role of GCD. | We recognize concerns about cumulative impacts on the grid, especially with coal plant retirements and renewables. The Final SEIS has been updated to specifically address these potential impacts, including the addition of PLEXOS modeling, which includes power availability and balancing considerations. |

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| 16 | 4 | CRTRIBE - Cultural and Tribal Resources | 3.12 Cultural Resources<br>This entire section is a continuation of the pernicious habit of Reclamation to only present and analyze impacts through the narrow Western perspective and understanding of the environment when complying with the National Historic Preservation Act and the National Environmental Policy Act. Reclamation consistently privileges, to the exclusion of all other forms of knowledge production, Western science methodologies and ideologies, that intentionally and consistently disenfranchise and dismiss Zuni forms of knowledge production. In the Zuni scoping comments attention was directed to the fact that Reclamation's negligence in past environmental and historic preservation compliance has been indelibly entangled in racist perspectives and practices that structurally underpin the development and formation of historic preservation values and approaches when narrow disciplinary archaeological interpretations and disciplinary perspectives and values are privileged in the identification and evaluations of ancestral/archaeological sites (resources) and effects/impacts to their integrity.<br><br>For example, this section focuses solely on those archaeological sites that are considered Register-eligible by the National Park Service and will presumably benefit from aeolian sand deposition on archaeological sites that benefit from high flow experiments (HFEs). It fails to identify or address that these same archaeological sites are considered living places where the spirits of Zuni ancestors continue to reside. As Zuni, we refer to these places as Ino:de Heshoda: we which are indelibly associated with historic events that have made and continue to make significant contributions to the broad pattern of Zuni history and cultural identity. These ancestral places are physical evidence that the Zuni ancestors resided (and continue to reside) in and traveled extensively throughout the Grand Canyon to collect what they needed to survive, to initiate the journeys to find the Middle Place, and that these ancestral places act as nodes of intersection and reactivation that tie the entire Zuni sacred geography together. | Language has been added to Section 3.13 Tribal Resources and referenced in Section 3.12 Cultural Resources: "The Zuni consider archaeological sites as living places where the spirits of their ancestors continue to reside. The Zuni refer to the places as Ino:Heshoda:we. They are indelibly associated with historic events that have made and continue to make significant contributions to the broad pattern of Zuni history and cultural identity. These ancestral places are physical evidence that the Zuni ancestors resided (and continue to reside) in and traveled extensively throughout the Grand Canyon to collect what they needed to survive, to initiate the journeys to find the Middle Place, and that these ancestral places act as nodes of intersection and reactivation that tie the entire Zuni sacred geography together." |
| 16 | 12 | ATTN - Attention | During the interval to revise this public draft SEIS, the Pueblo of Zuni requires face-to-face, government-to-government consultation to provide Reclamation the opportunity to address the Zuni concerns conveyed in scoping and in this letter. | Reclamation met with the Pueblo of Zuni's leadership shortly after the receipt of these comments. During that meeting, we came to a resolution regarding a path forward on these issues. |
| 16 | 1 | CRTRIBE - Cultural and Tribal Resources | Foremost, it is important to direct attention to the November 2, 2023 letter in which the Pueblo of Zuni provided Reclamation with specific scoping comments on the preparation of this Supplemental EIS. In those comments, Zuni advised Reclamation to consider how the National Environmental Policy Act (NEPA) standards and approaches-along with recognition of Tribal sovereignty and fiduciary trust responsibilities necessitate inclusionary spaces and equal opportunities in every step of NEPA review for Tribal knowledge sovereignty and subject matter expertise for best available sciences. Additionally, Zuni advised Reclamation to consider that in any effort to achieve good faith and reasonable NEPA compliance, information and data informing NEPA review must be gathered, analyzed, and considered by and through Native knowledge and science systems, values and uses, and perspectives and meanings (i.e., ontologies and epistemologies) in at least in equal standing with mainstream Western scientific methodologies and findings. Reclamation must also consider how appropriate attention to these concerns by trained, qualified, and tribally trusted personnel are fundamentally necessary to collectively fulfill and comply with, both reasonably and in good faith, the overall purpose and procedures of NEPA generally and for this proposed supplemental EIS specifically. | Reclamation thanks the Pueblo of Zuni for its input in the NEPA process and has worked to incorporate the recommendations into the Final SEIS. |

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| 16 | 3 | CONSCULT - Consultation tribal related | In reviewing this document, it becomes immediately apparent that the authors have wholly failed to meaningfully consider, understand or evaluate the expressed Zuni scoping comments. Moreover, the treatment of the issue of lethal management of non-native fish (small mouth bass) in the Colorado River through Grand Canyon is accomplished through simplistic and faulty considerations by suggesting that resolution of adverse effects to the Zuni traditional cultural property (the Colorado River and Grand Canyon) caused by the alternative(s) considered can be appropriately handled through consultation as part of compliance with the 2017 GCD LTEMP PA. The Pueblo of Zuni reminds Reclamation that consultation is not mitigation, rather, consultation is intended and should be a meaningful, honest, and transparent communication process where the agency and the Tribe work to reach a mutually satisfactory resolution of adverse effect. The document fails to provide any credible analysis of the psychological, emotional and material harm that the community of Zuni has and will experience as a direct result of Reclamation's implementation of lethal management dam release flows.<br><br>It is the position of the Pueblo of Zuni, that Reclamation's continuing reliance on the 2012 Memorandum of Agreement as a document that defines ways to avoid, minimize or mitigate adverse effects to Chimik'yana'kya dey'a, K'yawan' A:honanne, and Ku'nin A'I'akkwe'a which specifically stipulates "live removal" per stipulation 1 is not valid for the following reasons. The various alternatives under consideration in this document are designed to prevent small mouth bass reproduction or eliminate the viability of small mouth bass eggs from hatching. Whereas, the 2012 MOA was designed specifically with rainbow trout in mind as the primary fish of concern and efforts to implement live removal were considered feasible; the treatment of small mouth bass (or green sun fish or other piscivorous non-native fish) with this MOA through this NEPA and the associated NHPA process is inapt. More importantly, the Pueblo of Zuni directs your attention to the 2012 MOA stipulation 6(a): Termination which states " .. this MOA will expire eleven ( 11) years after the date of its execution by Reclamation, unless the signatories hereto, in consultation with the other parties and such others as may have become involved in implementation of this MOA, agree in writing to extend its terms." The 2012 MOA expired in 2023 and no effort has been made by Reclamation to consult with the parties to this agreement to extend its terms. Therefore, the 2012 MOA is no longer a valid document and should not be referenced as a legitimate compliance document in this public draft SEIS. | Reclamation met in person with the Pueblo of Zuni's leadership shortly after the receipt of these comments. Through discussion during that meeting, Reclamation and the Pueblo of Zuni came to a resolution regarding a path forward on these issues. The in-person consultation proved invaluable for overcoming differences and led to mutually desirable goals. In reference to the 2012 Memorandum of Agreement (MOA), the LTEMP Programmatic Agreement (PA) Stipulation V says that the 2012 MOA remains in effect until new MOA(s) are executed. Stipulation 2 of the 2012 MOA states, "Should live removal prove infeasible, Reclamation will reconsult with the Tribes and other consulting parties to determine acceptable mitigation for adverse effects of the action." Reclamation has consulted with Zuni and now has a plan for next steps. |
| 16 | 2 | CONSCULT - Consultation tribal related | On January 18, 2024, the Pueblo of Zuni provided thirty-eight specific comments in the provided Excel spreadsheet format identifying the chapter, page number, and line number(s) specifically requested by Reclamation on the Preliminary Draft SEIS. Clearly, after reading this public draft SEIS, the Pueblo of Zuni's comments and efforts at participating in this SEIS process as a cooperating agency was meaningless. | Reclamation values the input of Tribes in the SEIS process. The comments provided by the Pueblo of Zuni are important and have been carefully considered in the development of the Final SEIS. We appreciate your efforts in participating in this SEIS process as a cooperating agency. The revisions to the Final SEIS include significant edits consistent with comments submitted by the Pueblo of Zuni. |

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| 16 | 10 | CRTRIBE - Cultural and Tribal Resources | Overall, the traditional cultural land/waterscape that defines the greater Chaco area for Zuni is comprised of numerous contributing resources, elements, and spatially distinct yet intimately interconnected spatial middle zones of multi-layered, multi-dimensional, and inter-functional past, present, and future significance that render it a unified historic district of A:shiwi A:wan Dehwa:we. As a vast yet interconnected and interfunctional intensive spatial zone comprised of multiple intensive tangible middles, the greater Zuni Chaco Heritage Historic District provides the material basis for the origins, traditional histories and sacred geographies, and current collective identity and traditional practices of the Zuni people and the Zuni Tribe. For Zuni, the integrity of the greater Zuni Chaco Heritage Historic District-like so many temporal layers and spatial dimensions of its traditional religious and cultural importance-is most directly identified, calibrated, and navigated through processes of dynamic continuity, and what deep time and deep space processes of continuity have done-and are doing-and for what and for whom; Zunis "add on to what they already have so that if one looks beyond the superficial trappings of Western society, one finds a stable Zuni cultural core." | Added verbatim to Section 3.13.1, Tribal Resources: Affected Environment to provide deeper context for the discussion of the Zuni Chaco Heritage Historic District. |
| 16 | 11 | CRTRIBE - Cultural and Tribal Resources | The above Zuni information is critically pertinent to compliance with the 2017 GCD L TEMP Programmatic Agreement and must be appropriately addressed in the next iteration of this SEIS because it presents direct, indirect and cumulative effects that are glaringly absent from this draft. The integration and the analysis of this Zuni information into the final draft of this SEIS necessitates the active involvement and engagement of Zuni knowledge experts during the process to revise this SEIS. Beginning in 2009 and continuing to the present day, the multiple epistle, email and verbal correspondences to Reclamation from the Pueblo of Zuni well documents Zuni concerns with any type of lethal management and its impacts on the Zuni sacred geography that is Grand Canyon. This public draft SEIS egregiously fails to both substantively engage and consider the direct, indirect, and cumulative impacts of these practices on Zuni people and kin. The continuing failure of the federal government to take constructive and proactive steps to address the non-native fish (of which the small mouth bass is the "poisson dujour") issue in the Colorado River below Glen Canyon Dam underscores the repeated failures of Interior agencies to effectively respond to a known emerging issue and to effectively observe their trust responsibility to the Zuni people. As this public draft SEIS demonstrates, Reclamation repeatedly makes a conscious and willful decision to maintain standard reactive measures which knowingly and disproportionately impact the Zuni community, including direct, indirect, and cumulative effects on and impacts to opportunities and capacities for fulfillment of Zuni traditional practices and protocols, experiences of health and wellbeing, and possibilities for Zuni elected leadership to fulfill their oaths of office that require us to "cherish and protect all that contains life; from the lowliest crawling creature to the human" (Constitution of The Zuni Tribe, Article XVI - Oath of Office). | Reclamation has taken steps to consult with the Pueblo of Zuni on ways to balance the taking of life. Reclamation has incorporated more of the Zuni cultural perspective into the Final SEIS. Reclamation appreciates Zuni's consistent stances on the Colorado River and is working with the Tribal Council. Reclamation met with the Pueblo of Zuni's leadership shortly after receipt of these comments. During that meeting, we came to a resolution regarding a path forward on these issues. |

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| 16 | 9 | CRTRIBE - Cultural and Tribal Resources | The formation, maintenance, and practice of these Zuni people-place, society-space, and human-environment relationships with the greater Zuni Chaco Heritage Historic District-and the historical contexts and events and geographical planes and processes of significance that they embody, convey, live, and reactivate-can be delineated and diagrammed under three general "time periods" of Zuni socio-spatial and spatiotemporal formation, aggregation, and assemblage.<br>From the event of Zuni emergence in Chimik'yana'kya dey'a and Kuhnin ATakk'wa in time immemorial to the initial movement to and pause at Heshoda Bitsulliya Ki:whihtsi Bitsulliya on the northern route in search of Idiwan'a. Archaeologists identify the time of this pause as most intensively occurring between ca. 800 and 1150 C.E.<br>From the subsequent movement of Zuni ancestors from Kuhnin ATakk'wa along the northern migration route to the initial pause at Heshoda Bitsulliya Ki:whihtsi Bitsulliya between ca. 800 and 1150 C.E and the resumed journey to find Idiwan 'a. Archaeologists suggest that the most intensive aggregation of Zuni people finding Idiwan'a occurred between ca. 900 and 1300 C.E.<br>From the ongoing and cyclical continuum of spatiotemporal and socio-spatial practice that enfolds the event of emergence in time immemorial, journeys to find Idiwan'a, and subsequent obligations to return to, pause at, and steward and recover knowledge with and throughout the diversity of resources, elements, and the intensive spatial zones of multiple middles that help form, comprise, and sustain the integrity of the greater Chaco historic district and land/waterscape in and as the emerging ever-present.<br>These time periods are simultaneously layered and intersecting as they exist in assemblage with the greater Zuni Chaco Heritage Historic District, are dependent upon the integrity of its traditional religious and cultural land/waterscape for their maintenance and perseverance, and always involve processes of movement, pause, and return with this diverse and dynamic land/waterscape as it topologically and topographically connects Zuni of the present with those of the past and future. | Language was added verbatim to Section 3.13.1, Tribal Resources: Affected Environment to provide deeper context for the discussion of the Zuni Chaco Heritage Historic District. |

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| 16 | 8 | CRTRIBE - Cultural and Tribal Resources | The greater Zuni Chaco Heritage Historic District is simultaneously a dynamic and diverse and inter functional and unified geographical area densely lined and dotted with multiple intensive zones of historical significance and ongoing traditional religious and cultural importance. The interconnected and interrelated layers and dimensions of multiple intensive middle zones of the district both circularly and circuitously pivot-in space and time-on Heshoda Bitsulliya Ki:whihtsi Bitsullya, Chaco Canyon, while always connecting and radiating to and from the spatial anchors of Idiwana'a, the Zuni Pueblo, and Cltimik'yana'kya dey'a (place of emergence) and Kuhnin ATakk'wa (Grand Canyon). The spatial forms and surficial constellations of Chaco Canyon convey deep time and deep space Zuni understandings of the multi-dimensional cosmos, and take on wider communal layers of social, historical, geographical, and ceremonial significance as K'yakwe: A:mossi, or "House of Puebloan High Priests."<br><br>Diagramming the socio-spatial and spatiotemporal dimensions and layers of the greater Zuni Chaco Heritage Historic District requires accounting for the deep time and deep space lessons, historical, environmental, and ecological insights, and verbally conveyed cartographies of Zuni chiniky'ana'kona and Ino:de bena:we storytelling traditions. These deep time and deep space re-countings demonstrate that just as Zuni history is embodied and conveyed in and by specific geographies, these specific geographies are often readily identifiable in and as concentrated spatial zones of intensive significance that Zuni people remain deeply connected to through topological practices of oral tradition, ceremony, and everyday encounters. These spatial zones often depend on living socio-spatial relationships among the human, non-human, and more than-human for their integrity, health, and well-being, and find expression through various tangible resources, elements, and forms that may be characterized as objects, sites, structures, buildings, and/or districts. These include intensive zones of the land/waterscape that have given names and Ino:de Heshoda:we, or ancient homes, waterbodies and waterways such as springs, seeps, rivers, and lakes, Adeshkwi:we ("Shrines") and delashinnawe ("Sacred Old Places/Shrines of the World"), flora, fauna, and geological mineral gathering, hunting, and collection areas, each of which indelibly involve ongoing associations to the maintenance of Zuni traditional religious and cultural practices and identities, the recovery and reactivation of ancestral histories and geographies, and the overall health and wellbeing of Zuni people, the Zuni Tribe, and countless non-human and more-than-human Zuni relatives. | Language was added verbatim to Section 3.13.1, Tribal Resources: Affected Environment to provide deeper context for the discussion of the Zuni Chaco Heritage Historic District. |
| 16 | 6 | CRTRIBE - Cultural and Tribal Resources | The Tribal Resources section is deficient in understanding and contextualizing the Zuni submitted language within this compliance document. The Zuni submitted narrative was inserted in this section without any attempt by the authors to understand or contextualize the Zuni information within this compliance process. Moreover, and more importantly, the authors of this draft did not extend any effort to communicate with the appropriate Zuni representatives to understand the purpose of the offered language or how to incorporate it within this NEPA compliance document. Thus, Zuni is left to attribute this disparity to the ignorance, negligence, or bias of the authors and the inadequate results that stem from only relying on Class I information. To clarify, the Zuni language offered was to situate the SEIS study area within a larger National Register eligible historic district understood as the Zuni Chaco Heritage Historic District which exemplifies the critical and important role the Grand Canyon (place of emergence and initiation of migrations) plays in the broader Zuni cultural landscape. The boundaries of this historic district were provided to Reclamation and their contractors as very critical Zuni information to be seriously considered in the development of this SEIS. | We changed "Zuni cultural landscape" to "Zuni Chaco Heritage Historic District" in Section 3.13 under Class I Results. |

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| 16 | 5 | CRTRIBE - Cultural and Tribal Resources | This section demonstrates the intentional dismissal or eliding by Reclamation to give due consideration to the NEPA directive (40 CFR 1508.8) that requires analysis and assessment of direct, indirect, and cumulative impact to resources of traditional use and importance to Native American tribes. Additionally, the narrowminded and colonialist linear historical perspective of the human presence in the Grand Canyon that is offered arbitrarily distinguishes between two periods of the past which are labeled as "prehistoric" and "historic." The historic period is defined as beginning in 1776 with the arrival of the Dominguez-Escalante Expedition (the Spanish invaders and colonizers) and then Anglo-Americans (continuing colonization); whereas, the prehistoric period is the narrative solely developed by Western trained archaeologists based on a culturally biased interpretation of past archaeological material, assumed settlement patterns and mortuary practices. That this narrative is being presented as the "human history of the Grand Canyon" and that the various Tribal traditional histories are silent is offensive because it denies, in part, Zuni concepts of time that are expressed intergenerationally so that the past and future are intimately connected through Zuni people, landscape, kinship relationships with other life forms and resources. In presenting these archaeological interpretations as historic fact denies and disenfranchises Zuni traditional history from equitable consideration through epistemicide which involves the destruction, marginalization, or banishing of Zuni knowledge. The concept of knowledge democracy, which is critically lacking from this public draft SEIS and the entire Glen Canyon Dam Adaptive Management Program, acknowledges the importance of multiple knowledge systems and should be about open access for the sharing of that knowledge. Noticeably missing is an honest historical accounting of the forced displacement of Tribal people from sacred landscapes that became the Grand Canyon National Park and the associated racism and forced acts toward assimilation that were perpetuated by the US government on Tribal people; this is an important history that is insultingly trivialized by this brief accounting. | We added the language provided by the Zuni leadership regarding their concept of time within this letter to the section discussing the Zuni in Section 3.13.1 Tribal Resources: Affected Environment, and added a sentence to this section pointing the reader to Section 3.13. Also added to Section 3.12.1 Cultural Resources: Affected Environment: "The traditional territory of the Havasupai included the Grand Canyon and areas to the south of the canyon. Under pressure from ranchers and miners in the nineteenth century, the Havasupai's land on the plateau was taken from them, and they were forced to live in the canyon year-round. The U.S. government established a reservation in the Grand Canyon for the Hualapai in 1880 to encourage them to remain in the canyon. Like the Havasupai, the Hualapai traditional territory was also under pressure from Euro-American miners and settlers, including the construction of the Beale Wagon Road through their territory in 1857. The pressure eventually led to the Hualapai's fighting back during the Hualapai War of 1865–1869. The Hualapai lost and were forced to move to Parker and La Paz. In 1883, the Hualapai Reservation was established, and they were allowed to return to a fraction of their original territory. Conflicts between the Diné and the army resulted in a campaign to remove the Diné to New Mexico, and they began the "Long Walk" to New Mexico in 1864. Hundreds of Diné died under the harsh conditions of the forced march; those who survived were held by the U.S. government until 1868. When they returned, the Diné found that much of their territory was no longer theirs, which led to conflicts into the 1900s. In addition, in 1893 the Grand Canyon Reserve was established, which led the U.S. government to evict them from the reserve, but eventually their reservation was extended to the canyon. The Southern Paiute were devastated by European disease and then, after the 1850s, were affected by cattle ranching by the Latter-day Saints. The cattle degraded much of the resources the Southern Paiute depended on. In a vain effort to help the Paiute, the U.S. government sent them to the Moapa Reservation in Nevada; however, the Kaibab Paiute did not wish to leave. Under pressure from the creation of reserves and National Parks on the Arizona Strip, the Kaibab Paiute were moved to a small reservation at Moccasin and Pipe Springs. More acreage was given to them in 1917 in northern Arizona." |

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| 16 | 7 | CRTRIBE - Cultural and Tribal Resources | Within this Register-eligible historic district all lno:de Heshoda: we are historically significant Zuni landmarks that serve as tangible contextual entrance points to various spatial dimensions and temporal layers of ongoing traditional religious and cultural importance. Rather than isolated, standalone, or temporally distinct "archaeological" structures, aspects of integrity of lno:de Heshoda:we are first and foremost defined by how these ancestral places are able to connect to, calibrate, and direct Zuni practices of movement, pause, and return in relationship to ancestral movements, migrations, pauses, and creations. Likewise, instead of linear temporal periodizations or blocks of time gone past, the traditional religious and cultural importance and historical significance of Ino:de Heshoda:we are defined by how Zuni practices of movement, pause, and return work to (en)fold the past, present, and future at these places through interactions with the ancestors who continue to dwell with/in their spaces.<br><br>At lno:de Heshoda:we, past and present enfold in and through Zuni mo(ve)ments of communal pause-as Zuni offerings, prayers, songs, rituals, ceremonies, collections, and/or knowledge recovery; so, too, do these present mo(ve)ments enfold the future through information reactivation and enhanced capacities for collective continuance in and through communication with and learning from the ancestors dwelling within their structured spaces. For these reasons and in these ways, viable futures for traditional Zuni identities and practice intimately and indelibly depend on the integrity of Ino:de Heshoda:we as tangible reservoirs of Zuni history and human environment relationships, relational life/way lessons and processes, and navigational and calibrating landmarks through their intimate and expressive functions as intensive and concentrated information zones of the traditional cultural land/waterscape and the total environment.<br><br>The very material and embodied contexts of these living associations and ongoing practices with lno:de Heshoda:we both highlight and illustrate how typical archaeological temporal classification and designation schemes for these ancestral places are exceedingly limited, highly partial, and thoroughly lacking. Zuni insights into and understandings of the integrity and significance of Ino:de Heshoda:we-and what may adversely affect their integrity and capacities to retain or convey this significance-extend far before and far beyond reductionist and narrow archaeological values and periodizations and the ontologies, epistemologies, and methodologies mainstream Western archaeologists use to ascertain and define formation, use, function, integrity, meaning, and significance.<br><br>Given the lack of good faith and reasonable inclusions of the Zuni Tribe, all previous NRHP evaluations of Ino:de Heshoda:we listed in Tables 3-39 and 3-40 are incomplete and insufficient because of their ( 1) neglect to consider and account for all applicable NRHP evaluation Criteria for integrity and significance, and (2) failures to include Zuni special expertise in evaluations of significance, assessments of integrity, identifications of TCP status and function, and overall NRHP eligibility per 36 CFR 800.4(c)(l). NEPA analyses to date have also wholly failed to adequately account for how Ino:de Heshoda:we situated throughout and beyond the Grand Canyon are indelible parts of the Zuni human environment (per 40 CFR 1508.14), or how, as historic and cultural resources to and for Zuni (per 40 CFR l 502. I 6(g)), direct, indirect, and cumulative effects ( 40 CFR 1508.8) on Ino:de Heshoda:we impact Zuni traditional religious and cultural practices, health and wellbeing, and capacities for collective continuance. Further, as Ino:de Heshoda:we are important and unique historical and cultural resources, they require special management attention guided and directed by and through Zuni knowledge and values to protect them. | Reclamation acknowledges that Tribes have special expertise in assessing the National Register eligibility of cultural significant properties for each Tribe. Data on National Register eligibility were provided by the land managing agencies for the land they administer. Reclamation does not have authority to modify the data or National Register eligibility. Reclamation has included the following information provided by the Pueblo of Zuni on the Ino:de Heshoda:we in Section 3.13.1 Tribal Resources Affected Environment:<br>"To the Zuni, archaeological sites can be described as follows:<br><br>Rather than isolated, standalone, or temporally distinct "archaeological" structures, aspects of integrity of Ino:de Heshoda: we are first and foremost defined by how these ancestral places are able to connect to, calibrate, and direct Zuni practices of movement, pause, and return in relationship to ancestral movements, migrations, pauses, and creations. Likewise, instead of linear temporal periodizations or blocks of time gone past, the traditional religious and cultural importance and historical significance of Ino:de Heshoda:we are defined by how Zuni practices of movement, pause, and return work to (en)fold the past, present, and future at these places through interactions with the ancestors who continue to dwell with/in their spaces.<br>At Ino:de Heshoda:we, past and present enfold in and through Zuni mo(ve)ments of communal pause—as Zuni offerings, prayers, songs, rituals, ceremonies, collections, and/or knowledge recovery; so, too, do these present mo(ve)ments enfold the future through information reactivation and enhanced capacities for collective continuance in and through communication with and learning from the ancestors dwelling within their structured spaces. For these reasons and in these ways, viable futures for traditional Zuni identities and practice intimately and indelibly depend on the integrity of Ino:de Heshoda:we as tangible reservoirs of Zuni history and human environment relationships, relational life/way lessons and processes, and navigational and calibrating landmarks through their intimate and expressive functions as intensive and concentrated information zones of the traditional cultural land/waterscape and the total environment" (Kucate 2024)." |

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| 17 | 6 | CONSBIO - Consultation biology/ESA related | In evaluating the various flow alternatives presented in the draft SEIS it appears that several alternatives may require re-initiation of Section 7 consultation. For example, the low flows associated with the Non-Bypass Alternative (2,000 cfs) are well below the flows analyzed in current ESA compliance documents for the LTEMP and are reminiscent of hydropeaking flows from the 1990s. Hydropeaking does disadvantage the early life history stages of fish, however that disadvantage affects all fish species. Data from that time (see 1995 EIS and 2016 LTEMP EIS) demonstrated negative impacts to federally listed native fish species, particularly if those flows occur during the spawning season of native fish and/or their macroinvertebrate prey. Further, the 2016 Biological Opinion analyzed up to two High Flow Experiments annually and up to 38 HFEs over the 20-year LTEMP period. If the various flow alternatives could result in more High Flow Experiments in a given year or over the lifetime of the LTEMP that may not be analyzed in existing consultations. If Reclamation chooses to implement such flows, Section 7 consultation would likely need to be reinitiated and would likely need to include updates to the baseline for humpback chub. | Reclamation is aware of the additional ESA compliance efforts mentioned and will continue to work with the Service as we assess those alternatives for potential implementation in future years after FY24. We recognize the importance of ensuring that any flow alternatives requiring re-initiation of Section 7 consultation are thoroughly analyzed and comply with ESA requirements. Any decision to implement such flows will be made in close coordination with the U.S. Fish and Wildlife Service (Service) to ensure the protection of federally listed native fish species, particularly humpback chub. |
| 17 | 5 | SCOPE - Scope of the Analysis | Currently the plan states that smallmouth bass flow alternatives would end in 2027. The document implies this decision is predicated on the assumption that other tools may be available that would be effective by 2027. However, given uncertainties the Service recommends extending the timeframe for allowing smallmouth bass flow alternatives to be implemented through the lifetime of the original LTEMP, in case other tools or options are not available by 2027, or if other tools prove ineffective. If the smallmouth bass flow alternatives are effective, it will be important to be able to continue to implement them when needed to address smallmouth bass and the threat they pose to humpback chub. | This adaptive management process will require ongoing planning and implementation, with necessary NEPA efforts following 2027 to inform future decisions. We will consider this recommendation in our planning process. |
| 17 | 21 | AQUA - Aquatic Resources | Page 11, Comment #13, Section 2, P. 2-10 Sentence regarding the endangered species status of humpback chub population requires a "because" statement. Indicating a causal mechanism here and the result would strengthen the argument. | The following statement was added: "Downlisting of the species was also possible because of a large reproducing aggregation becoming established in western Grand Canyon following decline of Lake Powell that exposed historic habitat and warmer releases from Glen Canyon Dam (Rogowski et al. 2018; Van Haverbeke et al. 2017)." |
| 17 | 22 | EDIT - Editorial | Page 11, Comment 14, Section 2, P. 2-17 Missing Space in Header Title | Changes made as suggested. |
| 17 | 23 | ALTBYPASS - Alternatives - Non-Bypass | Page 11, Comment 15, Section 2, P. 2-17 The description of the Non-Bypass Alternative states that it is centered on substantial river stage changes that are targeted along the Lees Ferry reach. That would correspond to the RM 15. The other flow options are analyzed for effectiveness at RM 15 and RM 61. Recent survey efforts have detected SMB all the way at the confluence of the Little Colorado River. Humpback chub congregations begin at RM 30. If this alternative is not designed to impact those locations it should not be considered as meeting the purpose and need of the SEIS. | The Non-Bypass Alternative is not temperature driven like the Flow Option Alternatives initially analyzed in the smallmouth bass environmental assessment. The Non-Bypass Alternative relies on stage change that would impact different river miles as the hydrograph moves downstream. The Final SEIS has been updated to provide additional details on the Non-Bypass Alternative's impacts on different river miles. |
| 17 | 24 | AQUA - Aquatic Resources | Page 11, Comment 16, Section 2, P. 2-17 The document sites McKinney et al. 1999a in stating that the Non-Bypass Alternative "is predicted on the "flow fluctuations that reduced rainbow trout reproduction during the pre-ROD period (1965-1991) to the point where the fishery could only be maintained through stocking." What does this statement mean for potential impacts to rainbow trout and why? | The following text was added to Section 3.5.1 of the Final SEIS: "McKinney et al. (1999a) attributed the increase in abundance from 1991 to 1997 to increased minimum flows and reduced fluctuations in daily discharges resulting from the implementation of interim flows between 1991 and 1996 and adoption of the current modified low fluctuating flow regime in 1996; these conditions apparently stabilized spawning and rearing habitats for trout and promoted photosynthetic food production." |
| 17 | 25 | ALTASSUMP - General Assumptions Common to All Alternatives | Page 11, Comment 17, Section 2, P. 2-20, figure 2-1 Recommend adding statements to address how each of these alternatives will or won't be modified and effective at the two river miles analyzed throughout the rest of the document (RM 15 and 61). A reminder of the RM's where SMB have been recently detected would be helpful to the reader. | The Summary of Potential Effects Impacts table is limited in space and only contains a high-level review for each resource and alternative. Additional details on impacts of the alternatives at different river miles can be found in Chapter 3. Additional language has been added to Chapter 2 regarding the location of smallmouth bass in the river. |

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| 17 | 26 | ALTASSUMP - General Assumptions Common to All Alternatives | Page 11, Comment 19, Section 2, P. 2-23, figure 2-1 This table is not congruent with all the information presented in the rest of the document and needs to be thoroughly reviewed and updated. It should include the SMB lambda information as that is the most significant data to help compare the effectiveness of the different alternatives. Also for those modeled traces where an alternative flow would be needed, the table should also reflect and summarize what the impacts of the positive lambdas means for all the species and resources analyzed in this SEIS. | The Summary of Potential Effects table has been updated. |
| 17 | 27 | VISUAL - Visual Resources | Page 11, comment 19, section 2, p. 2-25, figure 2-2 Recommend adding details in this document validating and demonstrating how the Non-Bypass Alternative "could allow the area's landscape character to appear more natural". This statement appears to be unsupported. | Based on revised studies that identify sandbar size and the extent of riparian vegetation associated with the LTEMP alternatives, this conclusion has been revised here and in Chapter 3. |
| 17 | 28 | AQUA - Aquatic Resources | page 12, comment 20, section 2, p. 2-26, figure 2-2 Recommend adding details within this document that supports and validates the conclusion that small mouth bass spawning could be disrupted while not impacting native fish spawning. Data suggests that native fish occur and spawn at RM 30 and SMB occur and spawn all the way to RM 61. Also suggest adding modeled lambda information and explanation that demonstrates that in years where a tools would be warranted that this tool would actually impact lambda and reduce modeled population growth to below 1. Please add substantive information supporting the conclusion that the Non By-pass alternative would not impact aquatic food base items in the Lees Ferry and Marble Canyon areas. This document later states that these areas have the highest aquatic invertebrate food production of the river between GCD and Hoover dam. Please add information on potential impacts to rainbow trout to this table. | The following language was added to Section 3.5, Aquatic Resources: Summary: "The flow alternatives as proposed are intended to disrupt nest-builders (smallmouth bass, green sunfish, bluegill, largemouth bass). There is less effect on native broadcast spawners because of the widespread area and elevation of incubating eggs and the emergence and transport of the larvae. Smallmouth bass are nest builders where the female fans sediment from gravels of a specific location or nest about 2 feet in diameter. The female deposits her eggs in the nest, the eggs incubate 5-10 days, and the eggs and subsequent fry are guarded by the male. Whereas, native fish such as humpback chub, razorback sucker, flannelmouth sucker, bluehead sucker, and speckled dace are broadcast spawners where females scatter their eggs over a large area of gravel and cobbles many feet in diameter. The eggs are sticky and adhere to the cobble and hatch in 4-5 days without parental care, and the larvae emerge and drift downstream to suitable low-velocity habitat." |
| 17 | 29 | AQUA - Aquatic Resources | page 12, comment 21, section 2, p. 2-28, figure 2-2 Recommend adding details in the Special Status Species section on the modeled lambda effectiveness of each alternative in the hydrologic traces that indicated a flow alternative would be needed. This is needed to adequately compare the analysis. Additionally, add information explaining what will likely happen in those years/traces where the lambda stays above 1. Also in the document it appears that this section may actually be sub header "Threatened and Endangered Species" and not "Special Status Species" | Text has been added to the Aquatic Resources row of Table 2-2, Summary of Potential Effects, and Table 3-35 has been added to summarize the lambdas for each of the alternatives by year for river miles 15 and 61. It is unclear what will happen with model predictions for lambda >1. A lambda >1 means that recruitment is expected to exceed mortality of adults and that the numbers of smallmouth bass are likely to increase. The lambda values are from a mathematical demographic model that transitions the size of fish from one size class to the next largest class. Additional modeling would be needed to predict populations for lambda >1. |
| 17 | 30 | SOC - Socioeconomics | page 12, comment 22, section 2, p. 2-28, figure 2-2 Recommend adding information to indicate if the economic analyses are run representing any given year a flow alternative is needed or if they are run as if a flow alternative is needed in every given year. | The Summary of Potential Effects table is limited in space and only contains a high-level review of each resource and alternative. Additional details on the impacts are included in Chapter 3. Additional language has been added to the Summary of Potential Effects table. |
| 17 | 31 | EDIT - Editorial | page 12, comment 23, section 3, p. 3-3 Editorial strikethrough should be removed in 3.2.2 | The Final SEIS has been updated per comment. |

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| 17 | 32 | AQUA - Aquatic Resources | page 12, comment 24, section 3, p. 3-14 The Non-Bypass Flow Alternative section references research flows from the early 1990's where flows as low as 1,000 cfs, is there anything that we learned from those research flows that we should be referencing and including in the descriptions of potential impacts of these flows on aquatic resources? | Dam releases from June 1, 1990, through July 29, 1991, were identified as "research flows." These releases were implemented to evaluate controlled releases on aquatic resources. Research flows were characterized by fluctuating releases for periods of 10 to 30 days and constant releases for periods of 3 to 11 days. Minimum daily releases of 1,000 cubic feet per second (cfs) occurred from Labor Day to Easter, with releases of 3,000 cfs from Easter to Labor Day. Unfortunately, specific experiments or monitoring were not implemented to evaluate these low releases (DOI 1989; National Academy of Sciences 1996; Valdez and Ryel 1995). |
| 17 | 33 | EDIT – Editorial | page 12, comment 25, section 3, p. 3-22 Editorial spacing error in impact analysis area – word "these" | Text was removed for the Final SEIS. |
| 17 | 34 | AQUA – Aquatic Resources | page 12, comment 26, section 3, p. 3-50 The first paragraph of the macroinvertebrate section implies that the highest macroinvertebrate production below GCD occurs in the GCD reach. The next paragraph indicates that cold water can prevent eggs from hatching and limit success – recommend adding what temperature these impacts are related to. The paragraph continues to state that varial zone increases associated with hydropower production leads to desiccation-induced mortality of eggs. This information should be described appropriately in impacts analyses of the appropriate flow alternatives and added to the summary table (Kennedy 2016). | Macroinvertebrate populations have responded to temperature regimes from dam releases. River temperatures at Lees Ferry ranged 8°C to 11°C from 1995 to 2004, 8°C to 15°C from 2005 to 2021, and 8°C to 18°C (as high as 20°C) from 2022 to 2023. The temperature regimes, not the specific temperatures, are the factors influencing life stage development of these macroinvertebrates. An explanation of varial zone effects is included in the impacts analysis. |
| 17 | 35 | AQUA - Aquatic Resources | page 12, comment 27, section 2, p. 3-51 The section also states that Kennedy (2016) hypothesizes that dam operations may constrain abundance of aquatic insectsthereby limiting amount of prey available for native fish. How does this conclusion align with the Non-Bypass alternative, could there be even greater impacts to macroinvertebrates? Please explain this further and update summary table as appropriate. | The expected effects of the Non-Bypass Alternative have been revised and clarified in the impacts analysis to explain that this alternative is expected to negatively affect the food base from dewatering and possibly desiccation of shallow habitats where photosynthetic production is greatest. |
| 17 | 36 | AQUA - Aquatic Resources | page 12, comment 28, section 3, p. 3-51 Please add more information about findings of the "bug flows" and if food base was enhanced by steadier flows. | The following language was included to clarify the results of the bug flow experiments: "Macroinvertebrate production flows (bug flows) were conducted in 2018, 2019, 2020, and 2022 to improve the productivity and diversity of the aquatic food base and to learn more about the response of the food base to steady flow releases. These experiments demonstrated that steady flow releases increased the abundance of adult life stages of midges and caddisflies, which are dependent on stable nearshore habitats for egg-laying (Kennedy et al. 2016, Kennedy et al. 2023)." |
| 17 | 37 | AQUA - Aquatic Resources | page 12, comment 29, section 3, p. 3-54 Food Web Dynamics section - recommend expanding the analysis describing potential effects of fluctuating flows from power plant releases and the results of "bug flows". The section has one statement concerning a 400 percent increase in caddisflies but minimizes that increase as it could have been due to low sediment or steady flows. Expand this section to support that conclusion but also demonstrate that the steady flows may have caused a 400 percent increase (this is not stated). Recommend adding analysis of what this data may mean when considering non bypass alternative flows and potential impacts to the food web in the most productive section of the river below GCD, where these flows will impact the varial zone during macroinvertebrate production peak times. Please include these risks in the summary table. | The expected effects of the Non-Bypass Alternative have been revised and clarified in the impacts analysis to explain that this alternative is expected to negatively affect the food base from dewatering and possibly desiccation of shallow habitats where photosynthetic production is greatest. |

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| 17 | 45 | AQUA - Aquatic Resources | page 13, comment 27, section 3, p. 3-85 Recommend expanding this entire section to better explain what the lambdas in Appendix A mean in terms of comparing the various alternatives. Add a description of what the lambdas mean and how to compare them across the different SMB flow alternatives. There is no context in the document to help a reader who is not already involved in lambda type discussion to understand how to interpret the information being presented and its value in decision making. It is the most powerful success based tool in the document but isn't presented as such. Recommend adding an analysis where you look at the effectiveness of lambda only in the years where a an additional flow option is triggered due to anticipated temperatures. This will help to better tease out the effectiveness of each tool and allow a better comparison across tools. Breaking out lambda values specifically for the years in which the temperature is modeled to be above the trigger of 15.5 degrees Celsius will help to better tease out the effectiveness of each flow alternative and allow a better comparison across alternatives. As currently analyzed, an alternative flow option will only be triggered in a few of the 30 modeled hydrological traces, leading to SMB population growth on anticipated in a no action alternative in 17 percent of the traces. This means in 83 percent of all the modeled hydrological scenarios, no alternative flow would even be triggered. This can swamp out clearly demonstrating the effectiveness of each modeled flow alternative. Removing the excess signal will more clearly demonstrate that some flow alternatives do not meet the purpose and need of the SEIS. Further, this will affect the hydropower cost analysis associated with each flow alternative. Finally at the scale as described in the current analysis it's very difficult to tell if adding a flow spike(s) is needed or adds additional effectiveness as compared to the same flow alternative without flow spike(s). | An explanation of lambda is provided in the document. Also, Table 3-35 has been added that summarizes the percentages of 30 traces where lambda >1 for river miles 15 and 61 for each of the alternatives. The modeling for smallmouth bass propagule pressure and lambda population growth is described by Eppehimer and Yackulic (2024) in the USGS Modeling Impacts document (Yackulic et al. 2024). The additional analyses of lambda, as described in this comment, could help inform the efficacy of the proposed alternatives; however, these analyses are not available at this time and could be recommended for future analysis with the smallmouth bass model. |
| 17 | 38 | AQUA - Aquatic Resources | page 13, comment 30, section 3, p. 3-59 Flannelmouth sucker Life History - any conclusions about the variability reported by long-term fish monitoring by AZGFD and catch per unit effort? The document describes some significant variability among years. Are there any hypotheses on what might be driving that inter-year variability and therefore are there any potential connections to the different flow alternatives being analyzed? | In response to your questions, the following language was added to the Final SEIS regarding the life history of the flannelmouth sucker: "Walters et al. (2012) hypothesized that food availability and bioenergetics had a large influence on flannelmouth sucker and bluehead sucker. The food base of downstream areas where these species occur is driven by turbidity, temperatures, and proximity to tributaries. At least, these variables influence population dynamics of these species as food base affects survival and recruitment." |
| 17 | 39 | AQUA - Aquatic Resources | page 13, comment 31, section 3, p. 3-63, figure 3-30 Please add a column to this table indicating the Threat Levels per non-native fish as identified in the NPS 2013a Comprehensive Fisheries Management Plan. This would help the reader understand the magnitude of concern associated with each species in this table. Also consider adding a column indicating the prey base of the species and/or it's piscivorous nature. | The text in Section 3.5 of the Final SEIS identifies nonnative fish and their threat levels as outlined in the NPS (2013a) Comprehensive Fisheries Management Plan. However, for most of the nonnative fish listed in Table 3-33, a threat level is not specified in the plan. Therefore, adding an extra column indicating threat levels per nonnative fish is not necessary. |
| 17 | 40 | EDIT - Editorial | page 13, comment 32, section 3, p. 3-63, figure 3-30 Several spacing issues between words throughout this table in the Presence in Project Area column. | Table 3-33 has been updated per comment. |
| 17 | 41 | AQUA - Aquatic Resources | page 13, comment 33, section 3, p. 3-69 Please add clarifying information in the "Proposal to Manage Smallmouth Bass in the Grand Canyon" section on whether each of the flow alternatives can be adapted (or can't be) to be effective at both RM 15 and RM 61. From reading the flow alternatives description it doesn't sound like the Non Bypass Alternative could impact SMB all the way to RM 61. Where does the trough attenuate? Also please include description here about the modeled lambdas for each flow alternative and communicate what those values mean for the reader and how effective flows will be in the individual modeled traces where a flow alternative is triggered. | The information regarding the adaptability of each flow alternative to be effective at both river mile 15 and river mile 61, as well as the impact of the Non-Bypass Alternative on smallmouth bass up to river mile 61, can be found in Chapter 2 of the SEIS. Regarding the modeled lambdas for each flow alternative, including their effectiveness in individual modeled traces, this information is detailed in the Environmental Consequences section of Section 3.5. The language mentioned in the comment was removed as it was duplicative of information found in Chapters 1 and 2. |

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| 17 | 42 | AQUA - Aquatic Resources | page 13, comment 34, section 3, p. 3-75 Brown Trout section - The Runge 2018 cited paper concludes that brown trout management flows will not be an effective strategy - extrapolating from that conclusion - please explain why or why not the same types of flows (the non-by-pass alternative) is anticipated to be effective for SMB. Also please update the incentivized harvest section with the most recent data. This can be found in notes from Jeff Arnold's presentations to AMWG and the TWG. | The predicted efficacy of brown trout management flows is based on the results of trout management flows in 2003–2005 that were implemented to reduce recruitment of rainbow trout in the Lees Ferry reach (Korman et al. 2005, 2011; Korman and Campana 2009). Although these reduced survival of eggs and fry, compensatory responses resulted in a higher number of rainbow trout. We could not find more recent citable data on incentivized harvest. |
| 17 | 43 | EDIT - Editorial | page 13, comment 35, section 3, p.3-81 Mis-spelling of "few" and "trout" in first paragraph on page. | The Final SEIS has been updated per comment. |
| 17 | 44 | EDIT - Editorial | page 13, comment 36, section 3, p. 3-82 Font issue in second paragraph. | The Final SEIS has been updated per comment. |
| 17 | 46 | AQUA - Aquatic Resources | page 13, comment 37, section 3, p. 3-86 Please explain how warmer water releases under the no action alternative could increase growth rates of rainbow trout and/or place that information in context of overall concerns of warmer waters decreasing trout populations. | The following was added to the analysis of the No Action Alternative: "The No Action Alternative will continue to release warm waters as Lake Powell is expected to continue to decline in elevation. Warmer temperatures would increase growth rate of trout but also bioenergetic demand. Yard et al. (2023) determined that low reservoir elevations result in warmer water temperatures but also lower nutrient concentrations that translate to less production in the Lees Ferry reach and less food for trout. These factors would likely result in lower numbers of rainbow trout in the Lees Ferry reach." |
| 17 | 47 | AQUA - Aquatic Resources | page 14, comment 39, section 3, p. 3-86 The Nonnative and native fish paragraphs seem inaccurate for the no action alternative and read more like response to flow increases. | Added a comment regarding the No Action Alternative. |
| 17 | 48 | EDIT - Editorial | page 14, comment 40, section 3, p. 3-87 The paragraph on Spring HFE seems out of place in a section on the No Action alternative. | We reviewed the placement of the paragraph on the spring HFE within the No Action Alternative section in Section 3.6 to ensure that it is in place and consistent with the surrounding content. Your feedback was appreciated as we worked to improve the clarity and organization of the document. |
| 17 | 49 | AQUA - Aquatic Resources | Page 14, comment 41, section 3, p.3-88 Recommend additional emphasis on pointing out that the cool mix alternative is the only flow alternative in which the modeled lambda is always below 1 no matter what hydrological trace is used in the model and how that relates to its anticipated effectiveness. This is clearly the most effective flow alternative analyzed in terms of meeting the purpose and need. A lambda over 1 indicates that this alternative fails to limit additional recruitment of SMB which could continue to threaten humpback chub below the dam. In general explaining lambda in plain language will help readers less familiar with the subject matter understand the science being presented. | Both the Cool Mix Alternative and Cool Mix with Spike Alternative result in model predictions of lambda <1. An explanation of lambda is provided in the document. Also, Table 3-35 has been added that summarizes the percentages of 30 traces where lambda >1 for river miles 15 and 61 for each of the alternatives. The modeling for smallmouth bass propagule pressure and lambda population growth is described in Eppehimer and Yackulic (2024) as a chapter in the Modeling Impacts document of the USGS (Yackulic et al. 2024). |
| 17 | 50 | AQUA - Aquatic Resources | page 14, comment 42, section 3, p. 3-39 If the model anticipates that cooling can be accomplished to RM 15 or RM 30, what about RM 61 and if it's not to RM 61 then why are all the economic analyses carried to RM 61? This is internally inconsistent and confusing and should be addressed. Later sections of this chapter indicate that cooling can be achieved at RM 61. | The model predicts lambda responses at river miles 15 and 61. Table 3-35 has been added to the Impact Analysis that summarizes the lambda values for each alternative at each of these two locations. |
| 17 | 51 | EDIT - Editorial | page 14, comment 43, section 3, P. 3-89 In the cool mix with flow sike alternative section please correct the phrase "cold release" to "cold spike" for clarity. | The Final SEIS has been updated per comment. |
| 17 | 52 | AQUA - Aquatic Resources | Page 14, comment 44, section 3, p. 3-90 Please explain the SMB lambdas further in this section. If you limited the analysis to just hydrological traces where a flow alternative would be triggered - is there any modeled difference in success between cold mix and cold mix with a flow spike? Breaking out lambda values specifically for the years in which the temperature is modeled to be above the trigger of 15.5 degrees Celsius will help to better tease out the effectiveness of each flow alternative and allow a better comparison across alternatives. | The modeled difference between cool mix and cool mix with flow spike is described as two alternatives that enables a separation of the flow spike, although a flow spike alone was not modeled. Additional modeling outside what was provided by USGS is not available and would require USGS to run additional models. |

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| 17 | 53 | AQUA - Aquatic Resources | page 14, comment 45, section 3, 3-91 Strongly recommend adding some information for the reader to help interpret the difference in the lambdas between the cool mix and cold shock alternatives. This is important both in giving context of modeled effectiveness but also in understanding differences in other potential negative impacts of the two alternatives, including the increase in risk of SMB population growth. Add analysis and explanation that breaks out lambda values specifically for the years in which the temperature is modeled to be above the trigger of 15.5 degrees Celsius - this will help to better tease out the effectiveness of each flow alternative and allow a better comparison across alternatives. | Information clarifying lambda values < 1 and > 1 was added. Additional modeling outside what was provided by USGS is not available, which would require USGS to run additional models. |
| 17 | 54 | AQUA - Aquatic Resources | page 14, comment 46, section 3, p. 3-92 The aquatic food base section details anticipated negative impacts to the aquatic food base associated with magnitude of releases and the persistence of those impacts weekly for 12 weeks. These same effects should be in the Non-By Pass alternative based on velocities, number of weeks and repetitive nature of that alternative. | Language has been added to the Non-Bypass Alternative detailing the anticipated effects of low flows repeated for 12 weeks. |
| 17 | 55 | AQUA - Aquatic Resources | page 14, comment 47, section 3, 3-92 Please add how many spike flows are anticipated. The Cool Mix section states that "up to 3 cold shocks" may occur. | For both the Cool Mix with Flow Spike and Cold Shock with Flow Spike, the flow spikes are described as follows: "Additionally, up to three 8-hour flow spikes (up to 45,000 cfs) would be added between June and mid-July, if sufficient water is available." |
| 17 | 56 | AQUA - Aquatic Resources | page 14, comment 48, section 3, p. 3-93 Describe any measurable difference in the modeled lambda for the cold shock with spike flow alternative that would justify including spike flows in addition to the cold shock given the potential negative impacts associated with the spike flows. Limiting the lambda analysis to just hydrological traces where a flow is actually triggered may help to elucidate those differences such that they can be better described. | Additional modeling outside what was provided by USGS is not available, which would require USGS to run additional models. |
| 17 | 57 | AQUA - Aquatic Resources | page 14, comment 49, section 3, p. 3-94 The Non Bypass Alternative is described as an "experiment" and according to the SMB model and associated lambdas - this alternative performs no better than the no action alternative. All associated lambdas are above 1 in all of the hydrological traces in which a flow alternative would be triggered for the 30 hydrological regimes analyzed. Therefore, the Service does not believe that this alternative meets the Purpose and Need of this LTEMP SEIS and recommends it be removed from further consideration. | The Non-Bypass Alternative is one of five action alternatives evaluated in this SEIS. It is the purpose of this NEPA analysis to determine the most viable alternative that will best address the purpose and need, based on the best available scientific information. The Draft SEIS is an important part of the process that Reclamation uses for determining the preferred alternative. |
| 17 | 58 | AQUA - Aquatic Resources | page 15, comment 50, section 3, p. 3-95 The Non By-Pass Alternative was designed with low flows down to 2,000 cfs. With the new potential operational restrictions of maintaining penstock flows at least 3,000 cfs or perhaps even 3,500 cfs; how would those guidelines affect the modeled lambdas? | The Non-Bypass Alternative would only be implemented if it is selected as the preferred alternative through this NEPA analysis. We recognize that the alternative proposes low flows of 2,000 cfs, which are below authorized releases for Glen Canyon Dam. If an alternative were selected that exceeds the operational authority of Glen Canyon Dam, Reclamation would need to evaluate the alternative in light of applicable laws and policies, such as the GCDAMP and the Grand Canyon Protection Act. |
| 17 | 59 | AQUA - Aquatic Resources | page 15, comment 51, section 3, p. 3-95 The "triggers" for initiating a Non-By-pass flow appear to be different from the triggers for the other flow alternatives. This description ties the temperature trigger to 12 mile slough and reads as if written by a different author. Recommend ensuring the trigger for a flow alternative is the same for all alternatives. | The Non-Bypass Alternative describes the trigger as: "The weekly spikes would be triggered when temperatures reach 15.5°C (60°F) in areas where bass are observed spawning (that is, 3-mile slough)." This was the description provided for the alternative by WAPA. |
| 17 | 60 | AQUA - Aquatic Resources | page 15, comment 52, section 3, p. 3-96 The potential impacts to Aquatic Food Base paragraph should be coordinated with species expert Ted Kennedy as on face value it does not seem to account for all the potential impacts as outlined in previous sections of the SEIS. | Comments from Ted Kennedy were included and modifications were made to the document to accommodate his edits. |
| 17 | 61 | WILDLIFE - Wildlife | page 15, comment 53, section 3, p. 3-105 Based on the Amphibian and Reptile section, would the Non-By-pass alternative potentially cause any desiccation of amphibian eggs? If yes please add this to the analysis. If no please explain why those potential impacts are not expected. | Variability in flows associated with the Non-Bypass Alternative may disrupt amphibian reproduction by altering breeding habitat and flushing eggs or individuals downstream. Text has been added to the Environmental Consequences discussion to clarify that this is a potential impact. |

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| 17 | 62 | EDIT - Editorial | page 15, comment 54, section 3, p. 3-114 Humpback chub section has repeated words on one sentence (river flows). | The Final SEIS has been updated per comment. |
| 17 | 63 | EDIT - Editorial | page 15, comment 55, section 3, P. 3-29 Font/spacing issue in figure heading. | The Final SEIS has been updated per comment. |
| 17 | 64 | EDIT - Editorial | page 15, comment 56, section 3, p. 3-117, figure 3-30 Font/spacing issue in figure heading. | The Final SEIS has been updated per comment. |
| 17 | 65 | EDIT - Editorial | page 15, comment 57, section 3, p. 3-118, figure 3-31 Font/spacing issue in figure heading. | The Final SEIS has been updated per comment. |
| 17 | 66 | EDIT - Editorial | page 15, comment 58, section 3, p. 3-118, figure 3-31 In figure caption or in text please describe the "buffer" that is identified in the legend. Also please add confidence intervals to the caption. | Additional text has been added to the Final SEIS to explain the figure. |
| 17 | 67 | AQUA - Aquatic Resources | page 15, comment 59, section 3, p. 3-123 In Distribution and Abundance section please add information on recently augmented populations of razorback sucker in GCNP | The document now includes the following up-to-date information: "A Science Panel (Pennock et al. 2022) recently evaluated the prospect of augmenting the population of razorback sucker in GCNP. The majority (but not all) of the panelists agreed augmentation should occur in Lake Mead at multiple locations to spread the risk of post-stocking survival that is thought to be location-specific. The panel recommended stocking about 600 fish/year, 300 from Lake Mead and 300 from Lake Mohave, with fish <200 mm included to evaluate size effect. Stocking should be conducted once per year for three years with assessment and evaluation." |
| 17 | 68 | AQUA - Aquatic Resources | page 15, comment 60, section 3, 3-123 Please add information in this first paragraph indicating temperature effects at various RM along the river. These impacts are not equal. | A description of river temperatures is included in Chapter 3. Longitudinal temperatures can be estimated with the Wright model (Wright et al. 2008). The USGS has developed a more refined estimate of longitudinal temperatures, but those data were not available for this SEIS. |
| 17 | 69 | AQUA - Aquatic Resources | page 15, comment 61, section 3, p. 3-131 For the entire section of Issue 2 - recommend adding context of the lambda analysis for the different flow alternatives as described in other comments. Give context to what lambda means, how many traces actually would trigger a flow alternative and then the difference in the modeled ability of an alternative to impact lambda within a trace in which it is triggered. This will give the reader better context for understanding the effectiveness of the different alternative. Breaking out lambda values specifically for the years in which the temperature is modeled to be above the trigger of 15.5 degrees Celsius will help to better tease out the effectiveness of each flow alternative and allow a better comparison across alternatives. Please also add analysis explaining the differences in risks for those traces where a flow alternative would be triggered but lambda stays above 1. This will help the reader understand the difference in the continued threat of SMB establishment per alternative. Also please add information explaining how quickly bass can become established (as compared to other nonnative fish species). There is ample information from the Upper Basin Recovery programs that can be provided upon request demonstrating establishment in less than 5 years. This could also be done to model hydropower costs of the different flow options for a given hydrological scenario in any given year where temperatures are anticipated to rise above the trigger of 15.5 degrees Celsius. | Issue 2 focuses on how flow alterations affect threatened and endangered fish species (humpback chub, razorback sucker). The lambda values are indices of population growth generated by a smallmouth bass model for predicting intrinsic growth rates of smallmouth bass. The smallmouth bass model is not linked to a model for either humpback chub or razorback sucker. References are made to lambdas in this section as they apply to the possible effect of smallmouth bass on the two threatened and endangered species. It is also important to note that the smallmouth bass was first introduced into the Upper Basin reservoirs in 1967 (Flaming Gorge), 1972 (Rifle Gap), 1973 (Gunnison River), 1977 (Starvation), 1978 (Elkhead), and 1982 (Lake Powell). The species has been present in the Green and Colorado Rivers since the 1980s and expanded into the Yampa River during dam reparations at Elkhead Dam in 1978. The species expanded dramatically in the Yampa River when flows were only 1.8 cfs at Maybell in 2002. |
| 17 | 70 | AQUA - Aquatic Resources | page 15, comment 62, section 3, p. 3-133 Low water temperature swimming impairment is described here. It would be helpful to know the extent of this effect. For instance, can there be a proportion or other value be provided that would indicate how many young fish may be impacted? | Clarifying language has been added for temperature-related swimming performance of humpback chub, rainbow trout, and brown trout. |
| 17 | 71 | AQUA - Aquatic Resources | page 15, comment 63, section 3, 3-133 Here impacts of cold shock are suggested to be less due to distance from the dam. Can there be a value applied, roughly or estimable, that would demonstrate this pattern? Without data or citation this statement appears to be arbitrary. | Clarifying language has been added to the text, but specific values are not available. |

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| 17 | 72 | AQUA - Aquatic Resources | page 16, comment 64, section 3, 3-135 Add any potential impacts to humpback chub egg and fry from the Non-Bypass Alternative. There is a congregation of humpback chub at RM 30 that does not appear to have the impacts to their fry and eggs analyzed at all. The non bypass alternative anticipates up to 26 big fluctuations between May-Oct. It doesn't look like the fluctuations dissipate by the 30 mile humpback chub aggregation. Impacts to these fish, eggs and fry need to be analyzed and are not analyzed in any existing consultations. | The following language was added: "Age-0 and juveniles of both species could be at risk of predation or starvation if they are displaced from their habitats by the extreme low (2,000 cfs) and high (27,300 cfs) flows of this alternative. Also, the most upstream reproducing aggregation of humpback chub at river mile 30 (Valdez and Masslich 1999) could be negatively affected by the low flows that could strand the warm shoreline spring that provides a warm water refugium in an otherwise cold river. If larvae or age-0 fish are present, the low flow could strand the fish and the high flow could displace them downstream, reducing survival." |
| 17 | 73 | AQUA - Aquatic Resources | page 16, comment 65, section 3, 3-135 The following quote/conclusion does not seem to be supported by Appendix A (Figure 1): "The alternatives with the most potential effect for disrupting smallmouth bass spawning are the Cool Mix with Flow Spike and the Cold Shock with Flow Spike Alternatives; this is because these alternatives disrupt both the physical habitat of smallmouth bass nesting and the suitable and necessary temperature regimes." In contrast, Appendix A suggests that it is the Cool Mix and Cool Mix with Flow Spike are the alternatives with the most potential effect. We recommend revising this statement so that it is congruent with Appendix A. | The text has been changed as follows: "The alternatives with the most potential effect for disrupting smallmouth bass spawning, based on lambda <1, are the Cool Mix and Cool Mix with Flow Spike; this is because these alternatives disrupt both the suitable and necessary temperature regimes and physical habitat of smallmouth bass nesting and the rearing." |
| 17 | 74 | EDIT - Editorial | page 16, comment 66, section 3, 3-161, figure 3-35 Font/spacing issue in figure heading. | The Final SEIS has been updated per comment. |
| 17 | 75 | EDIT - Editorial | page 16, comment 67, section 3, 3-161, figure 3-37 Font/spacing issue in figure heading. | The Final SEIS has been updated per comment. |
| 17 | 76 | GEOSEDI - Geomorphology and Sediment | page 16, comment 68, section 1.2, p. 1-4 Add a definition of high-flow experiments for readers not familiar with the LTEMP. Consider summarizing the description of HFE in Section 3.4.1 on page 3-37. | A definition of HFEs has been added to Chapter 1. |
| 17 | 77 | PN - Purpose and Need | page 16, comment 69, section 1.2, p. 1-4 Add information about why BOR conducted the 3-day HFE in April 2023 for context. | Adequate description of the 2023 HFE has been included in the Final SEIS. |
| 17 | 78 | PROPACTION - Proposed Action | page 16, comment 70, section 1.2, p. 1-5 Add what specific sediment conditions are you trying to improve in the Grand Canyon (i.e. transport from one area to another). | The Final SEIS has been updated per comment. |
| 17 | 79 | EDIT - Editorial | page 16, comment 71, section 1.2, p. 1-5 Define "sub-annual flow options." | The Final SEIS has been updated per comment. |
| 17 | 80 | EDIT - Editorial | page 16, comment 72, section 1 This section needs a clearer definition of the project area versus the analysis area. If the analysis area is different for each resource, then define the analysis area for each resource somewhere in the document. | Please refer to Section 1.6 for information on the project area and analysis area. Any resource-specific changes will be identified in Chapter 3. |
| 17 | 81 | EDIT - Editorial | page 16, comment 73, section 1 It would be good to define the terms "sediment account period" and "implementation window" early on in the document. Consider adding some clarity on the purpose/need concerning the sediment accounting window. For a reader not familiar with the issues its confusing to seem to have to different "needs" for the SEIS. | A definition has been added to the glossary. |
| 17 | 82 | EDIT - Editorial | page 16, comment 74, section 1.3, p. 1-6 Define the term "slough modifications," and either put the location of the slough on a map or provide a narrative description of the slough. | The location has been added to sentence. The slough modification process is ongoing, and a final plan has not yet been developed. |
| 17 | 83 | EDIT - Editorial | page 16, comment 75, section 2.6, p. 2-11 The following sentence is very confusing to a reader not familiar with the issue. Consider re-phrasing. "To align with actual implementation without necessitating multiple weeks of hydropower maximization (that is, the operation of the hydropower system to generate the maximum amount of electrical power) within each month, daily bypass estimates from the smallmouth bass model were post-processed. Flows were simulated to occur all month, if they were triggered before the months halfway mark, and start in the subsequent month, if they were triggered after the halfway mark. Additionally, all days within a month would have bypass equal to the median of the month, with minimal changes observed in overall bypass across traces (USGS 2022)." | The Final SEIS has been updated per comment. |
| 17 | 84 | EDIT - Editorial | page 16, comment 76, section 2.7, P. 2-12 Explain the difference between an HFE and a flow spike. | The Final SEIS has been updated per comment. |

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| 17 | 85 | EDIT - Editorial | page 16, comment 77, figure 2-2  Is jet tube the same as river outlet works and the same as Bypass? If so, please select one term and try to use the same term throughout the document. | The river outlet works terms are defined in Chapter 1. Some figures are cited from outside sources and cannot be altered. |
| 17 | 86 | EDIT - Editorial | page 16, comment 78, section 3.2.2, p. 3-16  This sentence is missing some words: "Overall elevation changes in Lake Powell under the action alternatives are relatively minor, and water." | The Final SEIS has been updated per comment. |
| 17 | 87 | AQUA - Aquatic Resources | page 16, comment 79, p. 3-56  A sentence is the first paragraph says that roundtail chub were extirpated from the Colorado River. It would be more accurate to say that the project area is outside the current and historic range of the species, according to the species status assessment. https://ecos.fws.gov/ServCat/DownloadFile/215366 | Wording was edited as suggested: "Roundtail chub (G. robusta) was historically present in the Colorado River and some of its tributaries in the project area (LCR) and is now extirpated from the Colorado River, but remains in small numbers in Chevelon Creek, a tributary of the Little Colorado River (Valdez and Carothers 1998; Voeltz 2002)." |
| 17 | 93 | EDIT - Editorial | page 16, comment 85, section 3.9.1, p. 3-135  "If less electricity is unavailable at Glen Canyon Dam" Change to "If less electricity is available at Glen Canyon Dam" | The Final SEIS has been updated per comment. |
| 17 | 94 | EDIT - Editorial | page 16, comment 86, p. 3-143, tables 3-36 and 3-37  The titles of these tables say "5-year total emissions" of the pollutants, but these values aren't the total emissions. They appear to be the change in emissions compared to the No Action. Please revise as appropriate | The Final SEIS has been updated per comment. |
| 17 | 95 | WATERQUAL - Water Quality | page 16, comment 87, section 3.11.2, 3-161  Please explain why the concentration of 5.2 mg/L of DO is important. | Reclamation added the importance of 5.2 milligrams per liter (mg/L), which is the threshold below which oxygen concentrations are stressful to trout, to all of the alternatives under Issue 3. |
| 17 | 96 | CRTRIBE - Cultural and Tribal Resources | page 16, comment 88, section 3.12.2, p. 3-172  Please add additional clarifying language explaining the rationale behind the statement that the cold-water alternatives would have the same impacts as the No Action. | Flows under the cool and cold mix alternatives would be within permitted flows as analyzed in the LTEMP FEIS; therefore, no new impacts beyond those analyzed in the LTEMP FEIS would be anticipated. Discussion clarified. |
| 17 | 97 | CRTRIBE - Cultural and Tribal Resources | page 16, comment 89, section 3.12.2, p. 3-173  Please explain why aeolian transport of sand is important for cultural resources. Will it increase the area of sand bars, or decrease? | Language has been added to Section 3.12.1 Affected Environment: USGS Glen Canyon Dam Operations Study.<br>"A study conducted by the USGS demonstrated that flow changes from the operation of Glen Canyon Dam since 1963 have changed the amount of sediment and riparian vegetation along the Colorado River through the GCNP, which has led to a decrease in the amount of wind-borne sand protecting sites (Sankey et al. 2023 ). The wind-borne sediment helps protect sites from erosion, which may impact a site's physical integrity by incremental accumulation of sand over long periods of time. By examining aerial imagery, the USGS concluded that the number of sites along the river that have "the highest likelihood of receiving wind-blown sand from fluvial sandbars . . . decreased over each monitoring interval, from 98 in 1973 to only 4 in 2021-22" (Sankey et al. 2023:10). The change is generally the result of the increase in vegetation on the sandbars, which prevents the transport of sand. The vegetation increase can be attributed to the lack of floods, which would have normally occurred seasonally along the river prior to the construction of the dam (Sankey et al. 2023)." |
| 17 | 98 | CRTRIBE - Cultural and Tribal Resources | Page 16, comment 90, section 1.12.2, p. 3-173  Please add clarifying language explaining the rationale behind the statements that the alternatives would be similar to the No Action or one another, with regard to sediment transport. | The USGS analyzed the amount of daily exposed and available sediment. The discussion was clarified, and a reference to the modeling report was added to Section 3.12. |
| 17 | 99 | CONSBIO - Consultation biology/ESA related | page 16, comment 91, section 4.5, p. 4-3  Please update the second paragraph - as currently written it does not accurately reflect where we are currently in consultation on this SEIS. | The ESA consultation language has been updated to better describe current consultation. |

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| 17 | 88 | AQUA - Aquatic Resources | page 17, comment 80, table 3-29 Column 3. If you're going to name these places, please make sure they're on a map somewhere in the document, or otherwise described (such as RM #), so that the reader doesn't have to google the places. | River miles have been added to the locations in Table 3-32. |
| 17 | 89 | AQUA - Aquatic Resources | page 17, comment 81, section 3.5.2 Consider adding information about the effects of the alternatives on the New Zealand mud snail population size and distribution. | Language has been added acknowledging transport of organisms downstream with high flows. |
| 17 | 90 | EDIT - Editorial | page 17, comment 82, section 3.7.2, p. 3-109 Correct header "species status species" | The Final SEIS has been updated per comment. |
| 17 | 91 | EDIT - Editorial | page 17, comment 83, section 3.7.2, p. 3-110 "HFE releases and flow spikes may enhance germination for certain riparian plant species and prevent establishment of other species, changing composition in ways that could have beneficial impacts on invertebrate biodiversity and abundance." Please provide a citation for this statement. | The citation has been added as suggested. |
| 17 | 92 | WILDLIFE - Wildlife | page 17, comment 84, section 3.7.2, p. 1-113 This section says that the alternatives would affect none of the birds protected under MBTA, because these birds aren't in riparian areas. This is not correct. Many birds protected under MBTA nest in riparian areas. Please prove clarifying statement of the MBTA assemblage expected in this area. | Text in the Special Status Birds subsection of Environmental Consequences (see Section 3.7 of the Final SEIS) has been updated to reflect that some Migratory Bird Treaty Act–protected birds may be impacted by the Non-Bypass Alternative, the only alternative to have substantial impacts on riparian habitat. |
| 17 | 2 | HYDROLOGY – Hydrology | Page 3: The Service also suggests asking the authors to add an analysis where they compare the lambda of each flow alternative using only the hydrological traces where a flow alternative would be triggered due to anticipated river temperatures. Breaking out lambda values specifically for the years in which the temperature is modeled to be above the trigger of 15.5 degrees Celsius will help to better tease out the effectiveness of each flow alternative and allow a better comparison across alternatives. As currently analyzed, an alternative flow option will only be triggered in 17 percent of the 30 modeled hydrological traces; no alternative flows would be triggered in 83 percent of the modeled scenarios. The high percentage of hydrological models that would not trigger an alternative flow swamps out the effectiveness of each modeled flow alternative in the hydrological scenarios where a flow would be triggered. Adding an analysis that removes the excess signal will more clearly demonstrate which flow alternatives meet the purpose and need. At the current scale it is very difficult to tell if adding a flow spike(s) adds any additional effectiveness as compared to the same flow alternative without flow spike(s). This information also needs to be added to the summary table in Chapter 2. | An analysis was added comparing the lambda of each flow alternative using only the hydrologic traces where a flow alternative would be triggered due to anticipated river temperatures exceeding 15.5°C. This analysis should help clarify the effectiveness of each flow alternative and allow for a clearer comparison across alternatives. Additional information was added to the summary table in Chapter 2 (Table 2-2) to provide a more comprehensive overview of the effectiveness of each flow alternative. |
| 17 | 1 | AQUA - Aquatic Resources | Page 3: The Service is pleased at the incorporation of the Eppehimer and Yackulic smallmouth bass model in Appendix A assessing the potential for smallmouth population growth rate under each of the flow alternatives. The Service recommends expanding these discussions within the SEIS to provide more context and understanding for the reader on what the lambda values mean and how to compare them for effectiveness across the different flow alternatives. This model is the most powerful tool available to interpret and evaluate potential success of the alternatives and needs to be presented in a way that is simple for readers to understand, such as in tabular format. | The Eppehimer and Yackulic (2024) smallmouth bass model included in the GCMRC report (GCMRC 2024) is a valuable tool for assessing the potential for smallmouth population growth rate under each of the flow alternatives. We have expanded discussions within the Final SEIS to provide more context and understanding for readers on the significance of the lambda values and how to use them to compare effectiveness across the different flow alternatives.<br><br>Lambda values represent the population growth rate: values greater than 1 indicate population growth, and values less than 1 indicate population decline. We have also included a new table (Table 3-35) that shows the percentage of 30 traces with lambda greater than 1 for each of the six alternatives at river miles 15 and 61. This information is presented in a clear and understandable format to enhance the reader's understanding of the model and its implications for each alternative. |

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| 17 | 3 | ALTBYPASS - Alternatives - Non-Bypass | Page 4: The draft SEIS defines the need as to disrupt the establishment of smallmouth bass below Glen Canyon Dam by limiting additional recruitment, which could threaten populations of threatened humpback chub below the dam (page 1-6, section 1-4). The Service remains concerned that the Non-Bypass flow alternative does not meet this stated need. This alternative focuses on impacting the nest guarding behaviors of male smallmouth bass and reducing survivorship of eggs and fry. These impacts occur after a successful spawn and do not prevent spawning. The Eppehimer and Yackulic smallmouth bass population growth model indicates that the NonBypass flow option never reduces the smallmouth bass population growth below 1. In every modeled hydrological trace in which an additional flow option would be needed (17 traces), the Non-Bypass alternative appears to function equivalently to the No Action Alternative in terms of meeting the purpose/need of the SEIS. The model demonstrates that smallmouth bass would continue to recruit, and population would grow, and therefore establishment will still occur. The Service recommends removing the Non-Bypass flow option from further consideration as it does not meet the purpose and need of the SEIS, nor does it meet the needed management for the ecological issue stressing the stability of the humpback chub population. | Per NEPA requirements, Reclamation is required to analyze reasonable action alternatives. The Non-Bypass Alternative represents an alternative that was deemed reasonable for analysis. While it does not perform as well as the other action alternatives within the smallmouth bass model, it does show improvement over the No Action Alternative. However, based on the modeling results and analysis, it was not deemed the environmentally preferred alternative and will not be implemented in 2024. |
| 17 | 12 | HYDROLOGY - Hydrology | PDF Page 10, Comment #4: Recommend adding an analysis where you look at the effectiveness of lambda only in the years where a an additional flow option is triggered due to anticipated temperatures. This will help to better tease out the effectiveness of each tool and allow a better comparison across tools. As currently analyzed, an alternative flow option will only be triggered in 17 percent of the 30 modeled hydrological traces; no alternative flows would be triggered in 83 percent of the modeled scenarios. The high percentage of hydrological models that would not trigger an alternative flow swamps out the effectiveness of each modeled flow alternative in the hydrological scenarios where a flow would be triggered. Adding an analysis that removes the excess signal will more clearly demonstrate which flow alternatives meet the purpose and need. Further breaking out lambda values specifically for the years in which the temperature is modeled to be above the trigger of 15.5 degrees Celsius will better tease out alternative effectiveness. At the current scale it is very difficult to tell if adding a flow spike(s) adds any additional effectiveness as compared to the same flow alternative without flow spike(s).Further, this will affect the hydropower cost analysis associated with each flow alternative. Finally at the scale as described in the current analysis it's very difficult to tell if adding a flow spike(s) is needed or adds additional effectiveness as compared to the same flow alternative without flow spike(s). This information also needs to be added to the summary table in Chapter 2. | An analysis was added comparing the lambda of each flow alternative using only the hydrologic traces where a flow alternative would be triggered due to anticipated river temperatures exceeding 15.5°C. This analysis should help clarify the effectiveness of each flow alternative and allow for a clearer comparison across alternatives. Additional information has been added to the summary table in Chapter 2 (Table 2-2) to provide a more comprehensive overview of the effectiveness of each flow alternative. |
| 17 | 13 | ALTASSUMP - General Assumptions Common to All Alternatives | PDF Page 10, Comment #5: If after this SEIS process Reclamation decides to maintain all 5 SMB flow alternatives as a "menu" of options for use, the Service strongly recommends running the SMB model for the particular hydrology presenting in any given year and limiting menu "choices" to ONLY flow alternatives that reduce lambda to below 1 for that given hydrological scenario. Specifically, the Service recommends only implementing flow alternatives that are likely to reduce lambda to 0.96 or lower due to model uncertainties when the modeled lambda is very close to "1" in value. This could also be done to model hydropower costs of the different flow options for a given hydrological scenario in any given year where temperatures are anticipated to rise above the trigger of 15.5 degrees Celsius. If Reclamation is considering utilizing multiple alternatives, the Service encourages Reclamation to cooperatively develop any hybrid alternatives with the Service and other partners and to still prioritize options based on anticipated effectiveness during peak smallmouth bass spawning timeframes. It is essential to use the most effective alternatives to prevent establishment in 2024. | Thank you for your recommendations. Reclamation has considered implementing flow alternatives likely to reduce lambda to 0.96 or lower. Reclamation is developing a planning and implementation process that will include adaptive management strategies with cooperators and stakeholders. Additional information will be included in the LTEMP SEIS ROD. |

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| 17 | 14 | SCOPE - Scope of the Analysis | PDF Page 10, Comment #6: Currently the plan states that smallmouth bass flow alternatives would end in 2027. The document implies this decision is predicated on the assumption that other tools may be available that would be effective by 2027. However, given uncertainties the Service recommends extending the timeframe for allowing smallmouth bass flow alternatives to be implemented through the lifetime of the original LTEMP, in case other tools or options are not available by 2027, or if other tools prove ineffective.If the smallmouth bass flow alternatives are effective, it will be important to be able to continue to implement them when needed to address smallmouth bass and the threat they pose to humpback chub. | This adaptive management process will require ongoing planning and implementation, with necessary NEPA efforts following 2027 to inform future decisions. We will consider this recommendation in our planning process. Additional information will be included in the LTEMP SEIS ROD. |
| 17 | 15 | AQUA - Aquatic Resources | PDF Page 10, Comment #7: The SEIS lacks an analysis in the effects section to native and non-natives fish based on the lambda modeling (pp3-85 to 3-96). The effects analysis does not appear to have been updated following the addition of the lambda modeling. The effects analyses should also include effects to native fish if the flow alternative is not likely to be successful in years where the temperature modeling indicates temperatures will rise above 15.5 degrees celcious and trigger that flow alternative. A less effective alternative will allow population growth of smallmouth bass and have negative impacts to native fish. It looks like it was all written before the lambda modeling and didn't get it incorporated into the effects at all. | Language has been added to the Effects section in Section 3.5 of the SEIS that helps to clarify the lambda modeling. Also, a new table (Table 3-35) has been created that shows the percentage of 30 traces with lambda >1 for each of the six alternatives at river miles 15 and 61. |
| 17 | 18 | ALTASSUMP - General Assumptions Common to All Alternatives | PDF Page 11, Comment #10: Section 2, P. 2-3 Statement that river mile targets for implementation could vary depending on where bass are located could use more specifics or an example to be fully understood. It would be helpful if a realistic example were provided regarding how this may be exhibited. | Additional information has been added about the planning and implementation process. Further information will be available in the LTEMP SEIS ROD. |
| 17 | 19 | EDIT - Editorial | PDF Page 11, Comment #11, Section 2, P. 2-3 Missing Space in Header Title | Changes have been made as suggested. |
| 17 | 16 | SCOPE - Scope of the Analysis | PDF Page 11, Comment #8: Completing this process by late spring 2024 is imperative to prevent smallmouth bass establishment and to protect native and federally listed fish by having the most effective tools available when river temperatures increase. Reclamation should avoid any delays to this process that would result in the loss of the opportunity to use the most effective tools starting in June 2024. If there are delays or we dont select the most effective tools; we will lose a year and lose the advantage of the invading population having a restricted distribution close the dam. Many of these tools will be less effective the longer we wait to use them. | Reclamation understands the urgency and will avoid any delays that could result in losing the opportunity to use the most effective tools, aiming to start in June 2024. We are committed to completing this process efficiently to address these critical issues. |
| 17 | 17 | EDIT - Editorial | PDF Page 11, Comment #9: Suggest updating references used throughout the document. There is a lot of newer peer reviewed information that can be incorporated. Suggest coordinating with GRMRC and NPS to get updated references. | The Final SEIS has been updated to include additional resources and reference. |
| 17 | 20 | ALTASSUMP - General Assumptions Common to All Alternatives | PDF Page 11, Comment# 12, Section 2, P.2-4 GCD Operational constraints - the modeling assumed a minimum flow of 2,000 cfs through the penstocks in every flow alternative. In a public webinar it was shared that this operational constraint may be increased to 3,500 cfs based on recommendations from an upcoming cavitation report. If the operational constraint gets increased the Service recommend re-running the SMB lambda model to investigate if that operational constraint has any modeled impact to the likelihood of success (defined as reducing the lambda to below 1) for hydrological traces that would trigger a flow alternative. | The latest technical memorandum on Grand Canyon Dam operations states, "Turbine flowrates at elevation 3,490 ft are estimated to be 1,600 to 2,300 cfs per unit without damage to turbine runners or units."<br><br>Reclamation will continue to consider and analyze Grand Canyon Dam restraints and the potential impacts to smallmouth bass lambda modeling during the planning and implementation process. |

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| 17 | 10 | AQUA - Aquatic Resources | PDF Page 9, Comment #2: Suggest emphasizing and repeating information on page 1-3 that in 20 years of mechanical removal of smallmouth bass in the upper basin there has been limited success in reducing smallmouth bass densities to benefit native fish populations. | The following was added under "Smallmouth Bass" in Section 3.5.1: "Smallmouth bass were stocked in reservoirs of the Upper Basin starting in 1967 and through the 1970s as sportfish and predators of Utah chub. Smallmouth bass started expanding in the Yampa River of the Upper Basin in 2002 following record low flows (1.8 cfs at Maybell in August 2002). A concerted effort was made in the Upper Basin to control smallmouth bass starting in 2003, largely through mechanical removal, but after 20 years this species has been temporarily reduced in abundance in some areas but not eliminated (Breton et al. 2015). Additional efforts continue to use prescribed flows to control the species (Bestgen 2018), but these studies are incomplete at this time." |
| 17 | 11 | ALTBYPASS - Alternatives - Non-Bypass | PDF Page 9, Comment #3: The Need is to disrupt the establishment of smallmouth bass below Glen Canyon Dam by limiting additional recruitment, which could threaten populations of threatened humpback chub below the dam (page 1-6, section 1-4). A lambda over 1 indicates that this alternative fails to limit additional recruitment of SMB which could continue to threaten humpback chub below the dam. The Non Bypass option does not meet this stated need of the SEIS. The population growth model indicates that in every modeled hydrological trace in which temperatures would indicate that an additional flow option would be needed, the modeled lambda (population growth) is still above 1 for all 17 traces. This is the same overall result of the No Action Alternative. This result indicates that in all of the modeled traces where a flow option would be needed, the smallmouth bass would continue to recruit and population would grow. This result does not meet the need of the SEIS, nor does it meet the ecological needs of the issue. The Service recommends removing this option from further consideration as it does not meet the purpose and need of the SEIS. The Non bypass alternative also does not address or provide the needed management for the ecological issue stressing the stability of the humpback chub population. | Per NEPA requirements, Reclamation is required to analyze reasonable action alternatives, and the Non-Bypass Alternative represents an alternative that was deemed reasonable for analysis. While it may not perform as well as other action alternatives within the smallmouth bass model, it does show improvement over the No Action Alternative.<br><br>However, based on the modeling results and analysis, the Non-Bypass Alternative was not deemed the environmentally preferred alternative and will not be implemented in 2024. |
| 17 | 9 | ALTASSUMP - General Assumptions Common to All Alternatives | Please add a description of what the lambdas mean and how to compare them across the different SMB flow alternatives. There is no context in the document to help a reader who is not already involved in lambda type discussion to understand how to interpret the information being presented and its value in decision making. It is the most powerful success based tool in the document but isn't presented as such. Also this information needs to be added and highlighted in the summary table. A lambda over 1 indicates that this alternative fails to limit additional recruitment of SMB which could continue to threaten humpback chub below the dam. | We have expanded the discussions within the Final SEIS to provide more context and understanding for readers on what the lambda values mean and how to use them to compare effectiveness across the different flow alternatives.<br><br>Lambda values represent the population growth rate: values greater than 1 indicate population growth, and values less than 1 indicate population decline. We have also included a new table that shows the percentage of 30 traces with lambda greater than 1 for each of the six alternatives at river miles 15 and 61 (Table 3-35). This information is presented in a clear and understandable format to enhance the reader's understanding of the model and its implications for each alternative. |

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| 17 | 4 | ALTASSUMP - General Assumptions Common to All Alternatives | Specifically, the Service recommends only implementing flow alternatives that are likely to reduce lambda to 0.96 or lower due to model uncertainties when the modeled lambda is very close to "1" in value. This could also be done to model hydropower costs of the different flow options for a given hydrological scenario in any given year where temperatures are anticipated to rise above the trigger of 15.5 degrees Celsius. If Reclamation is considering utilizing multiple alternatives, the Service encourages Reclamation to cooperatively develop any hybrid alternatives with the Service and other partners and to still prioritize options based on anticipated effectiveness during peak smallmouth bass spawning timeframes. It is essential to use the most effective alternatives to prevent establishment in 2024. | Thank you for your recommendations. Reclamation has considered implementing flow alternatives likely to reduce lambda to 0.96 or lower and explore modeling hydropower costs for scenarios with temperatures above 15.5°C. Reclamation is developing a planning and implementation process that will include adaptive management strategies with cooperators and stakeholders. |
| 17 | 7 | ALTASSUMP - General Assumptions Common to All Alternatives | The preliminary draft SEIS contains many assumptions based on smallmouth bass detections and/or other sampling efforts that would need to occur in conjunction with the various alternatives as well as scenarios where flow alternatives may be curtailed or halted. The Service would like additional information about how those decisions will be made and if there will be input from cooperating agencies. As we enter into Glen Canyon Dam Adaptive Management Working Group (AMWG) Triennial Work Planning, time is of the essence to ensure sampling and removal efforts are prioritized and fully funded. The Service also strongly recommends monitoring of the effectiveness of implementing any flow alternatives. | Reclamation will work with cooperators and stakeholders on the planning and implementation process to ensure that adaptive management strategies are used. As part of the current Triennial Work Plan for FY24, there are experimental management funds that are available to study the effects of Glen Canyon Dam experiments. These funds could be used to assess effectiveness of flow implementation. Additionally, as we enter into the Glen Canyon Dam Adaptive Management Work Group (AMWG) Triennial Work Planning for FY25-27, we recognize that time is of the essence to ensure that sampling efforts designed to assess effectiveness are prioritized and fully funded. The DOI has established a rapid response team that is regularly discussing these concerns. We also agree with the strong recommendation for monitoring the effectiveness of the implementation of any flow alternatives. |
| 17 | 8 | COOPGEN - General Agency Cooperation | The Service stands committed and ready to assist Reclamation with all phases of this SEIS and the other concurrent NEPA planning processes. Please include the Service as early as possible so that we can provide input and be responsive to time intensive aspects of project requirements. If we can be of further assistance, please contact Jonna Polk, Assistant Regional Director, Ecological Services, at Jonna_polk@fws.gov or 918-408-0850. If you need any further clarification of our comments, please contact Deborah Williams, Colorado River Special Assistant, at Deborah_williams@fws.gov or 575-517-6091. | Thank you for your commitment to assisting with all phases of the SEIS and other concurrent NEPA planning processes. We will include the Service as early as possible to ensure that you can provide input and be responsive to the time-intensive aspects of project requirements. |

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| 18 | 9 | ALTASSUMP - General Assumptions Common to All Alternatives | Adjusting the sediment accounting period is key for improving Reclamations ability to implement HFEs and ensure sediment resources are protected as mandated by the GCPA. High flow experiments are critical to protect, mitigate adverse impacts to, and improve the transport and accumulation of sediment in Marble and Grand Canyons as mandated by the GCPA. Glen Canyon Dam effectively cut off approximately 95 percent of the historical sediment supply from the upper watershed (Topping et al. 2000). Since the dam was closed in 1963, at least 28 million metric tons of sand has eroded and about half of that eroded in the late 1990s, including six metric tons from each Marble and Grand Canyons. HFEs are the only mechanism for transporting sediment inputs from tributaries throughout Marble and Grand Canyons and are the sole source of mitigation to address the adverse impacts to sediment resources since the construction of Glen Canyon Dam. Sandbars and beaches are important for biological, cultural, and recreational resources along the Colorado River. Sandbars are vital as a foundation for riparian vegetation, to create low velocity habitat for young fish, provide a source of sand to be transported by wind to protect archaeological resources, and to build camping beaches for recreation.65 These are all values the GCPA was intended to safeguard and are key to consider when thinking about making changes to the sediment accounting windows that currently exist in the HFE protocol. Amending the HFE protocol to allow for more consistent high flows through Grand Canyon is needed given climate change. The warming climate and overallocation of water in the Colorado River Basin have led to lower water levels at Lake Powell, which has resulted in decisions by the Secretary of the Interior to not implement HFEs in years when the sediment triggers were met including 2015, 2021, and 2022.66 The absence of Spring HFEs during the first 10 years of the HFE protocol, coupled with analyses documenting reduced transport of fine sediments in years with low reservoir volumes and low Lake Powell elevations, have prompted the [Glen Canyon Dam Adaptive Management Program] to reassess the HFE protocol. The two 6-month (fall and spring) sediment accounting windows are proposed to be adjusted to operate under a new 1-year window in all but the no action alternative. The HFE protocol is being updated to improve Reclamations ability to implement HFE releases by adjusting sediment accounting periods and HFE implementation windows. Failing to take action to ensure more frequent and high magnitude HFEs is contrary to the mandates of the GCPA and does not meet the purpose and need of the proposed action. The Draft SEIS provides that taking no action under the existing conditions of drought and aridification could result in the continued trend of fewer and smaller HFE releases. Like historically, HFEs are more likely to be triggered in the fall with low likelihood of HFEs in the spring, and would be subject to the same concerns that HFEs would be triggered but not implemented like in 2021 and 2022. Reclamation concludes that the reduced number and magnitude of HFE releases would not optimize the best available science for sediment accounting and determined that the no action alternative does not meet the purpose and need of the proposed action. Further, fewer and smaller HFEs would amplify the impacts on sediment resources, which is contrary to the mandates of the GCPA. | Reclamation’s efforts to update the HFE protocol to improve its ability to implement HFE releases by adjusting sediment accounting periods and HFE implementation windows are crucial steps toward addressing these concerns and meeting the mandates of the Glen Canyon Protection Act. Your input was considered in the finalization of the SEIS and the decision-making process regarding HFEs. |

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| 18 | 3 | AQUA - Aquatic Resources | Further, preliminary modeling of potential smallmouth bass population growth (lambda) in 2024 based on water temperature predicted that taking no action led to population growth in 3% of traces at the confluence of the Little Colorado River (River Mile 61) based on the 30 hydrologic traces analyzed.18 The population growth results were similar for the non-bypass alternative.19 It should be noted that these percentages may be a little misleading in that these 19 are estimates for the entire year. As shown in Figure 3-3520, water temperatures of Glen Canyon Dam releases are not predicted to reach anywhere near the temperature threshold of 15.5C for about half the year (December through April), and the median release temperatures do not reach this threshold until late summer August to November. Thus, it would be helpful for Reclamation to revisit this analysis to separate out the population growth by month, week, or day (e.g. the % of traces in July that showed population growth of lambda greater than 1), based on how many times the 15.5C threshold is reached and for how long it continues. This would help assess the efficacy of the flow options and provide more granular picture of what operations under these alternatives might look like in a given summer. Since we do not have access to that analysis, we use the existing preliminary modeling as evidence to inform this analysis. | The lambda values provided in this SEIS are taken from the smallmouth bass model (Eppehimer and Yackulic 2024), which is based on a size-structure demographic model with transitional survival and recruitment rates. Lambdas are based on a model that represents the annual life history of the smallmouth bass, which is necessary for seasonal reproduction, survival, recruitment, and mortality to be realized for the population. Population growth by month, week, or day is not practical or realistic because the full complement of year-around survival, mortality, and recruitment must be realized to determine whether the population is stable, increasing, or decreasing. |
| 18 | 4 | ALTCOLDSHK - Alternatives - Cold Shock | Further, the cold-water flow options become more difficult and less effective to implement at target locations farther away from Glen Canyon Dam. As nonnative fish populations become established in the Little Colorado River confluence (River Mile 61), the amount and temperature of water required to cool the river this far downstream becomes incredibly challenging because of the miles of warming of those releases that occur between the dam and the target location. Acting now is important to addressing this serious problem for humpback chub and other native fish. | Your input underscores the importance of acting promptly to address this challenge for the benefit of humpback chub and other native fish populations. |
| 18 | 12 | POLICYGOV - Policy and Governance | Reclamation has authority to prioritize the cultural, environmental, and biological resources in Marble and Grand Canyons over hydropower interests. Reclamation has authority under the GCPA to ensure that the environmental, cultural, and biological resources below Glen Canyon Dam are protected even if in so doing impacts occur to hydropower resources. Section 1802(a) of the GCPA provides that: The Secretary shall operate Glen Canyon Dam in accordance with the additional criteria and operating plans specified in section 1804 and exercise other authorities under existing law in such a manner as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park and Glen Canyon National Recreation Area were established, including, but not limited to natural and cultural resources and visitor use.Former Reclamation Commissioner and Deputy Secretary of the Interior, Michael Connor, described the Act85 as follows: The GCPA is a congressional attempt to protect the natural and cultural environment downstream of Glen Canyon by defining the priorities under which DOI must operate the dam. The law of the river is still paramount in dictating releases, but now the protection of downstream resources takes priority over all other values. In fact, the legislative history indicates that the GCPA specifically rejects the notion that power generation has any priority over protection of downstream environmental, recreational, or cultural values. This reordering of priorities, recognizing traditionally overlooked values, is by itself enough to make the GCPA a significant piece of legislation. Further, the goal of the GCPA goes beyond protecting downstream resources and specifically contemplates improv[ing] the values for which Grand Canyon National Park and Glen Canyon National Recreation Area were established. Reclamation has authority under the GCPA that gives priority to protection of the Grand Canyon, and all other values must operate within this mandate. We request that Reclamation consider and prioritize safeguarding humpback chub and other native species over hydropower in this instance. | Reclamation will work with cooperators and stakeholders throughout the life of the LTEMP and LTEMP SEIS to minimize adverse impacts to downstream resources. Reclamation will continue to use adaptive management strategies to ensure that the best available science is used in the planning and implementation process. Additional language has been added to Chapter 1 to discuss planning and implementation. |

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| 18 | 11 | ALTASSUMP - General Assumptions Common to All Alternatives | Reclamation needs to be explicit about whether Lake Powell reservoir elevations of 3,500 feet will prevent implementation of HFEs in practice and take additional measures to ensure continued HFEs are possible. The Draft SEIS assumes that no HFEs will occur if Lake Powell is below 3,500 feet. The Draft SEIS does not clarify at what point Lake Powell falling below 3,500 feet eliminates the HFE (e.g. in the water year, within the month the HFE is planned). This should be made explicit so that it is not used too narrowly or broadly to prevent HFEs when triggered. Further, it should be clearly stated that, flow spikes can and will occur as needed to prevent the establishment of smallmouth bass despite the elevation of Lake Powell and will be timed with HFEs whenever possible. If this is not the case, then the flow options with flow spikes have little to no utility when the conditions are the worst for passage of nonnative fish and warmwater conditions in the Colorado River below Glen Canyon Dam. Finally, Reclamation has a responsibility under the GCPA to protect, mitigate adverse impacts to, and to enhance sediment resources in Grand Canyon. HFEs are critical to meeting this charge. Reclamation needs to work to secure additional water conservation measures in the basin to ensure that Lake Powell reservoir elevations stay well above 3,500 feet (the threshold for HFEs enumerated in the Draft SEIS) to ensure that cultural and environmental resources can be sustained. | This Final SEIS does not change the existing planning and implementation process for HFEs. Reclamation will continue to use the best available data and information for implementing any experimental flows at Glen Canyon Dam. |
| 18 | 15 | CONSCULT - Consultation tribal related | Reclamation should consider the most effective and least invasive means for preventing the establishment of smallmouth bass in the Colorado River below Glen Canyon Dam. The Pueblo of Zuni, the Hopi Tribe, and other tribes have expressed significant ongoing concerns regarding taking of life in the Marble and Grand Canyons. Specifically, the tribes oppose many, if not all, of the measures proposed by Reclamation to prevent the establishment of smallmouth bass in the Colorado River downstream of Glen Canyon Dam. Given these concerns, we strongly encourage Reclamation and other partners to prioritize and elevate consultation with the Grand Canyon affiliated Tribes to understand their interests, consider alternate solutions that do not conflict with their culture and values, and do so in a way that allows adequate time and engagement to ensure meaningful consultation and to influence outcomes. This consultation should be ongoing, not just during the Draft SEIS process, including during planning, design and implementation of actions related to preventing the establishment of nonnative fish in the Grand Canyon, and should include travel to respective reservations to reduce barriers to conversation and consultation. Further, preventative methodssuch as creating a barrier in Lake Powell to ensure nonnative species do not pass through the damhave long been advised as an action Reclamation could take that may not conflict with the values of and cause harm to tribes and Native communities. We strongly recommend that these proactive solutions be expedited and prioritized to carry out the agencys trust responsibility to the tribes and Native communities with ties to the Colorado River and its canyons. | As part of the original LTEMP and this SEIS, Reclamation has invited tribes to act as cooperating agencies. LTEMP PA stipulates ongoing annual meetings during which Reclamation engages Tribal viewpoints into our decision-making process. The biological opinion also mandates that Reclamation examines these proactive methods to prevent fish passage. Reclamation is currently consulting with Tribes to replace existing MOAs to address nonnative fish mortality. The draft MOA includes proactive methods from the biological opinion. This new MOA should be in place in June 2024. |
| 18 | 7 | ALTBYPASS - Alternatives - Non-Bypass | Reclamation should eliminate the Non-Bypass Alternative from consideration at this time because it does not meet the purpose and need of the proposed action and it fails to perform in preliminary modeling any better than the no action alternative in limiting the population growth rate of nonnative species in the Colorado River below Glen Canyon Dam. We appreciate that Reclamation modeled and analyzed this option for preventing smallmouth establishment below the dam considering its benefits for hydropower resources; however, the alternative (at least at current and projected Lake Powell reservoir elevations) does not As an initial matter, the flow options designed in the Draft SEIS are triggered when Glen Canyon Dam water releases through the penstocks reach a threshold temperature of 15.5C (60F). At that time, the goal is to reduce water temperatures in the Colorado River below Glen Canyon Dam to avoid the onset of spawning. The non-bypass alternative does nothing to address the threshold issue of increased water temperatures. Instead, the non-bypass alternative suggests releasing additional both low and high flow fluctuations to disrupt nesting by | Per NEPA requirements, Reclamation is required to analyze reasonable action alternatives. The Non-Bypass Alternative represents an alternative that was deemed reasonable for analysis. While temperature has been found to be effective at disrupting smallmouth bass spawning, there are additional options that should be considered. Reclamation has decided to include the Non-Bypass Alternative to analyze other strategies for disrupting recruitment. While it does not perform as well as the other action alternatives within the smallmouth bass model, it does show improvement over the No Action Alternative. Due to the modeling results and analysis, it was not deemed the environmentally preferred alternative and will not be implemented in 2024. |

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| *(see above)* | *(see above)* | *(see above)* | smallmouth bass and displace individual adult fish and harm the young being produced. This strategy essentially allows spawning and recruitment to continue. While the disruption of the physical habitat from flow fluctuations may result in nest abandonment or displace fry and eggs temporarily, it does not affect water temperature, thus allowing smallmouth bass the ability to renest, spawn and continue recruitment once river stage changes cease. The Non-Bypass Alternative does not act to mitigate warm water temperatures in the Colorado River below Glen Canyon Dam. Temperature is one of the most important factors limiting distribution of smallmouth bass (Bestgen 2018)30. Smallmouth bass have been observed laying eggs at water temperatures as low as 15 degrees Celsius (C) (59 degrees Fahrenheit [F]) in some systems; however, water temperature of 16C (61F) or greater are typically required for smallmouth bass to lay eggs.31 The Draft SEIS states Water temperatures of 16C (61F) or greater are also required for young of year to grow significantly, if hatched. Growth of smallmouth bass at a temperature of 16C (61F) is marginal. Therefore, if a fish is hatched and maintained at approximately 16C (61F) for the length of a typical growing season, it would be very unlikely to grow large enough to survive the winter (Shuter et al. 1980; Dudley et al 2104). Thus, the best chance for limiting recruitment would be to keep temperatures below these thresholds so no eggs are laid or the young of year stay so small that they do not survive to become adults. Preliminary modeling of the potential annual population growth rate for smallmouth bass under the non-bypass alternative showed population growth in similar number of traces as the no action alternative. Generally, the analysis found that at both River Mile 15 and 61 the non-bypass alternative reduced the estimated lambdas when compared with no action, but did not stop population growth. Figure 1, showed the number of traces that showed population growth (lambda greater than 1). The percentage of traces showing population growth for the non-bypass alternative are the same as for the no action alternative. Reclamation found that [t]he No Action Alternative would not meet the projects purpose or need. Likewise, the non-bypass alternative does not meet the purpose and need of the proposal. The Fish and Wildlife Service, in its scoping comments for this SEIS, agreed that [t]he scientific literature, in addition to recent flow and temperature modeling, indicate that cooling water temperatures to below 16C is the only effective method to prevent spawning, recruitment, and establishment of smallmouth bass in Glen Canyon and this is the best method for preventing their spread into western Grand Canyon. The Non-Bypass Alternative fails to meet the purpose and need of the proposed action during the 2024-2027 timeframe. The purpose and need of the proposed action is to analyze flow options at Glen Canyon Dam . . . to disrupt the establishment of smallmouth bass below Glen Canyon Dam by limiting additional recruitment (Emphasis added).38 While the non bypass alternative seeks to use fluctuating flows to cause male smallmouth bass to abandon nests in shallower nearshore habitats, such as backwaters or sloughs, and higher-velocity releases to displace eggs and fry, or cause abandonment by male smallmouth bass, these disruptions do not affect temperature limiting additional recruitment. The Service does not believe that penstock releases alone (the new Hydropower Alternative), would meet the purpose and need of this program in the short term as water temperatures at the penstock intakes are too warm to meet outflow temperature objectives needed to prevent spawning. | *(see above)* |

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| 18 | 6 | ALTRANGE - Inadequate Range of Alternatives | Reclamation should move forward with the suite of cold-water alternatives to prevent establishment of smallmouth bass in Marble and Grand Canyons. Given the current and projected reservoir elevation(s) at Lake Powell from 2024-2027 and the modest amount of water savings secured in the Final Near-Term SEIS, the cold-water flow options (Cool Mix, Cool Mix with Flow Spike, Cold Shock, and Cold Shock with Flow Spike) appear to be the best and most effective short-term option for preventing the establishment of smallmouth bass in Marble and Grand Canyons. Figure 3-5 from the Final Near-Term SEIS23, reproduced below, shows in purple the projected end-of-month reservoir elevations at Lake Powell through the end of 2026 based on the selected alternative. While the current reservoir elevation (3,560 feet) presents a lower risk of passing additional nonnative fish through the dam and warmer water releases than elevations reached in 2022 and 2023 (3,520 feet), Lake Powells elevation is still only 32% of capacity and is projected at the lower end of forecasts to fall in 2025 toward critical elevations and may fall below or hover around 3,500 feet for an extended part of 2026.If Lake Powell reservoir elevations again decline, which is very likely, it will mean 1) more and ongoing nonnative fish passage through the dam as the warmer reservoir layer with nonnative fish approaches the penstocks, 2) warmer dam releases and increased waternonnative fish spawning and establishment below the dam and further downstream, 4) the cold-water flow options will be harder to achieve target temperatures, and 5) more cold water bypass will likely be required in an effort to reverse those conditions (especially at downstream locations like the Little Colorado River and Diamond Creek) to prevent spawning of nonnative fish. Taking no action or implementing the non-bypass alternative will only increase the already unacceptable risk of additional reproduction and distribution of smallmouth bass in Marble and Grand Canyons.Table 1 shows that annual population growth is predicted in more traces in the no action and non-bypass alternatives than if the cold-water alternatives are deployed. This makes sense given how important temperature is at regulating spawning in smallmouth bass. The preliminary modeling reported in Appendix A predicts that smallmouth bass population growth (lambda) at river mile 15 and at the Little Colorado River confluence. While there was some population growth in traces for the Cold Shock and Cold Shock with Flow Spike alternatives, these alternatives still appear to have population growth in less traces than the no action and non-bypass alternatives. Reclamation should include these additional cold water flow options as additional measures to test as needed to cool water temperatures and prevent spawning and establishment of smallmouth bass. These options also have less impacts to hydropower production, so these might be alternatives that can be used in situations where those impacts are greatest and/or cannot be mitigated. Reclamation should adopt and implement the full range of proposed cold-water flow options that tackle both the temperature of the Colorado River and disruptions to spawning through changes in river velocity. We understand that these cold-water alternatives will need to be implemented, monitored, and the results documented to fully understand their effectiveness and impacts to other LTEMP resources. The sooner we can test the effectiveness of these toolshopefully in 2024 when conditions may be less dire in terms of reservoir elevations, warmwater releases, and nonnative fish passage, than is projected for 2025-2026the more information we will have to help refine these flow options, mitigate resource impacts, and operate under more challenging conditions. We suggest moving forward will all four cold waterflow alternatives to allow a range of tools that can be deployed based on when and where the threat is highest for nonnative reproduction each year. | We have considered your recommendation to adopt and implement the full range of proposed cold-water flow options, including Cool Mix, Cool Mix with Flow Spike, Cold Shock, and Cold Shock with Flow Spike, to address both water temperature and disruptions to spawning through changes in river velocity. Your input regarding the monitoring and documentation of the effectiveness and impacts of these options has also been noted. Your comment was taken into consideration during finalization of the SEIS and as we made decisions regarding the implementation of an alternative. |

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| 18 | 8 | ALTBYPASS - Alternatives - Non-Bypass | Reclamation should not move forward with the Non-Bypass Alternative because its benefits to hydropower generation do not outweigh the risks to other resources in Marble and Grand Canyons. The non-bypass alternative is the only flow option that does not operate within the spatial and temporal bounds and under the assumptions of the existing analysis in the LTEMP FEIS.41 Thus, Reclamation should be more cautious about implementing such an option without greater certainty of the impacts to LTEMP resources as outlined throughout the Draft SEIS as follows: Geomorphology and SedimentThe non-bypass alternative would cause the greatest reductions in mass balance starting in Spring 2025 and would generally produce the second-smallest sandbars, slightly surpassing volumes that would be generated under alternatives without flow spikes. Aquatic Resources/Native FishHigh flows resulting from the non-bypass alternative may cause some young [native] fish [to] become displaced from shorelines or backwaters and exposed to predation and starvation, but the effects should be minimal. The low flows, however, if they occurred April - June, could negatively affect young and juvenile flannelmouth suckers and bluehead suckers that could be displaced from desiccated shoreline habitats and backwaters. Aquatic Resources/Rainbow TroutThe flow fluctuations in the non-bypass alternative are expected to displace young and juvenile [rainbow] trout and expose these fish to starvation and predation. Aquatic Resources/ Food BaseThe non-bypass alternatives low flows would desiccate much of the river bottom, especially the shallow shelves where most primary and secondary production occur and the Draft SEIS admits that the effects of 2,000 cfs on the food base have not been evaluated. Riparian Vegetation/WildlifeThe daily flow fluctuations that would occur as a result of the non-bypass alternative may reduce shoreline stability and such instability could lead to a decrease in the abundance of aquatic invertebrates and greater disruption to wildlife habitat. Amphibians, reptiles, and insects may be less able to adapt to the less stable shoreline environment, resulting in decreased biodiversity or abundance. Threatened and Endangered SpeciesThe non-bypass alternatives low flow events have rarely been seen in the Colorado River downstream of Glen Canyon dam and studies (Valdez and Ryel 1995) indicate that much of the shoreline talus habitat and backwaters used by juveniles were dewatered during extreme low-flow events, forcing fish to move to mainstream habitats at risk of greater predation. This may harm native humpback chub and razorback sucker. Cultural Resources/Archaeological SitesThe low flows proposed under the Non-Bypass Alternative are outside those analyzed in the LTEMP FEIS and may lead to the exposure of archaeological sites and sacred sites.50 Such exposure could lead to damage or disturbance from wave action, wet/dry effects, and increased visitation. Tribal Resources/Taking of Life in the CanyonsThe non-bypass alternative has the greatest impacts on fish compared to the other alternatives. The high and low flows would be intended to reduce survival of smallmouth bass eggs and fry through desiccation of eggs, abandonment of nests and impacts on fry. The non-bypass alternative adds to the cumulative impacts on tribal values including those expressed by the Zuni who have linked fish mortality in the Canyons with adverse physical, mental, and psychological effects within the Zuni Pueblo. Because the action alternatives could result in the taking of life within the Canyons, they would have an adverse impact on the Zuni culture and TCPs, if Reclamation implements the flow options with expected fish mortality. Recreation/FishingThe non-bypass alternatives rapid fluctuations in water levels may [] disrupt fishing during implementation. High flows are likely to displace young and juvenile rainbow trout and expose these fish to starvation and predation,56 while low flows that occur between January and March, [] could negatively affect eggs and fry through desiccation and displace juvenile [rainbow trout]. Recreation/BoatingUnder the non-bypass alternative, low flows could limit the ability of boats to freely navigate in the Glen Canyon reach, which would adversely impact boating and the rafting concessionaire in the short term | Based on the information provided, including the potential impacts on geomorphology, aquatic resources, riparian vegetation, threatened and endangered species, cultural resources, tribal resources, recreation, and socioeconomic aspects, we acknowledge the significant concerns raised regarding the Non-Bypass Alternative.<br><br>Reclamation is required to analyze reasonable action alternatives per NEPA requirements, and while the Non-Bypass Alternative was considered reasonable for analysis, it has not been designated as either the preferred or environmentally preferred alternative.<br><br>Given the potential negative impacts outlined in your comment, we have carefully considered these factors in our final decision-making process. Moreover, the Non-Bypass Alternative has not been designated as either the preferred or environmentally preferred alternative, as it negatively affects several non–humpback chub resources. |

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| *(see above)* | *(see above)* | *(see above)* | compared with other alternatives. In the Grand Canyon, the low flows of 2,000 cfs would be below the safe whitewater minimum, which would adversely affect whitewater boating opportunities [in the park] and the ability of Hualapai River Runners to provide boating trips compared with all other alternatives. Recreation/SocioeconomicThe high and low fluctuations of water under the Non-Bypass Alternative could impact the boater experience in both the Glen Canyon and Grand Canyon reaches. The flow unpredictability could pose challenges for boaters navigating through the area and low flows would limit the ability of boats to navigate freely in the Glen Canyon reach. This would adversely impact boating and rafting concessionaires operations compared to other alternatives. To summarize, the non-bypass alternative has direct, indirect, and cumulative effects to nearly all the LTEMP resources and thus requires Reclamation to eliminate it from further consideration. This alternative likewise does not meet the mandates of the GCPA to protect, mitigate adverse impacts to, and improve the cultural and environmental resources in Grand Canyon or ensure the survival and recovery of native fish listed under the ESA. | *(see above)* |
| 18 | 1 | SCOPE - Scope of the Analysis | Reclamation should take immediate action to finalize the Draft SEIS and issue a record of decision so the cold-water alternatives can be implemented in summer 2024. We appreciate Reclamations recognition that the timing of this Draft SEIS is key.9 The need to operate Glen Canyon Dam to reduce water temperatures and/or conduct flow spikes as soon as summer 2024 cannot be understated. The inability to implement such flows in 2023 only set back efforts to curb population growth and expansion of smallmouth bass populations below Glen Canyon Dam (three times more smallmouth bass were captured in 2023 than in 2022). The U.S. Fish and Wildlife Service emphasized that the establishment of warmwater invasive fish, including smallmouth bass, below [Glen Canyon Dam] represents the greatest current potential threat to the continued survival and recovery of humpback chub in the Lower Colorado River basin. Similarly, the Arizona Department of Fish and Game stress[ed] the importance of preventative measures in the management of high-risk warmwater non-native fish through temperature control and commented that they support the proposed flow options and believe that they serve as viable options to contribute to efforts designed to reduce the risk of establishment of Smallmouth Bass. | The SEIS has taken into consideration the importance of timing and the need for immediate action. Your input regarding the need for temperature control and flow spikes to curb the growth and expansion of smallmouth bass populations has been noted and has been considered in the finalization of the SEIS. |
| 18 | 2 | AQUA - Aquatic Resources | Smallmouth bass populations below Glen Canyon Dam have increased significantly over the past two years and their distribution has expanded.12 Prior to 2022, there are records of 22 12 individuals being caught between Glen Canyon Dam and Pearce Ferry.13 These mostly large 13 adult or subadult fish were more highly concentrated above Lees Ferry (12 captures) and at the inflow into Lake Mead (7 captures), only a few were found near the confluence of the Little Colorado River (3 captures).14 These fish likely originated from passage through the dam at low elevations or past Pearce Ferry rapid above Lake Mead, but release temperatures from the dam were likely too cold for reproduction.15 However, [s]tarting in 2022, many of the bass are smaller, indicating that these fish have been produced locally, probably in and around the -12-mile slough in Marble Canyon.16 In 2022, 361 smallmouth bass were captured and that number increased three-fold to 1,073 smallmouth bass captured in 2023.17 These smallmouth bass were distributed more uniformly and consistently throughout the Colorado River below Glen Canyon Dam, but are still mostly heavily concentrated in Marble Canyon above Lees Ferry, as shown in Figure 3-24 from the Draft SEIS, reproduced below. | The language provided in this comment has been included in the section on smallmouth bass Distribution and Abundance. |

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| 18 | 10 | ALTASSUMP - General Assumptions Common to All Alternatives | The cold-water alternatives combined with modification of the HFE protocol will lead to a greater chance of spring HFEs and if flow spikes are combined with HFEs where possible dual benefits for sediment resources and preventing smallmouth bass establishment may be possible. The cold-water alternatives in combination with modification of the sediment accounting window will lead to favorable conditions for high flow experiments that have greater chance of occurring in spring mimicking pre-dam hydrology. The cold-water alternatives without flow spikes would increase the likelihood of spring HFEs by approximately 26 percent. The duration of springs HFEs would also increase to about 110 hours on average, but fall HFEs duration will likely decrease by half (56 hours compared to 98 hours under no action). The sediment mass balance for the alternatives without flow spikes would be slightly higher than the no action alternative because on average the HFE duration (spring and fall) would be slightly shorter. Sandbar volume would continue to increase with smaller, but more frequent growth. The cold-water alternatives with flow spikes lead to similar HFE regimes as those that would occur without flow spikes, but in some years, would cause sand export in the lead-up to HFE implementation reducing the resulting duration.77 Thus, Reclamation should combine. flow spikes with HFEs whenever possible and avoid flow spikes outside the accounting window, so as not to export sand prior to the HFE potentially affecting HFE duration or lead to deferral. Further, flow spike alternatives that increase sediment export, thereby decreasing the amount of available sand to perform an HFE . . . would cause a reduction in sandbar size, because HFEs are the only mechanism for providing substantial deposition of high elevation sandbars (Hazel et al. 2022). Flow spikes could lead to a negative mass balance over the long-term. As intended, the change to the sediment accounting period should enable decision-makers to more easily implement HFEs in the spring, which would better approximate pre-dam conditions of high spring run-off flows. While sand mass balance would undergo more gradual and frequent decreases following HFEs and this trend would be mirrored in sandbar growth patterns, the result may be smaller and slower growth but more consistent implementation and better timing of HFEs. When combined with the cold-water alternatives, Reclamation should combine HFE and flow spikes whenever possible to meet multiples goals of getting cold water into backwater habitats, disrupting spawning, and creating a river stage large enough to transport sediment and build sandbars in Marble and Grand Canyons. These efforts are needed to protect, mitigate adverse impacts to, and enhance the cultural, environmental, and recreational resources in the canyons. The Trust is supportive of modifying the sediment accounting window and strongly encourages Reclamation to proceed with this amendment of the HFE protocol. | Your support for modifying the sediment accounting window and encouragement for Reclamation to proceed with this amendment of the HFE protocol was taken into consideration during finalization of the SEIS and as we made decisions regarding the implementation of these alternatives.<br><br>Reclamation will use the best available sediment data and science during the planning and implementation process to combine HFEs and flow spikes when needed. |
| 18 | 5 | SCOPE - Scope of the Analysis | The continued reproduction, distribution, and establishment of smallmouth bass in Marble and Grand Canyons will continue exponentially along the invasion curve unless and until Reclamation takes immediate and decisive action to operate the most effective cold-water alternative(s) contemplated in the Draft SEIS to cool the river and prevent additional spawning of smallmouth bass. We do not have time to wait, take no action, or try actions like the non-bypass alternative at this juncture. We appreciate Reclamations efforts to move swiftly through this process under the National Environmental Policy Act and hope that the agency can issue a Record of Decision before summer of 2024. The Trust strongly recommends Reclamation take immediate action using the most effective means possible (e.g. implementation of the Cool Mix or Cool Mix with Flow Spike alternatives) based on its research and modeling to ensure that additional population growth and distribution of smallmouth bass does not occur in Marble and Grand Canyons in 2024 and beyond. | Your input regarding the Cool Mix and Cool Mix with Flow Spike alternatives was noted, and we considered it in the final decision-making process. |

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| 18 | 14 | CONSBIO - Consultation biology/ESA related | The Endangered Species Act requires Reclamation not to jeopardize the survival and recovery of endangered and threatened species. The Endangered Species Act provides a program for the conservation of . . . endangered species and threatened species and a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved. Congress intended by enacting the statute to halt and reverse the trend towards species extinction, whatever the cost. The ESA mandates the federal agencies afford first priority to the declared national policy of saving endangered species. Section 7 of the ESA prohibits federal agencies from undertaking actions that are likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat.92 Jeopardy results when it is reasonable to expect, .92 directly or indirectly, the action would appreciably reduce the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species. Adverse modification is defined as a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. As such, Reclamation has both a procedural and substantive obligation under Section 7(a)(2) of the ESA. First, to satisfy its procedural duty, Reclamation must consult with the Service before undertaking any action that may affect a listed species or its designated critical habitat using the best available science.95 Second, based on that formal consultation, the Service must issue a biological opinion to make a substantive determination and explain whether the agency action is likely to cause jeopardy to any listed species. Reclamations ongoing actions under the 2016 Long-term Experimental and Management Plan are taken pursuant to the 2016 LTEMP Biological Opinion issued by the Service, which found no jeopardy to listed species at that time. However, the 2016 LTEMP Biological Opinion detailed conservation measures necessary to prevent jeopardy and help ensure the survival and recovery of the threatened humpback chub. The danger to humpback chub from nonnative species was clear in 2016 and several significant measures were included to ensure Reclamation took steps to protect the humpback chub from these threats. The conservation measures set out the in the 2016 Biological Opinion include: explore the efficacy of a temperature control device at the dam to respond to potential extremes in hydrological conditions due to climate conditions that could result in nonnative fish establishment; pursue means of preventing the passage of deleterious invasive nonnative fish through Glen Canyon Dam; planning and compliance to alter the backwater slough at River Mile (RM) 12 (commonly referred to as Upper Slough), making it unsuitable or inaccessible to warmwater nonnative species that can compete with and predate upon native fish, including humpback chub; and planning and compliance of a plan for implementing rapid response control efforts for newly establishing or existing deleterious invasive nonnative species within and contiguous to the action area. These conservation measures are designed to minimize or reduce the effects of the proposed action or benefit or improve the status of listed species as part of the LTEMP. It is clear from the 2016 Biological Opinion that a need already existed to take actions around nonnative warmwater fish in 2016 and that it may become a more frequent need with lower reservoir elevations and warmer dam releases. As detailed in the Draft SEIS, the threat to the threatened humpback chub and endangered razorback sucker from the establishment of nonnative fish below the dam has increased significantly since 2022. Low reservoir elevations at Lake Powellthat have and will likely continue to pass nonnative fish through the penstocks as well as facilitate warmer water releases from the damhave created conditions in Marble and Grand Canyons that make the establishment of smallmouth bass below Glen Canyon Dam possible and likely if immediate actions are not taken by Reclamation. The problem may not be as acute today had Reclamation fulfilled the conservation measures it committed to in 2016. Given the three fold increase in captures of smallmouth bass below Glen Canyon Dam in 2023 and urgent need | Reclamation appreciates your comments regarding ESA consultation requirements. Reclamation has been actively coordinating with the Service since the beginning of the NEPA process. Reclamation will continue consulting with the Service now that a preferred alternative has been selected. |

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| *(see above)* | *(see above)* | *(see above)* | for the actions proposed in the Draft SEIS, Reclamation must reconsult with the Service. The Service should review Reclamations progress over the past decade and determine if more clear and mandatory measures are needed on the part of Reclamation to ensure the continued survival and recovery of humpback chub and razorback sucker in the Grand Canyon. The Service should consider the long-term consequences of nonnative fish establishment in the canyons when making its jeopardy decision. | *(see above)* |
| 18 | 13 | POLICYGOV - Policy and Governance | The GCPA should be included in the Draft SEIS as a key source of authority. The GCPA should be included as the source of authority for the Long-term Experimental and Management Plan in the introductory paragraph of the Draft SEIS at 1-1. The existing statement emphasizes hydropower generation of the dam without putting that in context of other resources that are required to be managed by Reclamation including the mandate to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park and Glen Canyon National Recreation Area were established. The Trust recommends being explicit about Reclamation authority to adaptively manage this stretch of river by including the following additional language: To adaptively manage this stretch of river according to the mandates of the Grand Canyon Protection Act of 1992 and other laws, the United States (US) Department of the Interior (Department) Bureau of Reclamation (Reclamation), developed the Long-Term Experimental and Management Plan (LTEMP) for operations of Glen Canyon Dam, the largest hydropower generating unit of the Colorado River Storage Project (CRSP; DOI 2016a). | Reclamation worked with cooperators and stakeholders throughout the life of the LTEMP and LTEMP SEIS to minimize adverse impacts to downstream resources. Reclamation will continue to use adaptive management strategies to ensure that the best available science is used in the planning and implementation process. Additional language has been added to Chapter 1 to discuss planning and implementation. |
| 19 | 6 | ENERGYPOW - Energy and Power | More critically the DSEIS fails to mitigate the effects on regional grid reliability caused by the loss of GCD generation or the costs of replacement power and transmission. Please revise the DSEIS such that it meets all applicable requirements. | Reclamation has updated the Final SEIS to include additional analysis on grid reliability, including the latest PLEXOS modeling data. See Section 3.3 for more information. |
| 19 | 1 | ENERGYPOW - Energy and Power | More critically the DSEIS fails to adequately assess the environmental and public safety effects that the alternatives will impose on the ultimate electric customers that are served from this resource. | Reclamation has updated the Final SEIS to include additional analysis on impacts to electric customers, including the latest PLEXOS modeling data. See Section 3.3 for more information. |
| 19 | 5 | ALTRANGE - Inadequate Range of Alternatives | Reclamation must critically analyze available alternatives to disrupt smallmouth bass populations below GCD include nonflow options. The inclusion of one non-bypass flow alternative is insufficient to fully address the requirements of an EIS. | Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. |
| 19 | 2 | ENERGYPOW - Energy and Power | The DSEIS analysis does not properly evaluate the impacts to electric generation. The costs of the replacement power and transmission are grossly underestimated and the proposed flow modifications will directly impact reliability. Loss of delivery to our communities due to reliability issues will threaten public safety. The costs of the flow-based alternatives need more rigorous analysis. | Reclamation has updated the Final SEIS to include additional analysis on impacts to hydropower resources, including generation, replacement power, and the latest PLEXOS modeling data. See Section 3.3 for more information. |
| 19 | 4 | ALTRANGE - Inadequate Range of Alternatives | The DSEIS does not consider non-flow alternatives to disrupt smallmouth bass populations, rather it leaves this analysis for future NEPA actions. Such non-flow options have already been identified by IEDA, SRP and the GCD Adaptive Management Work Group. This narrow focus of alternatives indicates a bias for a particular outcome. | Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. |
| 19 | 3 | ALTRANGE - Inadequate Range of Alternatives | The limited view of the impacts of the alternatives are disappointing. The DSEIS must be revised to consider accurate evaluations of a wider range of solutions to prevent the establishment of smallmouth bass and other nonnative warm water invasive fish. The DSEIS omits reasonable alternatives that could disrupt the establishment of smallmouth bass below GCD without flow modifications that diminish GCD electric generation. | Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. |
| 20 | 10 | ALTRANGE - Inadequate Range of Alternatives | ED7 asks that Reclamation critically analyze all available alternatives to disrupt smallmouth bass populations below GCD. The inclusion of one non-bypass flow alternative is insufficient to address the concerns raised in response to the Environmental Assesses, as the DSEIS nonetheless fails to articulate or mitigate the effect on regional grid reliability caused by the loss of GCD generation. | Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. |

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| 20 | 2 | ENERGYPOW - Energy and Power | ED7 provides electric service to customers in Maricopa County, Arizona. PS07 is a longtime Firm Electric Service ("FES") contractor \vith Western Area Power Administration ("W AP A") for capacity and energy provided by the Colorado River Storage Project ("CRSP"). A majority of the CRSP system's critical summer generation and capacity comes from GCD. PS07 is concerned about the short-term reliability impacts associated \ with the unavailability of capacity, whether due to LTEMP provisions rendering GCD generation unavailable, or due to increased demand on regional markets for summer peaking power. | Reclamation has updated the Final SEIS to include additional analysis on impacts to hydropower resources, including generation, replacement power, and the latest PLEXOS modeling data. See Section 3.3 for more information. |
| 20 | 1 | ALTRANGE - Inadequate Range of Alternatives | Electrical District Number Seven ("ED7'') appreciates the opportunity to provide con1ments in on the important strategic analysis at issue in this DS:t::1S, namely the available alternatives to reduce the threat of smallmouth bass below the Glen Canyon Dam ("GCD"). We support the concept of preventing establishment of smallmouth bass and other nonnative warmwater invasive fish, but the DSEIS fails to sufficiently analyze alternatives that mitigate health and safety concerns resulting from the loss of GCD summer electric capacity, in a time where market purchases may not be available to replace the loss. Accordingly, we submit the following comments on the DSEIS and encourage the Bureau of Reclamation ("BOR" or "Reclamation") to ensure an outcome that is equitable, sustainable, and compliant with the requirements of the National Environmental Policy Act ("NEPA"). As drafted, the. DSEIS does not meet NEPA's requirement to explore available alternatives. | Reclamation has updated the Final SEIS to include additional analysis on impacts to electric customers, including the latest PLEXOS modeling data. See Section 3.3 for more information.<br><br>Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. |
| 20 | 9 | ENERGYPOW - Energy and Power | Footnote 1: 1 ED7 in particular concurs in CREDA's comment that Hydropower Modeling Assumptions/'TMax should be rewritten by WAPA, as the Power and Energy analysis included in the DSEIS does not appropriately disclose an analysis of the effects, as required for either public comment or a final decision by the Secretary. | Reclamation worked closely with WAPA and integrated WAPA's findings as appropriate as we finalized the SEIS. Reclamation has included the PLEXOS modeling results in the Final SEIS to further analyze impacts to hydropower resources. UMPA's input, including WAPA's proposed Section 3.3 on Energy and Power, was carefully considered. |
| 20 | 3 | ALTRANGE - Inadequate Range of Alternatives | PS07 has reviewed the DSEIS, the input from stakeholders leading up to the DSEIS, and comments prepared for the DSEIS. ED7 wholly supports and agrees with the thoughtful comments of CREDA, IEDA, and SRP. The DSEIS omits reasonable alternatives that could disrupt the establishment of smallmouth bass below GCD without flow modifications that diminish GCD electric generation and capacity. | Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. |

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| 20 | 8 | ENERGYPOW - Energy and Power | The DSEIS does not adequately identify the effects on the public of a significant loss of summer electric capacity when market replacement resources may be scarce Due to drought and changing regional electric wholesale market conditions, the availability of market purchases of electric capacity and generation during critical summer months is not assured. The DSETS bypass flow alternatives assume that W APA will able to purchase replacement power to fulfill its contractual obligations to customers. (See DSEIS at 3- 19.) The DSEIS briefly notes that WAPA's operational flexibility is affected by the availability and price of replacement power, (Id. at 3-20), but does not appear to analyze the availability or price of the replacen1ent power the DSEIS identifies will be needed under the bypass alternatives. (Id at 3-1 9). ED7 is affected first-hand by the electric power spot market. In the rush to replace GCD generation, W APA and its contractors (including ED7) will all be looking for replacement po\ver in the same capacity-short market environment forcing prices to rise. Transmission constraints could further squeeze market replacement power purchases. ED7 has watched as increasingly drastic weather has caused the large importation of market purchases into the desert southwest, forcing the price of power to exceed $300/MWh, and spike to over $ I,000 in times of shortage. As the Supreme Court has recognized, "[i]mplicit in NEPA's demand that an agency prepare a detailed statement on 'any adverse environmental effects which cannot be avoided should the proposal be implemented,' .. . is an understanding that the EIS will discuss the extent to which adverse effects can be avoided." Robertson, 490 U.S. at 352. ED7 agrees with CREDA, IEDA, and SRP's comments that there are significant constraints on available capacity in the summer months. There are legitimate concerns that replacement capacity and peaking generation will not be available on the n1arket to fill the loss of GCD.1 This could lead to grid unreliability, which can threaten public safety. The DSEIS must be redrafted to analyze the effects of flow modifications on grid reliability, and must discuss the extent to which those adverse effects can be avoided via pursuing other mitigation opportunities, such as maintaining on-peak generation in the flow-based alternatives. | Reclamation has updated the Final SEIS to include additional analysis on impacts to electric customers, including the latest PLEXOS modeling data. See Section 3.3 for more information.<br><br>In addition, emergency operations at Glen Canyon Dam will continue to avoid any adverse impacts to human health and safety. |
| 20 | 7 | ALTRANGE - Inadequate Range of Alternatives | The DSEIS does not explore and objectively evaluate all reasonable alternatives The availability of nonflow alternatives to disrupt smallmouth bass populations needs to be evaluated in this SEIS, and not left to another "future NEPA actions" as proposed. (DSEIS, at 1-6). Narrowing the purpose of the DSEIS to only "analyze additional flow options at [GCD)" is just the type of "unreasonably narrow" objective that courts have chastised. (Id.) See Westlands Water Dist., 376 F.3d at 1155. The single-minded focus on flows drives the process to overlook reasonable alternatives to addressing the identified need. As raised by IEDA and members of the GCD Adaptive Management Work Group, including SRP, alternative potential solutions to prevent entrainment include manipulation of reservoir elevation, application of a them1al curtain or barrier net, habitat modifications, and physical modifications to address the -12-mile slough where the smallmouth bass and other invasive fish spawn. Failure to analyze these actions that address the identified need, when the costs of bypass flows to electric reliability arc so significant, would be indefensible. Failure to examine these viable alternatives to flow 1nodifications would render the DSETS legally inadequate. See Wes/lands Water Dist. v. U.S. Dept. of Interior, 376 F.3d 853, 865 (9m Cir.2004). | Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. These additional efforts require a longer time frame that could introduce additional risks to the smallmouth bass problem.<br><br>Reclamation has updated the Final SEIS to include additional analysis on impacts to hydropower resources, including the latest PLEXOS modeling data. See Section 3.3 for more information. |
| 20 | 4 | ENERGYPOW - Energy and Power | The DSEIS further fails to include adequate and meaningful discussion of the environmental and public safety effects that alternatives will impose on the electric utilities who receive electric generation and capacity from GCD, and the retail customers those electric utilities serve, due to the loss summer electric capacity. | Reclamation has updated the Final SEIS to include additional analysis on impacts to electric customers, including the latest PLEXOS modeling data. See Section 3.3 for more information.<br><br>In addition, emergency operations at Glen Canyon Dam will continue to avoid any adverse impacts to human health and safety. |

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| 21 | 6 | ENERGYPOW - Energy and Power | Among WAPAs comments and descriptions of impacts included in the attached revised Section 3.3, WAPA has identified the following actions it believes Reclamation should address prior to executing the action: Develop an implementation plan in consultation with WAPA that includes flexibility to minimize hydropower impacts. This includes considering the timing and implementation in relation to power demands on the bulk electric system. Reclamation may want to consider an option that provides increased generation during the evening super peak when wind and solar are less available to offset some of the impact identified in the SEIS. Establish off-ramps addressing both operational and financial considerations impacting WAPAs ability to operate and maintain the CRSP system, as well as a process agreement to provide WAPA adequate notice of experimental flows with a preferred 6 weeks of lead time to allow for purchase power needs. Secure funding to mitigate the financial impacts of the experiment on the Basin Fund. If not mitigated, this experiment could jeopardize the solvency of CRSP and force Reclamation and WAPA to suspend funding project requirements, including operation, maintenance, and capital expenditures, which could increase the likelihood of equipment failures and other impacts to the water and power system. Develop and implement a robust treatment plan that simultaneously addresses the three contributing factors leading to smallmouth bass establishment: entrainment, warm-water releases, and downstream habitat availability. Addressing one contributing factor without also addressing the others will be insufficient to prevent establishment. Cold water releases via bypass only treat a symptom of the problem. The primary cause of smallmouth bass establishment below Glen Canyon Dam is entrainment resulting from low reservoir elevations, and entrainment will continue even if this action is implemented. Consider, under the Colorado River Post-2026 Operations process, a strategy for maintaining a reservoir elevation of at least 3,570 feet during summer months to avoid entrainment of smallmouth bass and warm water releases (see Appendix A below for one such strategy). Modify the -12 mile slough so it does not provide smallmouth bass nesting or nursery habitat but supports other desired ecological functions. This could be an important and relatively simple activity to disadvantage bass establishment. See Attachment 3: WAPA Revised Draft SEIS Section 3.3 for more details about specification about the actions mentioned. Also see Appendix A (starting on page 4 of WAPA's letter) for details about their Proposed New Component Common to all Alternatives. | Additional implementation language has been added to Chapter 1 of the Final SEIS. Reclamation will work with WAPA prior to the development of the ROD on additional implementation guidelines, including off-ramps.<br><br>The analysis of hydropower impacts is based on current authorities. Options that might require new authorities are beyond the scope of this NEPA analysis.<br><br>Reclamation has incorporated findings from the "Invasive Fish Species Below Glen Canyon Dam: A Strategic Plan to Prevent, Detect and Respond" report (GCDAMP 2023) into this Final SEIS and will incorporate them into future NEPA actions, including long-term plans that include entrainment solutions. |
| 21 | 4 | SOC - Socioeconomics | Each Action Alternative would impact power generation at Glen Canyon Dam during summer months when power is in peak demand. These changes in operations would reduce available generating capacity at Glen Canyon Dam under all four bypass alternatives. This reduction in capacity would need to be replaced by purchases and generation from other sources. The estimated financial impacts from the proposed alternatives range from a net gain of $140,000 to a cost of $222.03 million, depending on the reduction in the amount of power generated and the cost to purchase power from replacement sources. The Cool Mix alternative in particular would have an average annual impact of $60-62 million over the 4 years, if implemented. To provide adequate protection for the Upper Colorado River Basin Fund (Basin Fund), WAPA recommends Reclamation consider the higher-end potential financial impacts that may affect the Basin Fund. At the 90th percentile for this action, for example, the impacts of the Cool Mix Alternative over the next 4 years are modeled to be $145 million for a trigger at river mile 15, and $202 million for a trigger at river mile 61. These impacts could be greater as modeling does not take into consideration real-time market dynamics that may increase prices above those used for this analysis. The Basin Fund cannot absorb those expenses and effectively fund Reclamation and WAPAs operations. | Reclamation integrated WAPA's findings as appropriate as we finalized the SEIS. Reclamation has included the PLEXOS modeling results in the Final SEIS to further analyze impacts to hydropower resources.<br><br>Reclamation will work with WAPA and other cooperators and stakeholders on the planning and implementation process to consider hydropower resource impacts. |

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| 21 | 3 | ENERGYPOW - Energy and Power | Given the importance of this action and magnitude of potential hydropower impacts, WAPA has provided a revised Section 3.3 incorporating PLEXOS and GTMax modeling. This revision more accurately discloses and analyzes hydropower impacts and provides a more robust treatment of the data to evaluate the risk to the hydropower resource and the potential effects of the proposed action. WAPA submits the attached revised Section 3.3 as a drop-in replacement for the corresponding section included in the public draft SEIS. WAPA also submits draft reports from WAPAs Desert Southwest Region, NREL, and Argonne on transmission and grid impact studies. See Attachment 3: WAPA Revised Draft Section 3.3 for specific revisions. See Attachment 1: Argonne Methodology Report, Attachment 2: GTMax SL Transmission Model Contractual Power Flows and Financial Analysis, Attachment 4: Argonne Section 4.1 SERM Detailed Hourly Results, Attachment 5: NREL Methodology - Description of System.and Attachment 6: WAPA Impact of Reduced Glen Canyon Hydroelectric Generation on Transmission Reliability - Summer 2024 for additional infromation. | Reclamation integrated WAPA's findings as appropriate as we finalized the SEIS. Reclamation has included the PLEXOS modeling results in the Final SEIS to further analyze impacts to hydropower resources. WAPA's proposed Section 3.3 on Energy and Power was carefully considered. |
| 21 | 7 | DATA - Data Sources | Meaningfully consider all public comments, including the revised Section 3.3, and re-issue the public Draft SEIS for comment once those comments and additional technical data have been incorporated. In WAPAs view, the current draft document does not include the best available scientific and technical information, and the public should have the opportunity to review and comment on such information. This action would help ensure the Secretary of the Interior has a complete analysis and related public comment to allow informed decisions on whether to undertake these experimental releases. Improving hydrology in the spring of 2024, improvements in humpback chub populations in Grand Canyon, and the relatively high level of uncertainty that smallmouth bass might establish between the Little Colorado River and western Grand Canyon suggest Reclamation has additional time to evaluate the impacts of the action alternatives and develop related strategies. Smallmouth bass have been present in western Grand Canyon for over 2 decades, and water temperatures have been suitable for spawning every summer in that part of the canyon since temperature loggers were added to the gauges in 2008. In WAPAs view, comprehensive strategies to prevent further establishment could provide security for humpback chub populations while also allowing continued operation of hydroelectric generating facilities. See Attachment 3: WAPA Revised Draft Section 3.3 for specific revisions. | Reclamation integrated WAPA's findings as appropriate as we finalized the SEIS. Reclamation has included the PLEXOS modeling results in the Final SEIS to further analyze impacts to hydropower resources. WAPA's proposed Section 3.3 on Energy and Power was carefully considered.<br><br>While smallmouth bass have been present in the Grand Canyon, only recently has there been substantial evidence for spawning activities that introduce significant risk to threatened and endangered species. |

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| 21 | 1 | ENERGYPOW - Energy and Power | The CRSP Act requires Reclamation to operate the hydroelectric powerplants associated with the project so as to produce the greatest practicable amount of power and energy that can be sold at firm power and energy rates. 43 U.S.C. 620f. Also, as a Cooperating Agency, WAPA shares Reclamations responsibility to consider the best available science and data in evaluating the impacts of proposed actions. In WAPAs view, the public Draft SEIS is inadequate in its description and methods of addressing hydropower impacts, and it proposes actions inconsistent with Reclamations mandate to operate the project to produce the greatest practicable amount of hydropower. | Hydropower is an authorized purpose of Glen Canyon Dam as stated in the 1956 Act. Although the 1956 Act refers to hydropower production as an "incident" to other authorized purposes, the 1956 Act also directs that Glen Canyon Dam's powerplant is to be operated "so as to produce the greatest practicable amount of power and energy that can be sold at firm power and energy rates" consistent with the Law of the River. Congress also addressed these authorities in the 1992 Grand Canyon Protection Act, calling for implementation of Glen Canyon Dam Operations "under existing law in such a manner as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park and Glen Canyon National Recreation Area were established, including but not limited to natural and cultural resources and visitor use" and "in a manner fully consistent with and subject to" the 1956 Act and other statutes "that govern allocation, appropriation, development, and exportation of the water of the Colorado River basin." These broadly worded provisions impose on the Secretary of the Interior an obligation to balance many different interests in the operation of Glen Canyon Dam. This NEPA analysis considers options to strike the appropriate balance between threats to listed, native fish, and other resources, including hydropower. Reclamation has updated the Final SEIS with information and modeling from WAPA to address impacts to hydropower resources and inform this balance. |
| 21 | 5 | SCOPE - Scope of the Analysis | The scope of this experiment, and its potential impacts, far exceed any prior experiment executed or envisioned as part of the Glen Canyon Dam Adaptive Management Program. For example, both the 2000 Low Summer Steady Flow experiment and the potential LTEMP Low Summer Flow experiment have estimated impacts on the order of about $25 million. In addition, WAPA and Reclamation have never implemented flow experiment of the type and magnitude proposed in this SEIS. As discussed further below, WAPA is concerned that these actions may impact the electrical system in ways that cannot be quantified beforehand. WAPA is uncertain of its ability to implement the experiment without substantial risk to the project, WAPAs physical infrastructure, and the reliability of the power grid in the western United States. | The range of impacts varies greatly, depending on hydrologic conditions. Reclamation intends to work closely with WAPA if projected impacts would greatly impact hydropower resources. It is important to note that the ranges of impacts could be overestimates, depending on how long proposed flows need to be ongoing if implemented. Reclamation will collaborate with WAPA and other cooperators and stakeholders in the planning and implementation process to consider hydropower resource impacts. |
| 21 | 2 | ENERGYPOW - Energy and Power | WAPA, as with all commentors, is limited in its ability to adequately comment on the Draft SEIS due to the insufficient description of hydropower impacts and methodology used in the draft analysis. Department of the Interior policy states: Scientific information considered in Departmental decision-making must be robust, of the highest quality, and the result of as rigorous a set of scientific processes as can be achieved. The best available science and data to assess the impacts to the CRSP hydropower resource are produced by the PLEXOS and GTMax modeling provided by the National Renewable Energy Laboratory (NREL) and Argonne National Laboratory (Argonne). WAPA is concerned that the public Draft SEIS instead includes data from competing models that have not been peer reviewed. In WAPAs view, including competing and untested modeling data creates unnecessary confusion and undercuts efforts to accurately describe the hydropower impacts. See Attachment 1: Argonne Methodology Report, Attachment 2: GTMax SL Transmission Model Contractual Power Flows and Financial Analysis, Attachment 4: Argonne Section 4.1 SERM Detailed Hourly Results, and Attachment 5: NREL Methodology - Description of System. | Reclamation integrated WAPA's findings as appropriate as we finalized the SEIS. Reclamation included the PLEXOS modeling results in the Final SEIS to further analyze impacts to hydropower resources. WAPA's proposed Section 3.3 on Energy and Power was carefully considered. |

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| 22 | 8 | ALTRANGE - Inadequate Range of Alternatives | Additional funding and actions to address the smallmouth bass and other warm water fish predator threat are critical. They include but are not limited to: channelization of the upper and lower slough to increase cold water flow through this warm water habitat, devices to mitigate for warm water fish entrainment through Glen Canyon Dam from Lake Powell, strategies to increase cold water delivery capabilities to the river such as: adding power capability to the bypass tubes to allow them to be utilized outside of experimental windows, lowering water release points from Lake Powell to reduce the dead pool and prolong cold water delivery to the river, and if possible address low dissolved oxygen and poor nutrient delivery in the process. | Thank you for your comment. Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. These additional projects include slough modifications, fish barriers, and thermal curtains. Reclamation will consider the additional project ideas identified in the comment. |
| 22 | 5 | GEOSEDI - Geomorphology and Sediment | Another aspect of the SEIS that is of great importance to the health of the river ecology, the maintenance of beaches for recreational use, and cultural resource protection is the high flow experiment (HFE) protocol. GCDAMP recreational fishing representatives, along with other stakeholders advocating for a healthier river system, have long sought a change to the sediment accounting window and hope to increase the possibility of more spring HFEs than have occurred under the present accounting window system. We strongly support changes to the sediment accounting window and the resultant possible inclusion of more spring HFEs to benefit the river system. While we understand that there are limited water resources, the purpose of HFEs and flows designed to help control smallmouth bass are both important to river health. The timing for flows to benefit sediment transport and build beaches, and flows that will best inhibit smallmouth bass may very well be at different times. It is important that managers plan for water deliveries to meet those two very different demands. | Thank you for your comment. We will consider these points while developing the Final SEIS. |
| 22 | 6 | ALTRANGE - Inadequate Range of Alternatives | Besides the flow options proposed in the SEIS, it is critical that managers continue to address conditions in Lake Powell and in the river to implement actions outside the scope of the SEIS as they are needed to deal with this threat. As an example of such a strategy, we are pleased to see that plans are underway to begin channelization of the upper and lower slough that is currently a haven for smallmouth bass and other warm water species that could threaten native fish downstream. Actions and funding to develop and install devices to reduce entrainment of warm water fish through Glen Canyon Dam from Lake Powell is a critical step in this battle and must continue as quickly as practical. | Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. |
| 22 | 2 | AQUA - Aquatic Resources | For example, during the short term actions being undertaken by the National Park Service while the SEIS is under review, all smallmouth bass and other warm water species are being removed from the river. Besides being an unsustainable, impractical method for controlling these species, electrofishing as currently being practiced during these actions, does not provide managers with an effective tool to measure the population of these fish to know with greater certainty how many of the targeted species are present in the river system, or their estimated numbers in certain key hot spots in the river. For effective management, it is crucial to know the age distribution, numbers in each year-class, and the origin of any particular year-class of fish to know if they are entrained fish, or if they were born in specific locations in the river. This information is critical in determining the effectiveness of any of the options chosen, and essential to inform managers if the current strategies are not effective, and additional strategies should be considered. There must be funding, personnel, and resources in place to assure the ability to collect systemwide data and quickly analyze that data to determine if the chosen action is effective or if refinements are needed to the management plan. | The same dilemma was faced by biologists in the Upper Colorado River Basin when they had to decide whether all smallmouth bass captured by electrofishing should be removed, or whether if some number of fish should be measured, weighed, marked, and released for life-history information and mark-recapture estimates of abundance. They decided to mark and release fish from their first electrofishing pass and remove all subsequent captures for the year. These data have enabled biologists to better understand the size and age profile of the smallmouth bass population and to evaluate efficacy of mechanical removal through abundance estimates (Breton et al. 2015). Biologists in Grand Canyon will need to decide similarly.<br><br>Reclamation will continue to implement monitoring strategies to ensure that adaptive management practices can continue throughout the life of LTEMP. |
| 22 | 1 | SCOPE - Scope of the Analysis | In seeking the ability to utilize multiple alternatives as part of the SEIS, that assumes the responsibility and ability to effectively determine the impact of any chosen action to reduce or eliminate smallmouth bass and other warm water species. How that is to be measured and accomplished is not described in this document, and must be included in order to effectively choose the best option. | Additional planning and implementation language has been added to Chapter 1 of the Final SEIS. Further details will be included in the ROD. |

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| 22 | 7 | PROPACTION - Proposed Action | There must be funding, personnel, and resources in place to assure the ability to collect systemwide data and quickly analyze that data to determine if the chosen action is effective or if refinements are needed to the management plan. | Reclamation will continue to implement monitoring strategies to ensure that adaptive management practices can continue throughout the life of LTEMP. |
| 23 | 2 | AQUA - Aquatic Resources | Absent measures to stop dam entrainment and modify side channel habitats that enable warm water fish reproduction, the "Cool Mix" and "Cool Mix Flow Spike" alternatives may slow and limit but will not stop adverse modification of designated critical habitat for Grand Canyon's endangered fish. BOR cannot omit analysis and disclosure under NEPA or ESA of the effects of warmwater invasive fish entertainment, as it has and is likely to continue to facilitate expansion on nonnative fish populations within side channels (for example, the "slough") and/or tributary streams whose water temperatures are relatively unaffected by mainstream water temperature changes | The purpose of this SEIS is to evaluate alternatives for controlling smallmouth bass to determine which alternative is the most likely to be the most effective. Aside from the proposed flow-prescribed alternatives, Reclamation and the NPS are evaluating the possibility of mechanically modifying the slough to eliminate this habitat as a refuge and spawning site for smallmouth bass and green sunfish. Reclamation is using the best available science to direct the development and implementation of the preferred alternatives. This is just one of many steps Reclamation is taking to reduce the threat of nonnative predatory invasive species, and this evaluation will continue under the post-2026 EIS. |
| 23 | 8 | OOS - Out of Scope | BOR and its sister agencies (NPS, USFWS) must undertake planning now to ensure the survival, and recovery of threatened and endangered fish in the context of minimum power pool, dead pool, and a warm Colorado River flowing through Grand Canyon. Worsening greenhouse gas pollution, regional warming, aridification, and Colorado River flow declines provide little assurance that, in the long term, sufficient water will be available to maintain Lake Powell levels to ensure critical cold water flows from Glen Canyon Dam to protect fish can be achieved. BOR and its sister agencies' duty to "carry out programs for the conservation"--i.e., recovery of listed species, should compel planning now to ensure for the survival and recovery of threatened and endangered fish. This must include planning for the climate inevitable obsolescence of Glen Canyon Dam and Lake Powell, and, in that context, it must provide for replacement power, a phased decommissioning of the dam, and associated engineering solutions that will exclude non-native fish invasion, maintain Grand Canyon as a native fish stronghold in the Colorado River system, and provide for the survival and recovery of endangered fish in the mainstem of the Colorado River in Glen Canyon National Recreation Area and Grand Canyon National Park. | Thank you for your comment. This is just one of many steps Reclamation is taking to reduce the threat of nonnative predatory invasive species. Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. However, many of these long-term projects are outside the scope of this LTEMP SEIS. Please refer to the post-2026 EIS for additional long-term management practices for Glen Canyon Dam. |
| 23 | 3 | AQUA - Aquatic Resources | BOR's failure in the DSEIS to analyze and disclose the rate and severity of downstream expansion of warmwater invasive fish resulting from entrainment, despite those data being at BOR's fingertips, and its failure to discuss those data and trends in the context of threats posed to the Little Colorado River population of humpback chub is evasive, and it violates NEPA. | The analyses described in this document are based on annual fish monitoring by GCMRC, NPS, AZGFD, and the Service. These cooperative efforts collect data to better understand the distribution, abundance, and dispersal of smallmouth bass and other nonnative fish species in the Colorado River and its tributaries downstream of Glen Canyon Dam. This information represents the best available science. These agencies, through the GCMRC, regularly publish reports and publications on the various resources being monitored, including the fish species. The GCMRC Wiki Site is publicly available for review of any of the past and ongoing work in the project areas. |

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| 23 | 5 | GEOSEDI - Geomorphology and Sediment | Conservation groups generally support modifying HFE protocols to time HFEs in late spring and early summer, which more closely reflects the timing of historical high flows resulting from snowmelt in the Rocky Mountains. BOR should refrain from HFE experiments pending modification of Glen Canyon Dam penstocks with fish exclusion devices and other measures to ensure against further entrainment of warmwater invasive fish, and to prevent "flushing" warmwater invasive fish already in the Colorado River farther downstream into designated critical habitat for humpback chub and razorback sucker. | Regular HFEs are necessary to maintain canyon sediment. Complaints and data indicate poor sediment conditions in recent years without HFEs. Data from Paul G. and Dave T. show that HFEs have effectively maintained or built sandbars.<br><br>Regarding fish exclusion devices, they are being studied but are not currently ready for installation or operation due to complexity. The sediment resource would deteriorate during the time needed to study, install, and operate such modifications.<br><br>Concerning the concern of flushing warmwater invasive fish downstream into critical habitat for humpback chub and razorback sucker, data from the HFE protocol era, and possibly earlier, including the 2008 environmental assessment, which included an HFE, suggest that such flushing did not occur. |
| 23 | 1 | ALTRANGE - Inadequate Range of Alternatives | Conservation groups support the "Cool Mix" and "Cool Mix Flow Spike" alternatives because, per USGS modeling, these are the only two alternatives that will inhibit smallmouth bass (SMB) reproduction and population growth within the mainstem of the Colorado River downstream of Glen Canyon Dam through 2027. DSEIS at Figure 1, Appendix A. However, as detailed below, neither of these alternatives alone provide sufficient measures for protecting the humpback chub and its critical habitat. | Thank you for your comment. Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. These additional projects aim to protect humpback chub and its critical habitat. |
| 23 | 7 | CONSBIO - Consultation biology/ESA related | Here, BOR and FWS must consider in the context of consultation the observed and predicted future climate change, regional aridification, Colorado River flow declines, declines in Lake Powell surface elevations, and resulting transport of warm water and warmwater invasive fish from Lake Powell into the Colorado River as degraded environmental baseline conditions that are degrading designated critical habitat for humpback chub and razorback sucker. | Thank you for your comments. Reclamation states in Section 3.2.1 of the Final SEIS that greenhouse gas emissions are expected to continue warming the Colorado River Basin. This warming (or aridification) is included in Reclamation's model, which was updated in 2021. Further, Reclamation acknowledges the climate change research performed by Bass et al. (2023) and Zhang et al. (2021) in the Final SEIS. Reclamation has incorporated and will continue to incorporate climate change science in the LTEMP SEIS and in their decision-making process. |
| 23 | 4 | AQUA - Aquatic Resources | Imminent and ongoing downstream expansion of warmwater invasive fish populations caused by BOR's operation of Glen Canyon Dam's penstocks is adversely modifying designated critical habitat and, with resultant predation, threatens to decimate humpback chub's last core source population at the Little Colorado River. FWS' determination of non-jeopardy in the 2016 LTEMP Bi-Op is predicated on assumptions that do not include dam operations causing the now ongoing, worsening, and uncontrolled invasion of warmwater invasive fish into the Colorado River upstream and within designated critical habitat for humpback chub and razorback sucker. | The population of humpback chub in the Little Colorado River and its inflow remains at about 10,000 adults. Warmer mainstem temperatures have allowed for expansion of the species in different areas of the Colorado River downstream of the Little Colorado River. The population of humpback chub in western Grand Canyon (Havasu Rapids to Pearce Ferry) is now estimated at over 100,000 adults, which is the largest concentration of this species in the entire Colorado River System. Warmer mainstem temperatures have also allowed for invasions and expansions of some nonnative fishes, specifically the green sunfish and smallmouth bass. As part of the annual fish monitoring by GCMRC, NPS, AZGFD, and the Service, the distribution and abundance of these species is being tracked on a regular basis. The flow alternatives evaluated in this SEIS are believed to be the most likely to negatively affect habitat, spawning, rearing, and recruitment of nest spawners, such as smallmouth bass and green sunfish, based on the best available scientific information. Reclamation intends to continue to monitor these species and evaluate and determine the best way to cause year-class failure in these species. |

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| 23 | 6 | ALTRANGE - Inadequate Range of Alternatives | The ongoing warmwater fish invasion now resulting from BOR's Glen Canyon Dam operations and BOR's failure since the 2016 LTEMP Bi-Op to implement conservation measures to prevent warmwater invasive fish from passing through the dam warrants BOR immediately advance modifications to Glen Canyon Dam that (1) prevent passage of warmwater fish from Lake Powell into the Colorado River in the first place, and (2) augment sedimentation and increase turbidity sufficient to reduce or inhibit predation of humpback chub by smallmouth bass and other warmwater invasive fish. Thus, in addition to the SEIS, BOR must immediately and concurrently initiate action to: *Modify the dam with fish exclusion devices to prevent entrainment of warmwater invasive fish; and *Modify the 12-mile slough to prevent warmwater invasive fish reproduction | Per the 2016 Biological Opinion, Reclamation has undertaken several investigations in pursuit of identifying a means to prevent passage of warmwater fish. This included a prize competition to evaluate fish passage, a fisheries study in the Glen Canyon Dam forebay with Utah State University to evaluate the vulnerability of entrainment of certain fish species, and a technical report in 2022 that explored exclusion options. These options are being narrowed down and considered for future implementation as part of the long-term strategy to address the warmwater nonnative fish issue. The 2016 Biological Opinion does not discuss sediment augmentation to increase turbidity to reduce or inhibit predation on humpback chub.<br><br>As mentioned in Section 1.4, Purpose of and Need for Action, Reclamation and its partners are pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. These additional projects include modification of the slough. Reclamation is working closely with NPS to evaluate the potential of slough modification in the coming year. |
| 24 | 3 | PN - Purpose and Need | First, UAMPS seeks clarification from BOR on the "Purpose of and Need for Action" in the LTEMP DSEIS. The LTEMP DSEIS states: "The need is to disrupt the establishment of the smallmouth bass below Glen Canyon Dam."1 This section uses the word "disrupt" rather than "prevent," which was the word used in the preliminary draft UAMPS received in January. It is unclear to UAMPS whether the additional flows are designed to disrupt an already present population or prevent the arrival of the population, and it would seem that the success criteria would change depending on which circumstance applies. UAMPS requests BOR provide more information on the objectives of the DSEIS with respect to smallmouth bass populations, and how they will know if those objectives are being met. | The purpose of and need for action outlined in the LTEMP SEIS is to disrupt the expansion of the nonnative warmwater invasive fish population, particularly smallmouth bass, below Glen Canyon Dam. Reclamation has designed these alternatives to analyze the impacts on the existing population of nonnative invasive fish directly below the dam.<br><br>The planning and implementation process will include monitoring and assessment strategies to gauge the success of these actions and to plan for future decisions regarding the smallmouth bass populations. |
| 24 | 4 | SCOPE - Scope of the Analysis | Second, UAMPS seeks clarification from BOR on the purpose and scope of the DSEIS. The stated purpose of the DSEIS is to "analyze additional flow options at Glen Canyon Dam in response to nonnative, invasive smallmouth bass and other warmwater nonnative species recently detected directly below the dam."2 But BOR also states that the scope and the assumptions behind the proposed alternatives "may vary depending on the specific resource being considered."3 Indeed, BOR states that it "would like the flexibility to implement temperature-based flow options to target smallmouth bass, depending on where they are found in the river."4 BOR relies on temperature changes at river mile 15 and river mile 61. UAMPS seeks clarification as to the exact scope of the DSEIS. Is it an area directly below the GCD or is it the entire area below the dam and up to and including river mile 61? Is it targeting smallmouth bass only, or all nonnative predatory fish? UAMPS believes that clarity and alignment on the purpose and the scope of the DSEIS will ensure that the objectives of the DSEIS are met. | The project area and the analysis area are two separate geographic ranges. The scope of the project aims to disrupt smallmouth spawning downstream of Glen Canyon Dam. For modeling purposes, river miles 15 and 61 were chosen due to the recent presence of smallmouth bass in those reaches. The analysis area covers the area of potential impacts from these alternatives. Therefore, the analysis area may differ, depending on the resource; for example, the cultural analysis will encompass a rim-to-rim area of potential effects (APE), while the socioeconomic and hydropower analyses will examine surrounding counties and communities. |
| 24 | 1 | LTEMPEIS - LTEMP EIS | The information contained in the LTEMP DEIS is insufficient for UAMPS to reach a preference for any of the alternatives presented. UAMPS is concerned about the increased rate pressure that will result from the LTEMP DEIS, especially considering it is proposed to be in place through operating year 2027 and does not appear to be a proven technique for reducing small mouth bass populations. Considering the increased power costs and increase in fossil fuel generation that will result from any of the Cool Mix Alternatives, it is unwise to proceed with a plan that lacks sufficient scientific support. | Reclamation has updated the Final SEIS to include additional analysis on impacts to hydropower resources, including the latest PLEXOS modeling data. See Sections 3.3 and 3.9 for more information.<br><br>The LTEMP SEIS does include smallmouth bass modeling that analyzes the effectiveness of each alternative's ability to disrupt smallmouth bass establishment. |

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| 24 | 5 | SCOPE - Scope of the Analysis | UAMPS disagrees with BOR's comment that "[e]ven with a compressed schedule, the information used in this analysis is sufficient,"5 especially given the relatively long implementation timeline - through operating year 2027. BOR should be required to substantiate the need for additional flows considering the adverse impact on UAMPS members from reduced power generation. The additional flows anticipated in the proposed alternatives would occur at a time when UAMPS members are actively seeking to develop new resources to meet load and replace retiring resources. To lose valuable hydropower for nearly four years when UAMPS members are facing upward rate pressure should require better supporting documentation from BOR supporting the need and effectiveness for the additional flows. Though BOR acknowledges that "[m]ore information may become available to evaluate particular resources as the NEPA process develops,"6 UAMPS believes that the real and negative effects that the LTEMP DSEIS will have on hydropower means that BOR should gather further data regarding our understanding of smallmouth bass populations before allowing an experimental solution. | Reclamation has updated the Final SEIS to include additional analysis on impacts to hydropower resources, including the latest PLEXOS modeling data. See Section 3.3 for more information.<br><br>In addition, planning and implementation language has been added to Chapter 1, which explains adaptive management strategies that will incorporate the best available science through the life of the LTEMP. |
| 24 | 9 | ALTRANGE - Inadequate Range of Alternatives | UAMPS finds that the discussion surrounding NPS' ability to treat slough habitat severely lacking especially in light of the fact that BOR states in the DSEIS that "[g]reater number of small mouth bass have been capture in the Lee's Ferry reach in 2022 and 2023 [...] [m]ost of the smallmouth bass in the Les's Ferry reach have been caught in and near the -12-mile slough."10UAMPS believes that treating the slough or otherwise addressing the large smallmouth bass population at the slough appear to be an efficient and targeted way of addressing smallmouth bass population growth in the Colorado River without reducing power generation. Much like the directed removal efforts, UAMPS believes that BOR should exhaust these targeted solutions first before addressing a broader and more damaging solution like additional flows from GCD. | Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. These additional projects include modification to the slough. However, the immediate threat posed by smallmouth bass requires action and cannot wait for more long-term projects. |
| 24 | 8 | ALTRANGE - Inadequate Range of Alternatives | UAMPS highly encourages BOR and the National Park Service ("NPS") to explore directed removal efforts that would accomplish the goals of DSEIS in a more efficient and targeted manner than adjusting flows at GCD. | Reclamation has been working with the NPS on short-term mechanical removal efforts. These efforts are not sustainable on a mid- or long-term timeline. Removal efforts are led by NPS and are intended to be used until longer term solutions are in place. |
| 24 | 11 | ENERGYPOW - Energy and Power | UAMPS requests a detailed analysis of how increased flows and the reduced hydropower that would result would affect reliability in the Western Interconnection. As an organization with members in seven western states, UAMPS is acutely aware of the lack of capacity generation in the West. Further reductions in output from GCD would be problematic to UAMPS members in fulfilling their obligations to provide essential electric service to their communities. | Reclamation has updated the Final SEIS to include additional analysis on impacts to electric customers, including the latest PLEXOS modeling data. See Section 3.3 for more information. |
| 24 | 6 | AQUA - Aquatic Resources | UAMPS requests that BOR provide the smallmouth bass data that they relied upon to inform the DSEIS. To be specific, UAMPS would like BOR to clarify what they meant when they state that "[s]pecific data on [smallmouth bass] have been collected but are not available or citable at this time."7 Related to that inquiry, UAMPS would also like to understand what BOR meant when it stated that "The smallmouth bass model does not link at this time to other population models, such as the humpback chub integrated model."8 It is because UAMPS takes seriously its obligations as a stakeholder along the Colorado River, UAMPS would like to better understand what data is not being cited to as part of this DSEIS. Further, and as it relates to the overall need and purpose of the DSEIS, it is necessary to understand how the smallmouth bass population impacts other native species like the humpback chub. Especially if BOR is proposing specific additional flows that would impact hydropower production, UAMPS feels it is important for UAMPS members and the public to understand what data is being examined, and also how this data will be utilized to determine whether or not any of these flows will have a meaningful impact. | The smallmouth bass model has been incorporated from the GCMRC report (GCMRC 2024). An explanation of values of lambda is now included in the document to explain that lambda > 1 means population growth and lambda < 1 means population decline. Further, explanation of lambda values for different alternatives and impacts to nonnative and native species is now included. The smallmouth bass model is a demographic model that transitions fish from one size class to another through estimates of survival and recruitment. A similar model has been developed for humpback chub, but the two models are not presently linked, as this will take a considerable amount of work and may be addressed for the post-2026 EIS. |

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| 24 | 7 | AQUA - Aquatic Resources | UAMPS seeks clarification on the results of direct removal efforts of smallmouth bass in general. As stated in the DSEIS, "[i]n September 2022 and August 2023, the [National Park Service] began to deploy the EPA-approved fish piscicide rotenone to kill [smallmouth bass]."9 BOR also states that this is a practice that can take place where smallmouth bass have been identified in the Colorado River, and UAMPS would like to know the results of these directed removal efforts. | Reclamation has been working with NPS on mechanical removal. The results of these removal efforts are not currently available. The -12-mile slough was treated with rotenone and ammonia, which have a short-term effect on green sunfish and smallmouth bass. Recent results of those efforts are available through presentation provided during the February 2024 AMWG meeting. |
| 24 | 10 | ALTASSUMP - General Assumptions Common to All Alternatives | UAMPS would like additional details on the effectiveness of the alternatives discussed in the DSEIS. In particular, BOR states that "[t]he effectiveness of [the Cool Mix with Flow Spike Alternative] at achieving temperature goals, given certain river outlet works availability, would be similar to those outlined in the Cool Mix Alternative."11 (BOR also states that these two would also have a similar effect as the Cold Shock with Flow Spike Alternative.) The net effect of these three alternatives with similar outcomes would be "cooling down to river mile 15 and the confluence of the Little Colorado River."12 BOR concluded that the other Cold Shock Alternative "may not be possible to reach desired target temperatures."13 In summation, the outcome of the one alternative that seems to be effective, is still effective at cooling down to river mile 15. Given these alternatives, UAMPS seeks to better understand how any of the discussed alternatives would cool the water sufficient to prevent smallmouth bass population growth beyond river mile 15 | Additional information from the latest GCMRC report (GCMRC 2024) has been added to the Final SEIS. This information includes clarification on the smallmouth bass lambda modeling. See Section 3.5 for additional information. |
| 25 | 21 | ALTASSUMP - General Assumptions Common to All Alternatives | 2-5: During development of the proposed accounting window changes to the HFE protocol, CREDA did not support scenarios or alternatives that include carrying over sediment from one year to the next year. It is unclear from the description of the third bullet whether this was intended in the General high flow implementation modeling details. On page 2-6 (final 4th paragraph of bullet), revise the description to be clear that actual borrowing month order is to be determined by Reclamation and WAPA. | This information is provided under the Hydropower modeling assumptions header and only pertains to modeling efforts. |
| 25 | 18 | ENERGYPOW - Energy and Power | 1-10: Revise Table 1-1s Energy and Hydropower component description when section 3.3 Energy and Power has been revised. | Table 1-1 has been updated per your comment. |
| 25 | 13 | PROPACTION - Proposed Action | 1-5: Consider including in reference that in 2015, green sunfish were present in the upper slough, hence one of the considerations in the decision being made to not implement an HFE in that year. That year distinguishes itself from other HFE years in that the presence of a non-native species and lack of control thereof was important enough to not implement an HFE. | The HFE of fall 2022 was not conducted when evidence of green sunfish and smallmouth bass reproduction was discovered at the -12-mile slough. An HFE could transport young of these species into habitat occupied by native fish, especially humpback chub, which could result in predation and competition. These types of evaluations and decisions about dam management will need to continue to be conducted under adaptive management, for which monitoring provides the best available scientific information for decision-making. |
| 25 | 14 | SCOPE - Scope of the Analysis | 1-7/1-8: Regarding the Scope: Please ensure that the analysis includes an evaluation of whether the alternatives are expected to prevent spawning and/or establishment in the whole of the project area, not just down to 15 mile or the LCR. Ensure that the risk assessment and impacts analysis undertaken in the DSEIS, and any decision-making process, include the contribution of 66,000 the western Grand Canyon humpback chub population (estimated at between and97,000), since this population was considered and factored into the recent trigger review of this species. | The alternatives are designed to incorporate adaptive management to target smallmouth bass at different river miles, depending on actual conditions established through monitoring. The alternatives have been designed to disrupt smallmouth bass establishment and modeled at different river miles to show two different potential implementation strategies. |
| 25 | 15 | COOPGEN - General Agency Cooperation | 1-7: To be consistent with other agency authorities and obligations, consider clarifying WAPAs description to the CRSP region of WAPAs marketing of cost-based hydropower from federal multiple purpose projects as opposed to the entire 15-state region comprising all WAPAs marketing areas. | Section 1.5 provides an introduction to the cooperating federal agencies. Additional details are provided in Section 3.3. |

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| 25 | 16 | SCOPE - Scope of the Analysis | 1-8: Given Reclamations recent 24-month study results and forecasts suggesting that DSEIS temperature triggers may not occur, if at all, until late summer or early fall, Reclamation should re-evaluate its Timing Considerations and project timeline, and reissue a public DSEIS following revision of section 3.3 as described above. Reissuance of a more complete DSEIS should result in a more complete disclosure and analysis of effects, including cumulative effects, as opposed to the information used in this analysis, which merely allows a limited comparison among the alternatives. | The risk of delaying implementation has not been deemed appropriate by Reclamation. Section 3.3 has been substantially updated based on public comments and provides an adequate analysis for impacts to hydropower resources. The public will be able to review the Final SEIS before the ROD is signed. |
| 25 | 17 | SCOPE - Scope of the Analysis | 1-9: Section 1.8 also should be revised to clearly state that any action taken under the SEIS to address SMB/non-native issues must be done in a manner consistent with the Colorado River Act Storage Project and other applicable provisions of federal law. The description of LTEMP releases in this section should be reviewed. Hourly, daily, and monthly are the appropriate descriptors given to LTEMP operational parameters. This section has added experimental timescales, which requires more explanation, and confusingly states in the last paragraph that LTEMP instead controls the timing of annual releases. | Section 1.8 was developed to clarify the relationship with ongoing Colorado River Operation NEPA processes (Interim Guidelines SEIS [IG SEIS] and post-2026 EIS). Section 1.8 includes language about being consistent with other laws. The section has been updated to provide some clarifying language. |
| 25 | 23 | ALTCOLDSHK - Alternatives - Cold Shock | 2-11: CREDA assumes the paragraph beginning In practice, flow implementation. applies to all bypass alternatives (and not just the Cool Mix Alternative described in section 2.6). Please confirm this assumption and consider including this paragraph within Implementation as opposed to in the description of only one of the bypass alternatives. If you do not confirm this assumption, please explain why the statement only applies to the Cold Mix Alternative. | Implementation language has been removed from Section 2.9 and restated in Section 2.3 for the Final SEIS. |
| 25 | 24 | ALTCOLDSHK - Alternatives - Cold Shock | 2-11: In describing the flow alternatives, the language stating, To align with actual implementation without necessitating multiple weeks of hydropower maximization (that is, the operation of the hydropower system to generate the maximum amount of electrical power) flies in the face of the LTEMP hydropower objective, as well as express statutory requirements. As the Basin States have noted, The U.S. District Court for the District of Arizona further clarified that the broadly worded provisions of the Colorado River Storage Project Act (CRSPA) and GCPA impose on the Secretary an obligation to balance many different interests in operating Glen Canyon Dam. The Secretary must continue to recognize that power production is a primary purpose of the Dam that must be balanced against other purposes, statutory requirements, and water delivery obligations as (s)he considers actions to implement the GCPA." | Implementation language has been removed from Section 2.9 and restated in Section 2.3 for the Final SEIS. |
| 25 | 25 | ALTBYPASS - Alternatives - Non-Bypass | 2-17: The Non-Bypass Alternative (as well as in Table 2-1) is described as including substantial river stage changes. Yet, the bypass flow alternatives also include release components that are extreme (or substantial). Consider replacing the description of the Non-Bypass Alternative with one provided by WAPA and the hydropower Cooperating Agencies. Please remove subjective descriptors, as they could reflect pre-decisional bias. | The Non-Bypass Alternative aims to solely use stage change to disrupt smallmouth bass spawning, which is why stage change is described in that section. The Flow Spike alternatives use high flows to cool river temperatures outside the main channel. Non-Bypass Alternative language has been updated accordingly. |
| 25 | 19 | ALTASSUMP - General Assumptions Common to All Alternatives | 2-2: Operational flexibility, as defined in LTEMP ROD page B-7, section 1.2 should be included as an Assumptions Common to All Action Alternatives: Reclamation also will make specific adjustments to daily and monthly release volumes, in consultation with other entities as appropriate, for a number of reasons, including operational, resource-related, and hydropower-related issues. Examples of these adjustments may include, but are not limited to, the following: For hydropower-related issues, adjustments may occur to address issues such as electrical grid reliability, actual or forecasted prices for purchased power, transmission outages, and experimental releases from other Colorado River Storage Project dams. In addition, specific reference to the Operating Criteria should be included. | The LTEMP ROD has been incorporated by reference. Additional implementation language has been added to Chapter 1. |
| 25 | 20 | ALTASSUMP - General Assumptions Common to All Alternatives | 2-4: The last bullet in the Assumptions Common to All Action Alternatives should be removed and replaced with a description of the GTMax, PLEXOS and other models utilized by WAPA. | The language was updated, and a reference for additional details in Section 3.3 was made. |

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| 25 | 22 | ALTASSUMP - General Assumptions Common to All Alternatives | 2-9: Hydropower Modeling Assumptions/GTMax should be rewritten by WAPA. The Power and Energy analysis included in the DSEIS does not appropriately disclose a full effects analysis required for either public comment or decision by the Secretary of the Interior. The GCMRC section should be removed from the DSEIS. Including competing models, competing tables and competing results for Power and Energy is a disservice to the public and the CRSP hydropower customers and prevents disclosure of clear information about each alternatives effects on Power and Energy. The Power and Energy analysis should be undertaken by WAPA with its protocols and models, consistent with previous Reclamation CRSP NEPA processes (Flaming Gorge, Aspinall, LTEMP). CREDAs participation and comments offered in the GCDAMP Annual Reporting, TWG, and most recently the DSEIS public webinars have underscored this request. The constrained optimization model as CREDA understands it, does not include capacity, rate, or Basin Fund analysis, which is inconsistent with the LTEMP, nor does it address electric grid impacts in any manner. Further, as CREDA understands the GCMRC model and results, it includes all 30 traces from the CRSS model, whether or not an experiment is triggered in a specific trace, and averages all those traces. This is an incorrect analysis and results in misinterpretation of the experiments effects. Instead, the analysis should analyze the traces IN WHICH AN EXPERIMENT OCCURS, and assess the effects of EACH EXPERIMENT, not an average of 30 traces, many of which do not include or trigger an experiment. CREDA has raised specific concerns in these recent meetings and is willing to make its hydropower subject matter expert members available to discuss further. | The Generation and Transmission Maximization (GTMax) modeling assumptions were drafted by WAPA. Reclamation included both the GTMax results and the GCMRC modeling results in the Final SEIS. Section 3.3 has been substantially updated with additional input from WAPA.<br><br>The 30 traces were used in the development of the IG SEIS and represent an actual range of potential hydrologies. This analysis is imperative to understand the likelihood of actually implementing these alternatives. Additional analysis has been included using data from months when experiments were triggered. |
| 25 | 33 | WILDLIFE - Wildlife | 3-129: CREDA appreciates the paragraph describing the vegetation model used and simplifications made regarding threatened and endangered bird analysis. Given the DSEIS is intended to supplement the LTEMP FEIS/ROD with relevant new information, please consider removing any impact analysis that is repetitive from the LTEMP documentation. | References to the content of the Final SEIS are provided in the threatened and endangered bird section to orient the reader. The section was reviewed for redundancies and edited as appropriate. |
| 25 | 34 | AIRCCGHG - Air Quality, Climate Change, Greenhouse Gases | 3-141: The paragraph referring to the SunZia Wind facility should be removed as it is inappropriate to single out one project and speculate as to its impact on the grid. It would be appropriate to merely state that the analysis utilized two scenarios in the emissions/air quality assessment. | The reference to the SunZia facility has been removed. It is not speculative to acknowledge that new renewable energy sources are planned in the basin in the foreseeable future, which makes it reasonable to include in this NEPA analysis. It is also not speculative to acknowledge that renewable energy resources have emissions that are lower than the grid average. |
| 25 | 27 | ENERGYPOW - Energy and Power | 3-16/3-17: The description of Affected Environment associated with WAPAs marketing area should be revised to reflect the CRSP region, not the entire WAPA territory. Reference to emergency assistance to California provided by WAPA in 2020 should be expanded to similar assistance in 2001, and 2022. Finally, the sentence describing authorization of power revenues should either remove reference to the Grand Canyon Protection Act (as it is not the only Act that refers to power revenues) or revise the text to state as authorized, as opposed to as dictated by. The GCPA does not mandate the use of CRSP power revenues for the GCDAMP | Section 3.3 has been substantially updated in the Final SEIS with WAPA's input. |
| 25 | 28 | ENERGYPOW - Energy and Power | 3-17 through 3-21: These sections should be revised by WAPA to address omissions such as reference to the June 6, 2018 Operating Criteria between WAPA and Reclamation; correct the description of reserves and regulation; include analysis of impacts to Renewable Energy Credits (RECs); remove reference to a subset of customers; and remove irrelevant reference to WAPA sales of electric power. | Section 3.3 has been substantially updated in the Final SEIS with WAPA's input. This includes analysis of renewable energy credits (RECs). |
| 25 | 35 | REC - Recreation | 3-188/3-189: The discussion on impacts on boating and camping for the bypass flow alternatives is confusing. It is described as the same as under No Action, because these alternatives allegedly operate flows within the current range of operations Refer to comment 11) above. | Language throughout the recreation analysis has been modified to clarify that instead of alternative flows operating within the current range of operations, total discharge volumes would be approximately the same as under the No Action Alternative. This would result in similar impacts to boating and camping under these alternatives. |

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| 25 | 36 | REC - Recreation | 3-191: Is the conclusion that the Non-Bypass Alternative would adversely affect whitewater boating opportunities in Grand Canyon National Park and the Hualapai River Runners based on the assumption that the 2,000 cfs flow occurs between 9 p.m. and 1 a.m. on Sunday evenings? Is whitewater boating occurring between those hours? The analysis and conclusions for the bypass alternatives seem incongruous with the analysis and conclusions for the non-bypass alternative. These paragraphs should be clarified, and the use of temporary and references to minimum flows of 2,000 cfs should be consistently described and applied. CREDA questions the cumulative effects statement that only the Non-Bypass Alternative would not result in a reduction of navigation concerns. | This conclusion is derived from impacts from low flows of 2,000 cfs extending beyond the 9 p.m. to 1 a.m. operation period because of the delay that it takes outflow water at Glen Canyon Dam to reach rapids and campsites up to hundreds of miles downstream. This nuance is noted in the Draft SEIS on page 3-188. The recreation analysis has been updated to clarify this in response to other comments as well. |
| 25 | 37 | SOC - Socioeconomics | 3-199: As discussed in a previous comment, the SEIS is intended to supplement information already existing in the LTEMP. Consider either a) removing the Nonuse Values subsection, as it is limited in its scope, or b) adding reference and description to Estimating Non-Use Values for Alternative Operations of the Glen Canyon Dam: An Inclusive Value Approach, Phase 3B Project Research and Findings as significant information directly relevant to LTEMP. Unlike previous non-use valuation studies (such as the 1987 Bishop study cited in the DSEIS) that were limited in their application to only a small subset of downstream resources, this study describes all resources considered in the LTEMP DEIS, including tribal communities. The study estimates the non-market, non-use values for an inclusive set of impacts that result from changing the operation (i.e., hydropower generation) of Glen Canyon Dam. To accomplish this, the research team developed an integrated, multi-stage protocol to identify the valued impacts and to estimate the balance of the negative and positive valuations of those impacts by a representative sample of the US public. The study found that the median household value for retaining the current pattern of GCD operations (i.e., hydropower generation) would be nearly $20 per year - amounting to approximately $2.5 billion per year over all US households. | Text in the Final SEIS was updated to reference, and use text from, the recommended study. |
| 25 | 38 | SOC - Socioeconomics | 3-209: See comment 23) above regarding Non-Bypass Alternative boating impacts. Comment 23: 3-188/3-189: The discussion on impacts on boating and camping for the bypass flow alternatives is confusing. It is described as the same as under No Action, because these alternatives allegedly operate flows within the current range of operations Refer to comment 11) above. | The discussion on pages 3-188 and 3-189 of the Draft SEIS has been revised for clarity in the Final SEIS. |
| 25 | 29 | ENERGYPOW - Energy and Power | 3-21: As described above, reference and use of the GCMRC models should be removed from the DSEIS. CREDA questions the GCMRCs model sufficiency for the effects analysis required in the DSEIS. CREDA understands the model has not been peer-reviewed or published, and therefore is not the best available science/tool available for power and energy assessment in the DSEIS, as described in comment 10) above. | The inclusion of the analysis undertaken by WAPA, as well as the information from the NREL and Argonne, is crucial for a comprehensive understanding of transmission reliability and the ability to weather impacts of reduced Grand Canyon Dam output. In response to your feedback, Section 3.3 of the Final SEIS was revised to include information from the WAPA analysis, along with the analyses from NREL and Argonne, to provide a more comprehensive analysis of transmission reliability. |

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| 25 | 39 | SOC - Socioeconomics | 3-210: CREDA disagrees with the statement that Additionally, individuals owning property in the region around Glen Canyon Dam are considerably more likely to support continuation of dam operations.. These people are more likely to receive the benefits of Glen Canyon Dam hydropower at their property. This statement is a mischaracterization of Jones et al. 2016, as well as technically incorrect (see comment 18) and should be removed. Comment 18: 3-24 through 3-35: This information should be withdrawn and revised by WAPA based on its GTMax, PLEXOS and other modeling results. As drafted, there are incorrect statements such as Overall, the effects described above may be most likely for power consumers in the surrounding counties and states; more severe impacts in the immediate areas around Glen Canyon Dam and less severe impacts farther away from the dam (p. 3-31). Those statements do not reflect the contractual and operational reality of CRSP firm electric service marketing and are misleading as to power and energy effects, as well as rate impacts to CRSP firm electric service customers. | The SEIS was revised to ensure that it reflects this broader perspective and acknowledges the support for hydropower from all CRSP customers. This will involve replacing language that specifically mentions property owners with more inclusive language that encompasses all CRSP customers, highlighting their support for hydropower based on the benefits it provides, such as reliable and low-cost electricity. |
| 25 | 40 | SOC - Socioeconomics | 3-219: The word end-use is incorrect and should be revised to wholesale. WAPA does not market directly to end-use customers. That obligation lies with WAPAs firm electric service customers (see first bullet, page 3 hereof). The word benefit should be revised to benefit- crediting in the last paragraph on this page. | Thank you for your comment. The SEIS, including the Environmental Justice section (Section 3.16), was developed in close coordination with WAPA as a cooperating agency. The language the commenter refers to was developed in coordination with WAPA. |
| 25 | 41 | SOC - Socioeconomics | 3-220: The paragraph describing tribal benefit crediting arrangements should be revised by WAPA. Specifically, references to the types of utilities who have entered into benefit crediting arrangements should be corrected, lower cost power should be removed, and the last sentence attempting to describe the history of benefit crediting should be removed as inflammatory, or rewritten based on the public record associated with WAPAs SLCA/IP post- 2004 resource pool public process. | Thank you for your comment. The SEIS, including the Environmental Justice section (Section 3.16), was developed in close coordination with WAPA as a cooperating agency. The language the commenter refers to was developed in coordination with WAPA. The term “lower cost power” was provided by WAPA. |
| 25 | 42 | SOC - Socioeconomics | 3-222: Remove the following sentence, as it is premature to include pending outcome of rate analysis: However, the cost of additional capacity required under the action alternatives to replace lost capacity at Glen Canyon Dam would have negligible impacts on electric bills paid by residential consumers. | Thank you for your comment. Because the bypass for smallmouth bass under the SEIS alternatives is treated as an experiment, WAPA would purchase replacement power on the market and customers would be kept whole, including Tribes. As a result, they would get their power as if no bypass had occurred, and there would be no impacts to customers or their electric bills. The SEIS has been revised to add clarification. |
| 25 | 30 | ENERGYPOW - Energy and Power | 3-24 through 3-35: This information should be withdrawn and revised by WAPA based on its GTMax, PLEXOS and other modeling results. As drafted, there are incorrect statements such as Overall, the effects described above may be most likely for power consumers in the surrounding counties and states; more severe impacts in the immediate areas around Glen Canyon Dam and less severe impacts farther away from the dam (p. 3-31). Those statements do not reflect the contractual and operational reality of CRSP firm electric service marketing and are misleading as to power and energy effects, as well as rate impacts to CRSP firm electric service customers. | Reclamation integrated WAPA’s findings as appropriate as we finalized the SEIS. Reclamation has included the PLEXOS modeling results in the Final SEIS to further analyze impacts to hydropower resources. WAPA’s proposed Section 3.3 on Energy and Power was carefully considered. |
| 25 | 31 | GEOSEDI - Geomorphology and Sediment | 3-37: Reference to the April 2023 event should be referred to as an action or flow or some other descriptor; it was by its terms not an HFE. | The Final SEIS has been updated per comment. |
| 25 | 26 | HYDROLOGY - Hydrology | 3-4: The third bullet under Assumptions is incorrect and should be modified or removed. See comment 13) above. | The Final SEIS has been updated per comment. |
| 25 | 32 | AQUA - Aquatic Resources | 3-48 through 3-54: The question of whether or not Glen Canyon Dam operations impact the abundance and diversity of aquatic insects in the Colorado River downstream of Glen Canyon Dam remains an open question, even after years of bug flow experiments. For purposes of this DSEIS, CREDA recommends removal of this information, or revise it to brief references or citations, as it is secondary to the specific resources and issues being analyzed. | The information on Macroinvertebrate Production Flows (“bug flows”) is being retained because it constitutes one of the actions taken since the 2016 LTEMP EIS, and the results help to inform the analysis of the effects of the alternatives of this SEIS. Some reviewers have requested an expansion of the information. Although the results were uncertain, we updated the Final SEIS to describe as best as possible the information from the best available scientific information (Kennedy et al. 2016; Metcalf et al. 2020; Miller et al. 2020). |

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| 25 | 43 | COOPGEN - General Agency Cooperation | 4-2: The third bullet should be replaced with a description of WAPA models and impact indicators provided by WAPA. | This section describes the agency involvement and is not an appropriate place to describe model descriptions. Model descriptions are provided in Chapters 2 and 3. |
| 25 | 44 | AQUA - Aquatic Resources | A-1: Shouldnt footnote a refer to all FIVE options? CREDA assumes that the Non-Bypass Alternative also includes the change to the sediment accounting window. Please confirm or revise the footnote accordingly. | Appendix A was removed, and now the GCMRC report has been incorporated by reference instead (GCMRC 2024). |
| 25 | 10 | SOC - Socioeconomics | Financial impacts to the Upper Colorado River Basin Fund (Basin Fund) and the programs it funds are not assessed or disclosed. Hydropower operations are not the cause of SMB incursion and should not be relied on to bear the costs of mitigation. In the event WAPA must purchase power to replace resources that are unavailable or lost due to bypass operations for non- reimbursable native fish control or HFEs, these costs are non- and should not be borne by WAPA or WAPAs hydropower customers. The Basin Fund is the primary funding source for Reclamations and WAPAs CRSP operations. In addition to funding operation and maintenance expenses of CRSP generation and transmission infrastructure, the Basin Fund repays the federal CRSP investment (with interest), provides irrigation assistance, provides funding to the Upper Basin States Memorandum of Agreement projects, and supports the Colorado River Salinity Control Program. In the event federal non-reimbursable funding is not provided for implementation of this SEIS, the Basin Fund may be insufficient to continuing funding the above listed programs, including the operation and maintenance of Glen Canyon Dam infrastructure, and the federal government may be unable to fulfill its contractual obligations to the Salt Lake City Area/Integrated Projects (SLCA/IP) firm electric service customers. Analysis of the Basin Fund impacts should be developed in cooperation with WAPA and must be included in the DSEIS. | Reclamation is committed to incorporating the best available science into the planning and implementation process to thoroughly assess impacts on hydropower resources. The Final SEIS has been updated to include additional data reflecting this commitment, including the PLEXOS modeling results. Please see Section 3.3 for more information. |
| 25 | 8 | ENERGYPOW - Energy and Power | Impacts to CRSP customers in their capacity as electric service providers who have an obligation to provide reliable electricity to retail customers must be added to the DSEISs effects analysis. These impacts are distinct from impacts to WAPA and the Upper Colorado River Basin Fund , although those impacts also potentially affect CRSP customers. Depending on the nature of the Alternative or elements thereof, whether the action is a management action or an experiment, resource adequacy and availability of replacement power and transmission could result in financial or economic impacts that must be disclosed and avoided or, if unavoidable, mitigated. The analysis should include the impact on those customers that count their CRSP generation toward meeting their resource adequacy requirements, as well as include their CRSP generation in their greenhouse gas and Renewable Energy Certificates (RECs) reporting. Reduced and/or bypassed generation at Glen Canyon Dam/CRSP has implications and impacts to both direct contracts of those resources, as well as exchange agreements that rely on the output of CRSP resources. | Because the alternatives in this SEIS are treated as experiments, WAPA would be responsible for the purchase of replacement power on the market, and customers would be kept whole. As a result, it is anticipated that customers would receive their power as if no bypass had occurred, and there would be no impacts to customers in 2024. This includes Tribes with benefit crediting agreements. Reclamation will work closely with WAPA and other stakeholders during the planning and implementation process to analyze and consider any future impacts to customers. The SEIS has been revised to add clarification. |
| 25 | 9 | SOC - Socioeconomics | Impacts to underserved and disadvantaged rural and tribal communities should be updated. Nearly half of Colorado River Storage Project (CRSP) power customers (including CREDA members) are electric service providers for areas that could be classified as disadvantaged communities. The DSEIS recognizes this fact in Sections 3.15 and 3.16, but the analysis should be expanded to include specific impacts to these environmental justice communities. | Impacts to environmental justice communities, to the extent that can be identified based on available information, is included in Section 3.16. Because the proposed actions would be considered experimental, no direct impacts to tribal power would be anticipated in 2024. Reclamation will analyze and consider impacts during the planning and implementation process in future years. See text added in Section 2.3.1, Planning and Implementation. |

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| 25 | 12 | AQUA - Aquatic Resources | Key information in the DSEIS about SMB begins at page 3-66. The fundamental premise behind the proposed action is smallmouth bass data and models. Unfortunately, as the DSEIS itself states: (s)pecific data on these fish have been collected but are not available or citable at this time. DSEIS at 3-68. Given the relationship and hypotheses related to smallmouth bass, humpback chub and temperature, it is imperative that the data and tools employed to analyze impacts and make decisions be linked and the results disclosed in the DSEIS. Public technical review of the preliminary model and its assumptions is necessary prior to issuance of a final SEIS. A detailed evaluation of model uncertainties, such as how available habitat changes under different alternatives, the influence of turbidity, prey resources, and the entrainment rate of smallmouth bass would help to characterize uncertainty of the model. DSEIS at 3-97 (emphasis added).These modeling efforts for the Colorado River ecosystem below Glen Canyon Dam are not completed; thus, they are not included in this evaluation. DSEIS at 3-135. CREDA understands that an independent science panel has been engaged by WAPA and Reclamation as part of the SEIS process. Has the panel been tasked with reviewing the preliminary model work by Eppehimer and Yackulic (DSEIS at 3-97 and Appendix A)? CREDA strongly supports that course and reiterates its request on the February 22, 2024 public webinar that information produced by the panel be made available to the public and be included in in this section (through and including p. 3-97) and reissued for public comment prior to the issuance of a Final EIS or ROD. | A comprehensive report "Modeling the Impacts of Glen Canyon Dam Operations on Colorado River Resources" has been completed (Yackulic et al. 2024) that provides all the information available for modeling of the various resources, including smallmouth bass. We used the chapter on smallmouth bass from that report (Eppehimer and Yackulic 2024) in this SEIS to help inform the most likely response by smallmouth bass to each of the alternatives. The indices of propagule pressure (entrainment of fish at the dam) and lambda (population growth) are used to help predict the most likely response for each alternative at river miles 15 and 61. The Final SEIS has been updated with this information. See Section 3.5 for additional information. |
| 25 | 6 | ENERGYPOW - Energy and Power | Notwithstanding significant electric grid, environmental, and drought-related changed conditions since the 2016 Record of Decision (ROD), and focusing in large part on Section 3.3 of the DSEIS, the DSEIS fails to adequately and fully analyze Power and Energy and the affected environment: The DSEIS focuses on economic value as an impact indicator, along with energy (GWh) impacts. Based on information and discussion presented at the January 23-24, 2024, GCDAMP Annual Reporting meeting, it is CREDAs understanding that the model used to develop this analysis has been neither peer-reviewed nor published. Further, the description of economic value is inconsistent with the LTEMP analysis that this DSEIS is supplementing. LTEMP and its Appendix K provide analysis that is measured in terms of changes in the value of regional power system capacity (the power system comprised of Westerns long-term firm (LTF) customers) and overall system-level electricity production costs (the entire Western Interconnection). The second analysis (presented in Section K.2) studied how system resources and operations under LTEMP alternatives affect the wholesale electricity rates paid by utility entities that receive federal preference power produced by Glen Canyon Dam. The third analysis (presented in Section K.3) studied the effects of alternatives on electricity rates paid by retail customers. Section 3.3 of the DSEIS should be revised to include analysis undertaken by WAPA, using its GTMax and other models, consistent with the analysis and impacts described in the LTEMP. | The Final SEIS has been updated to include additional analysis of hydropower resources, including the PLEXOS modeling results.<br><br>The GCMRC report (GCMRC 2024) was internally peer reviewed and was published after the Draft SEIS was published.<br><br>No impacts to customers are anticipated in 2024. Reclamation will work closely with WAPA and other stakeholders during the planning and implementation process to analyze and consider impacts to customers in future years. |
| 25 | 11 | SOC - Socioeconomics | Rate and contractual impacts are not assessed or disclosed. The DSEIS recognizes this omission, but also notes that a Cost Recovery Charge (CRC) cannot be implemented to cover non-reimbursable purchase power expenses. Since issuance of the LTEMP ROD, significant SLCA/IP rate design changes have been implemented, which, coupled with the potentially significant hydropower, financial and operational impacts posed by the Proposed Action, requires that SLCA/IP firm electric service rate and contract impacts be developed by WAPA and included in the DSEIS. | Thank you for your comment. Because the alternatives in this SEIS are treated as experiments, WAPA would be responsible for the purchase of replacement power on the market, and customers would be kept whole. As a result, Reclamation anticipates that customers would receive their power as if no bypass had occurred, and there would be no impacts to customers in 2024. This includes Tribes with benefit crediting agreements. Reclamation will work with WAPA and stakeholders to analyze and consider impacts during future years. The SEIS has been revised to add clarification. |

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| 25 | 45 | PI - Public and Stakeholder Involvement | The Basin Fund is the primary funding source for Reclamation and WAPAs CRSP operations. In addition to funding operation and maintenance expenses of CRSP generation and transmission infrastructure, the Basin Fund repays the federal CRSP investment (with interest), provides irrigation assistance, provides funding to the Upper Basin States Memorandum of Agreement projects, and supports the Colorado River Salinity Control Program. Federal non-reimbursable funding must be provided to implement and mitigate the costs and impacts of the SEIS.Section 1.4 of the LTEMP ROD establishes a decision-making/recommendation process associated with experiments undertaken under LTEMP. Given the potential direct and immediate impacts of actions being considered by this DSEIS to CRSP electric service customers, CREDA recommends that all LTEMP Cooperating Agencies be afforded the opportunity to participate in any decision-making/recommendation process associated with actions under this DSEIS. | The analysis of hydropower impacts is based on current authorities. Options that might require new authorities are beyond the scope of this NEPA analysis.<br><br>Reclamation will work closely with WAPA, other cooperating agencies, and stakeholders in the planning and implementation process to analyze and consider impacts to customers. |
| 25 | 3 | PN - Purpose and Need | The DSEIS acknowledges that Reclamation and the AMP are aware of non-flow mid-term actions which can and should be implemented in addition to flow-only actions. The Purpose and Need Statements focus on flow options is too narrow to achieve an objective to limit recruitment. Given the ongoing willingness of the National Park Service to consider -12 mile slough modifications and other non-native fish control actions in the near future, particularly since the slough is the more heavily populated area[], consider broadening the Purpose and Need Statement to address an objective to prevent and management establishment of the smallmouth bass, and to incorporate any requisite compliance for such actions into a redrafted Purpose and Need Statement and DSEIS. CREDAs March 10, 2023 comments noted that the Upper Basin State Technical Work Group representatives have stated that operational alternatives are not a panacea; fish exclusion should be an immediate priority. These statements appear to support a more comprehensive Purpose and Need Statement and Proposed Action, which would address a comprehensive adaptive approach to both the prevention of establishment and management of (established) populations of SMB. | Reclamation is actively working with the NPS on additional projects to address the issue of warmwater nonnative invasive fish species, including smallmouth bass. While the -12-mile slough is one particular area of concern, young-of-year smallmouth bass have been identified elsewhere in the river and require additional treatment, such as the proposed flow options, outside of a directed action at the slough. |
| 25 | 1 | SCOPE - Scope of the Analysis | THE DSEIS IS LEGALLY INADEQUATE TO ALLOW THE DECISION MAKER AND THE PUBLIC TO UNDERSTAND WHAT IS PROPOSED AND WHAT THE FULL ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTION AND ANALYZED ALTERNATIVES ARE EXPECTED TO BE. THE DSEIS SHOULD BE REVISED TO INCLUDE A HARD LOOK AT ALL NECESSARY INFORMATION AND ANALYSES AND REISSUED FOR PUBLIC COMMENT PRIOR TO ISSUANCE OF A FINAL SEIS, RECORD OF DECISION, OR IMPLEMENTATION OF ANY EXPERIMENTS. | The Final SEIS has been updated to incorporate public comments. Reclamation has incorporated the best available science into the impact analysis. The Final SEIS will be available for the public to review before the ROD is signed. |
| 25 | 7 | ENERGYPOW - Energy and Power | The impact of experiments on replacement power and transmission availability and grid reliability during the summer months of the experiment must be assessed in the DSEIS analysis. Significant changes in the Western Interconnection from both a resource mix and hydrologic condition have occurred since the LTEMP ROD was issued that require assessment in the SEIS. See the NERC Summer Reliability Assessment 2022 at pp.5-6: Drought conditions create heightened reliability risk for the summer. Drought exists or threatens wide areas of North America, resulting in unique challenges to area electricity supplies and potential impacts on demand: Energy output from hydro generators throughout most of the Western United States is being affected by widespread drought and below-normal snowpack. Dry hydrological conditions threaten the availability of hydroelectricity for transfers throughout the Western Interconnection. Some assessment areas, including WECCs California-Mexico (CA/MX) and Southwest Reserve Sharing Group (SRSG), depend on substantial electricity imports to meet demand on hot summer evenings and other times when variable energy resource (e.g., wind, solar) output is diminishing. In light of these challenging conditions, the DSEISs effects analysis must include analysis of the impacts on replacement power and transmission availability and grid reliability. | Reclamation has added the PLEXOS modeling for an analysis of impacts to the grid and replacement energy. The planning and implementation process will consider the impacts on dispatchable generation from Glen Canyon Dam when generators are bypassed, as well as the availability of replacement power. |

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| 25 | 2 | PN - Purpose and Need | The Purpose and Need Statement in the DSEIS has been revised from what was included in Reclamations 2023 Environmental Assessment,1 indicating what appears to be a change from a prevention standard to a disruption standard in the overall need for the Proposed Action. DSEIS at 1-6. However, the Proposed Action also is described as a measure needed to ensure the prevention of population establishment of smallmouth bass and other warmwater nonnative invasive fish species (SMB). DSEIS at 1-5. Is it Reclamations desire to prevent establishment of invasive species or to disrupt establishment? How is disrupt defined, and how would the experiments results be judged a success or a failure? | The purpose of and need for action outlined in the LTEMP SEIS is to disrupt the expansion of the nonnative warmwater invasive fish population, particularly smallmouth bass, below Glen Canyon Dam. Reclamation has designed these alternatives to analyze the impacts on the existing population of nonnative invasive fish directly below the dam.<br><br>The planning and implementation process will include monitoring and assessment strategies to gauge the success of these actions and to plan for future decisions regarding the smallmouth bass populations. |
| 25 | 4 | ALTRANGE - Inadequate Range of Alternatives | The range of alternatives included in the DSEIS is impermissibly narrow. As stated in Reclamations ,2 Notice of Intent Flow actions alone are insufficient to prevent the establishment of smallmouth bass below the Glen Canyon Dam. As rapidly as the system has been changing during the current extreme drought, the question of whether the SMB are already established (or not) below Glen Canyon Dam is secondary to the need to address the issue in a comprehensive manner, as outlined in the Strategic Plan (Plan). This Plan, as well as the most current available monitoring and independent science panel-informed information, should be considered as the best available science and should be incorporated into a broad range of alternatives most likely to address establishment and management of the invasive fish species addressed in the DSEIS. Proposed alternatives should not be limited to flow-only treatments, should include structural elements, and should be revised to include at a minimum all actions included in Table 1 of the Invasive Species Strategic Plan. | This is just one of many steps Reclamation is taking to reduce the threat of nonnative predatory invasive species. Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. However, many of these long-term projects are outside the scope of this LTEMP SEIS.<br><br>The Final SEIS has been updated with additional science and data that were unavailable for the Draft SEIS. Please refer to Chapter 1 for more information. |
| 25 | 5 | SCOPE - Scope of the Analysis | With respect to any experiment undertaken under this DSEIS, in order to fully inform the analysis of its direct, indirect, and cumulative effects, an experiment must include a description of the proposed experiment, the time or frequency of implementation of the experiment, and the triggers or other conditions that must exist prior to implementation of the experiment. Each experiment must also include a description of the hypotheses that will be tested by the experiment and benchmarks or other identifiable criteria that will allow the Secretary and interested parties to assess the experiments success or lack thereof, and when an experiment or action must be terminated because of unacceptable impacts (as specifically defined) to the threatened humpback chub, other legally protected resources, or the electrical grid. The experiments also fail to describe any monitoring included in an implementation plan or experimental design, which is necessary to implement adaptive management as a part of the LTEMP. See Adaptive Management The US Department of the Interior Technical Guide. The Description of Alternatives (Chapter 2) should be revised to include these elements. | Addition language regarding planning and implementation has been added to Chapter 1 of the Final SEIS. Further implementation guidelines will be included in the ROD. Cumulative impacts sections have also been updated with the best available information about past, present, and reasonably foreseeable projects in the area. |
| 28 | 3 | ENERGYPOW - Energy and Power | Currently the energy market is being strained and a further reduction of hydroelectric generation will add to constraint energy market with scarcity and higher prices. The DSEIS fails to reflect impacts in our market area and only examines the Palo Verde trading hub. | We appreciate your concern about potential impacts to WAPA customers outside the Palo Verde market. Reclamation has worked closely with WAPA during this SEIS process to analyze economic impacts within the region served by Glen Canyon Dam. We carefully considered your input as we finalized the document. |
| 28 | 4 | ENERGYPOW - Energy and Power | The DSEIS acknowledges that power generated through Glen Canyon Dam would need to be replaced and lays that responsibility onto WAPA for solutions. However, it does not address and considers the scarcity in energy generation faced by utilities. We express serious concerns regarding the draft SEIS 's failure to sufficiently analyze the impact that the flow options will have on hydropower production and the risk that reduced hydropower production may have on the ability for utilities to provide power to the Utah region during the summer. | The Final SEIS has been updated to include the PLEXOS model for additional analysis of replacement power. |

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| 28 | 2 | ALTRANGE - Inadequate Range of Alternatives | We acknowledge the importance of protected species and recognizes the risks associated with smallmouth bass (SMB) proliferation in the river reaches below Lees Ferry. Many years of good science and multi-millions of dollars have been invested in protecting endangered fish species and improving the habitat of the river. Although Reclamation has well intention in drafting the SEIS, it has been rushed and lacks a thorough and comprehensive examination of other alternatives other than use of the bypass tubes. Maintaining a higher elevation in Lake Powell should have been examined. | Management of Lake Powell elevations is outside the scope of this SEIS. Reclamation has acknowledged the immediate risk associated with smallmouth bass establishment. During this SEIS, Reclamation has worked closely with cooperating agencies and stakeholders to use the best available science and information to produce an adequate analysis of impacts. |
| 29 | 20 | ENERGYPOW - Energy and Power | [Page]1-10: Revise Table 1-1's "Energy and Hydropower" component description when Section 3.3 Energy and Power has been revised. | Table 1-1 has been updated per your comment. |
| 29 | 18 | AQUA - Aquatic Resources | [Page]1-6/1-7: Ensure that the risk assessment and impacts analysis undertaken in the DSEIS, and any decision-making process include the contribution of the western Grand Canyon humpback chub population (estimated at between 66,00018 and 97,000),19 since this population was considered and factored into the recent status review of this species.20 | The alternatives are designed to incorporate adaptive management to target smallmouth bass at different river miles, depending on actual conditions established through monitoring. The alternatives are designed to disrupt smallmouth bass establishment and modeled at different river miles to show two different potential implementation strategies. |
| 29 | 19 | PI - Public and Stakeholder Involvement | [Page]1-8: Given Reclamation's recent 24-Month Study results and forecasts arguing that DSEIS temperature triggers may not occur, if at all, until late summer or early fall, Reclamation should re-evaluate its Timing Considerations, project timeline, and reissue a public DSEIS following revision of Section 3.3. Reissuance of a more complete DSEIS should result in a more complete effects analysis, including cumulative effects, as opposed to "the information used in this analysis," which merely allows a limited "comparison among the alternatives." | The risk of delaying implementation has not been deemed appropriate by Reclamation. Section 3.3 has been substantially updated based on public comments and provides an adequate analysis for impacts to hydropower resources. The public will be able to review the Final SEIS before the ROD is signed. |
| 29 | 21 | ALTASSUMP - General Assumptions Common to All Alternatives | [Page]2-2: Operational flexibility, as defined in LTEMP ROD page B-7, Section 1.2 should be included as an Assumptions Common to All Action Alternatives: "Reclamation also will make specific adjustments to daily and monthly release volumes, in consultation with other entities as appropriate, for several reasons, including operational, resource-related, and hydropower-related issues. Examples of these adjustments may include, but are not limited to, the following: ... For hydropower-related issues, adjustments may occur to address issues such as electrical grid reliability, actual or forecasted prices for purchased power, transmission outages, and experimental releases from other Colorado River Storage Project dams." In addition, specific reference to the Operating Criteria should be included | The LTEMP ROD has been incorporated by reference. Additional implementation language has been added to Chapter 2. |
| 29 | 22 | ALTASSUMP - General Assumptions Common to All Alternatives | [Page]2-9: Hydropower Modeling Assumptions/GTMax should be rewritten by WAPA. The Power and Energy analysis included in the DSEIS does not appropriately disclose a full effects analysis required for either public comment or decision by the Secretary of the Interior. The GCMRC (Grand Canyon Monitoring and Research Center) section should be removed from the DSEIS. The Power and Energy analysis should be undertaken by WAPA with its protocols and models, consistent with previous Reclamation CRSP NEPA (National Environmental Policy Act) processes (Flaming Gorge, Aspinall, LTEMP). The "constrained optimization model" does not include capacity, rate, Basin Fund analysis, consistent with the LTEMP, nor does it address electric grid impacts in any manner. | The GTMax modeling assumptions were drafted by WAPA. Reclamation has included both the GTMax results and the GCMRC modeling results in the Final SEIS. Section 3.3 has been substantially updated with additional input from WAPA. |
| 29 | 25 | ENERGYPOW - Energy and Power | [Page]3-17 through 3-21: include analysis of impacts to Renewable Energy Credits (RECs) | The Final SEIS has been updated per comment. |

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| 29 | 27 | EJ - Environmental Justice | [Page]3-219: "end-use" is incorrect and should be revised to "wholesale". WAPA does not market directly to end-use customers. That obligation lies with WAPA's firm electric service customers. "benefit" should be revised to "benefit-crediting." | Thank you for your comment. Per coordination with WAPA, the sentence has been revised to say "customers" to correct the error and prevent confusion. Per guidance from WAPA, no change has been made to "benefit" in the referenced sentence. Benefit is the correct word in this paragraph. Of all the Tribes listed, there are a handful that operate their own utilities and do not have benefit-crediting contracts, so the more generic "benefit" is correct in that paragraph.<br><br>The SEIS, including the environmental justice section, has been developed and will continue to be developed in close coordination with WAPA as a cooperating agency. |
| 29 | 28 | EJ - Environmental Justice | [Page]3-220: The paragraph describing tribal benefit crediting arrangements should be revised by WAPA. Specifically, references to the types of utilities who have entered into benefit crediting arrangements should be corrected, "lower cost power" should be removed, and the last sentence attempting to describe the history of benefit crediting should be rewritten based on the public record associated with WAPA's SLCA/IP post-2004 resource pool public process.22 | Thank you for your comment. The SEIS, including the environmental justice section, has been developed in close coordination with WAPA as a cooperating agency. The language the commenter refers to was developed in coordination with WAPA. The term "lower cost power" was provided by WAPA. |
| 29 | 29 | EJ - Environmental Justice | [Page]3-222: Remove the following sentence, as it is premature to include pending outcome of rate analysis: "However, the cost of additional capacity required under the action alternatives to replace lost capacity at Glen Canyon Dam would have negligible impacts on electric bills paid by residential consumers. | Thank you for your comment. This text has been removed as a result of edits to the document. Because the bypass for smallmouth bass under the SEIS alternatives is treated as an experiment, WAPA would purchase replacement power on the market, and customers would be kept whole, including Tribes. As a result, they would get their power as if no bypass had occurred, and there would be no impacts to customers or their electric bills. The SEIS has been revised to add clarification. |
| 29 | 26 | ENERGYPOW - Energy and Power | [Page]3-24 through 3-35: This information should be withdrawn and revised by WAPA based on its GTMax and other modeling results. As drafted, there are incorrect statements such as "Overall, the effects described above may be most likely for power consumers in the surrounding counties and states; more severe impacts in the immediate areas around Glen Canyon Dam and less severe impacts farther away from the dam" (p. 3-31). Those statements do not reflect the contractual and operational reality of CRSP firm electric service marketing and are misleading as to power and energy effects, as well as rate impacts to CRSP firm electric service customers. | The Final SEIS has been updated to included additional analysis of hydropower resources, including the PLEXOS modeling results.<br><br>The GCMRC report (GCMRC 2024) was internally peer reviewed and published after the Draft SEIS was published.<br><br>No impacts to customers are anticipated in 2024. Reclamation will work closely with WAPA and other stakeholders during the planning and implementation process to analyze and consider impacts to customers in future years. |
| 29 | 9 | ENERGYPOW - Energy and Power | Additionally, SRP and other balancing authorities in the region, such as WAPA, are obligated to prevent emergencies and were not provided enough information in the DSEIS to evaluate the impacts of the experiment's implementation during emergency situations. The DSEIS identifies the option to utilize emergency provisions but does not define what constitutes an emergency, nor the procedure to enact those provisions. Examples of omitted relevant information include: clear definitions of what constitutes an emergency condition; a procedure for communication between GCD operators and power customers to notify dependent parties of an emergency; and the anticipated actions and timeline of a response from GCD operations. | Emergency operating criteria are defined in the LTEMP ROD and would be changed with this SEIS. This LTEMP SEIS would not impact the ability of the facility to respond to emergencies. |

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| 29 | 17 | AIRCCGHG - Air Quality, Climate Change, Greenhouse Gases | All proposed LTEMP scenarios will result in more extensive losses of carbon-free power and associated renewable energy credits (RECs) than the original analysis indicated for all entities, with varying degrees of severity. Based on current allocations of GCD hydropower, possible REC impacts to SRP alone range from a minimum annual loss of approximately 25,000 RECs in Scenario 2.8, to as high as approximately 150,000 RECs in Scenario 2.6. This means, under Scenario 2.6, SRP and its customers stand to lose upwards of 600,000 RECs throughout the flow period's duration. This is a substantial volume of RECs that SRP and its customers rely upon for achievement of corporate goals, meeting stakeholder commitments, and advancing decarbonization in the Southwest. Loss of these RECs will result in added costs for SRP and any customers who need to procure replacement RECs to meet aggressive sustainability targets and will reduce the effectiveness of GCD as a reliable decarbonization resource. | Thank you for your comment. Text has been added in Section 3.15.2 to note the potential that replacement power may result in the loss of RECs and may represent additional costs as a result. Reclamation will work with stakeholders during the planning and implementation process to analyze and consider impacts. |
| 29 | 8 | ENERGYPOW - Energy and Power | An absence of GCD generation would change the dynamics of regional power markets and may challenge the ability of SRP and others to procure adequate capacity for emergency system needs in advance or in real time. SRP's power generation resource needs are increasing at an unprecedented pace, driven by significant growth in its service territory and commitments to retiring coal generation facilities. The western power grid is expanding, as well, and lacks surplus capacity due to the same drivers: load growth, resource retirements and delays in replacement resources created by supply chain and other challenges. As a result, SRP will not be able to count on the market to provide replacement capacity. 12 | Reclamation has included PLEXOS modeling in the Final SEIS for an additional analysis of impacts to hydropower and the electric grid. Triggers, guardrails, and hydrology will be considered during the planning and implementation process. |
| 29 | 31 | ENERGYPOW - Energy and Power | Analysis of the Upper Colorado River Basin Fund must be completed by WAPA and included in the DSEIS. The Basin Fund is the primary funding source for Reclamation and WAPA's CRSP operations. It is used to fund operation and maintenance expenses, repays the federal CRSP investment (with interest), provides irrigation assistance, supports Colorado River Salinity Control, as well as fund the Memorandum of Agreement projects to the Upper Basin States. | Reclamation integrated WAPA's findings as appropriate as we finalized the SEIS. Reclamation has included the PLEXOS modeling results in the Final SEIS to further analyze impacts to hydropower resources. WAPA's proposed Section 3.3 on Energy and Power was carefully considered. |
| 29 | 15 | ENERGYPOW - Energy and Power | Assessment of such impacts resulting from implementing this experiment during the summer months is an essential part of the DSEIS analysis. From a financial perspective, impacts to the Upper Colorado River Basin Fund (Basin Fund) are not assessed or disclosed. In the event that WAPA must purchase power to replace hydropower generation lost due to the implementation of bypass operations for non-native fish control, these costs should not be borne by the Basin Fund or the hydropower customers. Additionally, the DSEIS does not address the potential financial impacts to the region. Basin Fund revenues are not a proxy for regional cost impacts. | Reclamation integrated WAPA's findings as appropriate as we finalized the SEIS. Reclamation has included the PLEXOS modeling results in the Final SEIS to further analyze impacts to the Basin Fund. WAPA's proposed Section 3.3 on Energy and Power was carefully considered. |
| 29 | 1 | PI - Public and Stakeholder Involvement | Furthermore, the DSEIS does not include all necessary information and analyses to allow the public a full and transparent view of the potential impacts of the proposed experimental flows on GCD hydropower operations and resultant costs and reliability impacts to SRP and many other federal preference power contractors in the West who rely on GCD hydropower as part of their overall portfolio. | The Final SEIS has been substantially updated to include additional inputs from WAPA. Please refer to Section 3.3 for additional information. |
| 29 | 5 | AQUA - Aquatic Resources | Given the hypotheses and relationship between SMB, humpback chub and temperature, it is imperative to link the tools employed to analyze impacts and make decisions and disclose the results in the DSEIS. Technical review of the preliminary model and its assumptions is necessary prior to issuance of a Final SEIS. "A detailed evaluation of model uncertainties, such as how available habitat changes under different alternatives, the influence of turbidity, prey resources, and the entrainment rate of smallmouth bass would help to characterize uncertainty of the model."8 "These modeling efforts for the Colorado River ecosystem below Glen Canyon Dam are not completed, thus, they are not included in this evaluation."9 | The smallmouth bass model was only recently developed. It will be refined as more and new data are collected from monitoring and research, which will help refine the model parameters. This refinement will continue into the post-2026 EIS. Also, the smallmouth bass model is not currently linked to other demographic models, such as the humpback chub model or a preliminary model for rainbow trout. Reclamation will continue to work with the USGS and other agencies to refine these analytical tools and ensure that monitoring is providing the best available scientific information. |

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| 29 | 2 | SCOPE - Scope of the Analysis | Given the proposed flows are experiments,5 metrics should be assigned to determine their effectiveness. To fully inform the analysis of their effects (direct, indirect, and cumulative), experiments must include a description of the proposal, its implementation time or frequency, and triggers or other conditions that must be met prior to implementation. They must also include a description of hypotheses that will be tested and benchmarks or other identifiable criteria that will allow the Secretary and interested parties to assess the experiments' success (or lack thereof), and when an experiment or action must be terminated because of specifically defined unacceptable impacts to the threatened humpback chub or other legally protected resources. The experiments also fail to describe any monitoring included in an implementation plan or experimental design, which is paramount to the LTEMP's principles of adaptive management. The Description of Alternatives (Chapter 2) should be revised to include these elements.6 | Reclamation designed the alternatives in this SEIS to incorporate adaptive management practices to allow for flexibility in implementation, depending on current conditions. Additional planning and implementation language has been added to Chapter 1. |
| 29 | 16 | ENERGYPOW - Energy and Power | Impacts to SRP and other CRSP firm electric service customers, in their capacity as electric service providers obligated to provide reliable electricity to retail customers, must be added to the DSEIS's effects analysis. These impacts are distinct from impacts to WAPA and the Basin Fund. | No impacts to customers are anticipated in 2024. Reclamation will work closely with WAPA and other hydropower stakeholders during the planning and implementation process to analyze and consider impacts to customers in future years. |
| 29 | 30 | ENERGYPOW - Energy and Power | Rate impacts are not assessed or disclosed. The DSEIS recognizes this omission,23 but also notes that "a Cost Recovery Charge (CRC) cannot be implemented to cover non-reimbursable purchase power expenses."24 WAPA has implemented significant rate design changes since the original implementation of LTEMP. Pair this with significant hydropower resource and financial impacts posed by the DSEIS, rate impacts should be developed by WAPA and must be included in the DSEIS. | Reclamation has updated the Final SEIS to include additional analysis on impacts to electric customers, including the latest PLEXOS modeling data. See Section 3.3 for more information. |
| 29 | 10 | ENERGYPOW - Energy and Power | Regarding impacts to hydropower, the DSEIS should include provisions to establish a process to prevent emergency provisions before they are necessary.14 The process should define conditions of unacceptable risk and a communication procedure between operators, schedulers and off-takers before bypass operations commence, and again after the summer to re-evaluate. At a minimum, Reclamation should work with WAPA and its contractors to develop a protocol for planning and coordinating bypass experiments that includes assessment of expected power supply availability, pricing, and demand expectations for the period the specific bypass event is being considered. This should include an assessment of grid conditions and an appropriate period of time in advance of a specific bypass operation. Summer is an especially dynamic time for grid conditions, which necessitates a continuous and periodic assessment of grid conditions prior to the start of a planned bypass. Inclusion of a daily assessment during a bypass event to evaluate grid conditions for the following day's planned bypass should be identified as part of the protocol to avoid creating emergency situations. Any protocol for these experiments must ensure grid reliability as a key component. | Reclamation has added the PLEXOS modeling results to the Final SEIS for an analysis of impacts to the grid and replacement energy. The planning and implementation process will consider the impacts on dispatchable generation from Glen Canyon Dam when generators are bypassed, as well as the availability of replacement power. The environmental implications, including potential increased carbon emissions from alternative power sources, were considered in the development of the Final SEIS. |
| 29 | 24 | ENERGYPOW - Energy and Power | Section 3.3 of the DSEIS should be revised to include analysis undertaken by WAPA, using its GTMax model, consistent with the analysis and impacts described in the LTEMP. The impact on replacement power availability and grid reliability during the summer months of the experiment must be assessed in the DSEIS analysis. | Section 3.3 of the Final SEIS has been substantially updated with input from WAPA. Reclamation has added the PLEXOS modeling for an analysis of impacts to the grid and replacement energy. The planning and implementation process will consider the impacts on dispatchable generation from Glen Canyon Dam when generators are bypassed, as well as the availability of replacement power. |

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| 29 | 14 | ENERGYPOW - Energy and Power | The DSEIS description of hydropower's "economic value" is inconsistent with the LTEMP and its Appendix K, which states the economic value is "measured in terms of changes in the value of regional power system capacity (the power system comprised of Western's long-term firm electric service customers) and overall system-level electricity production costs (the entire Western Interconnection)." The second analysis (presented in Section K.2) studied how system resources and operations under LTEMP alternatives affect the wholesale electricity rates paid by utility entities that receive federal preference power produced by GCD. The third analysis (presented in Section K.3) studied the effects of alternatives on electricity rates paid by retail customers. 17 For this reason, the DSEIS should be revised to include analysis undertaken by WAPA, using its GTMax model, consistent with the analysis and impacts described in the LTEMP. The DSEIS's effects analysis must include thorough assessment of the impacts to replacement power availability and grid reliability. | Section 3.3 of the Final SEIS has been substantially updated with input from WAPA. Reclamation has added the PLEXOS modeling for an additional analysis of impacts to economic value. |
| 29 | 13 | ENERGYPOW - Energy and Power | The DSEIS fails to include scarcity pricing related to regional capacity shortages resulting in an under-representation of the replacement cost of power. | Reclamation has added to the Final SEIS the PLEXOS modeling for an analysis of impacts to the grid and replacement energy. The planning and implementation process will consider the impacts on dispatchable generation from Glen Canyon Dam when generators are bypassed, as well as the availability of replacement power. |
| 29 | 11 | ENERGYPOW - Energy and Power | The DSEIS is disappointingly lacking in the analysis of potential impacts to grid reliability. It also does not provide adequate information for SRP to perform an in-house analysis. Relevant data not provided include expectations of hydropower generation for each alternative in units of power (e.g., MW on an hourly basis), impacts to CRSP firm electric service customer allocations, and the probability of alternate operations occurring in given hours, weeks, or months. The DSEIS does not include impacts to the compounded loss of capacity SRP will experience due to the exchange agreement, nor the potential impacts to transmission stability as a result of reducing GCD output to a minimum during high-demand time periods. As a result of a lack of available surplus capacity for the reasons listed above, SRP and other utilities that rely on GCD in their portfolio will not be able to count on the market to provide the capacity that is needed. The "hydro resource availability will have impacts on wholesale markets, and critical conditions could reduce these utilities' opportunities for short-term transactions that may be needed in real-time operations to maintain reliability."15 | The SEIS evaluates the potential impacts of flow options on hydropower production and recognizes the importance of ensuring a reliable and affordable power supply to the region. We took into consideration your concerns regarding the potential impacts on the energy market in your area. Your input was valuable as we refined our analysis. |
| 29 | 23 | ALTASSUMP - General Assumptions Common to All Alternatives | The GCMRC model and results include all 30 traces from the CRSS model, whether an experiment is triggered in a specific trace and averages them. This analysis results in misinterpretation of the experiment's effects. Instead, the analysis should analyze the traces in which an experiment occurs and assess its effects, not an average of 30 traces, many of which do not include or trigger an experiment. | The 30 traces were used in the development of the Interim Guidelines SEIS and represent an actual range of potential hydrologies. This analysis is imperative to understand the likelihood of actually implementing these alternatives. Additional analysis has been included using data from months when experiments were triggered. |
| 29 | 6 | ENERGYPOW - Energy and Power | The LTEMP notes that a tiered and adaptive approach identifies safeguards for adjusting or terminating condition-dependent flow and non-flow treatments if they prove ineffective or result in unacceptable adverse impacts on other resources-- "hydropower and energy" being an explicit resource area therein. Associated tiers, trigger, and off-ramps "balance the need to use the most effective methods necessary, while avoiding deleterious methods unless necessary, by demonstrating lower tiers being ineffective."10 Whether a determination of SMB management effectiveness is possible absent applying bona fide metrics to these "boutique flows," and given that any assigned success metric may not be discernable given fish are currently being entrained through GCD, SRP's concerns relating to the hydropower resource and what in its opinion constitutes "unacceptable adverse impacts" are laid out below. | Thank you for your comment. Reclamation will work with cooperators and stakeholders on adaptive management strategies throughout the life of the project to define success and impacts using updated data and monitoring efforts. |

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| 29 | 3 | AQUA - Aquatic Resources | Under these experimental releases, flow changes and decreased temperatures may make some habitats less favorable for spawning. However, fish by nature will seek other habitats to spawn; as temperatures become disadvantageous, SMB will move, as would any species, to find suitable habitats. There are many backwater/off-channel areas other than the -12 River Mile (RM) slough that would provide spawning opportunities. These flows may push smallmouth (and other non-native warm water species) farther downstream into warmer, more suitable habitat--closer to the species they were crafted to protect. Further, proposed flow fluctuations intended to disrupt guarding behaviors of male SMB will likely have no effect on nest success (i.e., on survival of eggs/larvae). Conditions arising from the duration of low-flow components contemplated in this proposal would be temporary and given the territorial nature of SMB, they will likely return; the absence of a nest guarding male SMB also does not guarantee a decrease in nest success. Again, there is no metric to determine this. | The GCDAMP will continue to monitor fish populations from Glen Canyon Dam to the Lake Mead inflow and will use this information in an adaptive management framework to inform adjustments or revisions to the selected alternative to control smallmouth bass. |
| 29 | 4 | ALTRANGE - Inadequate Range of Alternatives | While some of the below actions have been affirmed in other compliance analyses and enacted in other cases, the DSEIS fails to address viable means to programmatically consider SMB presence (i.e., taking a "tier-based approach" to first implement lower-impact actions) like the processes cited above, to include: * Mechanical removal (electroshocking and an SMB incentivized harvest program, like for brown trout) * Continued targeted rotenone treatments * Preventing the risk of continued entrainment (a barrier net or thermal curtain)7 * Steps to address SMB and other non-native fish spawning and habitat in the -12 RM slough. | Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. These efforts are out of scope for this NEPA effort. |
| 29 | 12 | ENERGYPOW - Energy and Power | While SRP has taken steps to plan for uncertainty in future years based on hydrologic conditions, SRP does not have near-term solutions to replace GCD's capacity for year-over-year near-term proposed policies. If GCD is not generating the anticipated amounts of power during peak summer months at critical hours in a region that is already without surplus capacity, SRP does not anticipate replacement power to be available for purchase during those times. | Thank you for your comment. Because the alternatives in this SEIS are treated as experiments, WAPA would be responsible for the purchase of replacement power on the market, and customers would be kept whole, including Tribes. As a result, Reclamation anticipates customers would receive their power as if no bypass had occurred, and there would be no impacts to customers in 2024. This includes Tribes with benefit crediting agreements. Reclamation will work closely with WAPA and hydropower stakeholders to analyze and consider impacts during the planning and implementation process in future years. The SEIS has been revised to add clarification. |
| 29 | 7 | ENERGYPOW - Energy and Power | While the DSEIS implies that a power emergency may allow for full availability of GCD generation, it is not certain SRP would be able to recover the dependent exchange agreement capacity. Stated plainly, the potential compounded loss of capacity from GCD and dependent exchange power unacceptably increases regional risk to resource availability, the ability to serve electrical load, and the potential for rolling blackouts if remaining regional capacity is insufficient.11 | Thank you for your comment. Because the alternatives in this SEIS are treated as experiments, WAPA would be responsible for the purchase of replacement power on the market, and customers would be kept whole, including Tribes. As a result, Reclamation anticipates customers would receive their power as if no bypass had occurred, and there would be no impacts to customers in 2024. This includes Tribes with benefit crediting agreements. Reclamation will work closely with WAPA and hydropower stakeholders to analyze and consider impacts during the planning and implementation process in future years. The SEIS has been revised to add clarification. |

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| 30 | 5 | COOPGEN - General Agency Cooperation | As passionate stewards of the Grand Canyon, we are the only contracted companies authorized to share this national resource with the general public. Not only do we have very specific contracts which govern our access and operations, but per the Concessions Act, they allow each business the opportunity for a reasonable rate of return on their investment made. These recreational businesses and guest experiences must also be considered in all management decisions as required in the Grand Canyon Protection Act. Large changes to the LTEMP could potentially have unintended consequences causing material changes to the outfitters long-term contracts in place with the National Park Service and Department of Interior. They could also dramatically alter the structure of the Colorado River Management Plan. We urge the Bureau to continuously consult with the National Park Service (GCNRA, GRCA, and LAKE) and the concessioners to ensure this does not happen. | Reclamation will continue to consult with cooperators and stakeholders through the lifetime of the LTEMP project. |
| 30 | 2 | REC - Recreation | By the same token, we caution that especially under low water and sediment depleted conditions, multiple flow spikes may further erode the sediment resource that is key to the health of the Colorado River ecosystem, as well as an absolute necessity for the river recreation industry in Grand Canyon. Therefore, in sediment depleted conditions we urge that flow spikes be as low, short, and few as possible. | Reclamation considered impacts to sediment and beach building while developing the Final SEIS and selecting a preferred alternative. |
| 30 | 3 | SCOPE - Scope of the Analysis | We also urge that regular monitoring of resource conditions, especially after each proposed flow action component concludes, must be conducted in order to provide the data necessary to ensure that the purpose and need of the EIS is being met, as well as the resource goals of the Long Term Experimental and Management Plan, and the mandates of the Grand Canyon Protection Act. The Adaptive Management approach is best, and the decision-making matrix and implementation plan must be based on current science to ensure that proposed actions are actually benefitting resources, while minimizing any adverse effects to the extent possible. | Reclamation is committed to continuing ongoing monitoring strategies along the Colorado River. This will be imperative for an adaptive management approach, which was identified as a key factor for this LTEMP SEIS. |
| 30 | 4 | PI - Public and Stakeholder Involvement | We also urge the Bureau to reconsider the membership makeup of the HFE decision-making Planning and Implementation (PI) Team. The PI team should be broadened to include other stakeholders, including representatives of the recreation industry and tribal nations that have previously been excluded from this process. | Thank you for your comment. Reclamation has considered it in the final SEIS. |
| 30 | 1 | REC - Recreation | While the Draft SEIS does not specifically designate an agency preferred alternative, we definitely have an opinion on what not to do! The Non-Bypass Alternative has so many fundamental flaws, including potential of flows as low as 2000 cfs, that we strongly oppose this alternative in its entirety. We recognize the complexity of all the proposed alternatives, but in general we oppose any alternative that would limit river flows below 8000 cfs at any time during the commercial rafting season. Any cuts to flows resulting in less than 8000 cfs must be considered only under the most extreme emergency conditions. They should be minimal, temporary, and should require a sufficient advanced notification in order for outfitters to prepare accordingly! Our river trips in mid to late September 2023 were greatly affected when the BOR made radial cuts in flows well below 8000 cfs without sufficient notification. Safety of all stakeholders on the river at all times should be top priority in any action the Bureau takes. | Thank you for your comment. Reclamation has considered it in the Final SEIS. Reclamation identified a preferred alternative in the Final SEIS. |
| 31 | 3 | COOPGEN - General Agency Cooperation | As non-consumptive users, our rights will not interfere with any of the other users of Colorado River water. For 60 years Lake Powell has stood as the guardian and fulfilled its role as a management tool for adequate Basin State water allocation. It is now time to rethink those original policies and include other stakeholders in future policy considerations. We feel that recreationists have a right to access and use stored water. As a natural resource, water is to be used for the benefit of all of us. It is in the public interest to allow recreational use of our natural resources that leads to no adverse effect or depletion of those assets. | Changes to water rights are outside the scope of this SEIS. Impacts to recreational resources were analyzed in the Final SEIS. |

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| 31 | 4 | SOC - Socioeconomics | BOR should analyze the full impact of recreation opportunities with releases and experimental flows. In 2023 Glen Canyon NRA had an all time high visitation record of 5.2 million. Economic impact reports from NPS released last year showed that Glen Canyon had lost over $200 million in economic benefit to the region surrounding the lake during the two years of low water levels. When developing future plans potential economic loss needs to be considered. This is why the timing of releases is so crucial as it could cost GCNRA millions of dollars in economic benefit. In 2022 GCNRA economic output was $372,677,000.1 That is more than $7 million per week. The Bureau of Reclamation needs to consider the full impact of water levels and releases on the economy when selecting an alternative and making a decision. Releases that cause lake levels to drop for an extra week or two cost local communities millions of dollars. Its economic multiplier is 10, giving rise to over $4 billion in direct economic value to its surrounding and regional areas. The low water years at Lake Powell were nothing short of a wipeout that cost their local economies over $300 million in two years. We now know that the low-water levels cost the area surrounding Lake Powell hundreds of millions of dollars in direct economic benefit. In 2022, Glen Canyon NRA showed a $207 million dollar decline. Those numbers are big enough they should be factored into this decision. In 2019 both GCNRA and Lake Mead generated more economic output confirming that higher water levels support economies. According to the Bureau of Economic Analysis, outdoor recreation boosted the economy by $1.08 trillion in 2022.2 "Boating/fishing was the second-largest conventional activity for the nation at $32.4 billion" | Thank you for your comment. Impacts to recreation in Lake Powell (and related economic contributions) are anticipated to be negligible, as elevation reductions are not anticipated to result in changes that would go below the critical thresholds at which impacts to recreation would occur. In addition, as discussed in Section 3.2, Hydrology, changes to reservoir levels would be temporary in nature and would be negligible, compared with elevation changes as a result of non-project activities. |
| 31 | 5 | ATTN - Attention | BRC would like to be considered an interested public for this project. Information can be sent to the following address and email address: Ben Burr BlueRibbon Coalition P.O. Box 5449 Pocatello, ID 83202 brmedia@sharetrails.org | Blue Ribbon Coalition has been added to the LTEMP SEIS mailing list. |
| 31 | 1 | REC - Recreation | The negative impacts of lost recreation access disproportionately impact Navajo Nation tribal communities on the southern border of the GCNRA, as well as Page, Arizona. | Thank for you your comment. The potential for impacts to environmental justice communities from changes in recreation access is noted in Section 3.16.2. |
| 31 | 2 | HYDROLOGY - Hydrology | We also believe that BOR should time releases based on whether lake levels in Lake Powell currently provide access to important amenities on the lake. For example, BOR should delay experimental releases, if doing so would impact access to the Castle Rock Cut. The timing of releases should be taking recreation into consideration. BOR should also not be implementing releases if nests and smallmouth bass are not detected beneath Glen Canyon Dam. | Reclamation will consider lake elevations during the planning and implementation process. |
| 33 | 3 | SOC - Socioeconomics | Moreover, the DSEIS should include a complete analysis of the proposed actions' impact on hydropower and CRSP. This would include, at a minimum, consideration of components included in the LTEMP FEIS in 2016. Such components included impacts to the Basin Fund and CRSP operations, changes to marketable capacity, availability of replacement power, effects on regional energy prices, effects on WAPA wholesale prices, and effects on retail rates for the millions of CRSP retail customers. | Reclamation is committed to incorporating the best available science into the planning and implementation process to thoroughly assess impacts on hydropower resources. The Final SEIS has been updated to include additional data reflecting this commitment. These updates include PLEXOS modeling results and input from WAPA. |
| 33 | 4 | ENERGYPOW - Energy and Power | Reclamation must work with WAPA to ensure that all foreseeable impacts on hydropower are included within any final SEIS. This will allow for decision makers to weigh complete and accurate information. It will also allow for full consideration of the impacts on CRSP and the millions of CRSP retail customers who will bear the costs associated with the proposed actions within the DSEIS. | The SEIS evaluates the potential impacts of flow options on hydropower production and recognizes the importance of ensuring a reliable and affordable power supply to the region. We took into consideration your concerns regarding the potential impacts on the energy market in your area. Reclamation worked closely with WAPA on the development of the Final SEIS. |

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| 33 | 1 | ENERGYPOW - Energy and Power | The DSEIS attempts to address the economic impacts to hydropower if flow options are implemented. However, this analysis fails to provide accurate and complete economic impacts caused by the power generation reductions. Such gross inadequacies prevent a decision maker and the public from being able to make a fully informed decision regarding the proposed actions. Reclamation should work closely with WAPA to amend the energy and power section (Section 3.3) of the DSEIS, so that complete and accurate information can be weighed prior to issuing a final SEIS. | The Final SEIS has been updated to included additional analysis of hydropower resources, including the PLEXOS modeling results.<br><br>The GCMRC report (GCMRC 2024) was internally peer reviewed and published after the Draft SEIS was published.<br><br>No impacts to customers are anticipated in 2024. Reclamation will work closely with WAPA and other stakeholders during the planning and implementation process to analyze and consider impacts to customers in future years. |
| 33 | 2 | ENERGYPOW - Energy and Power | The methodology implemented in the DSEIS misapplies the use of averages by including when experimental low options would not be triggered. This flawed methodology drastically minimizes the actual impacts which the experimental low options would have on hydropower. | Additional analysis has been included in the Final SEIS to focus on impacts to resources during months when experiments are implemented. |
| 34 | 6 | AQUA - Aquatic Resources | Additionally, as two decades of observation of SMB in the Upper Colorado River basin demonstrate, turbidity does not deter SMB and therefore reliance on turbidity but not colder dam releases is likely to prove disastrous for native fish downstream, and threatened Humpback Chub in particular. | Thank you for your comment. We considered these points while developing the Final SEIS. |
| 34 | 1 | ALTRANGE - Inadequate Range of Alternatives | An experimental and adaptive approach is necessary given the urgency and scientific uncertainty around effective control of SMB, Green Sunfish, and other non-native piscivores in this system, and because multiple flow configurations, other non-flow options, and altered timing of implementation may be needed. Integration of monitoring information, and feedback that improves management are crucial to long-term success of this effort, and hopefully will help satisfy the BORs Section 10 responsibilities to species listed under the Endangered Species Act. | Reclamation is dedicated to incorporating adaptive management practices into the LTEMP SEIS and the planning and implementation process moving forward. This includes the continuation of fish monitoring strategies. |
| 34 | 14 | ALTRANGE - Inadequate Range of Alternatives | Another option we recommended was propagation and release of a large number of mature, predatory, endangered Colorado River pikeminnow. This option would require low cost at a medium-to-long-term timeframe, with medium levels of compliance and low implementation cost. In addition to applying additional pressure to non-native fish, this option would help achieve an essential goal of the AMP and GCPA, namely returning a top aquatic predator to the Colorado River ecosystem. Like all Alternatives and non-flow Options, such an action would require continued monitoring, likely in perpetuity. | Thank you for your comment. Propagation and release of Colorado River pikeminnow is outside the scope of this SEIS. |
| 34 | 7 | ALTRANGE - Inadequate Range of Alternatives | GCWC strongly supports integrating all 4 with bypass flow alternatives as experiments into an Adaptive Management Alternative in an experimental framework, consistent with the LTEMP, the GCPA, and the AMP, that includes specific hypotheses to be tested, data collection through appropriate monitoring, comprehensive analysis of results, and flexibility to facilitate adaptive design of subsequent flow experiments: starting initially with the Cool Mix with a single Flow Spikedesigned as an appropriately timed Spring HFE (assessed in the context of the proposed changes to the HFE protocols in this Draft SEIS, and with flexibility for repetition as fits the availability of sediment and water in the system). The monitoring and analysis associated with this Alternative should also include information around interactions with nonflow and other actions intended to prevent establishment and expansion of SMB and other non-native piscivorous species, including synergistic or conflicting effects of actions and their timing. We are concerned that multiple Spike Flows conducted outside of the HFE protocols and HFE implementation planning/assessment have the potential to increase the risk of reducing sediment mass balance and water availability for triggering spring HFE implementation and/or reduce sandbar gains from a prior HFE. | Thank you for your comment. Reclamation considered this when developing the Final SEIS and selecting a preferred alternative.<br><br>The planning and implementation process will consider and analyze any potential impacts from flow spikes. |

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| 34 | 8 | SCOPE - Scope of the Analysis | GCWC strongly supports the most flexible adaptive management approach possible for controlling or eliminating smallmouth bass (SMB) and other warmwater non-native fish and crayfish in this river ecosystem. All possible strategies for limiting or controlling the establishment of reproducing populations of these highly piscivorous non-native species should remain on the table and available to the river ecosystem managers. In particular, GCWC supports rigorous, effective, and rapidly-reported monitoring to ensure knowledge is gained, and an active (where possible, proactive) approach to management. The many large uncertainties regarding success of limiting or control of SMB and other non-native aquatic species require that every option must be available to resolve these invasions, both upstream and downstream of the dam. | Reclamation is dedicated to incorporating adaptive management practices into the LTEMP SEIS and the planning and implementation process moving forward. This includes the continuation of monitoring strategies. |
| 34 | 9 | ALTNODTAIL - Alternatives - Considered but Eliminated from Detailed Analysis | Grand Canyon Wildlands Council strongly supports modifying the high flow experiment (HFE) sediment accounting and implementation schedule to improve chances of implementing springtime HFEs, whenever possible. As we have recommended since 2011 and as we all saw in 2023, timing high flows from the dam at periods when flooding naturally (spring and early summer) in this river ecosystem has tremendously advantages, beneficially increasing or improving shoreline habitat quality, recreational camping beach area, and water and hydroelectric power production planning. Conducting HFEs in late autumn, as has generally been the practice since 2000, is not only ecologically wasteful (sandbars erode back over the winter months), but also adds to the uncertainty of water availability in the critical early and mid-summer months and the remainder of the water year. Adopting the proposed changes in sediment accounting for a one-year timeframe and implementation timing whenever possible in springtime are essential steps to move this important ecosystem towards the goals of the National Park Service and the Grand Canyon Protection Act (1992), on which the LTEMP is founded. | Thank you for your comment. Reclamation considered this when developing the Final SEIS and selecting a preferred alternative. |
| 34 | 13 | ALTRANGE - Inadequate Range of Alternatives | It also is essential that the -12 Mile Slough be modified to eliminate SMB and other non-native aquatic predator refuge. The proposed reductions in size and function of the Slough are a good solution. However, that process is immersed in recalcitrance based on mis-information to Tribes and the bureaucracy of the National Park Service. The Slough is not a natural feature, but was created when fine sediment was flushed from the dam tailwaters in 1965, exposing the cobbles there. It is neither ecologically appropriate, nor within the NPS mission to maintain this unnatural feature that so deeply threatens the Colorado River ecosystems native fish populations. In addition, any action taken at the Slough can be undone, if the NPS so wishes. Therefore, there appear to be no clear reasons for the delays in this important action. Please move forward swiftly with the plan to modify the Slough to keep it from contributing to the non-native aquatic species problem. | Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. These efforts include a proposed modification to the -12-mile slough. These efforts are out of scope for this NEPA effort. |
| 34 | 10 | PI - Public and Stakeholder Involvement | Lastly regarding HFEs, and like Grand Canyon River Guides, many of the Native American Tribes, and others, GCWC continues to urge Reclamation to revisit the HFE decision-making about its Planning and Implementation (PI) team membership. More comprehensive involvement is critical to realizing the spirit of the 1992 Grand Canyon Protection Act to adaptively manage Glen Canyon Dam in such a manner as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park and Glen Canyon National Recreation Area were established. The PI Team needs to include the voices of all AMP stakeholders, as we have previously requested. | Reclamation is committed to collaborating with stakeholders; however, changes to the planning and implementation team are beyond the scope of this SEIS. |

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| 34 | 5 | REC - Recreation | Of additional great concern is the failure of the Draft SEIS to accurately portray the impacts from the Non-Bypass Alternative on sandbars/camping beaches by stating that camping opportunities would be affected to a similar extent as under the other action alternatives. This assessment appears faulty in light of years of evidence showing dramatic flow fluctuations adversely affect sediment resources, especially during periods with inadequate sediment mass balance in the system. It concludes by summarizing that the Non-Bypass Alternative would adversely affect whitewater boating due to low minimum flows but makes no mention of its impact to camping beaches and therefore sandbars and riparian habitats, along with cultural resources. In the context of recreation alone, from navigability/safety, to trip management, to the quality of the recreational resource and recreational experience, the Non-Bypass Alternative is unacceptable and unworkable. | The analysis of sandbars and camping beaches in the recreation section has been revised per updated modeling results. |
| 34 | 12 | ALTRANGE - Inadequate Range of Alternatives | Our previously submitted analysis of non-flow-related options indicated that physical barrier screens, in-reservoir nets, floating barriers, turbine mortality, and electrofishing appeared to be equally easily accomplished and inexpensive short-term (emergency) management actions. If all were to be undertaken simultaneously, these may be the best collective strategy considered to reduce the likelihood of SMB establishment. In addition, we recommend the use of upstream curtain barriers and other means of reducing transport of fish through the dam, with implementation and monitoring at Reclamations earliest possible time frame. | Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. These efforts are out of scope for this NEPA effort. |
| 34 | 2 | ALTBYPASS - Alternatives - Non-Bypass | The Non-Bypass alternative will have significant negative and unacceptable impacts on multiple resources including loss of sediment and damage to ecological and cultural resources/integrity, riparian and aquatic resources, and river based recreational resources, and therefore should be avoided altogether. | Per NEPA requirements, Reclamation is required to analyze reasonable action alternatives. The Non-Bypass Alternative represents an alternative that was deemed reasonable for analysis. While it does not perform as well as the other action alternatives within the smallmouth bass model, it does show improvement over the No Action Alternative. Due to the modeling results and analysis, it was not deemed the environmentally preferred alternative and will not be implemented in 2024. |
| 34 | 3 | ALTBYPASS - Alternatives - Non-Bypass | Under the Non-Bypass Alternative, flows could swing between a low of 2,000 cfs to a high of over 27,000 cfs. This is contrary to the stated goals of the Grand Canyon Protection Act and flies in the face of findings from several decades of research and monitoring, which both informed the LTEMP ROD and emerged during its implementation to date. As we stated during scoping, analysis of impacts under this alternative needed to be conducted across multiple time scales in order to be valid representations. | Per NEPA requirements, Reclamation is required to analyze reasonable action alternatives. The Non-Bypass Alternative represents an alternative that was deemed reasonable for the specific purpose and need associated with the LTEMP SEIS. While this alternative does not perform as well as the other action alternatives within the smallmouth bass model, it does show improvement over the No Action Alternative. Due to the modeling results and analysis, it was not deemed the environmentally preferred alternative and will not be implemented in 2024. |
| 34 | 4 | ENERGYPOW - Energy and Power | We restate here that impacts from any actions undertaken should not unfairly burden any one group, and such burdens as may arise from such management actions should be recognized by Reclamation and mitigated, where possible. However, the threats posed by non-native SMB and other species invasions are dire and very likely irreversible. Therefore, GCWC does not support limitations on management actions to benefit hydroelectric power production or downstream water delivery that may reduce the effectiveness of the flow management actions. Such limitations could ultimately increase the costs to hydropower and water users by orders of magnitude to try to obtain minimal, or even net zero effectiveness in preventing extirpation and extinction, with SMB established, because of failure to act immediately with the greatest possible effectiveness. The Non-Bypass Alternative would be a giant step backwards, waste precious time, and would seriously hamper the Glen Canyon Dam Adaptive Management Program (AMP) and even potentially its ongoing funding. | Reclamation considered impacts to hydropower while selecting a preferred alternative. The urgency of addressing the immediate threat to native species is paramount. The best available science is guiding this process to ensure that the most effective options are selected to balance many different interests in the operation of Glen Canyon Dam. |

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| 34 | 11 | ALTRANGE - Inadequate Range of Alternatives | While the focus on discharge-related options is the primary emphasis of this SEIS, multiple nondischarge- related control measures also are needed, such as measures that reduce throughdam transport of non-native fish, tailwater control efforts (including management of the -12L Mile Slough), and other methods. We know from the Green, Yampa, and Colorado River reaches above Lake Powell that establishment of SMB is a primary factor in population declines of humpback chub and other native fish species outside of Grand Canyon. The Yampa River invasion provides the cautionary tale of the ecological consequences that arise from failing to pursue intervention early in the non-native fish colonization process (Dr. Rich Valdez, personal communication). The costs involved in controlling established SMB through long-term management and to keep federally listed native fish from jeopardy and the brink of extinction there, are orders of magnitude greater than the cost of early prevention of establishment and those goals have proven impossible to obtain. We have also repeatedly heard from our Tribal colleagues in the AMP that taking of life in the Colorado River significantly harms indigenous cultural integrity and therefore should be avoided when possible. | Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. These efforts are out of scope for this NEPA effort.<br><br>Reclamation considered the potential costs of managing an established invasive species in the development of this SEIS. |
| 35 | 3 | CONSCULT - Consultation tribal related | 1. The Draft SEIS Fails to Adequately Discuss CRIT's Interests in the Proposed Action. Under NEPA, agencies must consider, to the extent practicable, whether there is or will be an impact on the natural or physical environment that significantly and adversely affects Native American tribes. Specifically, the Bureau must consider whether significant environmental effects may have an adverse impact on Native American tribes that appreciably exceeds those on the general population. See, e.g. , EPA's 1998 Environmental Justice Guidance; Executive Order 12898. In addition to considering impacts to tribes, agencies must consult with interested tribes under the NHP A, as noted in the Draft SEIS. Draft SEIS 3-164. | Thank you for your comment. Reclamation values the input of Tribes in the SEIS process. The Tribal Resources and Environmental Justice sections include analysis of impacts to these groups. |
| 35 | 8 | CRTRIBE - Cultural and Tribal Resources | As described above, the Draft SEIS fails to adequately analyze the additional impacts to newly exposed tribal and cultural resource sites. Nonetheless, the Draft SEIS claims that any "adverse effects to cultural resources [from the non-bypass alternative] would be resolved under the LTEMP PA." Draft SEIS at 3-172 and 3-179. It is unclear how the Draft SEIS can state that all additional impacts will be mitigated by the PA, given that there is no analysis on the extent and severity of those impacts. | Reclamation acknowledges that the flows proposed under the Non-Bypass Alternative may result in the exposure of cultural resources of interest to the Tribes. Reclamation does not know of any prehistoric sites under the current level of the Colorado River. Reclamation assists Tribes and NPS to monitor the river corridor each year. If resources are exposed and experience adverse effects, consultation would be conducted regarding the resource per Stipulation IA: Coordination and Section 106 Consultation and resolution of adverse effects developed per Stipulation IB Mitigation of Potential Adverse Effects. |
| 35 | 5 | CONSCULT - Consultation tribal related | As mentioned above, CRIT's reservation is located along the Colorado River and the ancestral homelands of its members extend over much larger sections of the river, including sections within the scope of the SEIS. Because the river holds significant spiritual and cultural value to the Tribes, CRIT has an interest in the river and any projects that may affect it. We are concerned that any impacts associated with the L TEMP may affect the river as a whole, which will impact CRIT tribal members. Accordingly, CRIT must be consulted on the development of the project, and the potential impacts to CRIT should be adequately discussed in the Final SEIS. | Reclamation looks forward to consulting with the Colorado River Indian Tribe (CRIT) on these issues. |
| 35 | 2 | CONSCULT - Consultation tribal related | Further, CRIT asks that it be consulted in the development of the Final SEIS given the significant spiritual and cultural value that the Colorado River holds for the Tribes. | Reclamation looks forward to consulting with CRIT on these issues. |

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| 35 | 7 | CRTRIBE - Cultural and Tribal Resources | Further, the Draft SEIS acknowledges that, under the non-bypass alternative, new tribal and cultural resource sites would be exposed and there would likely be impacts to those sites from wave action, wet/dry effects, and increased visitation. Draft SEIS at 3-172 and 3-180. Despite acknowledging that the non-bypass alternative will degrade newly exposed sites, the Draft SEIS fails to analyze the significance or extent of that degradation. 40 C.F.R. SSSS 1502.16(a). This analysis was not performed in the 2016 FEIS either because such low water levels were outside of its scope. Accordingly, the Draft SEIS should include the necessary analysis to determine the additional impacts on newly exposed tribal and cultural resource sites. | Reclamation acknowledges that the flows proposed under the Non-Bypass alternatives may result in the exposure of cultural resources of interest to the Tribes. Reclamation does not know of any prehistoric sites under the current level of the Colorado River. Reclamation assists Tribes and NPS to monitor the river corridor each year. If resources are exposed and experience adverse effects, consultation would be conducted regarding the resource per Stipulation IA: Coordination and Section 106 Consultation and resolution of adverse effects developed per Stipulation IB: Mitigation of Potential Adverse Effects. |
| 35 | 10 | SCOPE - Scope of the Analysis | In determining the scope of an EIS, NEPA requires agencies to consider connected actions. Connected action are those that are "interdependent parts of a larger action." 40 C.F .R. SS SS 1501.9(e). Accordingly, NEPA does not permit agencies to "piecemeal" larger projects into smaller parts and analyze each of the pieces independently. Native Ecosystems Council v. Dombeck, 304 F.3d 886. 897 (9th Cir. 2002); see also 40 C.F.R. SSSS 1501.9(e). Rather, agencies must analyze the impacts of the larger project as a whole "in the same impact statement." Id. The Draft SEIS looks solely at discrete changes in the flow regime. However, these changes in the flow regime are a single part of a much broader project to develop ongoing guidelines for the operation of the river as a water delivery system. By considering the change in the flow regime as a stand-alone project, as opposed to considering it as a component of the overarching plan for the river, the Draft SEIS impermissibly breaks the project down into smaller parts. Rather than piecemealing the project, the Draft SEIS should consider the impacts of the LTEMP together with the impacts of general river operation. | The Final SEIS includes resource analysis of average impacts across the life of the project and more detailed analysis of resources just when experiments are run. This analysis captures impacts on a broad and detailed scale for readers.<br><br>In addition, the planning and implementation process will include a comprehensive review and analysis of impacts. |
| 35 | 1 | CRTRIBE - Cultural and Tribal Resources | In particular, the Tribes are concerned about the impacts to petroglyphs, intaglios, pictographs, sleeping circles, trails, manos and metates, and other cultural resources that may result from the project. Accordingly, CRIT asks that the impacts to these cultural resources and sites be thoroughly analyzed and mitigated to the extent feasible. | Reclamation reached out to NPS regarding petroglyphs or pictographs and asked whether any were impacted or would be impacted by high-flow events. NPS replied that there would be no impacts to petroglyphs or pictographs because none have been identified within the 40,000 to 90,000 HFE range. Pre-dam flows were twice as high as current flows and HFEs. Added to Section 3.12.2 under Issue 1: “No impacts to petroglyphs or pictographs would occur because no petroglyph or pictograph sites are below the water level reached by the HFEs.” |
| 35 | 9 | CRTRIBE - Cultural and Tribal Resources | Moreover, the PA only lays out procedures for monitoring the impacts of the project, and states that mitigation measures "will be developed." 201 7 L TEMP PA at 7. Although monitoring newly exposed sites will certainly be a helpful and necessary first step, it does not provide any protection to cultural resource sites. Further, any mitigation measures that were developed for the 2016 FEIS were not based on the current project, and the Draft SEIS does not assess their effectiveness under the currently proposed alternatives. Thus, the Draft SEIS fails to provide sufficient detail on mitigation measures, as required by NEPA. Accordingly, the Draft SEIS should disclose specific mitigation measures that may be used to reduce impacts, such as erosion to tribal and cultural resource sites, under the current alternatives. | Under the current project, only the Non-Bypass Alternative has the potential to adversely impact historic properties important to Tribes outside the impacts analyzed in the 2016 LTEMP FEIS. However, the resolution of any adverse effects would still fall under the 2016 LTEMP PA under Stipulation 1B. Reclamation feels that those measures remain adequate to address adverse impacts, should this alternative be selected. |
| 35 | 11 | ATTN - Attention | Thank you for your consideration. To understand how these comments were taken into account in your decision-making, we ask for a written response prior to a final decision. Please copy the Tribes' Attorney General Rebecca A. Loudbear, at rloudbear@critdoj .com and THPO Director Bryan Etsitty, at betsitty@crit-nsn.gov, on all correspondence to the Tribes. | NEPA requires comment responses to be incorporated in the Final SEIS, and we have therefore included this comment response matrix. In addition, Reclamation will conduct further consultation with CRIT. |

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| 35 | 4 | CRTRIBE - Cultural and Tribal Resources | The Draft SEIS discusses the impact of the LTEMP on the following tribes: the Havasupai Tribe, Hopi Tribe, Hualapai Tribe, Navajo Nation, Pueblo of Zuni, and Southern Paiute Consortium. Draft SEIS at 3-174. Although CRIT is mentioned in passing in the Tribal Resources section (Draft SEIS at 3-177), the Draft SEIS fails to adequately describe the significance of the river and its cultural resources to CRIT. | Reclamation looks forward to consulting with CRIT on these issues. Reclamation values the input of Tribes in the SEIS process. |
| 35 | 6 | CRTRIBE - Cultural and Tribal Resources | The Draft SEIS discusses the various types and characteristics of tribal and cultural resources, such as petroglyphs, present in the project area, (Draft SEIS at 3-168 to 3-170), but then fails to analyze the impacts that higher flows will have on those resources. The Draft SEIS states, without further explanation, that there will be no additional impacts to tribal and cultural resources under the flow spike alternatives (i.e. the Cool Mix with Flow Spike Alternative and Cold Shock with Flow Spike Alternative) as compared to the no action alternative, which would maintain the same operations as are currently in place and were described in the 2016 FEIS. Draft SEIS at 3-172 and 3-179. However, the 2016 FEIS focused on the impacts of high flows on terraces and provided no petroglyph-specific analysis. 2016 FEIS Appendix Hat 8-12. Given this gap in the analysis, there is no basis for the Draft SEIS to conclude that there will be no additional impacts to petroglyphs from high water levels. The Draft SEIS must include a description of which tribal and cultural resource sites will be impacted by higher flows and the significance of those additional impacts. | Reclamation reached out to NPS regarding petroglyphs or pictographs and asked whether any were impacted or would be impacted by high-flow events. NPS replied that there would be no impacts to petroglyphs or pictographs because none have been identified within the 40,000 to 90,000 HFE range. Pre-dam flows were twice as high as current flows and HFEs. Added to Section 3.12.2 under Issue 1: “No impacts to petroglyphs or pictographs would occur because no petroglyph or pictograph sites are below the water level reached by the HFEs.” |
| 36 | 2 | AQUA - Aquatic Resources | In order to meet the purpose and need of this plan, as well as compliance with all applicable laws, the final selected alternative must take swift action to ensure that the problem does not grow in the future. Central to this is BOR taking action that lowers temperatures in the Colorado River below the Glen Canyon Dam - this will help reduce the reproductive potential of invasive fish like smallmouth bass that have already managed to enter the lower Colorado River Basin. It is crucial to saving the ecosystem and protecting the native fish species like the humpback chub, which is protected under the Endangered Species Act (ESA). | Thank you for your comment. Reclamation recognizes the immediate need for action and considered these points while developing the Final SEIS. |
| 36 | 12 | ALTRANGE - Inadequate Range of Alternatives | Lastly, lower water levels in Lake Powell are the main cause of the issue as they have allowed the warm-water smallmouth bass to pass through the Glen Canyon Dam. With projections of increased drought conditions, Lake Powell water levels need to be addressed on a broader, systemic level and long-term solutions, including passthrough prevention and more funding to control invasive fish populations, need to be considered to not only prevent the smallmouth bass from entering the Grand Canyon but to protect the entire Grand Canyon ecosystem. | Management of Lake Powell elevations is outside the scope of this SEIS. Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. These efforts are out of scope for this NEPA effort. |
| 36 | 4 | AQUA - Aquatic Resources | NPCA believes that reservoir releases with various temperature and flow velocity combinations is the best solution to protect the native fish species and ecology of the Grand Canyon. This mirrors Alternative 3: Cool Mix with Flow Spikes, which NPCA believes would be the most effective in addressing the smallmouth bass invasion. Cooler water releases have the highest certainty of preventing the establishment of new warm-water invasive fish through lowering the water temperature. This should be done through the release of water from the bypass tunnels in combination with the release of water from the penstocks. Flow spikes are important to include in the action due to their ability "to disrupt spawning in margin habitats that may be warmer than the mainstream river" and benefit sediment. | Thank you for your comment. We considered these points while developing the Final SEIS and selecting a preferred alternative. |

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| 36 | 7 | AQUA - Aquatic Resources | NPCA strongly urges against Alternative 1: No Action Alternative, which would result in the "continued warming of water and the spread of smallmouth bass and other warmwater nonnative species in the Colorado River below Glen Canyon Dam" if low levels at Lake Powell continue. Grand Canyon National Park is already dealing with invasive smallmouth bass entering the lower Colorado River Basin through Glen Canyon Dam because of low water levels and allowing warmer water from the upper levels of Lake Powell to pass through the penstocks. The National Park Service has done the best it can to respond to this crisis, but ultimately the BOR must take action to remedy this situation as required by the Grand Canyon Protection Act of 1992, as well as a legal obligation under the ESA, to not only prevent smallmouth bass from entering the Grand Canyon, but also from reproducing there. | Thank you for your comment. We considered these points while developing the Final SEIS and selecting a preferred alternative. |
| 36 | 3 | WATERQUAL - Water Quality | NPCA supports the high-flow experiment (HFE) protocol adjustments that are common to all natural cycle. This would allow for more HFEs to occur and optimize the success of these HFEs, with strong implications for shorelines and beaches. These HFEs also have implications for cultural sites along the Colorado River. This adjustment to HFE timing is crucial for adequately managing the river moving forward and NPCA agrees with BOR's decision to optimize the timing of HFEs. | Thank you for your comment. We considered these points while developing the Final SEIS. |
| 36 | 5 | GEOSEDI - Geomorphology and Sediment | Sediment-enriched flows are needed to ensure the restoration of beaches, which is important not only for the ecology of the Grand Canyon but for the economy as well. | Reclamation considered sediment resources and beach building in the Final SEIS. |
| 36 | 8 | AQUA - Aquatic Resources | Similarly, NPCA opposes Alternative 6: Non-Bypass Alternative. The modeling results for the Non-Bypass Alternative in years with warmer water levels is similar to the No Action Alternative, as lambda (the growth in smallmouth bass population) still remains over 1.0, indicating population increase. When the Non-Bypass Alternative is used, it could indicate a reduction in HFEs, which have significant implications for native fish and the shorelines along the river. This option is inadequate to address the severity of the issue and does not meet the purpose and need established for this planning effort. Any combination of tools should not include the Non-Bypass Alternative for the same reason of its ineffectiveness in reducing the smallmouth bass population growth. | Per NEPA requirements, Reclamation is required to analyze reasonable action alternatives. The Non-Bypass Alternative represents an alternative that was deemed reasonable for analysis. While it does not perform as well as the other action alternatives within the smallmouth bass model, it does show improvement over the No Action Alternative. Due to the modeling results and analysis, it was not deemed the environmentally preferred alternative and will not be implemented in 2024. |
| 36 | 11 | POLICYGOV - Policy and Governance | The minimal loss to hydropower is consistent with the Grand Canyon Protection Act of 1992, which mandates the dam must be operated in a manner consistent with protecting the natural and cultural resources of the Grand Canyon. | Thank you for your comment. We considered these points while developing the Final SEIS. |

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| 36 | 9 | HYDROLOGY - Hydrology | We also request the BOR make corrections and clarifications to the LTEMP Draft SEIS, specifically regarding assumptions used to perform analyses for smallmouth bass flow alternatives. The hydrologic data for this SEIS appears to be taken from the 2023 Revised Supplemental Environmental Impact Statement for Near-term Colorado River Operations. This is based on a set of 30 hydrologic traces, most of which had cooler water temperatures (below 15.5 Celsius), meaning the tool(s) would not need to be used the vast majority of the time. However, the presentation of this modeling provides a misleading analysis for the alternatives as they were analyzed for effects based on averaging over all traces, giving an inaccurate calculation of the actual beneficial impacts of using the tool(s) during the limited instances they would be used. This does not provide an accurate calculation for considering how these alternatives would influence smallmouth bass population as several alternatives have actions that only occur in warmer water levels. It is important for BOR to calculate and present future smallmouth bass population growth with modeling data that considers the warmer, lower water levels that have been more reflective of the immediate term at Lake Powell. This miscalculation affects sediment and dissolved oxygen (DO) as well, demonstrating the importance for BOR to correct it. NPCA recommends BOR corrects these assumptions to ensure that the analyses of the proposed alternatives and their effectiveness are as accurate as possible. Additionally, the presentation of lambda needs to be split up for the years that the bypass tool is being used, as this demonstrates the non-bypass doesn't work to address the problem before us and the purpose and need of the planning. It is essential that BOR accurately present this information to prevent unnecessary confusion and misinterpretation that feeds misinformation. | The project timeline does not allow for further modeling. Reclamation used the best available hydrologic modeling during the analysis. The Final SEIS has been updated to include monthly analysis when experiments are run to more clearly analyze impacts to avoid averaging impacts when experiments are not implemented.<br><br>The planning and implementation process will continue to analyze and consider impacts using future conditions. |
| 36 | 10 | ENERGYPOW - Energy and Power | We understand that the use of the bypasses will have a minor impact on hydropower production. The assumptions to estimate how the alternatives affect hydropower appear sound in this SEIS indicating only a maximum 1-2% value reduction for hydropower. This estimated loss appears minimal and necessary as both the flow spikes and the use of the bypasses are essential for ecological restoration purposes and protecting the Grand Canyon's critical ecosystem. | Thank you for your comment. Reclamation considered these comments during the development of the Final SEIS and when selecting a preferred alternative. |
| 37 | 9 | EDIT - Editorial | Figure 3-25 should be updated to include relative abundance from 2016-2023, which is contained within the Department's most recent Lees Ferry monitoring annual report (Rogowski et al.2023). The Department has observed catch per unit effort below one fish/min since 2021, which falls below the management goal outlined in the Department's fisheries management plan for Lees Ferry. It is important that the status of the Rainbow Trout fishery is accurately reported within the SEIS. | Figure 3-25 in the Draft SEIS was sourced directly from Rogowski et al. (2023) and cannot be updated. Reclamation integrated the best available data for the Final SEIS. Reclamation is open to considering any new data and science during the planning and implementation process. |
| 37 | 12 | EDIT - Editorial | Additionally, on pg. Preparers-2, Scott Roger's title should be corrected to "Aquatic Wildlife Program Manager, Region 2". | The Final SEIS has been updated per comment. |
| 37 | 6 | PI - Public and Stakeholder Involvement | Additionally, the Department has concerns that the current decision process through the implementation process does not allow for adequate time to thoroughly discuss, deliberate, and make a determination on implementation for these actions together or separately. While the draft SEIS establishes new management options that are needed, this may put additional strain on the decision process. Thus, the Department continues to recommend Reclamation identify clear guidance that ensures adequate time for review and coordination of flow experiments to be considered for implementation. | Reclamation acknowledges the immediacy of the smallmouth bass threat, which requires action. Reclamation provided the best available science for the analysis. |
| 37 | 14 | AQUA - Aquatic Resources | Additionally, the graphs showing predicted SMB growth rates (lambda) by pool elevation and inflow developed by Grand Canyon Monitoring and Research Center (GCMRC) that were presented at the Technical Working Group (TWG) Annual Reporting and the February AMWG meetings should be included as well. | The report by GCMRC (GCMRC 2024) is the most current information that we have on the smallmouth bass growth rate lambda. This resource has been incorporated by reference. |

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| 37 | 7 | WATERQUAL - Water Quality | In the introduction to water quality on 3-152, the document implies that DO is the exception to water quality parameters being "highly defined" by the water quality in Lake Powell, because of the rapid effect downstream biotic and abiotic processes have on DO within the water passed through the dam. However, low DO in the Colorado River directly below the dam (e.g. 5 miles) is directly correlated with DO levels at the level of the penstocks, and low DO events have been observed in this section of Lees Ferry. The replenishment of DO through photosynthetic processes only occurs during daylight hours and may not be adequate to provide refugia from significantly low DO events coming through the dam at night. It is also important to acknowledge that despite this section being a relatively small area of the Colorado River ecosystem, it also represents the most important reach of the Rainbow Trout fishery, an LTEMP resource, to fishing guides and recreational anglers. Although the Alternative flows outlined in this SEIS were not designed to address low DO concerns, Alternatives which include bypass will mitigate low DO in some capacity, assuming flows occur during periods of low DO, which are most prominent in the fall. The effect of Alternatives that utilize bypass on DO is likely understated within the SEIS. This is because the discharge from the bypass tubes may only marginally affect DO when measured directly below the turbine outflows (as they are modeled in the SEIS), but could have a much more significant increase to DO even just hundreds of meters downstream. | The commenter is correct in the assessment of low dissolved oxygen levels directly downstream of Glen Canyon Dam. Releases through the bypass valves may or may not be oxygenated, depending on antecedent inflows and time of year. Withdrawal from the hypolimnetic layer in a strongly stratified reservoir could contain low dissolved oxygen levels, whereas releases from the bypass valves in a weakly stratified reservoir or during spring or fall overturn would contain oxygenated waters. Relying on the bypass values to oxygenate the dam tailwaters could have variable results. |
| 37 | 13 | SCOPE - Scope of the Analysis | It is evident from this modeling that Alternatives that incorporate sustained use of bypass (i.e., cool mix) to maintain release temperatures less than 16degC are more effective at reducing the probability of establishment of SMB with less uncertainty than cold spikes and alternatives without any bypass. Although this document does not prescribe or advocate for the use of one Alternative over another, establishing the relative effectiveness of each to accomplish the stated goal is critical information for the Leadership Team to have when discussing implementation of experimental or management flows | Additional details have been provided in the Final SEIS about the effectiveness of the alternatives using lambda and the smallmouth bass model results. The Final SEIS identifies a preferred alternative. |
| 37 | 11 | EDIT - Editorial | On pg. Reference-31, the reference "Rogowski, D., C. Madonia, K. Manuell, R. Osterhoudt, L. Winters, and P. Wolters. 2023. Arizona Game & Fish Department, Lees Ferry Long-Term Monitoring. Grand Canyon Monitoring and Research Center, Flagstaff, Arizona." does not exist. The correct citation for the 2022 Lees Ferry annual report is "Rogowski, D., J. Fennell, and D. Fonken. 2023. Status of the Lees Ferry Trout Fishery 2022. Annual Report, prepared by the Arizona Game and Fish Department, Research Division, for the US Geological Survey, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona. Arizona Game and Fish Department, Phoenix, Arizona". | The Final SEIS has been updated per comment. |
| 37 | 2 | ALTBYPASS - Alternatives - Non-Bypass | The Department has concerns with the inclusion of the non-bypass Alternative within this SEIS. Given the predicted effects stated within Appendix A, it does not appear to reduce the SMB population growth rate compared to the No Action Alternative and thus, does not meet the need as established in Section 1.4, nor the the Secretary's Designee directive from May 2022 AMWG to develop "operational alternatives that could help prevent cool- and warmwater invasive fish establishment". | Per NEPA requirements, Reclamation is required to analyze reasonable action alternatives. The Non-Bypass Alternative represents an alternative that was deemed reasonable for analysis. While it does not perform as well as the other action alternatives within the smallmouth bass model, it does show improvement over the No Action Alternative. Due to the modeling results and analysis, it was not deemed the environmentally preferred alternative and will not be implemented in 2024. |
| 37 | 5 | CUMU - Cumulative Impacts | The Department has previously expressed concerns with combining flow actions to address SMB and High Flow Experiments to address beach building by way of the sediment accounting window within the same SEIS. The Department continues to stress the importance that these actions should not be considered mutually exclusive because the intended purpose benefits separate resources goals. Related to this concern, implementation of each should not be influenced by the other (e.g. cost, impact to water, or hydropower resources). | The LTEMP SEIS analyzes multiple experimental flows. The inclusion of HFEs and smallmouth bass flows under this SEIS does not link the two experiments. |

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| 37 | 4 | REC - Recreation | The Department recognizes that the flow regimes outlined by the GCMRC and Reclamation to suppress SMB will disrupt recreational opportunities at Lees Ferry during high flows; however, they also represent an overall benefit to the LTEMP resource if effective in their suppression of SMB by maintaining colder water releases below the dam. The Department does appreciate the inclusion of considerations for mitigating impacts to anglers within each of the alternatives. The Department continues to recommend Reclamation consider implementing peak flows during times of lowest use (i.e. weekdays), as feasible, to minimize impacting recreational users, and to provide adequate time for public announcements for recreationalists to adjust plans and minimize impacts to boating and angling trips. | Thank you for your comment. Reclamation considered it in the Final SEIS. |
| 37 | 3 | AQUA - Aquatic Resources | The inclusion of the predicted SMB population growth rates (lambda values) within Appendix A is a valuable addition to the draft SEIS. Reclamation should consider incorporating these graphs and analysis within the main text of the SEIS within the Alternatives' descriptions. | Lambda has been described in the document, and Table 3-35 in the Final SEIS presents the lambda values for each alternative.<br><br>In addition, Reclamation incorporated by reference the latest report from the GCMRC (Yackulic et al. 2024), which includes the latest information on smallmouth bass modeling. Please note that this report has replaced the smallmouth bass model report that was Appendix A of the Draft SEIS. |
| 37 | 8 | EDIT - Editorial | There are some instances of Lees Ferry being mistakenly described as being at river mile (RM) 15; however, Lees Ferry is traditionally considered at RM 0. This has led to some errors within the text related to river miles. The modeling for SMB lambdas appears to be done at RM 61 (the Little Colorado River) and 15 miles below Lees Ferry, which may be contributing to the confusion. Examples of river miles for Lees Ferry that need to be corrected occur on page 2-1, 2-10, and 3-3, but should be corrected throughout. References of locations further downstream seem to be in relation to Lees Ferry and are correct (e.g. Little Colorado River at river mile 61, Pumpkin Springs, RM 213). Additionally, the description of river mile contained within the Glossary is misstated as "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". This is incorrect, river miles are listed in reference to Lees Ferry being 0. River miles upstream of Lees Ferry are denoted as negative river miles (e.g. the slough at -12 mile) | The Final SEIS has been updated per comment. |
| 37 | 10 | AQUA - Aquatic Resources | With expansion of Humpback Chub (HBC) into the western Grand Canyon, especially into the areas previously inundated by Lake Mead, the Department's perception of suitable or preferred habitat for this species is being challenged. The information that is contained within the Habitat section for HBC (pg. 3-118) is based on observations that were made when HBC were relatively rare in the system. As populations have increased the specific habitat that this species was and is reliant on is broadening. A recently published manuscript by Department staff considers this change in perspective and may be a beneficial reference for this section (Boyer et al. 2024). | Thank you for bringing this most recent information on habitat to our attention. We have inserted the following paragraph into the Habitat section for humpback chub (see Section 3.8 in the Final SEIS): "Recent surveys of an expanding population in western Grand Canyon found humpback chub in open, silt-laden habitats, suggesting this species may be able to occupy a wider range of habitats. This habitat is found in exposed deltaic sediments at the inflow of Lake Mead following a decline in lake elevation. Hoop net catch data showed no difference in juvenile/subadult humpback chub catch between hoop nets set in rocky habitat compared with habitat with only fine sediment. Humpback chub catch for all life stages in a river segment characterized by silt banks exceeded or was not significantly different from catch in rocky segments (Boyer et al. 2024)." |

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| 37 | 1 | ALTRANGE - Inadequate Range of Alternatives | Within the scoping comments, the Department encouraged Reclamation to plan for flexibility within the implementation of action alternatives to fit within the adaptive management framework of the program. While the Department recognizes that this can be a challenge within compliance documents that are not meant to be determinative (i.e., advocate for one alternative), it is important to contain options within the Alternatives (e.g., days in which flows should be implemented, ratios of bypass to powerplant discharge, shape of hydrographs) to either be more effective in their purpose or reduce impacts to other resources. Additionally, the flow Alternatives were specifically designed for SMB and may not be as effective for other cool- and warmwater species. Having a suite of parameters within flow Alternatives that could be manipulated would allow for a more focused response to a variety of high risk non-native species, without additional compliance, would be beneficial for adaptive management. In some cases, the Alternatives could contain more discretionary language to facilitate future improvements to the Alternative flows or needs established by the GCDAMP. | Reclamation is committed to implementing adaptive management strategies into the LTEMP SEIS. Additional language has been added to Chapter 2, including descriptions of the planning and implementation process. |
| 38 | 4 | REC - Recreation | A deeper look at the modeling for these types of flows shows that adverse impacts to the recreational experience extend far below the LCR. Of great concern is the failure of the Draft SEIS to accurately portray the impacts from the Non-Bypass Alternative on camping beaches by stating that camping opportunities would be affected to a similar extent as under the other action alternatives. This assessment deserves greater explanation in light of years of evidence showing dramatic flow fluctuations adversely affect sediment resources and specifically camping beaches along the river corridor especially during periods with inadequate sediment mass balance in the system. It concludes by summarizing that the Non-Bypass Alternative would adversely affect whitewater boating due to low minimum flows but makes no mention of its impact to camping beaches. Overall, from navigability/safety, to trip management, to the quality of the recreational resource and recreational experience, the Non-Bypass Alternative is unacceptable and unworkable. | The analysis of sandbars and camping beaches in Section 3.14, Recreation, of the Final SEIS has been revised per updated modeling results. |
| 38 | 5 | ALTRANGE - Inadequate Range of Alternatives | Advance a range of alternatives (Cool Mix, Cool Mix with Spike, Cold Shock, and Cold Shock with Spike) as experiments for maximum flexibility and adaptability, based on monitoring, and assessment of effectiveness. The use of bypass is the only tool that will prevent SMB from gaining a foothold and spreading throughout the system. With a lack of consensus among fishery biologists about which experimental action would have the biggest impact on disrupting Smallmouth Bass during the spawning cycle, GCRG suggests an incremental and adaptive approach to experimental options that would minimize the negative impacts to other resources. We suggest initial experimentation with whichever alternative is deemed most potentially efficacious. This might, for example, be the Cool Mix Alternative, with plans in place to monitor results. If further action is needed to attain goals, the Cool Mix with a single Flow Spike should be initiated next, with intent to disrupt the spawning cycle. | Reclamation is committed to implementing adaptive management strategies in the LTEMP SEIS. Additional language has been added to Chapter 2, including descriptions of the planning and implementation process. |
| 38 | 6 | ALTNO - Alternatives - No Action | After 20 years of monitoring native fish in the Upper Basin, we have learned that turbidity has no effect on Smallmouth Bass predation, therefore, the No Action alternative would be irresponsible in regard to the endemic, threatened species of native fish in Grand Canyon. | Thank you for your comments. Reclamation considered these for the Final SEIS. |
| 38 | 3 | REC - Recreation | Along with the negative impacts from the Non-Bypass Alternative to the sediment resources and ecology of the Colorado River ecosystem in Grand Canyon is the extreme challenge of navigation. As the Grand Canyon river guiding community experienced in September 2023, there are severe and significant risks to running the river below 6,000 cfs. Consequences from 2023 included life-threatening injuries that were happening faster than SAR Teams could respond, and damaged equipment across all types of watercraft. Dropping levels down to 2,000 cfs would make river running infeasible and have major impacts to those unlucky visitors whose experience would not be that of a world-class whitewater rafting trip through the Grand Canyon. | Thank you for your comment. The recreation analysis currently describes the adverse effects on navigability and trip management and the public safety concerns that would result from implementing minimum flows of 2,000 cfs. |

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| 38 | 2 | AQUA - Aquatic Resources | Along with the sediment, other devastating potential adverse impacts include damaged cultural resources, aquatic resources and more, by shortsightedly treating the dam like the headgate of a giant canal system. For example, this alternative would adversely impact the foodbase that has only recently seen significant improvement from the bug flows. We know through these studies that massive fluctuations would have significantly negative impacts to the aquatic invertebrates. This SEIS analysis underestimates and fails to consider as a key part of the aquatic environments Gross Primary Productivity (GPP). The Non-Bypass Alternative is ostensibly designed to de-water Smallmouth Bass (SMB) nests, followed by a rapid high spike flow to flush out any remaining nests. Unique to this alternative is no effort to cool the water, instead relying solely on water velocity to dislodge spawning SMB nests. This suggests that all of the other flow alternatives, which do involve a technique to lower water temperatures, are based on a faulty assumption (that SMB spawning is in fact inhibited by lower temperatures). This flies in the face of science demonstrating otherwise and as such should not be considered for implementation. | There are several hypotheses for how to disrupt smallmouth bass spawning. Reclamation has presented a range of alternatives to cover these hypotheses, along with an impact analysis for each. Your comments were considered during development of the Final SEIS and when selecting a preferred alternative. |
| 38 | 12 | PI - Public and Stakeholder Involvement | At the same time, GCRG continues to respectfully request that this SEIS should revisit the HFE decisionmaking process as part of its evaluation of the HFE protocol. Greater inclusivity is fundamental to more fully realize the goals of the Grand Canyon Protection Act (GCPA), by expanding membership of the implementation/planning group [PI Team] described on page C-6 of the LTEMP ROD. The PI Team should include ALL stakeholders as GCRG and others requested in our October 2021 letter to Secretarys Designee, Wayne Pullan. Otherwise, key stakeholders (recreation, environmental, and Tribes) are disenfranchised from the decision-making process for this key tool to manage downstream resources specifically cited as justification for their membership on the AMWG. In our 2021 letter we stated, "If the inclusion of our voices can only be achieved through a National Environmental Policy Act process, we request that the Secretary consider including our voices on the PI Team during the AMP's next NEPA-related effort." The LTEMP SEIS should address how marginalizing some stakeholders from the process meets the stated goals of the GCPA and the underlying intent behind formation of the AMWG. GCRG believes that the current PI Team configuration does not in fact meet those mandates and must therefore be modified so that all voices and perspectives can be heard and incorporated into the decision-making process for High Flow Experiments. Supporting greater transparency, equity, and inclusion should be an important component of this LTEMP SEIS so that we can make the best recommendations to the Secretary of the Interior as we face the challenges ahead. | Reclamation is committed to collaborating with stakeholders; however, changes to the planning and implementation team are beyond the scope of this SEIS. |
| 38 | 7 | ALTRANGE - Inadequate Range of Alternatives | Furthermore, as these experimental actions are just a band-aid to the current situation, plans to modify the dam-conditioned environment of the slough in Glen Canyon, and installing a curtain in the forebay of Glen Canyon Dam are paramount to providing long-term solutions to this dire situation. | Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. These efforts are out of scope for this NEPA effort. |
| 38 | 10 | AQUA - Aquatic Resources | Given the admittedly experimental nature of these alternatives, GCRG advocates for expressly including a process to monitor and assess the effectiveness of any implemented alternative. It is paramount that the entire range of near term, midterm, and long-term activities to prevent nonnative predatory fish (and other species) from establishing and/or expanding be employed in an integrated fashion. It is an all-hands-on-deck moment for the ESA-listed species that the BOR is legally mandated to protect. As such, the eventual decision space provided by the conclusion of this NEPA process must allow for rapid yet thoughtful, science-based adjustments for the next experiment, based on the results of monitoring studies in meeting the desired outcomes. | As part of GCDAMP, the program will continue to monitor fish populations through the Grand Canyon and will use the information to refine or modify actions outlined in the alternatives through adaptive management. Additional language has been added to Chapter 2 about adaptive management, planning and implementation. |

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| 38 | 9 | REC - Recreation | Impacts to recreation and the recreational resource in Grand Canyon In our scoping comments, Grand Canyon River Guides suggested that the SEIS should analyze how the different flow alternatives would impact recreation and in particular explain the metrics to assess and compare alternatives in terms of impacts to river recreation. Unfortunately, the Draft SEIS ignored this suggestion and consequently fails to adequately assess impacts to recreation. Section 3.14.1 assesses the Affected Environment for recreation resources and limits discussion of boating in Grand Canyon National Park to camping beaches. It does not describe safety or the visitor experience, or make any mention of the considerations river guides must make on a daily basis due to predicted flow levels. This is perpetuated in Section 3.14.2 where the Draft SEIS assesses the environmental consequences of the different proposed alternatives and fails to include any impact indicators to consider these important elements of boating the Colorado River through the Grand Canyon. Despite making no mention of this in the Affected Environment, the Environmental Consequences section describes presumed safe whitewater boating levels and cites a nearly 40-year-old study (Bishop et al. 1987) to capture the presumed preferred flow levels. In the future, we would like to see 8,000 cfs as the minimal flow for navigational safety. Anything below 8,000 cfs should be in worst case scenario circumstances only - bottoming out at 6,000 cfs as an absolute low. Safety and navigability must be maintained as a priority to protect the unparalleled visitor experience that has made Grand Canyon whitewater trips world renowned. | Thank you for your comment. The affected environment has been updated to include optimum and safe minimum flows for whitewater boating through the Grand Canyon, and an assumption has been added that clarifies 8,000 cfs as the safe whitewater minimum in the analysis. The Bishop et al. (1987) and Stewart et al. (2000) studies represent the best available science on streamflow effects on whitewater boating in the Grand Canyon. |
| 38 | 1 | ALTBYPASS - Alternatives - Non-Bypass | Non-Bypass alternative is of serious concern. This alternative would not involve the use of Glen Canyon Dams bypass system, but rather would focus on significant river stage fluctuations to theoretically disrupt smallmouth bass spawning. Under the Non-Bypass Alternative, flows could swing between a low of 2,000 cfs to a high of over 27,000 cfs. If implemented, this alternative would wreak havoc to numerous sensitive resources downstream. While we can appreciate theoretical experimentation, many GCRG members witnessed firsthand the significant damage to downstream resources that occurred when Glen Canyon Dam was operated under a similar paradigm in the 1980s. Prior to completion of the Glen Canyon Environmental Studies (which ultimately led to the passage of the Grand Canyon Protection Act of 1992), similar fluctuations destroyed the sediment resource to a level from which we are still unable to recover. We find it both ironic and deeply disturbing that this SEIS would even include such an alternative that ignores the lessons of the past and is contrary to the legal obligations of the Grand Canyon Protection Act. The Non-Bypass Alternative would be a giant step backwards and would seriously diminish the credibility of the BOR and the intent behind establishing the Glen Canyon Dam Adaptive Management Program (AMP). | Per NEPA requirements, Reclamation is required to analyze reasonable action alternatives. The Non-Bypass Alternative represents an alternative that was deemed reasonable for analysis. While it does not perform as well as the other action alternatives within the smallmouth bass model, it does show improvement over the No Action Alternative. Due to the modeling results and analysis, it was not deemed the environmentally preferred alternative and will not be implemented in 2024. |
| 38 | 8 | REC - Recreation | Please note that Grand Canyon River Guides remains concerned that the alternatives that include spike flows (Cool Mix plus Spike Flow, and Cold Shock plus Spike Flow) could be detrimental to sediment and substantially erode sand that has accumulated in the channel, precluding the opportunity to conduct an HFE. We disagree with the Draft SEIS conclusion that in the long term, flow spikes have the highest potential to increase camping areas in the Grand Canyon. In fact, the SEIS explains that in some years, flow spikes would cause sand export in the lead up to HFE implementation, which would reduce the resulting HFE duration. Flow spikes would decrease mass balance at Marble Canyon to a slightly greater extent relative to the alternatives without flow spikes, while contributing slightly more volume to sandbars. Evidently the SEIS ignores that the best tool to preserve camping beaches is by taking advantage of the scientifically proven benefits of HFEs conducted under sediment enriched conditions. | The Final SEIS has been updated to include additional details on sand mass balance impacts during alternatives with flow spikes.<br><br>Reclamation will incorporate the best available science during the planning and implementation process, including updated sand mass balance modeling. Adaptive management will be used to implement alternatives that best fit the purpose and need. |

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| 38 | 11 | SOC - Socioeconomics | This analysis continues to diminish the value and potential impacts to recreational boating in the subsequent discussion of Socioeconomics in Section 3.15. This analysis depends entirely on a study conducted in 2017 (Neher et al.) which aims to capture a willingness to pay per private whitewater trip by boat through the Grand Canyon under varying flows. Not only does this fail to capture the commercial visitors perspective, but it does not even recognize the contributions of commercial river concessionaires and their knowledgeable guides (our membership). There is no discussion of how commercial operators in Grand Canyon support their local communities as they provision these trips, or the hundreds of employees they support, or the dramatic impact to the user experience that results in repeat visits and strong affinity to support the protection and conservation of the Grand Canyons unique values over the long term. | Information has been added in Section 3.15, Socioeconomics Affected Environment, to note the existing concessionaire (this is also noted in Recreation section) and the associated contributions. Analysis in the Draft SEIS by alternative included qualitative discussion of impacts to the concessionaire (see discussion by alternative under Issue 1). |
| 40 | 1 | ALTRANGE - Inadequate Range of Alternatives | Maricopa Water District ("MWD") appreciates the opportunity to provide comments in on the important strategic analysis at issue in this DSEIS, namely the available alternatives to reduce the threat of smallmouth bass below the Glen Canyon Dam ("GCD"). We support the concept of preventing establishment of smallmouth bass and other nonnative warmwater invasive fish, but the DSEIS fails to sufficiently analyze alternatives that mitigate health and safety concerns resulting from the loss of GCD summer electric capacity, in a time where market purchases may not be available to replace the loss. Accordingly, we submit the following comments on the DSEIS and encourage the Bureau of Reclamation ("BOR" or "Reclamation") to ensure an outcome that is equitable, sustainable, and compliant with the requirements of the National Environmental Policy Act ("NEPA"). As drafted, the DSEIS does not meet NEPA's requirement to explore available alternatives. | The Final SEIS has been substantially updated to include additional inputs from WAPA on impacts to hydropower resources. Please refer to Section 3.3 for additional information. Reclamation will consider these impacts when selecting a preferred alternative and in the planning and implementation process moving forward. |
| 40 | 9 | ALTRANGE - Inadequate Range of Alternatives | MWD asks that Reclamation critically analyze all available alternatives to disrupt smallmouth bass populations below GCD. The inclusion of one non-bypass flow alternative is insufficient to address the concerns raised in response to the Environmental Assesses, as the DSEIS nonetheless fails to articulate or mitigate the effect on regional grid reliability caused by the loss of GCD generation. | Reclamation has included all alternatives from the Draft SEIS in the Final SEIS. |
| 40 | 3 | ALTRANGE - Inadequate Range of Alternatives | MWD has reviewed the DSEIS, the input from stakeholders leading up to the DSEIS, and comments prepared for the DSEIS. MWD wholly supports and agrees with the thoughtful comments of CREDA, IEDA, and SRP. The DSEIS omits reasonable alternatives that could disrupt the establishment of smallmouth bass below GCD without flow modifications that diminish GCD electric generation and capacity. | Reclamation is pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. These efforts are out of scope for this NEPA effort. |
| 40 | 10 | ENERGYPOW - Energy and Power | MWD in particular concurs in CREDA's comment that Hydropower Modeling Assumptions/ TMax should be rewritten by W AP A, as the Power and Energy analysis included in the DSEIS does not appropriately disclose an analysis of the effects, as required for either public comment or a final decision by the Secretary. | Reclamation integrated WAPA's findings as appropriate as we finalize the SEIS. Reclamation included the PLEXOS modeling results in the Final SEIS to further analyze impacts to hydropower resources. Please see Section 3.3 for additional information. |
| 40 | 2 | ENERGYPOW - Energy and Power | MWD provides electric service to customers in Maricopa County, Arizona. MWD is a long-time Film Electric Service ("FES") contractor with Western Area Power Administration ("W AP A") for capacity and energy provided by the Colorado River Storage Project ("CRSP"). A majority of the CRSP system's critical summer generation and capacity comes from GCD. MWD is concerned about the short-te1m reliability impacts associated with the unavailability of capacity, whether due to L TEMP provisions rendering GCD generation unavailable, or due to increased demand on regional markets for summer peaking power. | The SEIS evaluates the potential impacts of flow options on hydropower production and recognizes the importance of ensuring a reliable and affordable power supply to the region. We took into consideration your concerns regarding the potential impacts on the energy market in your area. Reclamation worked closely with WAPA on the development of the Final SEIS. |

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| 40 | 7 | ALTRANGE - Inadequate Range of Alternatives | The availability of nonflow alternatives to disrupt smallmouth bass populations needs to be evaluated in this SEIS, and not left to another "future NEPA actions" as proposed. (DSEIS, at 1- 6). Narrowing the purpose of the DSEIS to only "analyze additional flow options at [GCD]" is just the type of "unreasonably na1TOw" objective that courts have chastised. (Id.) See Westlands Water Dist., 376 F.3d at 1155. The single-minded focus on flows drives the process to overlook reasonable alternatives to addressing the identified need. As raised by IEDA and members of the GCD Adaptive Management Work Group, including SRP, alternative potential solutions to prevent entrainment include manipulation of reservoir elevation, application of a the1mal curtain or barrier net, habitat modifications, and physical modifications to address the -12-mile slough where the smallmouth bass and other invasive fish spawn. Failure to analyze these actions that address the identified need, when the costs of bypass flows to electric reliability are so significant, would be indefensible. Failure to examine these viable alternatives to flow modifications would render the DSEIS legally inadequate. See Westlands Water Dist. v. US. Dept. of Interior, 376 F.3d 853, 865 (9th Cir.2004). | Reclamation is currently pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. The timeline for these efforts differs from this NEPA effort. These efforts are out of scope for this NEPA effort. |
| 40 | 8 | ENERGYPOW - Energy and Power | The DSEIS does not adequately identify the effects on the public of a significant loss of summer electric capacity when market replacement resources may be scarce Due to drought and changing regional electric wholesale market conditions, the availability of market purchases of electric capacity and generation during critical summer months is not assured. The DSEIS bypass flow alternatives assume that W AP A will able to purchase replacement power to fulfill its contractual obligations to customers. (See DSEIS at 3-19.) The DSEIS briefly notes that WAPA's operational flexibility is affected by the availability and price of replacement power, (Id. at 3-20), but does not appear to analyze the availability or price of the replacement power the DSEIS identifies will be needed under the bypass alternatives. (Id. at 3-19). MWD is affected first-hand by the electric power spot market. In the rush to replace GCD generation, WAP A and its contractors (including MWD) will all be looking for replacement power in the same capacity-short market environment forcing prices to rise. Transmission constraints could further squeeze market replacement power purchases. MWD has watched as increasingly drastic weather has caused the large importation of market purchases into the desert southwest, forcing the price of power to exceed $300/MWh, and spike to over $1,000 in times of shortage. As the Supreme Court has recognized, "[i]mplicit in NEPA's demand that an agency prepare a detailed statement on 'any adverse environmental effects which cannot be avoided should the proposal be implemented,' ... is an understanding that the EIS will discuss the extent to which adverse effects can be avoided." Robertson, 490 U.S. at 352. MWD agrees with CREDA, IEDA, and SRP's comments that there are significant constraints on available capacity in the summer months. There are legitimate concerns that replacement capacity and peaking generation will not be available on the market to fill the loss of GCD.1 This could lead to grid unreliability, which can threaten public safety. The DSEIS must be redrafted to analyze the effects of flow modifications on grid reliability, and must discuss the extent to which those adverse effects can be avoided via pursuing other mitigation opportunities, such as maintaining on-peak generation in the flow-based alternatives. | Thank you for your comment. Because the alternatives in this SEIS are treated as experiments, WAPA would be responsible for the purchase of replacement power on the market, and customers would be kept whole, including Tribes. As a result, customers would receive their power as if no bypass had occurred, and there would be no impacts to customers. This includes Tribes with benefit crediting agreements. The SEIS has been revised to add clarification. |
| 40 | 4 | ENERGYPOW - Energy and Power | The DSEIS further fails to include adequate and meaningful discussion of the environmental and public safety effects that alternatives will impose on the electric utilities who receive electric generation and capacity from GCD, and the retail customers those electric utilities serve, due to the loss of summer electric capacity. | The SEIS evaluates the potential impacts of flow options on hydropower production and recognizes the importance of ensuring a reliable and affordable power supply to the region. We took into consideration your concerns regarding the potential impacts on the energy market in your area. Your input was valuable as we refined our analysis. |

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| 41 | 1 | ENERGYPOW - Energy and Power | Concerns regarding infrastructure integrity of Glen Canyon Dam if any of the bypass flow options are implemented. During the 38 Sovereigns webinar discussion led by Reclamation on February 28, 2024, Reclamation expressed concerns regarding the integrity of the river outlet works at Glen Canyon Dam due to potential cavitation and scouring in the river bottom that may occur with greater intensity at lower Lake Powell elevations. Reclamation became aware of damage following the implementation of High Flow Experiments (HFEs) under LTEMP when the river outlet works were used during the experiment. Since then, Reclamation has indicated it is continuing to evaluate the extent of these concerns both physically and through computer modeling and that, with stakeholder input, will be considering some infrastructure modifications that may help mitigate or eliminate these concerns when needing to operate the dam at low lake levels. The final SEIS must incorporate Reclamation's ongoing analysis of flows through the river outlet works. It is imperative that the infrastructure be fully operational to manage deliveries to the lower basin for extended periods of time under low lake elevations. Any of the bypass flow options identified in the DSEIS, let alone existing HFEs under LTEMP currently, should not be conducted if protective modifications are not in place, the river outlet works are showing signs of ongoing degradation, or if there is otherwise a risk to the integrity to the infrastructure. | Infrastructure constraints were built into the modeling effort for the LTEMP SEIS. Reclamation will continue to consider these constraints during the planning and implementation process. |
| 41 | 6 | ENERGYPOW - Energy and Power | Conclusion The CRCNV appreciates the opportunity to provide comments to the DSEIS to the 2016 LTEMP ROD. As stated in the 7 Basin States Letter, while the CRCNV is supportive and appreciative of Reclamation's efforts to address the concerns and risks of warm water nonnative fish species establishment in Colorado River below Glen Canyon Dam, the actions must not be taken at the expense of compromising the integrity of dam infrastructure, depleting the Basin Fund for its primary purpose, or putting the electric power grid at risk. | Thank you for your comment. Reclamation appreciates your input and has considered these perspectives in the development of the Final SEIS and the selection of a preferred alternative. |
| 41 | 5 | ENERGYPOW - Energy and Power | The final SEIS must include a sufficient plan for implementation. Utility planning is complex and requires careful, thoughtful, and frequent communication. Detailed implementation and communication plans should also address how frequently Reclamation will communicate with WAPA about the likelihood that a trigger will be met as well as the quantity of lost generation and the days and hours during which it will be lost so that WAPA can replace the power in as prudent a manner as possible. The implementation plan should also include sufficient notice to allow WAPA the opportunity to analyze the generation pattern and recommend alternative days and hours for the experiment which could aid in minimizing the impact to the Basin Fund. The final SEIS should contain timelines for analysis and dialogue that ensure WAPA will have the tools it needs to manage the impacts of the experiments in a prudent manner. | Reclamation will use the best available science during the planning and implementation process to consider impacts to hydropower resources. Additional data have been included in the Final SEIS. Please see Chapters 1 and 2 for additional information. |

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| 41 | 4 | ENERGYPOW - Energy and Power | The final SEIS must include offramps if WAPA is unable to secure replacement power. The CRCNV has commented multiple times that hydropower resources are a critical component to operating the power grid, particularly during the hot summer months when power is in short supply and the transmission grid is "stressed" by heavy flows. The hydropower community relies on hydropower resources to serve load. For larger utilities, this reliance on hydropower resources and their green attributes, are included in long-term resource plans that are presented to their customers, governing bodies, and, in some situations, public utility commissions that review the reasonableness of those plans. Utilities have already had to adjust their resource plans in response to the drought and WAPA-199 which relieved WAPA of its obligation to provide a firm amount of power up to a contractual amount and forced power customers to accept the risk of replacing that supply. Reclamation should have a similar obligation to engage in prudent resource planning and, if they intend to remove resources from service, should also be required to ensure that an adequate supply of replacement resources is available. WAPA has already received early indication from its trading partners that replacement power of the amount needed by WAPA to replace lost generation may be unavailable. The unavailability of power indicates that there is insufficient generation in the regional market to serve demand and such a supply and demand imbalance could not only disrupt market prices but also impact system reliability. The final SEIS must contain offramps should WAPA be unable to secure replacement power. | Emergency operating criteria would continue as outlined in the LTEMP ROD. Reclamation will work closely with WAPA to address any necessary off-ramps due to a lack of replacement power. |
| 41 | 3 | ENERGYPOW - Energy and Power | The final SEIS needs to include offramps for financial protection of the Basin Fund. WAPA has long been relied upon to produce hydropower impact analyses in support of the Bureau's proposed actions related to experimental flows. WAPA's role in this regard makes sense because WAPA is the entity that markets and transmits hydropower resources generated at the dams and actively transacts in the wholesale power markets. In the DSEIS, Reclamation has produced its own analysis of hydropower impacts. However, the CRCNV is aware that WAPA has produced a competing analysis that is significantly more impactful to the hydropower community. The fact that stakeholders have two sets of competing numbers merely shows that there is a wide range of outcomes related to the impact of the experiments and, where there is a wide range of unresolved outcomes, there is significant financial risk to the Basin Fund. Costs for experimental flows are non-reimbursable costs, meaning that WAPA does not include them in power customer rates. The money to pay for experimental flows, which in this case is the cost of replacing lost generation, is taken out of the Basin Fund, but is not recovered from customers. While the Basin Fund has been used in the past to support experiments, those experiments were short-lived and far less costly. In this case, the cost of the flow options has the potential to bankrupt the Basin Fund within a short period of time, jeopardizing WAPA's ability to pay for the operation and maintenance of the CRSP facilities, support environmental programs such as the Upper Colorado River Recovery Implementation Program, support salinity programs, and provide irrigation assistance. Before any of the flow options are implemented, Reclamation and WAPA must identify a source of funding that is adequate to sustain the Basin Fund or include offramps to protect the Basin Fund to avoid its depletion. | Emergency operating criteria would continue as outlined in the LTEMP ROD. Reclamation will work closely with WAPA to address any necessary off-ramps due to a lack of replacement power. |

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| 41 | 2 | ENERGYPOW - Energy and Power | The final SEIS should discuss in greater detail the impact of each of the flow options on Western Area Power Administration (WAPA) and the hydropower community. The final SEIS should address the impacts of Reclamation's proposed actions on the powerplant equipment at Glen Canyon Dam, the financial impact of the proposed actions on the Basin Fund, and the impact of the proposed action on WAPA if it is unable to secure replacement power to meet its firm contractual commitments. It should also include important offramps that give stakeholders some protection if the proposed actions are ineffective, have unintended consequences or become cost prohibitive. | These infrastructure concerns are paramount for Reclamation, and the interim guidance is designed to protect the facility while potential solutions are explored and implemented. The LTEMP SEIS and associated modeling efforts considered operational and infrastructure constraints. Additional language has been added to Chapter 1 to address infrastructure concerns.<br><br>PLEXOS modeling has been added to the Final SEIS. The cumulative impacts section has been updated in Section 3.3. Emergency operations will continue as described in the LTEMP ROD, regardless of the alternative selected. The planning and implementation process will consider impacts on hydropower resources, with Reclamation closely collaborating with WAPA on operational decisions. Reclamation will work closely with WAPA to address any necessary off-ramps due to a lack of replacement power. |
| 42 | 3 | PROPACTION - Proposed Action | A primary concern of the Upper Division States' Representatives is that the Draft SEIS evaluates two proposed actions separately, yet neither action is informed by the potential impacts of the other on the resources and the impacts to other experiments. | LTEMP SEIS analyzes multiple experimental flows. The inclusion of HFEs and smallmouth bass flows under this SEIS does not link the two experiments. |
| 42 | 7 | CONSBIO - Consultation biology/ESA related | Additionally, the cumulative effects of the proposed operational alternatives may require additional compliance with consultation requirements under the Endangered Species Act. | Reclamation has considered and will continue to consider cumulative effects in its consultation process with the Service under Section 7(a)(2) of the ESA. Section 4.5 has been updated for the Final SEIS. |
| 42 | 28 | EDIT - Editorial | Also, a disproportionate amount of the text is dedicated to background information (e.g., Affected Environment sections) and could be incorporated by reference to the original LTEMP EIS. Instead, the Final SEIS should place more emphasis on clearly describing the analyses completed for the Environmental Consequences sections of the Draft SEIS and the findings of those analyses. | Thank you for your comment. The Affected Environment sections were written by subject matter experts who incorporated by reference as much information as was reasonable. However, the LTEMP SEIS needed to contain sufficient information to be a standalone document. |
| 42 | 1 | PN - Purpose and Need | As drafted, the purpose and need for modifying the High Flow Experiment (HFE) Protocol merely describes the proposed action Reclamation is seeking to take. The Final SEIS should describe the underlying need to modify the HFE Protocol. | Thank you for your comment. The need for modifying the HFE protocol is to improve Reclamation's ability to implement HFE releases. This is based on the latest scientific information. Details of the proposal to amend the HFE protocol can be found here: https://www.usbr.gov/uc/progact/amp/amwg/2023-08-17-amwg-meeting/20230817-ProposalAmendHigh-FlowExperimentProtocolOtherConsiderations-508-UCRO.pdf. |
| 42 | 18 | CUMU - Cumulative Impacts | Because the Draft SEIS evaluates the two proposed actions separately, neither action is informed by the potential impacts of the other. There is potential for compounding effects if both actions are implemented within the same year. The full impacts and tradeoffs of potential implementation of both actions outlined in the Draft SEIS within the same year should be analyzed and considered, including the full range of impacts of potential multiple bypass actions within a single HFE implementation window. | The LTEMP SEIS analyzes multiple experimental flows. The inclusion of HFEs and smallmouth bass flows under this SEIS does not link the two experiments. However, modeling in the LTEMP SEIS includes both changes to HFE protocol and smallmouth flows to best show potential compounding impacts. |
| 42 | 13 | AQUA - Aquatic Resources | Because the intention of most of these operational alternatives is to reduce water temperatures, the Final SEIS should take into further consideration that SMB may behaviorally avoid cold-water temperatures and seek warmer temperatures downstream, along the channel margins, in backwaters or in tributaries to the river such as the Little Colorado River. This is imperative as the Draft SEIS does not provide evidence that SMB would not potentially be displaced downstream. Other literature, not specific to this River system, suggests that as water temperatures decline below 15degC, SMB migrate to deeper water and are known to migrate more than 47 miles to reach winter refugia (Breton et al. 2014). | The Final SEIS has been updated to include further analysis on smallmouth bass displacement. Please see Section 3.5 for additional information. Reclamation will continue to monitor fish population and adaptively manage for any displacement. |

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| 42 | 36 | WATERQUAL - Water Quality | Downriver warming of water released from Glen Canyon Dam is calculated with an adaptation of the model developed by Dibble et al. (2021) for SMB flow alternatives. Dibble et al. (2021) includes a description of their model and documentation of the performance of their model relative to measurements; however, it is not clear if similar model performance is still achieved when the model is adapted from a monthly to daily scale for the Draft SEIS. The Final SEIS should include the performance of the adapted model as applied for the Draft SEIS. | Reclamation will use the best available models to forecast water temperatures while making adaptive management decisions in the future.<br><br>Overall, the model performs well, even with the change from a monthly to daily timestep. The signed error (Bias) did not change and while root mean squared error (RMSE) increased, the daily timestep provides more information on timing of when temperatures would exceed a target threshold. There is good agreement between the observed and modeled daily temperatures, though there is higher error, compared with an evaluation of mean monthly temperatures. They both display similar biases, but the fit, expressed in RMSE, is better with the monthly data. The higher variability of daily temperatures (compared with monthly temps) is contributing to the greater RMSE when the model moves from monthly to daily timesteps in the Dibble model. There is also an increase in error moving downstream, reflecting the influence of local meteorology on water temperature. In addition (discussed in the supplemental materials [S2] of Dibble et al. 2021), the time of year affects the error as well. This explanation was added to the SEIS. |
| 42 | 46 | CUMU - Cumulative Impacts | For all alternatives, the combined effects of the SMB and HFE releases have minimal analysis, except under the Geomorphology/Sediment Analysis (Section 3.4). Generally, the focus of this Draft SEIS appears to be on SMB releases. For Spike Flow Alternatives, any analysis related to HFE releases appears to simply be subsumed into the analysis of the spike flows. For Non-Spike Flow Alternatives, the analysis for HFE releases seems minimal, and generally limited to geomorphology/sediment issues. The combined effects of the SMB and HFE releases should be more fully analyzed and described in the Final SEIS. | Modeling in the LTEMP SEIS includes both changes to HFE protocol and smallmouth bass flows to best show potential compounding impacts. Impacts from HFE protocol changes are minimal and are mostly covered in the original LTEMP FEIS. |
| 42 | 35 | AQUA - Aquatic Resources | Further clarification of the choice of 16deg with a 0.5degC margin is needed, given that spawning is shown as low as 13degC in Figure 3-23 in the Draft SEIS. | Smallmouth bass can spawn at 13°C; however, the majority initiate spawning at 16°C, as evidenced by the Upper Basin work. Bestgen showed that smallmouth bass in the Upper Basin initiate spawning at 16°C. |
| 42 | 26 | AQUA - Aquatic Resources | Further, the document does not fully take into account the literature documenting reduced reproductive success of SMB due to timing and changing of flows (not temperature reduction) (Winemiller and Taylor 1982; Peterson and Kwan 1999; Larimore and Duever 1968; Bestgen and Hill 2016; Bestgen 2018). | Most of these references are cited in the document. We considered the additional sources for the Final SEIS. |
| 42 | 33 | AQUA - Aquatic Resources | In addition to predicting SMB intrinsic rate of population growth (lambda, l) under the six flow alternatives, the Final SEIS should contain an estimate of the current SMB population size and analyses of how long it would take for SMB to establish and move downstream to the location of HBC given entrainment and spawning projections under a variety of hydrologic conditions. | This would require additional analysis that is not readily available. USGS, NPS, AZGFD, and the Service are monitoring population size in the Grand Canyon. Population sizes are currently too small for mark/recapture abundance estimates. Reclamation and its partners will continue to monitor fish population in Grand Canyon. |
| 42 | 22 | AQUA - Aquatic Resources | In particular, the Final SEIS should provide a clear assessment of the magnitude and timing of the risk SMB pose to HBC. Without such an assessment of the risk to HBC from SMB, it is unclear to the reader why there is an urgent need for operational alternatives to control SMB. | The best available tool for evaluating risk to humpback chub is the smallmouth bass model and the predicted lambdas. Reclamation and its partners will continue to monitor fish in the Grand Canyon and monitor risk for the post-2026 EIS. |
| 42 | 10 | ALTRANGE - Inadequate Range of Alternatives | Moreover, the operational alternatives analyzed in the Draft SEIS may individually need to be implemented depending on conditions. The Upper Division States' Representatives recommend that more than one single operational alternative be available for implementation in a given year. | Reclamation is committed to implementing adaptive management strategies in the LTEMP SEIS. Additional language has been added to Chapter 1, including descriptions of the planning and implementation process. The LTEMP ROD will further discuss implementation of alternatives. |

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| 42 | 20 | ALTRANGE - Inadequate Range of Alternatives | Operational alternatives alone are insufficient to meet the purpose and need of the proposed action due to continuing entrainment of SMB through Glen Canyon Dam. Any use of operational alternatives to help disrupt establishment of non-native species should be implemented in conjunction with non-operational alternatives (e.g., -12-mile slough modification and installation of a fish exclusion device) as detailed in the Non-Native Fish Strategic Plan2. The Draft SEIS recognizes the concurrent efforts to implement such non-operational alternatives; however, it is unclear whether these concurrent actions are considered and analyzed in the impacts to fisheries, particularly under the No Action Alternative. It is also important to note that, as detailed in the Non-Native Fish Strategic Plan, the actions considered in the Draft SEIS may not be successful in the absence of timely implementation of the additional, non-operational alternative management actions. | Reclamation is currently pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. These efforts are out of scope for this NEPA effort. Impacts from these additional projects will be analyzed in separate NEPA efforts and will include cumulative impacts from the LTEMP SEIS. |
| 42 | 31 | PN - Purpose and Need | Reclamation inconsistently describes the proposed action and purpose of SMB flow alternatives within the Draft SEIS. For example, in the Proposed Action section of the Draft SEIS, Reclamation indicates that "the reduction of water temperature and adjustments in flow velocity may serve as essential tools to disrupt the successful spawning and establishment of SMB." Within the Purpose of and Need for Action section, Reclamation indicates that "the need is to disrupt the establishment of SMB below Glen Canyon Dam by limiting additional recruitment...". Spawning is the act of reproducing and is the first step in recruitment. However, recruitment also involves growth and transitioning to different life stages. Disrupting spawning is a good way to lead to recruitment failure, but spawning and recruitment are two different things and should not be used interchangeably. Also, because SMB are being entrained through the dam, additional SMB continue to be recruited into the system. | The goal of the smallmouth bass experiments is to reduce or reverse population growth by impacting spawning and, to a lesser degree, other life cycle stages and entrainment. Chapter 1 has added clarifying language to emphasize the broader goal of reducing smallmouth bass populations below the dam. |
| 42 | 44 | ENERGYPOW - Energy and Power | Section 3.3.1 provides a thorough description of multiple components of hydropower production and distribution. Section 3.3.2 is too narrowly focused and needs to address potential impacts to the various components described in 3.3.1. Further, the average of thirty traces, including the years in which no experiment was triggered, is not a sufficient metric to analyze hydropower impacts as it mutes the larger extreme impacts. For the Cool Mix Alternative, the average of all 30 traces, including zeros, at RM 15 is 147 GWh, while the average of the 8 traces in which an experiment is triggered at RM 15 is 584 GWh. The economic impact of the Cool Mix Alternative increases from an estimate of $12.82M (averaging all 30 traces) to an average of $60.72M (averaging the 8 traces that trigger an experiment at River Mile 15) (WAPA GTMax Model 2024). Additionally, Table 3-15 shows that the 90th percentile and maximum statistics are considerably larger than the average, suggesting that, when flow experiments occur, the impacts are large. These larger impacts should be more fully considered in the Final SEIS. | While this is a fast-track project to address physical and biological timing constraints, Reclamation worked closely with WAPA to ensure that the best available scientific information guided our decisions. Efforts have been made to model and understand the impacts to the grid system to the best of our ability within the project’s timeline. Reclamation remains committed to addressing these concerns and ensured that the Final SEIS reflects the most accurate and up-to-date information available. It is important to note that we used WAPA’s analysis to inform our decisions. |
| 42 | 43 | ALTASSUMP - General Assumptions Common to All Alternatives | The adjustment of the sediment accounting period allows for more discretion related to HFE releases in the spring or fall. However, the Draft SEIS does not explain its assumption that spring HFEs are preferred over fall HFEs, nor why increasing the likelihood of spring HFEs by 26% is beneficial. Additionally, the Draft SEIS lacks clarity regarding analysis of potential expansion of the HFE implementation window for different alternatives, including those with proposed flow spikes during the HFE implementation window. Section 3.4 Geomorphology/Sediment appears to provide the most robust analysis of the HFE flows, including (1) how changes to flow and the sediment accounting period would affect the probability of triggering HFEs; and (2)how flow fluctuations and flow spikes would affect sediment load transport, accumulation, and erosion. The Upper Division States' Representatives encourage Reclamation to include a similar level of detail regarding potential impacts of changes to the HFE implementation window. | The assumption that spring HFEs are preferred was used for modeling purposes to show the potential change when compared with the original LTEMP FEIS. The changes in HFE implementation are common to all action alternatives. Additionally, the revised protocol analyzed in this SEIS was developed through the AMWG. Details of the proposal to amend the HFE protocol can be found here: https://www.usbr.gov/uc/progact/amp/amwg/2023-08-17-amwg-meeting/20230817-ProposalAmendHigh-FlowExperimentProtocolOtherConsiderations-508-UCRO.pdf. |

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| 42 | 14 | SCOPE - Scope of the Analysis | The alternatives analysis must meaningfully discuss the impacts of the proposed action. The Draft SEIS includes one action alternative that modifies the HFE Protocol and separate action alternatives related to SMB that incorporate the modified HFE Protocol. The alternatives analysis for the action modifying the HFE Protocol, and the combined effects of the SMB and HFE releases do not take a hard look at the impacts of modifying the HFE Protocol. Additional modeling and impact analysis should be conducted regarding the HFE Protocol. The HFE modeling should extend through the entire period of the LTEMP to comport with the intention stated in this Draft SEIS. | The changes in HFE implementation are common to all action alternatives and therefore are combined with impacts from the smallmouth bass flow experiments. The changes to the HFE protocol are minimal in and of themselves and are mostly covered in the original LTEMP FEIS. |
| 42 | 24 | EDIT - Editorial | The document would benefit greatly from review by a technical editor to reduce repetitive text, especially in the Description of Alternatives. Also, unnecessary technical jargon such as "univoltine" and "multivoltine" species should be replaced with plain language. | Thank you for your comment. Technical editors have reviewed the Final SEIS. |
| 42 | 29 | POLICYGOV - Policy and Governance | The Draft SEIS describes the implementation of the Spring 2023 HFE as occurring "outside the HFE protocol, but consistent with LTEMP."1 The Upper Division States' Representatives raised concerns about the implementation of the Spring 2023 HFE, particularly with respect to the process and compliance with the LTEMP ROD. The Upper Division States' Representatives believe the Supplemental Information Report did not demonstrate that the action was in compliance with the LTEMP. | Thank you for your comment. Although mentioned in the Draft SEIS, the Spring 2023 HFE is not the subject of analysis because it is not within the scope of the alternatives. |
| 42 | 17 | AQUA - Aquatic Resources | The Draft SEIS discusses how increasing water temperatures has helped humpback chub (HBC) populations grow as it increases their hatching success, larval survival, and larval and juvenile growth; improve swimming ability; and reduced predation vulnerability (Hamman 1982; Ward 2011; Ward and Morten-Starner 2015). Therefore, the effects of the proposed operational alternatives target temperature of 15.5degC should be analyzed as they may negatively impact HBC, which have demonstrated increased survival and success due to warmer water temperatures. | The reduced temperatures are not expected to negatively affect adult and juvenile humpback chub. Most humpback chub populations are sufficiently far from Glen Canyon Dam, so temperatures will be moderate and warm. Additional analyses will be conducted in the post-2026 EIS. |
| 42 | 39 | ENERGYPOW - Energy and Power | The Draft SEIS does not include an initial statement at the beginning of Section 3.3.2 to describe why two modeling approaches (from two different entities)were used for the hydropower analysis. The Upper Division States' Representatives recommend including in the Final SEIS only the analysis and tables of information provided by WAPA as part of its comments on the Draft SEIS. | Reclamation incorporated WAPA’s findings as necessary in finalizing the SEIS. The PLEXOS modeling results have been included in the Final SEIS to enhance the analysis of impacts on hydropower resources. WAPA’s proposed Section 3.3 on Energy and Power was thoroughly reviewed. |
| 42 | 50 | AQUA - Aquatic Resources | The Draft SEIS does not provide specifics or provide a risk assessment on the threat posed by SMB located between Glen Canyon Dam and Lees Ferry (river mile 0), to the population of HBC primarily located at river mile 61 near the Little Colorado River, beyond generally referencing the large impacts to HBC populations from SMB in the Upper Colorado River Basin. The Final SEIS would benefit from modeling the rate and time of the expansion of SMB into HBC habitat using assumptions for temperature, population growth and expansion and other parameters. On page 3-68, the Draft SEIS states the modeling used for SMB is currently not linked to other population models, including the HBC; therefore, it is not clear whether SMB would prove to be a significant threat to the threatened species. Also, noted on page 3-86, high velocities of HFE releases could displace nonnative fish, such as green sunfish (Lepomis cyanellus) and SMB, into population centers of HBC, where nonnative fish prey on and compete with the native fish. Adding specifics in the Final SEIS could provide a rationale for not only the Proposed Action, but also the selection of the preferred Alternative. The Draft SEIS discusses how increasing water temperatures has helped HBC populations grow as it increases their hatching success, larval survival and larval and juvenile growth, improved swimming ability, and reduced predation vulnerability (Hamman 1982; Ward 2011; Ward and Morten-Starner 2015). Therefore, the effects of the operational alternatives target temperature of 15.5degC should be analyzed and presented in the Final SEIS as they may negatively impact HBC, which have been shown to have increased survival and success due to warmer water temperatures. | The smallmouth bass model was only recently developed. It will be refined as more and new data are collected from monitoring and research that will help refine the model parameters. This refinement will continue into the post-2026 EIS. Also, the smallmouth bass model is not currently linked to other demographic models, such as the humpback chub model or a preliminary model for rainbow trout. Reclamation will continue to work with the USGS and other agencies to refine these analytical tools and ensure that monitoring is providing the best available scientific information. |

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| 42 | 38 | HYDROLOGY - Hydrology | The Draft SEIS does not provide the level of justification needed for the use of only 30 hydrologic traces, which are the basis for most analyses in the Draft SEIS. Additional information is needed to: 1) clarify the criteria for choosing the 30 hydrologic traces out of the 90 considered in the Interim Guidelines SEIS, 2) demonstrate that 30 traces will produce statistically valid results, and 3) quantify the extent to which the 30 traces provide "a wide range of hydrologic conditions" and "a robust range of monthly data." This information should be provided in the Final SEIS. | The project timeline does not allow for further modeling. Reclamation used the best available hydrologic modeling during the analysis and considers it a robust representation of recent hydrology. This SEIS is focused within existing LTEMP limits and therefore 30 traces were sufficient. |
| 42 | 47 | WATERQUAL - Water Quality | The Draft SEIS inconsistently describes how flow alternatives would be implemented according to temperature and river mile targets. The initial modeling assumption section states that action alternatives are initiated if water temperatures either at river mile 15 or river mile 61 are at or above 15.5degC [page 2-4].It also states that temperature targets for cold water alternatives were calculated either at river mile 15 or river mile 61 [e.g., page 2-8]. Later sections imply that the four bypass alternatives are designed to maintain temperature targets or a cold shock all the way down to the Little Colorado River (river mile 61) [e.g., pages 3-88 to 3-94]or would be initiated based on temperature at the Little Colorado River [e.g., page 2-15]. The Non-Bypass alternative is also described to be initiated based on forecasted temperatures in areas where spawning is observed, such as the -12-mile slough [e.g., pages 2-17, 3-95]. The Final SEIS should ensure that all river mile implementation assumptions are consistent and expressly related to mainstem temperature targets either at river mile 15 or 61. | Reclamation has revised the Final SEIS to address any inconsistencies. |
| 42 | 49 | ALTSHKSPK - Alternatives - Cold Shock with Flow Spikes | The Draft SEIS inconsistently describes when flow spikes maybe available or implemented. As an example, the Draft SEIS notes that flow spikes could occur during 1) May, June, July, August, and September [e.g., page 2-17], 2)during May to July [e.g., page 3-103], and 3) June to mid-July [e.g., page 3-103]. The timing of flow spikes should be a consistent assumption and reflected as such throughout the Final SEIS. | The Final SEIS has been updated to ensure consistency in describing the timing of flow spikes throughout the Final SEIS. This includes clarifying when flow spikes may be available or implemented. However, the actual implementation and the modeling assumptions may differ slightly, as described in Chapter 2. |
| 42 | 51 | EDIT - Editorial | The Draft SEIS mentions on page-4-3 that a Biological Assessment (BA) was developed in relation to LTEMP. Because there is no citation, it is unclear if this is a reference to the original LTEMP BA or a new BA related to the LTEMP Draft SEIS. | This paragraph has been clarified based on the ongoing consultation with the Service. |
| 42 | 42 | EDIT - Editorial | The Draft SEIS must distinguish more clearly between the two distinct Eppehimer et al. (2024) references, the manuscript for publication and the United States Geological Survey data repository. | The Final SEIS has incorporated the latest GCMRC report (GCMRC 2024) and clarified the difference between that report and the Eppehimer et al. (2024) reference. |
| 42 | 41 | ALTASSUMP - General Assumptions Common to All Alternatives | The Eppehimer et al. (2024) pre-print report does not provide specifics regarding modeling methodology and/or data used to support models, and instead refers to supplemental materials, which makes it more difficult for the reader. *The Eppehimer et al. (2024) pre-print admits that the model could be improved by refining certain model inputs, including the quantification of life-stage specific entrainment survival. Given the statement on page 6 of the Supplemental Materials, which states that the entrainment survival rate could be biased either high or low, it is difficult to have confidence in this estimate. | The Eppehimer and Yackulic smallmouth bass model included in the GCMRC report (GCMRC 2024) is a valuable tool for assessing the potential for smallmouth population growth rate under each of the flow alternatives.<br>We have expanded discussions within the Final SEIS to provide more context and understanding for readers on the significance of the lambda values and how to use them to compare effectiveness across the different flow alternatives.<br><br>Lambda values represent the population growth rate: values greater than 1 indicate population growth, and values less than 1 indicate population decline. We have also included a new table (see Table 3-35 in the Final SEIS) that shows the percentage of 30 traces with lambda greater than 1 for each of the six alternatives at river miles 15 and 61. This information is presented in a clear and understandable format to enhance the reader's understanding of the model and its implications for each alternative. |

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| 42 | 21 | EDIT - Editorial | The Final SEIS should be reviewed by a technical editor to reduce repetitive text, delete unnecessary technical jargon, provide clear citations, and clearly and thoroughly describe the analyses and findings. | Thank you for your comment. Technical editors have reviewed the Final SEIS. |
| 42 | 27 | DATA - Data Sources | The Final SEIS should be updated to include the most recent studies and citations. For example, the Aquatic Resources section [pg. 3-82] contains extensive detail on prior fish removal efforts, but there is a lack of recent information beyond 2018. The Final SEIS should include recent information on SMB rapid response actions as well as targeted efforts in the slough. In addition, clear citations should accompany any data provided. Citations should provide access to full bodies of work to demonstrate that the best available information and science is being utilized. Presentations supporting the Draft SEIS, such as the January 2023 temperature modeling presentation (Mihalevich), should be listed in the Draft SEIS with a link to slides and/or other presentation materials. | The Final SEIS has been updated to include additional references and citations, including the GCMRC report (GCMRC 2024). Links are included in the full references where feasible. The Final SEIS also includes as much information as possible on targeted efforts in the slough. Additional NEPA efforts are required for that work. |
| 42 | 9 | COOPGEN - General Agency Cooperation | The Final SEIS should clarify and expressly state that implementation of operational alternatives is temporary and will follow the communication and consultation processes that have been developed according to Section 1.4 of the LTEMP Record of Decision. | The LTEMP FEIS ROD has been incorporated by reference. Additional implementation language has been added to Chapter 2. |
| 42 | 37 | SCOPE - Scope of the Analysis | The Final SEIS should include a monitoring plan to track impacts to the structural integrity of the bypass tubes and identify "offramps" for termination of the use of the bypass tubes if the structural integrity is compromised. | Thank you for your comment. Reclamation will work with cooperators and stakeholders on adaptive management strategies and the planning and implementation process, including identifying off-ramps. Additional language has been added to Chapter 2, and further details will be provided in the ROD. |
| 42 | 34 | WATERQUAL - Water Quality | The Final SEIS should provide the basis for determining that the uncertainty in temperature forecasts is accounted for by a 0.5degC margin (i.e., the margin between the 16degC biological impact temperature and the 15.5degC used as the trigger in modeling flow alternatives) by providing 95 percent confidence intervals for the raw data used for this analysis. If variation in the uncertainty in temperature forecasts is larger than 0.5degC, a different temperature trigger may be required to adequately address uncertainty in temperature modeling of the flow alternatives. Demonstrated downriver model performance against measurements and the calculated model uncertainty for downriver warming are needed for the downriver temperature model as it was applied, after adaptation of the model of Dibble et al. (2021). | Reclamation has included additional details on the planning and implementation process in Chapter 2 of the Final SEIS. This process includes a combination of analysis using temperature modeling and observed temperatures. Further details will be provided in the ROD. |
| 42 | 25 | SCOPE - Scope of the Analysis | The Final Supplemental Environmental Impact Statement (SEIS) should provide a clear assessment of the magnitude and timing of the risk smallmouth bass (SMB) pose to humpback chub (HBC). For example, the document does not fully provide a rationale for assuming the necessity and effectiveness of any of the temperature-based operational alternatives at disrupting SMB establishment and population growth through spawning because SMB spawning has been documented at temperatures as low as 12.5degC (Graham and Orth, 1986). It is unclear if any of the operational alternatives will reduce water temperatures below 13degC. | The Draft SEIS and Final SEIS both state the underlying assumptions of the smallmouth bass model, which demonstrate that some flow alternatives would affect the population growth rate below 1 (indicating negative population growth). Reclamation also disclosed other non-flow-related projects that are being considered by Reclamation and other agencies that could be accomplished in the future. |

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| 42 | 15 | GEOSEDI - Geomorphology and Sediment | The Flow Ad Hoc Group of the Technical Work Group, in partnership with the Grand Canyon Monitoring and Research Center and Reclamation, developed a Proposal to Amend the HFE Protocol and Other Considerations (Proposal). The Proposal was accepted by the Technical Work Group and recommended and accepted by the Adaptive Management Work Group in the Fall of 2023. The Proposal recommends several additional analyses necessary to appropriately formulate HFE Protocol alternatives and fully analyze impacts. Based on the Proposal, the Final SEIS should analyze: 1. the risk of spring HFEs to distribute nonnative fish farther downstream and whether that risk is significantly less than implementation of fall HFEs; 2. potential treatment of rollover sediment; 3. sediment accounting windows longer than one year; 4. the full potential impact to hydropower generation, the power grid, and hydropower customers and beneficiaries, including Tribal Nations and disadvantaged communities; and 5. impacts to cultural resources. The Upper Division States' Representatives recommend the Proposal be used to amend the HFE Protocol, and the amended Protocol be utilized in the Final SEIS. | 1. The planning and implementation process will analyze and consider issues such as the distribution of nonnative fish further downstream when considering experiment implementation recommendations.<br><br>2. Sediment rollover is included in this Final SEIS, and the document has been updated to clarify its use. However, modeling assumptions were based on annual accounting periods due to the difficulty in predicting decisions to not implement an HFE when sediment triggers are met.<br><br>3. The language has been updated to more clearly reflect the use of sediment rollover.<br><br>4. This issue is being addressed with the addition of the PLEXOS model.<br><br>5. Cultural resources were fully analyzed in the LTEMP FEIS, with no additional impacts identified in the LTEMP SEIS. The LTEMP PA addresses any adverse effects on historic properties. |
| 42 | 16 | AQUA - Aquatic Resources | The LTEMP Record of Decision and the Biological Opinion document concerns regarding impacts to fisheries from HFEs. Specifically, there is concern that HFEs and other experiments, such as "Bug Flows", may actually promote the establishment of warmwater non-native species by relocating the species farther downstream or by creating more suitable habitat, respectively. This concern is supported by research conducted by Breton et al. 2014. The Final SEIS should evaluate this potential risk or clarify how risks from the proposed operational alternatives differ from those risks presented by experimental flows. | There is no direct evidence for displacement during these high-flow events; however, measurement is difficult without tagging fish. Reclamation will monitor fish and associated resources through the Grand Canyon to determine responses to selected alternatives. Refinements or modifications will occur through adaptive management. |
| 42 | 30 | AQUA - Aquatic Resources | The paragraph regarding "equalization flows" on page 3-83 should be removed as it seems to have no relevance to this SEIS. | This paragraph was removed from the Final SEIS. |
| 42 | 5 | ALTRANGE - Inadequate Range of Alternatives | The scope of the Draft SEIS states the operational alternatives could be implemented between 2024 - 2027 and that "Reclamation's goal is to implement additional strategies in the future to prevent the establishment of smallmouth bass and other warmwater nonnative fish." The Final SEIS needs to include information regarding the "additional strategies" to prevent the establishment of SMB and other warmwater nonnative fish. The Upper Division States' Representatives recommend including expectations on timelines for implementation of mid- and long-term strategies, and prioritizing installation of an entrainment control device at Glen Canyon Dam. | Reclamation is currently pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. These efforts are out of scope for this NEPA effort. Impacts from these additional projects will be analyzed in separate NEPA efforts and will include cumulative impacts from the LTEMP SEIS. |
| 42 | 2 | SCOPE - Scope of the Analysis | The Upper Division States' Representatives agree that the stated purpose and need to "disrupt the establishment" of SMB below Glen Canyon Dam provides a more accurate description of the goal of the proposed alternatives and emphasizes the necessity of additional mid- and long-term actions. However, the Final SEIS must include metrics to evaluate the success of meeting the disruption goal. | Thank you for your comment. Reclamation plans to work closely with cooperators to evaluate and define success criteria. This process will include adaptive management strategies and is subject to change based on future conditions. Additional information may be included in the ROD. |

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| 42 | 12 | SCOPE - Scope of the Analysis | The Upper Division States' Representatives also recommend two additional points for inclusion in the Final SEIS: (1) offramps for emergency exception criteria, including a threshold below which the Upper Colorado River Basin Fund (established under Section 5 of the Colorado River Storage Project Act) cannot fall, and (2) the criteria Reclamation will use to evaluate the effectiveness of the chosen operational alternative(s) at disrupting SMB establishment. To determine the effectiveness of the operational alternatives for disrupting SMB establishment, Reclamation should include evaluation of: 1. spawning behavior of SMB before, during, and after implementation of an operational alternative; 2. estimated population sizes of SMB and select native fish species before and after implementation of an operational alternative in a given year and before and at the end of 2024 2027 experimental period; 3. evidence of displacement of SMB to warmer downstream waters; 4. evaluation of habitat and/or spawning behavior before and after flow releases; and 5. temperature monitoring through river mile 61 and specifically at some of the nearshore habitat areas, including the -12-mile slough to ensure that the releases effectively disrupt the nonnative species establishment in these environments that can act as refuges for nonnative species. | Reclamation will continue to work closely with WAPA in the planning and implementation process to establish off-ramps. Emergency operations at Glen Canyon Dam will not change under the Final SEIS. Reclamation plans to work closely with cooperators to evaluate and define success criteria. This process will include adaptive management strategies and is subject to change based on future conditions. Additional information may be included in the ROD. |
| 42 | 4 | SCOPE - Scope of the Analysis | The Upper Division States' Representatives also remain concerned about the two distinct timelines for the proposed actions, in particular how those different timelines impact the alternatives' analysis. The Draft SEIS is unclear as to which timelines are carried forward in the analyses. | Section 2.3 of the Final SEIS contains information on implementation of the proposed action, including the timelines for the smallmouth bass operations (2024–2027) and the changes to HFE protocol (the lifetime of the LTEMP). |
| 42 | 45 | COOPGEN - General Agency Cooperation | The Upper Division States' Representatives recommend WAPA and Reclamation coordinate the timing of any experiments to avoid implementing the alternative during peak energy use times in order to lower the costs of experiments. | Reclamation will continue to work closely with WAPA in the planning and implementation process to coordinate timing of HFEs. |
| 42 | 11 | COOPGEN - General Agency Cooperation | The Upper Division States' Representatives request that Reclamation create a process or schedule consistent with the existing LTEMP communication and consultation processes in order to provide Western Area Power Administration (WAPA) sufficient time to plan for experimental flows, including potential grid stabilization or replacement purchase power activities. | Reclamation will continue to work closely with WAPA in the planning and implementation process to coordinate timing of experiments, including allowing an adequate amount of preparation time. More information will be provided in the ROD. |
| 42 | 8 | ALTBYPASS - Alternatives - Non-Bypass | The Upper Division States' Representatives strongly encourage additional analysis of the non-bypass alternative in order to provide implementation flexibility, particularly in light of the structural damage to the bypass tubes following the most recent 2023 HFE. | Additional language has been added to Chapter 1 about operational constraints at Glen Canyon Dam. |
| 42 | 23 | EDIT - Editorial | The Upper Division States' Representatives suggest clarifying the description of Reclamation's duties in the following sentence under page 1-5, stating: "The Secretary is also vested with the responsibility of managing the mainstream waters of the Colorado River pursuant to federal law," by appending to the end of the sentence: "below Glen Canyon Dam." | The Final SEIS has been updated per comment. |
| 42 | 48 | ALTSHKSPK - Alternatives - Cold Shock with Flow Spikes | Throughout the Draft SEIS, flow spikes are sometimes referenced for the purposes of cooling side channel habitat [e.g., pages 2-1,3-12] and sometimes referenced for the purpose of increasing velocities to reduce spawning habitat [e.g., pages 2-8, 2-20]. While flow spikes may accomplish both, the Final SEIS needs to be clear about the primary intent of flow spikes, as temperature and velocity are two different variables. | The Final SEIS has been updated to clarify impacts from flow spikes.<br>As described in the comment, flow spikes can cool side channel habitat and reduce spawning habitat. |
| 42 | 19 | ALTNO - Alternatives - No Action | Throughout the Draft SEIS, Reclamation frames the impacts under the No Action Alternative in terms of ongoing drought, aridification, and low reservoir conditions. While these conditions are integral to the underlying purpose and need for the proposed actions, the proposed operational alternatives do not directly mitigate or address drought and low reservoir conditions. Drought will likely continue to impact resources under the action alternatives as well as under the No Action Alternative. The Upper Division States' Representatives recommend that Reclamation reframe the impacts under the No Action Alternative to better align with the proposed actions. | Effects from all of the alternatives are generally framed within climate change/aridification (especially the Hydrology section (Section 3.2), not just the No Action Alternative. |

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| 42 | 32 | ALTASSUMP - General Assumptions Common to All Alternatives | Throughout the Draft SEIS, the lambda (l) variable is used to represent populationgrowth rate and describe effectiveness of alternatives. Since this is the metric beingused to assess the effectiveness of alternatives, the Final SEIS must includeadditional explanation about the variable (e.g., What does it mean when Lambda > 1?What does Lambda < 1 mean? Does a lambda of 1.5 carry the same weight as a lambdaof 2 or 3?) | In response to your feedback, we have included additional explanation about the lambda (λ) variable in the Final SEIS. Lambda is used to represent the population growth rate and describe the effectiveness of alternatives. When lambda > 1, it indicates that the population is increasing, meaning that the alternative is effective in promoting population growth. When lambda < 1, it indicates that the population is decreasing, meaning that the alternative is effective in reducing the population. The value of lambda provides a relative measure of effectiveness, with higher values indicating greater effectiveness. |
| 42 | 40 | WATERQUAL - Water Quality | Water Quality impacts (Section 3.11) were analyzed using the CE-QUAL-W2 model, yet the SMB population growth model incorporates Glen Canyon Dam release temperatures that are modeled based on historical data from 2000-2021 (Eppehimer et al 2024). The Final SEIS should justify the use of the Eppehimer 2024 model over the more established CE-QUAL-W2 model that is traditionally used by Reclamation, as the Eppehimer model: 1) only includes data through 2021, and 2) still has a Root Mean Square Error of 1.28degC for 2023(GCDAMP 2024 Annual Reporting Meeting, January 23, 2024). The use of a separate temperature model introduces additional uncertainty especially if the implementation of alternatives will be based on temperature forecasts using Reclamation's standardCE-QUAL-W2 model. *The Final SEIS should include figures of the fitted and actual temperature profiles to assess the fit of actual vs modeled data and relative accuracy of the analysis. *The Final SEIS Section 3 discussion needs to be expanded to include displays of the temperature residuals (i.e., modeled minus observed). *The Root Mean Square Error and the residuals from the model testing should be evaluated in the context of the 0.5degC temperature difference factor associated with the use of 15.5degC as the trigger in the SMB flow alternatives rather than the 16degC temperature requirement for SMB oviparity and Young-Of-Year growth. | The use of Eppehimer allowed for more traces to be analyzed due to the faster nature and ease of use; timing is highly important to meet the NEPA timeline. Additionally, CE-QUAL allows for additional outcomes, including total dissolved solids (TDS). Both are robust models that have been used in an appropriate manner to cover a range of potential impacts. Reclamation will use best available modeling data and actual data to make future adaptive management decisions. |
| 42 | 6 | POLICYGOV - Policy and Governance | With respect to concurrent NEPA actions on other Colorado River Operations, Section 1.8 of the SEIS should state that additional environmental analysis and compliance for the LTEMP may be needed for any post-2026 operations, as the LTEMP is subject to Glen Canyon Dam annual releases. | Reclamation does not want to speculate on future NEPA actions. Any cumulative impacts require additional details and will be analyzed in the post-2026 EIS. |
| 43 | 4 | SCOPE - Scope of the Analysis | It is recommended that Reclamation include in the preferred alternative the full array of flow option alternatives analyzed in the DSEIS. As the actions are experimental in nature, the use of a range of potential flows will allow adaptive management to address changing conditions on the river. The implementation of the various flow options would be subject to warmwater nonnative fish population size and distribution, hydrology, reservoir elevations, water temperature, and potential impacts to infrastructure. | Reclamation has identified the Cool Mix Alternative as the preferred alternative in the Final SEIS. Reclamation has included adaptive management strategies in the Final SEIS to allow for implementation changes in future years. |
| 43 | 12 | POLICYGOV - Policy and Governance | Meaningful consultation with the States must continue before Reclamation considers implementation of any of the alternatives described in the DSEIS. The Basin States' Representatives request that the current Communication and Consultation Process described in the LTEMP ROD continue to be utilized to analyze the various flow options, including discussion of their impacts on Glen Canyon Dam operations and critical infrastructure, in order to recommend flow experiments to the Secretary of the Interior. The Communication and Consultation Process must also consider circumstances when an experiment may warrant discontinuation and evaluate the flow options throughout the potential periods of implementation. Adequate notice of the timing of a planned flow experiment will be necessary to facilitate consideration of potential resource impacts, to coordinate monitoring prior to, during, and following the implementation of the flow options, and to address impacts to the Basin Fund and market grid reliability. Successful implementation will necessitate reliable temperature models and meetings to occur in a timely manner before a potential trigger is hit. | Reclamation is not proposing any changes to the consultation process described in the LTEMP FEIS ROD. Reclamation will continue to coordinate with cooperators and stakeholders during the planning and implementation process. |

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| 43 | 11 | AQUA - Aquatic Resources | Potential conditions for discontinuing the experimental flow options should be informed by the monitoring of warmwater nonnative fish species and consideration of the effectiveness of actions. To ensure decisions are well-informed, adequate analysis and data collection should occur before, during, and following a flow experiment. Several factors to consider when evaluating the potential discontinuation of warmwater nonnative fish management actions are included in the Strategic Plan (see Section 3.4, page 11, titled "Offramps"). This information should be used to inform the Communication and Consultation Process | USGS, NPS, AZDFG, and the Service are monitoring populations in the Grand Canyon. Reclamation and its partners will continue to monitor fish population in the Grand Canyon and use this information to make adaptive management decisions. Additional language has been added to Chapter 2 regarding the planning and implementation of experiments. |
| 43 | 1 | ENERGYPOW - Energy and Power | Reclamation has made public statements regarding significant infrastructure concerns associated with LTEMP ROD experimental operations at Glen Canyon Dam and releases through the River Outlet Works (ROW). The most recent such statement was provided by the Secretary of the Interior's Acting Designee during the February 28-29, 2024 meeting of the Adaptive Management Work Group. While the Basin States' Representatives support Reclamation's efforts to address the threat of warmwater nonnative species, we oppose proposed experimental operations that use the ROW if such operations may negatively affect the rights afforded to the Colorado River Basin States through the Law of the River. While the DSEIS indicates that the ROW flow releases could be reduced to half tube increments, it is not clear what potential impacts may occur if the ROW are used at a reduced rate at any given reservoir elevation and for an extended duration. The operation of the ROW for experimental environmental flows should be an opportunity to further our understanding of their integrity and vulnerabilities. Therefore, thorough inspections and observations should occur before and after potential implementation of the flow options, maintenance should be consistent and preventative, and experimental flows should not occur if there is a risk that they will cause irreparable damage to the ROW. | Chapter 3 has been updated to address infrastructure concerns. These infrastructure concerns are of paramount importance to Reclamation, and the Final SEIS is designed to protect the facility while potential solutions can be explored and implemented. The LTEMP SEIS and the associated modeling efforts considered operational and infrastructure constraints. |
| 43 | 8 | SCOPE - Scope of the Analysis | Since an HFE only alternative was not analyzed, it is difficult to differentiate between potentially short-term impacts stemming from the combined proposed actions (HFEs and smallmouth bass flows through 2027) and longer-term impacts (HFEs only from 2027 to 2036). Additional information should be provided to differentiate these impacts. | Additional analysis has been included in the Final SEIS to analyze impacts to resources during months when experiments are implemented and annual averages. |
| 43 | 6 | GEOSEDI - Geomorphology and Sediment | The GCDAMP's HFE Amendment Proposal highlights additional considerations that were not included in the DSEIS, including specific language changes to the HFE protocol and additional research questions to analyze during the implementation of Spring HFEs. The Basin States' Representatives would like to see the HFE protocol amended to include the proposed changes from the HFE Amendment Proposal and the complete updated protocol included in the Final SEIS for clarity regarding the proposed action. | Thank you for your comment. Updates to the HFE protocol will be provided during the planning and implementation process. |
| 43 | 7 | CUMU - Cumulative Impacts | The interactions between the various flow alternatives designed to disrupt smallmouth bass spawning and the proposed adjustment to the HFE sediment accounting period and implementation window are not clearly documented in the DSEIS, making it difficult to comment on the cumulative impacts if the actions were to occur within the same year. Further analysis should be provided to better inform the communication and consultation process as specified in Sections 1.3 and 1.4 in Attachment B of the ROD (Communication and Consultation Process) that is further discussed below. This was also a recommendation in the GCDAMP's HFE Amendment Proposal. | Analysis and models for each alternative considered both smallmouth bass experiments and changes to the HFE protocol. |

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| 43 | 2 | AQUA - Aquatic Resources | The need for actions to prevent the establishment of warmwater nonnative fish species has been acknowledged by the Glen Canyon Dam Adaptive Management Program (GCDAMP). A consensus-based document titled "Invasive Fish Species Below Glen Canyon Dam: A Strategic Plan to Prevent, Detect, and Respond" (Strategic Plan) was recommended for adoption by the Secretary of the Interior by the GCDAMP's Adaptive Management Work Group in February of 2023. The Strategic Plan as well as the "Proposal to Amend the High-Flow Experiment Protocol and other Considerations" (HFE Amendment Proposal), are guiding documents from the GCDAMP. The Basin States' Representatives support continued reliance on these reference documents in the DSEIS. | Thank you for your comment and support. We considered these comments in the development of the Final SEIS. |
| 43 | 10 | AQUA - Aquatic Resources | While minimization of predation on humpback chub is the intent behind the experimental flow options, it is imperative that potential impacts to humpback chub from the flow options themselves are closely monitored. If the experimental flows are found to negatively impact the humpback chub population below the current triggers identified in the 2016 Biological Opinion, Reclamation should immediately discontinue the use of the flow actions and consider alternative measures. | This evaluation and refinement would be accomplished under adaptive management. Additional language has been added to Chapter 2 regarding the planning and implementation of experiments. |
| 43 | 3 | ALTRANGE - Inadequate Range of Alternatives | While the actions in the DSEIS are experimental in nature and of a limited duration, the long-term management of an invasive species is often far more costly than short-term prevention efforts. The Basin States' Representatives would like to see actions taken to address the threat of warmwater nonnative fish in the Colorado River ecosystem and maintain that a multi-faceted approach, such as potential installation of a fish exclusion device and modification of the -12-mile slough, are necessary. | Reclamation is currently pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. The timeline for these efforts differs from this NEPA effort. These efforts are out of scope for this NEPA effort. |
| 43 | 5 | AQUA - Aquatic Resources | While the DSEIS acknowledges the choice in temperature target of 15.5degC (Chapter 3, page 3-70) for the flow options was based on observations of smallmouth bass in the Upper Colorado River Basin, the Basin States' Representatives want to acknowledge the potential for smallmouth bass to spawn at temperatures as low as 12.5degC in other systems as indicated in Figure 3-23, page 3-55. While many factors play into a species spawning success, it is imperative that Reclamation consider this range in temperature while evaluating the effectiveness of the proposed actions. If smallmouth bass are found to be spawning in the Colorado River at temperatures below the 15.5degC target, flow options should be reevaluated and potentially discontinued. | The potential for spawning to temperatures as low as 12.5°C has been considered during the development of alternatives, as evidenced by the Cold Shock Alternatives. Reclamation considered your comments during the selection of the preferred alternative. |
| 44 | 7 | PI - Public and Stakeholder Involvement | Notably, the Bureau's stated next steps are to release a final SEIS with Record of Decision by "early summer 2024", less than one year after this NEPA process was formally initiated.7 This timeline does not allow for incorporation of the hydropower analysis nor is it sufficient time to analyze the impacts of the proposed action on the hydropower system, thereby raising questions of predetermination. | Due to the immediate threat posed by smallmouth bass, Reclamation was forced to act on an expedited timeline to conduct this NEPA effort. Reclamation worked closely with WAPA and other hydropower cooperators to incorporate an adequate impact analysis of hydropower resources. See Section 3.3 for additional information. |
| 44 | 1 | POLICYGOV - Policy and Governance | a. WAPA's hydropower analysis constitutes significant new information pursuant to 40 CFR 1502.9(d)(ii). On March 15, 2024, WAPA provided the Bureau with a hydropower analysis that proposes edits to Section 3.3 of the Draft SEIS. 40 CFR 1502.9(d)(ii) mandates that the Bureau "prepare supplements to either draft or final environmental impact statements if a major Federal action remains to occur, and...[t]here [is] significant new...information relevant to environmental concerns and bearing on the proposed action or its impacts." | Reclamation integrated WAPA's findings as appropriate as we finalized the SEIS. Reclamation included the PLEXOS modeling results in the Final SEIS to further analyze impacts to hydropower resources. Please see Section 3.3 for additional information. |

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| 44 | 6 | DATA - Data Sources | According to the Bureau "[t]o accurately model the alternatives [in the Draft SEIS], Reclamation, in coordination with...WAPA, developed a series of assumptions based on current conditions, operating criteria, system constraints, and the best available science."5 Contrary to this statement, the Draft SEIS is not based on the best available science. Rather, the best available science should include the hydropower analysis provided by WAPA. This analysis was completed on March 15, 2024, five weeks after the Bureau published the Draft SEIS. Based on the record, the Bureau has failed to do adequate fact gathering in support of its proposed action. Notably, the Ninth Circuit has found that "[t]he comprehensive 'hard look' that NEPA requires just be timely, objective, and taken in good faith and not merely to rationalize a pre-determined decision."6 As explained above, the Bureau's efforts in gathering facts in support of its proposed action, specifically the best available science, are deficient. Although stakeholders to this proceeding have highlighted such inadequacies throughout the public comment period, the Bureau has failed to take the time and resources necessary to resolve these issues. | Analysis that was completed after the Draft SEIS was published could not be included in the draft. However, Reclamation worked closely with WAPA to incorporate additional analysis, including the PLEXOS modeling results, into the Final SEIS. Please see Section 3.3 for additional information. |
| 44 | 5 | COOPGEN - General Agency Cooperation | c. The Bureau is required to include WAPA's hydropower analysis in its analysis of the proposed action. In accordance with NEPA regulations and Ninth Circuit precent, WAPA's hydropower analysis must be included in the Bureau's NEPA analysis of the proposed action. The Bureau, as the lead agency, is "required to use any environmental analysis from cooperating agencies, which may have jurisdiction by law or expertise in particular areas, in preparing its NEPA documents."8 Additionally, "[w]hen a federal agency is required to invite the participation of other governmental entities and allocate responsibilities to those governmental entities," like is the case here, "that participation and delegation of duty must be meaningful.'"9 As set forth in the Draft SEIS, WAPA is a Cooperating Agency with expertise in hydroelectric power and related services.10 This expertise is specific to the Glen Canyon Dam operations at issue in the Draft SEIS. As recognized by the Bureau, "WAPA delivers only power and energy produced from [Colorado River Storage Project ("CRSP")] resources to a subset of customers, and deliveries are directly affected by Glen Canyon Dam operations and water releases."11 WAPA spent the time and resources needed to execute a well-informed hydropower analysis that addresses impacts of the proposed action on the hydropower system. The Bureau must once again supplement its environmental impact statement in order to include the hydropower analysis and ensure that WAPA's participation as a Cooperating Agency is meaningful. The Bureau's decision to publish the Draft SEIS without considering the hydropower analysis ignores WAPA's role as a Cooperating Agency, its relevant expertise, and ultimately violates NEPA's stated policy of "provid[ing] for informed decision making and foster excellent action."12 | Reclamation worked closely with WAPA on the development of the Draft SEIS and included the GTMax modeling results. Reclamation integrated WAPA's additional findings as appropriate in the Final SEIS. Reclamation included the PLEXOS modeling results in the Final SEIS to further analyze impacts to hydropower resources. Please see Section 3.3 for additional information. |
| 44 | 2 | ENERGYPOW - Energy and Power | Here, WAPA's hydropower analysis constitutes significant new information. The hydropower analysis incorporates data created by two national laboratories, Argonne National Laboratory, and the National Renewable Energy Laboratory. This data analyzes potential impacts of the proposed action to the hydropower resource and broader electric system. Specifically, the data estimates the impacts on generation amount, generation value, marketable capacity, availability of replacement power, cost of replacement power, source of replacement power, emissions, locational marginal pricing, reliability, and transmission (both physical and contractual). As explained by the Ninth Circuit and the US Supreme Court, "[a]n agency's NEPA responsibilities do not end with the initial assessment; supplemental documentation 'is at times necessary to satisfy the Act's 'action-forcing' purpose.'"3 Here is such an instance. In order to meet its NEPA obligation, the Bureau must supplement its environmental review with the hydropower analysis to adequately reflect the impacts of the proposed action on hydropower. | The PLEXOS modeling results have been added to the Final SEIS. Please see Section 3.3 for additional information. Additionally, Reclamation will continue to work with WAPA and other stakeholders on adaptive management solutions throughout the life of the LTEMP. |

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| 44 | 3 | PI - Public and Stakeholder Involvement | The Bureau has failed to utilize public comment and the best available scientific information, thereby failing to take the requisite hard look. Furthermore, the Bureau's inadequate efforts and compressed timeline raise questions of predetermination. A federal agency must "'take a 'hard look' at the environmental consequences of proposed actions utilizing public comment and the best available scientific information.'...A 'hard look' seeks to ensure the 'agency did a careful job at fact gathering and otherwise supporting its position.'"4 [4 Biodiversity Conservation All. v. Jiron, 762 F.3d 1036, 1086 (10th Cir. 2014) (internal citations omitted).] | Reclamation has incorporated and will continue to incorporate public comment into this NEPA effort. We have made changes and updates to the Final SEIS and has included this public comment response matrix. |
| 45 | 6 | REC - Recreation | American Whitewater appreciates inclusion in the SEIS of published scientific research that documents whitewater boating opportunities in the Grand Canyon, the quality of the recreational experience, and its economic impact at various flow levels. Studies referenced in the SEIS include Neher et al. (2017)8 and Bishop et al. (1987).9 Additionally, Shelby et al. conducted a study in 199210 describing preferred flows for both commercial and private whitewater trips in the Grand Canyon. The Shelby et al. (1992) study should also be used to inform the analysis of impacts to recreation in the Final SEIS. | Thank you for your comment. Shelby et al. (1992), "Effects of Streamflows on River Trips on the Colorado River in Grand Canyon, Arizona," was reviewed and incorporated into the analysis in the FEIS. |
| 45 | 3 | REC - Recreation | Flows of 2,000 cfs are not only extremely dangerous for boaters, they are unnavigable for common types of boats in the grand canyon. Flows this low would be in direct violation of the Grand Canyon Protection Act of 1992 (GCPA), which directs that recreation needs to be protected as a valued resource in the Grand Canyon.3 The GCPA's purpose was to address the negative impacts of fluctuating reserving releases on downstream environmental and recreational resources.4 It would be impossible to attempt to only operate flows as low as 2,000 cfs during the nighttime (9pm to 1am) because of the delay that it takes outflow water at Glen Canyon Dam to reach rapids and campsites up to hundreds of miles downstream. This nuance is duly noted in the SEIS on page 3-188, but the reasoning is not sufficiently applied to the Non-Bypass Alternative. | The Final SEIS has been updated to include additional information on impacts to boating under the Non-Bypass Alternative. |
| 45 | 1 | ENERGYPOW - Energy and Power | On page 3-23, the draft SEIS says that under this alternative, there will be no impacts to hydropower. This needs to be restated to clarify that if no action is taken, conditions for endangered species will rapidly deteriorate and more severe action will need to be taken. The longer that action is delayed, the near-future impacts to hydropower are likely to increase significantly. The specific impacts may be unknown at this time, but it needs to be acknowledged that the No Action Alternative will assuredly lead to greater impacts to most resources if small mouth bass can't be controlled and impacts to endangered species becomes more severe. | Reclamation will consider impacts to hydropower while selecting a preferred alternative. The urgency of addressing the immediate threat to native species is paramount. The best available science is guiding this process to ensure that the most effective options are selected to balance many different interests in the operation of Glen Canyon Dam. |
| 45 | 4 | REC - Recreation | The campsites in the Grand Canyon are heavily dependent on sandbar availability and river flow levels; campsites that are available at 2,000 cfs are likely not available at 27,000 cfs and vice versa. Even if you were able to plan ahead for the flow fluctuations, and typical Grand Canyon trips would have at least 3 flow fluctuation events during their trip, it would severely reduce the available camp options and certainly cause a lot of confusion. Available campsites have already decreased by over 30% since 2007 due to decreased amounts of sand in the canyon.5 Rapids in the Grand Canyon would also become unnavigable at flows as low as 2,000 cfs, causing safety hazards and logistical issues for trips that are already very complicated to plan. The proposed low flows are 3,000 cfs or 60% lower than the 5,000 cfs minimum identified in the LTEMP ROD and would represent a drastic change in flow conditions.6 American Whitewater and our members are strongly opposed to the Non-Bypass Alterative and we ask that it is removed from further consideration. | The Final SEIS has been updated to clarify these impacts. Recreational impacts would be considered during the planning and implementation process. Adequate lead time will be given before implementation to allow for planning of safe river travel. |

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| 45 | 5 | ALTCOLDSHK - Alternatives - Cold Shock | The Cool Mix with Flow Spike Alternative is American Whitewater's preferred alternative because it achieves the control of small mouth bass, while also having positive impacts to recreational opportunities in the Grand Canyon and relatively minimal impacts to other resources. The Draft SEIS states that the two flow spike alternatives would have the greatest potential to increase campsites in the Grand Canyon compared to other alternatives. Additionally, the cool mix alternatives would lead to fewer fish kills compared to the cold shock alternatives, which is more in line with tribal practices and beliefs as stated in the Draft SEIS on page 3-178. In the implementation of this alternative, American Whitewater requests that close coordination with the HFE program occur so that Glen Canyo Dam operations under this alternative support rather than negatively effect the desired outcome of HFEs. This means that flow spikes must be managed with the latest science on sediment accounting in order achieve multiple benefits of small mouth bass management and sandbar development for campsites in the Grand Canyon. It has further been determined that flow spike durations of 72-hours have a much higher likelihood of transporting sufficient amount of sand, compared to the 36-hour timeframe proposed in the Draft SEIS. We greatly appreciate that across all alternatives, HFE management will be adjusted to incorporate the best available science on sediment accounting periods and implementation windows.7 | Thank you for your comments. Reclamation considered these for the Final SEIS. Reclamation will use the best available science and models for the planning and implementation process. |
| 45 | 2 | SOC - Socioeconomics | The Non-Bypass Alternative has unacceptable impacts to whitewater recreation in the Grand Canyon and should not be further considered. This alternative includes flows in the Grand Canyon as low as 2,000 cfs for up to 4 hours a day once a week,1 which would significantly disrupt both private and commercial boating trips in the Grand Canyon, a $46 billion industry | Thank you for your comment. We will consider these points while developing the Final SEIS. |
| 46 | 3 | ALTRANGE - Inadequate Range of Alternatives | Although Reclamation has well intention in drafting the SEIS, it has been rushed and lacks a thorough and comprehensive examination of other alternatives other than use of the bypass tubes. Maintaining a higher elevation in Lake Powell should have been examined. | Reclamation is currently pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. The timeline for these efforts differs from this NEPA effort. These efforts are out of scope for this NEPA effort. |
| 46 | 2 | ENERGYPOW - Energy and Power | Currently the energy market is being strained and a further reduction of hydroelectric generation will add to constraint energy market with scarcity and higher prices. The DSEIS fails to reflect impacts in our market area and only examines the Palo Verde trading hub. | The SEIS evaluates the potential impacts of flow options on hydropower production and recognizes the importance of ensuring a reliable and affordable power supply to the region. We will took into consideration your concerns regarding the potential impacts on the energy market in your area. Your input will be valuable as we continue to refine our analysis. |
| 46 | 1 | ENERGYPOW - Energy and Power | The DSEIS acknowledges that power generated through Glen Canyon Dam would need to be replaced and lays that responsibility onto W APA for solutions. However, it does not address and considers the scarcity in energy generation faced by utilities. We express serious concerns regarding the draft SEIS's failure to sufficiently analyze the impact that the flow options will have on hydropower production and the risk that reduced hydropower production may have on the ability for utilities to provide power to the Utah region during the summer. | Thank you for your comment. Because the alternatives in this SEIS are treated as experiments, WAPA would be responsible for the purchase of replacement power on the market, and customers would be kept whole, including Tribes. As a result, customers would receive their power as if no bypass had occurred, and there would be no impacts to customers. This includes Tribes with benefit crediting agreements. The SEIS has been revised to add clarification. |
| 46 | 4 | ENERGYPOW - Energy and Power | We strongly urge further studies to avoid reduction of hydropower generation and the impact to reliability and affordability in the region. | The Final SEIS has been updated to include additional analysis of hydropower resources, including the PLEXOS modeling results.<br><br>No impacts to customers are anticipated in 2024. Reclamation will work closely with WAPA and other stakeholders during the planning and implementation process to analyze and consider impacts to customers in future years. |

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| 47 | 1 | ALTRANGE - Inadequate Range of Alternatives | Description of Alternatives: The alternatives proposed in the Draft Supplemental Environmental Impact Statement (DSEIS) are too narrow and should incorporate a broader range of strategies beyond flow adjustments to address the establishment and management of smallmouth bass below the Glen Canyon Dam. Alternatives should not be specifically focused on flow action alone, which are insufficient to prevent the establishment of SMB below Glen Canyon Dam. A broader set of alternatives, including structural measures, is deemed necessary to effectively address the issue. Alternatives should include structural elements and actions outlined in the Invasive Species Strategic Plan, while also emphasizing the need for comprehensive experiments with clear descriptions, hypotheses, benchmarks, and monitoring to assess impacts on threatened species and the electrical grid, as part of the Long-Term Experimental and Management Plan (LTEMP). | Reclamation is currently pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. The timeline for these efforts differs from this NEPA effort. These efforts are out of scope for this NEPA effort. |
| 47 | 3 | ENERGYPOW - Energy and Power | HL&P echoes CREDA's concerns about the adequacy of the DSEIS's analysis of power and energy impacts. CREDA emphasizes the need for a more detailed and accurate assessment of the effects on power generation, electricity rates for utility entities, and overall system-level electricity production costs. This includes the impact of experiments on replacement power and grid reliability, especially during summer months. | Reclamation added the PLEXOS modeling for an analysis of impacts to the grid and replacement energy. The planning and implementation process will consider the impacts on dispatchable generation from Glen Canyon Dam when generators are bypassed, as well as the availability of replacement power. |
| 47 | 2 | SOC - Socioeconomics | The DSEIS's effects analysis must include the financial and economic impacts on CRSP customers who are obligated to provide reliability electricity. The impacts are distinct from those of the Upper Colorado River Basin Fund and WAPA, therefore these impacts should be disclosed, and if possible, mitigated. As hydropower continues to be less available and reliable, HL&P is forced to seek replacement power which comes at a high cost and increases the negative environmental impacts of drought on our customers. Reductions to CRSP hydropower production are detrimental to HL&Ps customers, and reductions during summer months are especially impactful to our rates and reliability. As a small public power utility, we operated with a lean staff and budget which makes it especially difficult to economically replace CRSP power. Financial impacts to the Upper Colorado River Basin Fund (Basin Fund) and the programs it funds must be assessed and disclosed. Operations of hydropower are not the cause of the invasion of SMB and should not be burdened with the costs of mitigation measures. If WAPA is required to buy power to compensate for resources that are unavailable or lost due to operations aimed at controlling non-native fish or High Flow Experiments (HFE), these expenses should not fall upon WAPA or its hydropower customers. | Thank you for your comment. Because the alternatives in this SEIS are treated as experiments, WAPA would be responsible for the purchase of replacement power on the market, and customers would be kept whole, including Tribes. As a result, customers would receive their power as if no bypass had occurred, and there would be no impacts to customers. This includes Tribes with benefit crediting agreements. The SEIS has been revised to add clarification. |
| 48 | 2 | ENERGYPOW - Energy and Power | During the February 28-29, 2024, meeting of the Glen Canyon Dam Adaptive Management Group, Reclamation shared the knowledge they had gained by operating the Glen Canyon Dam at low elevations (near 3,520') in March 2023, as well as knowledge gained regarding the condition of the River Outlet Works (ROW) from operating the ROW during the April 2023 experimental high flow releases. Reclamation also expressed the potential for unknown issues from operating the ROW for extended periods of time. CAWCD cautions against the use of ROW for experimental operations if such operations may result in any diminishment of the rights afforded to the Colorado River Basin States through the Colorado River Compact, the CRSPA, or any other law to which the GCPA is subject. It is crucial that Reclamation complete its evaluation of infrastructure vulnerabilities and take immediate actions to develop and implement solutions. Protection of Glen Canyon Infrastructure may involve a host of strategies including infrastructure modifications, strategic releases from CRSPA units, and water use reductions in the upper basin, among others. Infrastructure modifications should be prioritized to ensure compliance with required water deliveries under the Colorado River Compact. | Chapter 1 has been updated to address infrastructure concerns. These infrastructure concerns are of paramount importance to Reclamation, and the Final SEIS is designed to protect the facility while potential solutions are explored and implemented. The LTEMP SEIS and the associated modeling efforts considered operational and infrastructure constraints. |

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| 48 | 3 | ALTRANGE - Inadequate Range of Alternatives | Given the significant infrastructure concerns that currently exist at Glen Canyon Dam, and the pervasive issue of invasive species, CAWCD believes that flow-related actions are only one tool and a myopic way to address the issue and that additional actions like the installation of fish exclusion device(s) are necessary and urgently needed for the long-term prevention of establishment of invasive species from Lake Powell into the reach below Glen Canyon Dam. In addition, CAWCD believes that a permanent solution to the persistent issue of invasive species lie in an assortment of flow and non-flow related treatments rather than a singular alternative or solution. Rather, solutions to invasive species must be dexterous such that a treatment option can be chosen from an assortment of tried-and-true options based on a decision tree or tiers of treatment needed using the existing adaptive management process. | Reclamation will continue to consider a multi-tiered approach to addressing invasive species at and below Glen Canyon Dam. This approach includes short-, mid-, and long-term solutions. |
| 48 | 1 | POLICYGOV - Policy and Governance | Water Deliveries: Operations to protect, mitigate and improve resources in Grand Canyon National Park and Glen Canyon National Recreation Area downstream of Glen Canyon Dam must remain consistent with and subject to the existing laws governing allocation, appropriation, development and exportation of the Colorado River resource. See Grand Canyon Protection Act (GCPA), Pub. L. 102-575, 106 Stat. 4602, 4669, SS 1802(b). The priority given to water storage, allocation and delivery under the GCPA substantially limits the Secretary's ability to change other elements of Glen Canyon Dam operations. Accordingly, under existing LTEMP framework, water deliveries must be made "in a manner that is fully consistent with and subject to the Colorado River Compact, the Upper Colorado River Basin Compact, the Water Treaty of 1944 with Mexico, the decree of the Supreme Court in Arizona v. California, and the provisions of the Colorado River Storage Project Act of 1956 (CRSPA) and the Colorado River Basin Project Act of 1968 that govern allocation, appropriation, development, and exportation of the water of the Colorado River Basin, and consistent with applicable determinations of annual water release volumes from Glen Canyon Dam made pursuant to the Long-Range Operating Criteria (LROC) for Colorado River Basin Reservoirs, which are currently implemented through the 2007 Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead" (2007 Interim Guidelines). See Record of Decision for the Glen Canyon Dam Long-Term Experimental and Management Plan (Dec. 2016) at 1. | As discussed in Chapter 1 and as consistent with the 1992 Grand Canyon Protection Act, the scope of LTEMP and this SEIS is limited to sub-annual operations—hourly, daily, and monthly releases—of Glen Canyon Dam. These subannual releases do not and will not affect annual operations from Glen Canyon that address the allocation, appropriation, development, and exportation of Colorado River water addressed in the 1992 Grand Canyon Protection Act and elsewhere in the Law of the River. |
| 49 | 2 | ENERGYPOW - Energy and Power | Currently the energy market is being strained and a further reduction of hydroelectic generation will add to the constraint energy market with scarcity and higher prices. The DSEIS fails to reflect impacts in our market area and only examines the Palo Verde trading hub. | The SEIS evaluates the potential impacts of flow options on hydropower production and recognizes the importance of ensuring a reliable and affordable power supply to the region. We took into consideration your concerns regarding the potential impacts on the energy market in your area. Your input was valuable as we refined our analysis. |
| 49 | 1 | ENERGYPOW - Energy and Power | The DSEIS acknowledges that power generated through Glen Canyon Dam would need to be replaced and lays that responsibility onto WAPA for solutions. However, it does not address and considers the scarcity in energy generation faced by utilities. We express serious concerns regarding the draft SEIS's failure to sufficiently analyze the impact that the flow options will have on hydropower production and the risk that reduced hydropower production may have on the ability for utilities to provide power to the Utah region during the summer. | The Final SEIS has been updated to include additional analysis of hydropower resources, including the PLEXOS modeling results.<br><br>No impacts to customers are anticipated in 2024. Reclamation will work closely with WAPA and other stakeholders during the planning and implementation process to analyze and consider impacts to customers in future years. |
| 49 | 3 | ALTRANGE - Inadequate Range of Alternatives | We acknowledge the importance of protected species and recognizes the risks associated with smallmouth bass (SMB) proliferation in the river reaches below Lees Ferry. Many years of good science and multi-millions of dollars have been invested in protecting endangered fish species and improving the habitat of the river. Although Reclamation has well intention in drafting the SEIS, it has been rushed and lacks a thorough and comprehensive examination of other alternatives other than use of the bypass tubes. Maintaining a higher elevation in Lake Powell should have been examined. | Reclamation is currently pursuing additional tiered projects with short-, mid-, and long-term timelines, including associated NEPA efforts. The timeline for these efforts differs from this NEPA effort. These efforts are out of scope for this NEPA effort. |

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| 49 | 4 | ALTBYPASS - Alternatives - Non-Bypass | We recognize the challenge for Reclamation in balancing the priorities and complex issues related to operating the dam. We do support these efforts to address the interests of protecting the hydropower resource in balance with other social, cultural, tribal, and environmental purposes. We strongly urge further studies to avoid reduction of hydropower generation and the impact to reliability and affordability in the region. In summary, we urge you to adopt the "None-Bypass Option" to avoid these significant risks to power supply. | Reclamation appreciates your comment and will consider all alternatives when preparing the ROD. |
| 50 | 39 | AQUA - Aquatic Resources | 2.13, table 2-2, p. 2-26 The effects of no bypass alterantive for aquatic resources indicate little impact to rainbow trout and food base. Our undestanding is that large fluctions in the past created a large boom/bust cycle in rainbow trout and negatively impacted rainbow trout (korman et al 2011). Though some other studies have shown compensatory effects in rainbow trout to Spring HFEs and other disturbance flows, the nonbypass alternative would be increasing fluctuations now in a time when rainbow trout have a very low population size and are already stressed by warm river temperatures, low dissolved oxygen, increased predation from brown trout and (given alterantive is showing low effectiveness to control SMB), additional predation from SMB... so its likely that these combination of factors would increase risk that the popultion would not respond with sufficient compensatory effects to overcome the negative impacts from the non-bypass alternative. Please see all the edits and refrences below to suppport this and then come back to these summaries and edit them to fully reflect the information in chap 3 after those revisions. | The low-flow (2,000 cfs) element of the Non-Bypass Alternative will dewater margins and shallow habitats, negatively affecting young trout and their food base. This information was added to the Final SEIS. Please see Section 3.5 for additional information. |
| 50 | 157 | CRTRIBE - Cultural and Tribal Resources | 3.12.1, p. 3-166 There is evidence of Early Formative occupation of Grand Canyon NP | Language was added to Section 3.12.1, Cultural Resources Affected Environment. |
| 50 | 101 | AQUA - Aquatic Resources | 3-93 for cold shock with flow spike native fish and non-native fish you need to include the most important effects - that compared to no action or nonbypass young native fish under this alternative would not be subjected to increasing predation from expanding populations of SMB, GSF, that are likely under no action and non bypass. This is the most important effect and needs to be clearly stated and interpreted in these sections | A figure has been added to the Impact Analysis that provides the average lambdas and ranges (maximum and minimum values) for the 30 traces at river miles 15 and 61 for each of the five alternatives and No Action Alternative. This figure shows that the Cool Mix and Cool Mix with Flow Spikes are the least likely alternatives to allow smallmouth bass population growth (lambda>1). This also shows that the range of lambda values for cold shock with flow spike is as high as 1.6 at river mile 15 and over 2 at river mile 61. |
| 50 | 164 | GEOSEDI - Geomorphology and Sediment | Also for the Sandbar Model results (figure 3-22) you fail to disclose a very important aspect of that for the alts with flow spikes and for the non-bypass that these results are limited to only showing building but not erosion using the Mueller model. So these results must be interpreted in that light. And again, these results lump all 30 runs which shows effects of the spikes and fluctuations when averaged in with runs where those tools weren't used, which makes their impacts appear much smaller. It is critically important under GCPA that this analysis fully and clearly discloses the erosive impacts to sand mass balance that would decrease the likelihood of HFEs over time in comparison to the other alternatives with the expanded HFE window. Again - all graphs and metrics need to be split out for the set of months or years where the tools were employed not lumped in with all 30 runs if many of them didn't use the tool because that will minimize the effect. It may even be necessary to contrast the effects on a one year basis between those years in which the tool is being used with the years it is not being used. Please see all the edits and references below to support this and then come back to these summaries and edit them to fully reflect the information in chap 3 after those revisions. | Language, figures, and tables were added to Section 3.4.2 regarding effects of alternative flow options during periods when they would be implemented. Language regarding caveats for use of the Mueller and Grams (2021) model was added, clarifying that the model did not include flow spikes or large flow fluctuations in its calibration period. |
| 50 | 64 | AQUA - Aquatic Resources | figure 3-23, p. 3-55 Consider changing the figure title to "Optimal Temperature Ranges for Spawning, Egg Incubation,and Growth of Native and Nonnative Fishes of the the Colorado River System Below Glen Canyon Dam" | The figure reflects temperature ranges as determined by Valdez and Speas from a comprehensive literature search and reflects the range of temperature for each life stage. |

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| 50 | 66 | AQUA - Aquatic Resources | figure 3-29, p. 3-56 Razorback sucker have been found from Phantom Ranch to Pearce Ferry; might have to re-check accounts of speckled dace being captured as high up as Glen Canyon Dam, maybe from the Paria River downstream. Strike out 'with tributary fish being smaller' from sentence, "This species has been reported to be as large as..." since it was already mentioned that bluehead sucker may be smaller in tributaries. Strike out 'subspecies, as', from sentence "A related subspecies, the Zuni bluehead sucker, occurs in the headwaters of the Little Colorado River along with bluehead sucker that is the same subspecies species as in the mainstream Colorado River (AZGFD 2002a). | All changes were made as recommended, except that we retained designation of the Zuni bluehead sucker as a subspecies. |
| 50 | 134 | WATERQUAL - Water Quality | figure 3-35, p. 3-157 This figure isn't very readable and again it would be most effective to provide the data for how the alterantives perform different for the years in which temperature was over 15.5C. That is the way to tease out what the tools actually do - otherwise the action is lost in the noise of what is 83% performance of no action. We want to know what a tool does when its needed and its used, not what what it does when its not needed and not used. Having an average value of DO for the most biologically critical months for only those months where temp was over 15.5C and tools were triggered would also be useful in addition to the graph because those values can then be quoted in the impact summary at the top of the document - please do that as was done for hydropower so we can compare all resources equally - compare apples to apples. The ame applies to Figure 3-36 and Figure 3-37. | This comment was considered in the development of the Final SEIS. |
| 50 | 135 | WATERQUAL - Water Quality | figure 3-37, p. 3-161 It appears this table is avearging results across all 30 runs and in its current form it is very difficult to understand and tease out differences between alternatives. This is not a fair comparison to hydropower results that are broken out for the months in which the tools in the alternatives are actually used (when temp was over 15.5C) in table 3-25. We believe that is only in 17% of the runs and if you are averaging across all the runs then the results we are seeing are mostly averaged with the 83% of the runs that didn't have DO problems. There hydropwer effects are assessed only the the months in which temperature was over 15.5C and the bypass tools or non-bypass tool where used. If you assess DO the same way, you will show a markedly different set of results that will show DO going a lot lower for some alternatives than others. The alternatives with bypass will perform decidedly better in the years in which those tools are actually needed and actually used. This graph doesn't work as currnetly presented to help distinguish fairly between altearntives. | The figures were updated in the Final SEIS to only compare years where an experiment was implemented. |
| 50 | 136 | WATERQUAL - Water Quality | figure 3-38, 3-162 Again - same comment - we don't expect diffeernces between alternaties when the different tools that are triggered - when temp > 15.5C. When temp is < 15.5C then the alterantives don't differ - they all behave like no action. So you need to tease that out to for a fair comparison to hydropower results that are broken out for the months in which the tools in the alternatives are actually used in table 3-25. We believe that is only in 17% of the runs and if you are averaging across all the runs then the results we are seeing are mostly averaged with the 83% of the runs that didn't have DO problems. There hydropwer effects are assessed only the the months in which temperature was over 15.5C and the bypass tools or non-bypass tool where used. If you assess DO the same way, you will show a markedly different set of results that will show DO going a lot lower for some alternatives than others. The alternatives with bypass will perform decidedly better in the years in which those tools are actually needed and actually used. This graph doesn't work as currnetly presented to help distinguish fairly between altearntives. | The figures were updated in the Final SEIS to only compare years where an experiment was implemented. |

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| 50 | 25 | AQUA - Aquatic Resources | Food base implications from Non-Bypass alternative The food base impacts in the plan need improvement and input from GCMRC. The plan currently seems to conclude the Non-Bypass fluctuations from 2000 cfs to 27000 cfs that might occur every week throughout the summer for over 20 times a summer would have little to no impact on food base. These findings are inconsistent with findings of the effects from past HFEs or from past bugflows where altered flows, even when occurring only once a year, have shown marked impacts that were positive or negative to macroinvertebrates or gross primary production (GPP). The plan states that these Non-Bypass flows wouldnt desiccate macroinvertebrates because they are short and at night, citing Blinn 1999. Blinn 1999, looked at effects in early spring from the 1996 Beach Building Flow when temperatures at night were much lower and the frequency of the flow was only once that year. These Non-Bypass flows would occur repeatedly throughout the summer up to over 20 times during much hotter months. Also, the fluctuations do not collapse much by the LCR, so the fluctuation would propagate through Marble Canyon during the day, which would be in hot temperatures in direct sunlight. There may also be some impacts to macroinvertebrates and the food base from the flow spikes or from spring HFEs; however, the frequency of those spikes is limited to 3 per year, they dont involve the drop before the increase, and the timing of those corresponds well with natural pre-dam spring peak flows and that should be noted in the plan. Given the preponderance of studies that indicate natural timed flows are better for many organisms that evolved with that timing (see Poff et al 1997, Poff and Matthews 2013, etc.), NPS requests analysis in the SEIS of timing of flows in relation to natural and historical flow regime. | The Final SEIS has been revised in accordance with your comment. Please see Section 3.5 for additional information. |
| 50 | 130 | AQUA - Aquatic Resources | p, 3-135 Again this statement needs to be reconciled. We do think one of the five action alterantives will have a population level impact on HBC and other native fish - that is the Non-Bypass alternative. Based the modeling it will not stop SMB and other warm water invasives from growing and expanding and directly affecting HBC by preying upon them. So please reconcile these statements to reflect that if the atlernative doesn't control SMB, then it IS likely to have a population level impact on native fish. This is your statement "Generally, the five alternatives are not expected to have a negative population-wide effect on native fish, as these species have adapted to a large range of flows and temperatures in the Colorado River. However, all alternatives do assume that smallmouth bass populations will have impacts on native fish populations. These alternatives are not expected to have long-term, negative effects on the rainbow trout in the Lees Ferry reach." We would suggest rewording it as: "Generally, the four bypass alternatives are not expected to have a negative population-wide effect on native fish, as these species have adapted to a large range of flows and temperatures in the Colorado River. However, all alternatives do assume that smallmouth bass populations will have impacts on native fish populations. Based that, and the modeling of lambda values for SMB populations, the Non-Bypass Alternative may be expected to have population level impacts to native fish similiar to those in No Action that may be caused by the expansion of SMB. Also the Non-Bypass Alternative may have negative effects on the rainbow trout in the Lees Ferry reach, but the other four action alteratives are not expected to impact rainbow trout populations in Lees Ferry." | Language in the Final SEIS was added to clarify the differences for these alternatives. Please see Section 3.5 for additional information. |

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| 50 | 153 | CRTRIBE - Cultural and Tribal Resources | p. 3.12 We do not agree with the assessment for the Non-Bypass Alternative that available sediment would be similar to that under the No Action Alternative. Previous studies (Leopold and Maddock 1953, Brooks 1958, Howard and Dolan 1981, Burkham 1986, and Topping et al. 2000) have shown that river-deposited sediment supply has been reduced by flow regimes that result in continual sediment scour from the river bed thus limiting opportunities for sediment deposition on archaeological sites via aeolian processes. Flows of 27,300cfs occurring at weekly intervals would continue, and we believe increase, sediment scour through eastern Grand Canyon and particularly in Marble Canyon. *Continuing loss of sediment would likely lead to a reduction in HFEs which Sankey et al. (2023) have identified as an important contemporary mechanism (Sankey 2023, presentation for the Glen Canyon Dam Adaptive Management Program) for increasing sand supply within the river corridor. Sankey et al. (2018) state that Windblown river sand deposited in dunefield archaeological sites increase cumulatively when upwind river sandbars are resupplied by consecutive annual HFEs. Loss of sand mass through Marble Canyon could limit our ability to supply necessary sand to protect archaeological sites.*There is a likelihood that the weekly 27,300cfs peak flow could erode, and potentially eliminate existing sand bars that serve as source sand for downwind archaeological sites. That process is already occurring under the current discharge regimes. Sankey et al. (2023) report that under the aeolian classification system, Type 3 sites, those with no recent sandbar source, has increased from 27 sites in 1973 to 148 site between 2021 and 2022. Removal of additional sediment with the proposed 27,300cfs flow could further erode away sand bars to downwind sites.*Low flows are also identified by Sankey et al. (2022) as another mechanism to maintaining a sandy landscapes in the Grand Canyon. While the Non-Bypass Alternative does have a short-duration low-flow (2000cfs), the flow will not be sustained for a sufficient amount of time necessary for the newly exposed sand to dry out and be available for wind transport to higher elevation archaeological sites. | Per the current 2024 GCMRC modeling, there will be variations in HFEs and slight differences in sandbar development between the alternatives (Salter and Grams 2024); however, the daily amount of exposed sand available for eolian transport to protect archaeological sites is not expected to vary substantially between the alternatives (Kasprak et al. 2024). Language has been added to clarify the results of the modeling to Issue 2 in Section 3.12.2 Cultural Resources Environmental Consequences. |
| 50 | 115 | WILDLIFE - Wildlife | p. 3-105,106 You include only three amphibian species in the riparian zone. Change to 5 documented amphibian species, which includes native lowland leopard frog (Rana yavapaiensis) in western GRCA and tiger salamander( Ambystoma mavortium) in the Glen Canyon reach. A single isolated population of lowland leopard frog exists in a perennial side canyon in western GRCA. This population is of unique genetic value, and subject to deleterious effects from aquatic invasive species, such as predatory fish and crayfish. Northern leopard frogs (Rana pipiens) are functionally extinct in GRCA in the riparian zone in the post dam era, but exist in small pockets on the northern rims of GRCA. Northern and lowland leopard frogs are both AZ Species of Special Concern, and habitat suitability models have been created for GRCA in anticipation for future reintroduction and population supplementation efforts. | Both lowland leopard frog (Rana yavapaiensis) and tiger salamander (Ambystoma mavortium) are now included in the affected environment section. The lowland northern salamander has also been added to the table of special status species and is now included in the discussion of impacts to special status species. |
| 50 | 117 | WILDLIFE - Wildlife | p. 3-106 Include potential impacts to native amphibian species from warm water predatory fishes. Predator fish can have adverse effects on amphibians at community and population levels (Watson and Mullin, 2007). Small-mouth bass significantly affected the survivorship of native frogs (eg. red-legged frogs) especially when in combination with other predatory aquatic invasive species (Kiesecker and Blaustein, 1998). Predatory fish have likely rsulted in altered amphibian species assemblages and reduce community diversity (Hecnar and Mcloskey, 1997). | Additional text and citations have been added to the discussion of impacts for amphibians to clarify increased predation as an impact from the No Action Alternative. |

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| 50 | 120 | WILDLIFE - Wildlife | p. 3-106 "where you state ""Amphibians tend to use backwaters or shallow waters of aquatic and riparian habitats"" you should also provide literature references for how much warmwater non-natives like SMB and GSF impact native amphibians. Here is literature to consider drawing from to include this important effect that will differ among the alternatives: Smallmouth bass and green sunfish predation on amphibians Fish are not the only taxa affected by invasive M. dolomieu; mammals, birds, amphibians, reptiles, and invertebrates can be impacted as well. M. dolomieu will consume almost any prey small enough to ingest including crayfish, rats, mice, young waterfowl, frogs, snakes, and salamanders (Sanderson et al. 2009). Frog species can be impacted by predation from M. dolomieu, although the severity could depend on the presence of other invasive species and the life stage of the frog (Kiesecker and Blaustein 1998). Sanderson BL, Barnas KA, Wargo Rub AM (2009) Nonindigenous species of the Pacific Northwest: An overlooked risk to endangered salmon? BioScience 59(3): 245256, http://dx.doi.org/ 10.1525/bio.2009.59.3.9 Kiesecker JM, Blaustein AR (2008) Effects of introduced bullfrogs and smallmouth bass on microhabitat use, growth, and survival of native redlegged frogs (Rana aurora). Conservation Biology 12(4): 776787, http://dx.doi.org/10.11 11/j.1523-1739.1998.97125.x Introduced predatory centrarchids are likely responsible for the decline of native ranid frogs in California and for the decline of California tiger salamander Ambystoma californiense populations (Hayes and Jennings 1986; Dill and Cordone 1997). Dill, W.A., and A.J. Cordone. 1997. History and status of introduced fishes in California, 1871-1996. California Department of Fish and Game Fish Bulletin, volume 178. Hayes, M.P., and M.R. Jennings. 1986. Decline of ranid frog species in western North America: are bullfrogs (Rana catesbeiana) responsible? Journal of Herpetology 20(4):490-059.<br>This study reports on the effect of the invasion of fish upon the composition of the amphibian community in 3 man-made ponds in east central Missouri. Fourteen species of anuran and caudate amphibians utilized 1 or more of the ponds before the invasion by fish of 2 of them. The amphibian community of the pond colonized by 6 species of fish was reduced to adults of 2 species of ranids. That of the pond invaded by 2 species of fish changed very little as did that of the pond which remained fish-free. The green sunfish, Lepomis cyanelus, was the species most responsible for the demise of the amphibian community. Sexton, O.J. & Phillips, Christopher. (1986). A qualitative study of fishamphibian interactions in 3 Missouri ponds. Transactions of the Missouri Academy of Science. 86. 25-35. " | We incorporated this literature in the Affected Environment and Environmental Consequences sections. |
| 50 | 116 | WILDLIFE - Wildlife | p. 3-106 Change Grand Canyon pink rattlesnake to Western rattlesnake (Crotalus oreganus). Crotalus viridis is the prairie rattlesnake not found in the GC river corridor. | Pink rattlesnake has been changed to western rattlesnake. |
| 50 | 119 | WILDLIFE - Wildlife | p. 3-106 Hecnar, S.J. and M'Closkey, R.T., 1997. The effects of predatory fish on amphibian species richness and distribution.Biological conservation,79(2-3), pp.123-131. | This literature was incorporated in the Affected Environment section in the discussion of amphibians and reptiles. |
| 50 | 118 | WILDLIFE - Wildlife | p. 3-106 Walston, L.J. and Mullin, S.J., 2007. Responses of a pond-breeding amphibian community to the experimental removal of predatory fish.The American midland naturalist,157(1), pp.63-73. | This literature was incorporated in the Affected Environment section in the discussion of amphibians and reptiles. |
| 50 | 122 | WILDLIFE - Wildlife | p. 3-110 We disagree with the analysis conclusion that "Under the No Action Alternative there would be no change to the current trajectories for wildlife species that use riparian habitats, including invertebrates, amphibians" We would point to the references we provided for page 3-106 for the abundant literature for SMB and GSF impact amphibian populations. Any amphbians in backwater habitats are likely to be impacts if SMB and GSF establish along the river. There should discussion of that impact for any alternative where the average lambda is greater than 1 in months where temperatures exceed 15.5C | The sentence in question has been removed, and the text has been revised to acknowledge that under the No Action Alternative native wildlife species may be impacted by increased predation by smallmouth bass and other invasive species. |

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| 50 | 124 | WILDLIFE - Wildlife | p. 3-112 Again where you state "Alternatives with higher daily fluctuations (in particular the Non-Bypass Alternative) would have the potential to lower insect production, potentially resulting in relatively greater impacts on the northern leopard frog." you should add a sentence or two about how alternatives that allow warm water non-natives to increase (no action and non-bypass) that there would be increased predation on northern leopard frogs by SMB and GSF... see above references from page 3-106. | Additional text and citations have been added to the discussion of impacts for amphibians to clarify increased predation as an impact from alternatives that result in growth of smallmouth bass populations. |
| 50 | 123 | WILDLIFE - Wildlife | p. 3-112 For the Non-bypass alterantive, we would request that you add in impacts to amphibians from increasing popuatlions of SMB and GSF. Based on lambda modeling results, this alternative should perform very simliarlly to no action and these popuations should expand and impact these species throughout the system like they will affect native fish. See references above on page 3-106. | Additional text and citations have been added to the discussion of impacts for amphibians to clarify increased predation as an impact from alternatives that result in growth of smallmouth bass populations. |
| 50 | 125 | WILDLIFE - Wildlife | p. 3-112 include lowland leopard frogs as a special status species and include with the comment above indicating likely increased predation and lowering survivability with the spread of SMB and GSF. | This species has been added to the special status species table and is included in the discussion of impacts for special status amphibians and reptiles. |
| 50 | 126 | WILDLIFE - Wildlife | p. 3-113 Here you conclude that HFEs could displace amphbicans and other species, however you don't mention that the non-bypass flucutations may do the same thing. But HFEs would occur typically once a year and, with the action changes to the HFE protocol, 80% of those will be in spring when natural peak flows would have occured, but the non-bypass fluctations may occur up to 26 times a year throughout the summer so they are much more likely to have an impact. Also a much larger and important impact is that SMB and GSF may prey upon amphibians and have greatly reduced amphibicans where they occur. So alternatives which allow SMB and GSF to expand (no action and non-bypass) would have negative impacts to these amphibian popuations (see refs above for p 3-106). | Additional text and citations have been added to the discussion of impacts on amphibians to clarify increased predation by invasive species as an impact from alternatives that result in growth of smallmouth bass populations. Additional text has been added to the Non-Bypass Alternative section of the Environmental Consequences to address impacts of HFEs. |
| 50 | 127 | WILDLIFE - Wildlife | p. 3-113 Under special status species, potential impacts to northern leopard frogs from alternatives that allow SMB and GSF to expand should be mentioned. | We have added text to the special status species sections under Issue 2 clarifying that impacts under the No Action Alternative and Non-Bypass Alternative include increased predation and potential pathogens from the increases in nonnative fish populations. |
| 50 | 128 | AQUA - Aquatic Resources | p. 3-124, 125 Rogers et al. 2023 Razorback Sucker Xyrauchen texanus Research and Monitoring in the Colorado River Inflow Area of Lake Mead and the Lower Grand Canyon, Arizona and Nevada describes a RBS detection at RM 15 | Sonic and radio detections have occurred as far upstream as river mile 15 since 2014. Language has been added to describe these new findings. |
| 50 | 129 | AQUA - Aquatic Resources | P. 3-133, 134 MOST IMPORTANT COMMENT - The effects of non-bypass alternative on HBC does not currently address at all its failure to control SMB and other warm water non-natives - that is the most important effect of this alternative as has comparable performance for SMB lambda in the modeling results to no action. Therefore you need to have the same impacts listed here for the expansion of SMB, GSF and other warm water non-natives on HBC and RBS throughout the system. This is a very important edit- maybe the most important one in this whole analysis. Please include the resutls of the SMB lambda analysis in this section and fully discuss the immpacts with the same text that is in the no action section. It should read, "Based on the SMB lambda modeling results, under the Non-Bypass Alternative, the humpback chub and razorback sucker may be subjected to increasing levels of predation and competition from nonnative fish, especially smallmouth bass and possibly green sunfish and other invasive, aquatic species. Although population levels of humpback chub are likely the highest since construction of Glen Canyon Dam, invasions of nonnative species, especially smallmouth bass, could lead to the decline of some population centers of native fish species, such as near the mouth of the Little Colorado River. Smallmouth bass populations could theoretically expand throughout the Colorado River ecosystem below Glen Canyon Dam (potentially as far downstream as below Havasu Rapid and the Lake Mead inflow), where they could negatively affect the expanded population of humpback chub and interfere with movement of razorback sucker into the Colorado River from Lake Mead. | Thank you for your comment. The potential impact of smallmouth bass is addressed in the No Action Alternative earlier in the section. Additional language was added to reinforce this under the Non-Bypass Alternative. |

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| 50 | 49 | HYDROLOGY - Hydrology | p. 3-14 This page states "When the high flow is then later released, this slug of water is expect to overtake the low flow wave by the time it researches river mile 61" but that does not appear to be the case in figure 2-6. There is still a trough present at the LCR. Please edit this text as it doesn't appear correct and please state what the min and max will be based on that routing diagram when it gets to the LCR as well as what time of day it would be be hitting by the time it gets there. That would be important information grounded in the hydrology modeling. The current text is not grounded in the modeling and is incorrect. | The Final SEIS has been revised. The trough is present at the Little Colorado River and is nearly entirely collapsed at Pumpkin Spring. |
| 50 | 131 | VISUAL - Visual Resources | p. 3-148 The potential changes in vegetation and sandbar size could be substantial depending on the frequency of higher flows and the flow stage changes, within and between years - there is a big dfference between effects if spike flows occur once versus monthly in how sandbars and vegetation would respond to the changing water levels. The sand mass could be depleted quickly following spike flows, and the non-bypass proposed flows especially have the potential to erode beaches quickly, which will affect sandbar size and thus vegetation along the beaches. If you use a qualitative assessment, you need to define what metrics are being used (top of page). | The analysis of effects on landscape character has been updated based on revised studies that identify modeled sandbar size and extent of riparian vegetation associated with LTEMP alternatives. Additional information and details associated with impacts on these elements can be found in Section 3.6 (Terrestrial Resources and Wetlands) and Section 3.4 (Geomorphology/Sediment). |
| 50 | 132 | VISUAL - Visual Resources | p. 3-150 Under Cumulative Effects it states that all flow options would remain within the existing flows outlined in the LTEMP FEIS. Page 2-18: Under the Non-Bypass Alternative, flows could drop as low as 2,000 cfs and rise as high as approximately 27,300 cfs. The minimum flows proposed under this alternative fall below those developed in the LTEMP ROD (5,000 cfs at night and 8,000 cfs during the day). This alternative would exceed the maximum daily range of 8,000 cfs analyzed in the LTEMP ROD. Modeled ramp rates were slightly outside the LTEMP requirements. Actual ramp rates would be within the operating range of the LTEMP ROD | Text regarding flow rates was removed and instead focuses on the fact that all proposed flow options would operate within the spatial and temporal bounds and under the assumptions of the existing analysis conducted in the LTEMP FEIS, similar to other resource sections. The cumulative analysis tiers to conclusions from Section 3.6 (Terrestrial Resources and Wetlands) and Section 3.4 (Geomorphology/Sediment). |
| 50 | 133 | WATERQUAL - Water Quality | p. 3-156 On this page for background please include information this year's GCMRC ARM in January about how deam release reached critically low dissolved oxygen levels in 2023 with the elevated river temperatures - this is critical information to include here. Bridget Deemer presented on this and you and can and should include that info as background. | Information from the GRCMC ARM has been added to the affected environment. |
| 50 | 137 | WATERQUAL - Water Quality | p. 3-163 You state "Across all alternatives, 74 percent of the years by trace combinations would be likely to have mean DO concentrations less than 5 mg/L in the late summer and early fall" but this is not the most important result to compare between alternatives. all the alterantive behave the same in months where temp < 15.5C, they only behave differently in months were temp > 15.5C so those are the months you need to break out there and provide the average DO levels for each alternative under those situations - that is how to compare between the how the alternatives peform for this metric. | This comment was considered in the development of the Final SEIS. |
| 50 | 159 | CRTRIBE - Cultural and Tribal Resources | p. 3-167 I am wondering why all your cultural references are for GLCA? | Information on Grand Canyon National Park resources was added to Section 3.12.1 Cultural Resources Affected Environment. |

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| 50 | 138 | CRTRIBE - Cultural and Tribal Resources | p. 3-170 "This background section on cultural resources fails to explain how dam operations affect sediment deposition and how aeolian transport of the sediment is what keeps cultural sites covered so they are protected from both physical erosion and visitor disturance. Please add these paragraphs from pp. 3-147 and 3-148 from the original LTEMP EIS to explain this important dyanmic: There are a number of ways in which dam operations may affect cultural resources, including the periodicity of inundation and exposure, changing vegetation cover, streambank erosion, slumping, and influencing the availability of sediment. Direct and repeated inundation/exposure may affect resources such as the Spencer Steamboat, which is in the active channel (Figure 3.8-1), or Pumpkin Springs, a TCP along the bank that is subject to inundation during high flows (e.g., equalization flows and HFEs). Streambank erosion, slumping, flowrelated deposition, and indirect effects of deposition may affect cultural resources contained within terrace contexts in proximity to inundated areas. Fine sand or sediment can be blown from flow-deposited source areas and deposited on cultural sites (East et al. 2016) (Figure 3.8-2). The effects of deposition or erosion may be negative or positive depending on the nature of the site. One important recent finding is that sandbars created by high-flow events at Glen Canyon Dam can provide sources of windblown sand that can cover archaeological sites (East et al. 2016) as well as anneal, or reverse, the formation of gullies (Sankey and Draut 2014). In this context, changes in dam operations can affect erosion rates on archaeological sites (East et al. 2016, Collins et al. 2016). In addition, bank deposition and aeolian transport of sediment can affect the character of other types of TCPs. The activities of research and monitoring may also have the potential to negatively affect the character-defining elements of archaeological sites and TCPs. For purposes of the original LTEMP EIS analysis, a review of sites inventoried and monitored as of 2016, and additional analysis performed by Reclamation and NPS working with USGS and GCMRC researchers using their classification system cited above,9 it was determined that up to 220 archeological and historic site properties could be affected by dam operations or non-flow aspects of this NEPA action. Determinations of eligibility have been completed for all known properties. Additional information, including inventory and monitoring, data recovery activities, and completion of determinations of eligibility for sites along the river, are continuing to provide up-to-date information on sites potentially affected." | The following was added to Section 3.121 Affected Environment under Analysis Area in keeping with the LTEMP SEIS:<br>"There are a number of ways in which dam operations may affect cultural resources, including the periodicity of inundation and exposure, changing vegetation cover, streambank erosion, slumping, and influencing the availability of sediment. Direct and repeated inundation/exposure may affect resources such as the Spencer Steamboat, which is in the active channel . . ., or Pumpkin Springs, a TCP along the bank that is subject to inundation during high flows (e.g., equalization flows and HFEs). Streambank erosion, slumping, flow-related deposition, and indirect effects of deposition may affect cultural resources contained within terrace contexts in proximity to inundated areas. Fine sand or sediment can be blown from flow-deposited source areas and deposited on cultural sites (East et al. 2016). . . . The effects of deposition or erosion may be negative or positive depending on the nature of the site. One important recent finding is that sandbars created by high-flow events at Glen Canyon Dam can provide sources of windblown sand that can cover archaeological sites (East et al. 2016) as well as anneal, or reverse, the formation of gullies (Sankey and Draut 2014). In this context, changes in dam operations can affect erosion rates on archaeological sites (East et al. 2016, Collins et al. 2016). In addition, bank deposition and aeolian transport of sediment can affect the character of other types of TCPs. The activities of research and monitoring may also have the potential to negatively affect the character-defining elements of archaeological sites and TCPs. (DOI 2016a, p. 3.147)." |

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| 50 | 139 | CRTRIBE - Cultural and Tribal Resources | p. 3-170 Please also include the updated information from the January 2024 GCMRC ARM from Joel Sankey and Helen Fairley that documents how many cultural sites have moved out of the 'type 1" site condition where aeolian transport is occuring freely. This transition has happened largely due to the period of no HFEs in the last 5 years. This is an important background condition that makes it imperative to have HFEs with the frequency orignally planned under the LTEMP EIS - so please get their latest info and if needed contact them for the interpretation to get a short paragraph about that current state. | Language added to Section 3.12.1 Affected Environment: USGS Glen Canyon Dam Operations Study:<br><br>"A study conducted by the USGS demonstrated that flow changes from the operation of Glen Canyon Dam since 1963 have changed the amount of sediment and riparian vegetation along the Colorado River through the GCNP which has led to the decrease in the amount of wind-borne sand protecting sites (Sankey et al. 2023). The wind-borne sediment helps protect sites from erosion, which may impact a site's physical integrity by incremental accumulation of sand over long periods of time. By examining aerial imagery, the USGS concluded that the number of sites along the river that have 'the highest likelihood of receiving wind-blown sand from fluvial sandbars . . . decreased over each monitoring interval , from 98 in 1973 to only 4 in 2021-22' (Sankey et al. 2023:10). The change is generally the result of the increase in vegetation on the sandbars, which prevents the transport of sand. The vegetation increase can be attributed to the lack of floods, which would have normally occurred seasonally along the river prior to the construction of the dam (Sankey et al. 2023)." |
| 50 | 141 | CRTRIBE - Cultural and Tribal Resources | p. 3-172 For the Non-Bypass Atlernative on this page, you have some impacts, but you miss one of the bigger and important ones of this alternative. When the # of HFEs are split out by the years that the Non-Bypass tool is actually used, we are pretty sure you will see fewer HFEs and shorter HFEs because of the erosion of sand mass balance in those year - please look at those results and then update this section for the Non-bypass to state that fewer HFEs will impact cultural sites by leading to less deposition and less aeolian transport and therefore more exposure of archeological sites. Ths is a very important dyanamic that has been studies by GCMRC for many years and its one of the important Grand Canyon Protection Act responsibilities that must be addressed. Thank you. | Per the current 2024 GCMRC modeling, there will be variations in HFEs and slight differences in sandbar development between the alternatives (Salter and Grams 2024); however, the daily amount of exposed sand available for eolian transport to protect archaeological sites is not expected to vary substantially between the alternatives (Kasprak et al. 2024). Language has been added to clarify the results of the modeling to Issue 2 in Section 3.12.2 Cultural Resources Environmental Consequences. |
| 50 | 140 | CRTRIBE - Cultural and Tribal Resources | p. 3-172 You state on page 2-10 that "If drought and aridification conditions continue, the No Action Alternative could also result in the continued trend of fewer and smaller HFE releases" that seems correct and should be restated here. Currently this section indicates that HFEs will happen just fine under no action, but that ignores the fact that HFEs didn't occur between 2018-2023 even though they were triggered. It would much more accurate and fair to say on p 2-10, that in fact under no action with a lower Lake Powell elevation and that we would expect to have fewer HFEs than LTEMP intendend. This is important because the strategy for depositing and retaining sediment on beaches and sandbars in the LTEMP was based on FREQUENT HFEs. The changes to the HFE protocol to expand the window to 1 year will help address this issue an maitain a frequency of HFEs to protect the resources that is closer to what was originally planned in the LTEMP EIS. See page 3-53 and 3-54 in the original LTEMP EIS that explains why HFEs need to be conducted frequently. You can include a statemetn from the LTEMP EIS p 3-181 that explains why you need frequent HFES - it states "... the net effect of high flows in building eddy sandbars results from the magnitude and the frequency of high flows and the deposition they cause. Erosion ensues rapidly after each high flow, and the rate of erosion declines thereafter but persists. The longer the time period between HFEs, the more erosion occurs (Melis 2011)." | Language was added to Section 3.12.2 Issue 2 No Action Alternative. If drought conditions continue, the No Action Alternative could result in the continued trend of fewer and smaller HFE releases. Language was added about HFE frequency in Affected Environment of Sediment section. |

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| 50 | 142 | CRTRIBE - Cultural and Tribal Resources | p. 3-173, 174 on this page and on the 3-174 under the summary you state "Non-Bypass Alternative - Impacts under the Non-Bypass Alternative would be the same as those impacts described for the Cool Mix Alternative, including sand bar development" but we do not think this is correct. When the # of HFEs are split out by the years that the Non-Bypass tool is actually used, we are pretty sure you will see fewer HFEs and shorter HFEs because of the erosion of sand mass balance in those year - please look at those results and then update this section. | Per the current 2024 GCMRC modeling, there will be variations in HFEs and slight differences in sandbar development between the alternatives (Salter and Grams 2024); however, the daily amount of exposed sand available for eolian transport to protect archaeological sites is not expected to vary substantially between the alternatives (Kasprak et al. 2024). Language has been added to clarify the results of the modeling to Issue 2 in Section 3.12.2 Cultural Resources Environmental Consequences. |
| 50 | 143 | CRTRIBE - Cultural and Tribal Resources | p. 3-178, 179 Where you discuss taking of life, it should be noted that for No action and non-bypass that if they do not prevent SMB and other warmer water non-natives from growing and expanding that other methods, likely more mechanical and chemical treatements, may need to be used by other agencies to try to control these species. | There was a change to 3.13.2 Issue 1: Under the No Action Alternative, Reclamation would not change Glen Canyon Dam's current operations. Effects on Traditional Cultural Properties would not be different from those effects analyzed in the LTEMP FEIS, which may include management activities to prevent further spread of nonnative fish. |
| 50 | 147 | REC - Recreation | p. 3-182 "The section for day-rafting, boating and camping that starts on 3-182 you need to add a section about the impacts of larger flucutaitons such as those in the non-bypass alternative, paritcularly the impacts of flows lower than 5,000 cfs. NPS had to warn boaters in sept of 2023 when flows were suddenly reduced to 5,000 cfs and NPS recieved many reports of motorized boating incidents, primarly broken props. Also NPS had to suspend some administration rapid response electrofishing efforts becaue it was felt 5,000 cfs created unsafe navigability situations in Lees Ferry for motorized craft trying to operated at night. Please include in this section somewhere text from the 2016 LTEMP about how flucutations and lower flows impact recreation boating. Here is the 2016 text from p. 3-183: ""The Bishop study (Bishop et al. 1987) further evaluated whitewater boaters preferences with respect to levels of daily flow fluctuations. The study, which was conducted at a time when very large fluctuations were common, identified fluctuations in excess of 10,000 cfs as being noticeable and perceived as less natural to canyon visitors. High fluctuations, ranging from 3,000 to 25,000 cfs/day, were also noted as contributing to issues related to selection of campsites, time allowed at attractions, mooring and tending of boats, transiting major rapids, and trip scheduling. River guides reported that tolerable fluctuations increased with increasing average daily flow, as shown in Table 3.10-2 (adapted from Bishop et al. 1987), and that the ability to run a whitewater raft trip was particularly sensitive to flow fluctuations when daily flows were low. Shelby et al. (1992) documented that with daily fluctuations of 9,00010,000 cfs, boatmen reported problems with boats left hanging on beaches by receding water levels." | Added information regarding reduced navigability and public health and safety has been added to the analysis. |
| 50 | 146 | REC - Recreation | p. 3-182 "Where you state ""Most anglers elect no tto fish in the Glen Canyon reach during HFE releases."" you should also add information from 2016 LTEMP to discuss how the larger fluctuations on the non-bypass alternative that may occur up to 26 times a summer resembler the preMLFF flows that existed before 1995 and then in sert this pargraph from the 2016 LTEMP EIS p 3-174 that states ""High water levels, as well as rapid changes in water levels, directly affect the safety of wading fishermen due to the potential for being swept away by the river current. The 1995 Glen Canyon Dam EIS (Reclamation 1995) included a reference to three drownings that were possibly related to river stage or stage change and noted that high flows (30,000 cfs or more) reduced the safety of wading in the river. After the adoption of the MLFF operating protocol in 1996, ramping rates were restricted, which has likely reduced the level of this risk, as has the reduction of normal high flows to 25,000 cfs.""" | Change was made to the analysis. |

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| 50 | 144 | REC - Recreation | p. 3-182 In the paragraph where you state "Recent drought conditions and aridification have resulted in warming water temperatures below Glen Canyon Dam, which could impact rainbow trout energetics and survival (Rogers 2015; Korman et al. 2022)." you should do 2 things - 1) copy this statement to the other parts of the plan where you talk about rainbow trout, 2) add information about the low dissolved oxygen conditions in 2023 that are also adding a major new stressor to the rainbow trout population, and recent information from D. Ragowski and Scott Rodger that the health of the rainbow trout this spring is not good. For information on the low DO conditions in in 2023 look at the presentations from Bridget Deemer and Josh Korman presented at the January 2024 GCMRC ARM. | Reclamation was unable to obtain the presentation cited. However, low dissolved oxygen conditions were emphasized in the Affected Environment section in the Final SEIS. Reclamation welcomes additional data and information to be considered during the planning and implementation process. |
| 50 | 145 | REC - Recreation | p. 3-182 The wording in this paragraph needs to be changed - it current reads as if we are encouraging a brown trout recreational fishery - the incentivized harvest program is a removal program not a recreational fishery program. You state "The NPS currently utilizes an incentivized harvest program to encourage anglers to catch and keep brown trout in the Lees Ferry reach. The program has increased the popularity of brown trout fishing since 2016; however, the brown trout fishery in this reach is still not highly sought-after. Fishing in the remainder of this analysis refers to the rainbow trout fishery." please reword to state this "The NPS currently utilizes an incentivized harvest program to encourage anglers to remove brown trout in the Lees Ferry reach. The program has more participation each year; however, the the number of participants is still low, thought the numbers of fish removed by this small number of anglers has increased greatly and is showing reductions to the population. Fishing in the remainder of this analysis refers to the rainbow trout fishery." You can find a citation for these statements at the January 2024 GCMRC ARM presentations. | The Final SEIS was updated per comment. |
| 50 | 148 | REC - Recreation | p. 3-186 "This section on boating and camping in Grand Canyon should again include information in the 2016 LTEMP that is very relevant about how larger flucutations like those in non-bypass option impact camping and how sediment is crucial to maintain recreational campsites that should be included or at least referenced. Please include ""High fluctuations, ranging from 3,000 to 25,000 cfs/day, were also noted as contributing to issues related to selection of campsites, time allowed at attractions, mooring and tending of boats, transiting major rapids, and trip scheduling."" from LTEMP p. 183 and these sentences from pages 3-179, 3-180 and 3-181 of the LTEMP ""The number of available campsites and the amount of campsite area at any particular time are affected by river flow (i.e., fewer campsites are available at higher flows, and vice versa). Because of their singular importance in supporting river use, there have been numerous campsite inventories over the years; NPS reported in the CRMP that there are more than 200 regularly used camping beaches in the GCNP planning area. The number and usability of campsites vary from year to year based on several factors, including flow regimes; vegetation changes; erosion from tributary flooding, wind, or recreation use; or closure of sites to protect sensitive resources (NPS 2005a). The primary factors identified in campsite loss were riparian vegetation growth and sandbar erosion. The diminishing availability of campable area, particularly in some of the narrower reaches of the river corridor, is an important issue for national park managers and recreational river runners. Over the long term, eddy-sandbar size can only be increased if (1) adequate sediments are available for deposition, (2) high-flow deposition is substantial, (3) high flows occur frequently, and (4) erosion that occurs between high flows is less than the deposition. Thus, the net effect of high flows in building eddy sandbars results from the magnitude and the frequency of high flows and the deposition they cause. Erosion ensues rapidly after each high flow, and the rate of erosion declines thereafter but persists. The longer the time period between HFEs, the more erosion occurs (Melis 2011)." | The Final SEIS was updated per comment. |

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| 50 | 149 | REC - Recreation | p. 3-190 Where you state, "Reducing the overall rainbow trout population could negatively affect the rainbow trout fishery; however, these effects are not likely to be significant overall due to the short-term nature of flow implementation." We disagree. As stated above in many places, this assumption is based on the Korman 2011 study that assumes a compensatory response from rainbow trout, but the population size being so low now and the additional stressors from high temrperature, low DO, additional predation and other recent poor health indicators suggest it cannot be assumed there would be a compensatory response. Also these non-bypass large flucutations could occur up to 26 times a summer. | The Final SEIS was updated per comment. |
| 50 | 62 | AQUA - Aquatic Resources | p. 3-54 Differences in parasite density and abundance between the Little Colorado River and Colorado River are also caused by differences in salinity, not just temperature. The salinity in the LCR may actually work as a prophylactic for fishes. See Ward, D. L. (2012). Salinity of the Little Colorado River in Grand Canyon confers anti-parasitic properties on a native fish. Western North American Naturalist, 72(3), 334-338. Temperatures in the Colorado River (especially in the last few years) have allowed for parasites to complete their life cycles. | The Final SEIS was updated per comment. |
| 50 | 63 | AQUA - Aquatic Resources | p. 3-55 Strike out 'two other native fish species' so the sentence should read, "In addittion, the flannelmouth sucker and bluhead sucker,....". When two other native fish species is mentioned, it sounds like two more native fishes other than what has been mentioned are goign to be mentioned in the senence. The word coexist in the last sentence prior to the figure,"....helps to explain why these species can coexist in a system...." makes me think that nonnative fish species and native fish species are inhabiting the same space peaceably. Consider changing the sentence to, "This figure illustrates the large overlap in temperature requirements of native and nonnative fish species found in the Colorado River and its tributaries, which may explain why nonnative and native fish species co-habitate a similar environment." | The phrase was deleted as recommended. The language recommended for the figure was included. |
| 50 | 65 | AQUA - Aquatic Resources | p. 3-56 Strike out "Of the remaining three species-" from the first sentence on page 3-56. Consider changing the sentence to, "The Zuni bluehead sucker, Little Colorado sucker, and Little Colorado spinedace are endemic to the upper reaches of the Little Colorado River. Change mainstream to mainstem in sentence, "....have been extirpated from the mainstream between....." Change all occurences of mainstream to mainstem when referring to the mainstem Colorado River. | The Final SEIS has been updated per comment. |
| 50 | 67 | AQUA - Aquatic Resources | p. 3-57 Where is the supporting citation for this sentence? "Bluehead suckers are found more often in GCNP with warmer dam releases." Change capitalization of "Lower" to "lower Colorado River" in sentence, "relatively high numbers of individuals remain in the Lower Colorado River between Lava Falls Rapid (river mile 179) and Lake Mead". Where is more recent information from the larval fish studies (which occurs every year)? The data from this sentence, "Sampling of the larval fish community in the western Grand Canyon between Lava Falls and Pearce Ferry collected bluehead sucker larvae throughout the analysis area (Albrecht et al. 2014). In this analysis area, the bluehead sucker was the most abundant species in the larval fish community, composing almost 40 percent of the total catch." is ten years old now. | Capitalization has been made consistent with the remainder of the document. An additional reference and text were included from more recent larval sampling efforts. |
| 50 | 68 | AQUA - Aquatic Resources | p. 3-58 This sentence, "Smaller tributaries may provide nursery grounds for populations of large adjacent rivers (Rinne and Magana 2002)." could use some clarity | This sentence was clarified in the text. |
| 50 | 69 | EDIT - Editorial | p. 3-59 Add a comma after Paria Rivers in sentence, "Within the Grand Canyon, this species may be found in the mainstream Colorado River and its tributaries, including the Little Colorado and Paria Rivers, and Shinumo, Bright Angel, Kanab, and Havasu Creeks." | The Final SEIS has been updated per comment. |

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| 50 | 70 | AQUA - Aquatic Resources | p. 3-62 Under life history: Strike 'this' and replace with 'Speckled' in sentence, "This Speckled dace spawns twice, once in spring and again in late summer (AZGFD 2002b)" Under Factors Affecting....: This sentence, "Although this species is the most widely distributed and abundant native fish species in the Grand Canyon ecosystem, its abundance and distribution could be affected by many of the same factors that affect the abundance and distribution of the other native fish in the ecosystem, namely altered temperature, flow, and sediment regimes and predation by nonnative fish" needs to be reconsidered. Speckled Dace may not be the most widely distributed or abundant fish species any longer (e.g., flannelmouth sucker). Consider changing sentence to, "Speckled Dace abundance and distribution could be affected by many of the same factors that affect the abundance and distribution of the other native fish in the ecosystem, namely altered temperature, water flow, sediment regimes, and predation by nonnative fish." Under nonnative fish: The three species of fish mentioned in this sentence "Among these nonnative species, three are largely restricted to Lake Powell and/or Lake Mead and are found in the Colorado River and its tributaries below Glen Canyon Dam only occasionally; these species are black crappie, bluegill, and gizzard shad (Table 3-30)." are actually becoming increasingly more common to catch below Glen Canyon Dam, especially bluegill. | The Final SEIS has been updated per comment. |
| 50 | 72 | AQUA - Aquatic Resources | p. 3-64 There is a more recent compilation of non-native occurances in the appendix of the NPS Expanded Non-Native Aquatic Speces Management Plan EA | The table was verified to include all species listed in the environmental assessment appendix that have or do occur in the Grand Canyon. The citation was added to the table (NPS 2018). |
| 50 | 73 | AQUA - Aquatic Resources | p. 3-68 first para states SMB may have moved down the LIttle Colorado River, but recent conversations with FWS (David Ward) and Arizona Game and Fish (indicated there are no SMB in the LCR in Grand Canyon, and only one source in the drainage which is being actively addressed by removal, thus most most SMB originated either in Mead or entrained from Powell, until recent reproduction below the Glen Canyon Dam beginning in 2022 | According to our information the smallmouth bass is currently found in reservoirs of the upper Little Colorado River and may be transported downstream by high flows. |
| 50 | 75 | AQUA - Aquatic Resources | p. 3-68 This section really needs the graph of lamba from the appendix inserted directly into the text here - that is the most important data/modeling result in this plan and should be directly in the text given its importance for this decision as are the hydropower impacts. Also like hydropower we should have clear reporting of the statistics, not just a graph. Please add a table with the average lambda for all 30 runs for each alternative, and a % of runs for which the lambda is greater than 1. Those 2 statistics should be in there in a table and should also be ported up to the top summary. | We have provided a summary table of lambdas for each of the alternatives in support of the figure from Eppehimer and Yackulic (2024) as presented in Appendix A of the Draft SEIS. Please note that Appendix A has been removed from the Final SEIS and replaced by incorporated the more recent GCRMC report (GCRMC 2024). |
| 50 | 74 | AQUA - Aquatic Resources | p. 3-68 first para - "Starting in 2022, many of the bass are smaller, indicating that these fish have been produced locally, probably in and around the -12-mile slough." Is this conclusion correct or should it actually be qualified a bit to state that the majority of SMB may have been produced in the slough but many may have been entrained as young or spawned in other backwater areas including just below the dam it seems like its very possible some were the result of entrainment of small individuals passing through the dam given findings upstream of the slough | The conclusion that the smaller smallmouth bass found in and around the slough are from local reproduction in 2022 and 2023 is based on the first-time temperatures were suitable for spawning in that area. |
| 50 | 76 | AQUA - Aquatic Resources | p. 3-69 Add a sentence on turbidity effects on predation of SMB on fish species. Although turbidity has been reported to reduce SMB feeding efficiency (Ward and Vaage 2019), evidence from the Upper Basin, which is perpetually turbid with values usually above 50 FNU and often above 1000 FNU, seems to indicate that SMB can survive and thrive at NTU/FNU regularly higher than 50 (125 JTU, approx), and have population level effects on native fishes (Bestgen and Hill 2016).<br>Ward, D.L. and Vaage, B.M., 2019. What environmental conditions reduce predation vulnerability for juvenile Colorado River native fishes?. Journal of Fish and Wildlife Management, 10(1), pp.196-205. | Thank you for the comment and resource summaries provided. However, the discussion about smallmouth bass feeding efficiencies related to turbidity is not the context of the section referenced. The only discussion about turbidity is related to fry displacement, as the section is focused on life histories with habitat and reproduction being the focus. Additional turbidity language has been included in Chapter 1. |

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| 50 | 78 | AQUA - Aquatic Resources | p. 3-70, 74, 75 The sections on cold-water nonnative Species and brown trout seems to be outdated - only talks about dynamics to about 2015 in much of it with incorrect conslusions or up to 2018 with the Runge report. There is a lot of new info since then. For instance this statement "Because spawning by brown trout in the Grand Canyon occurs primarily in tributaries " is now totally incorrect. It may have been correct in 2014 but hasn't been correct since as we've documented a lot of spawning in Lees Ferry since 2015 - that whole paragraph needs to be updated with what we've seen from 2015-2024 with current population a graphs. Brown trout are no longer 'on the cusp' of recruiting locall hatched fish - they have recruited every year since 2016. Again - please see the presentations and graphs of rainbow trout and brown trout from the GCMRC Annual Review Meeting proceedings from Jan 23-25 2024 to get the necessary updated info that shows the updated and very low population levels of rainbows, the increasing number of browns and , the information about the low dissolved oxygen levels and the increased temperatures. Or if needed I'm sure Brian Healy and Josh Korman could provide the best data and references. | In the text, we acknowledge that brown trout have expanded from their former population center in Bright Angel Creek and have become common in the Lees Ferry Reach. We also acknowledge that spawning by brown trout is taking place in the Lees Ferry Reach. We have revised the language accordingly. |
| 50 | 77 | AQUA - Aquatic Resources | p. 3-72 The section on Rainbow trout seems to be outdated - only talks about dynamics to about 2018... its missing all the dyanmics and pressures that have been occuring in the last 2-3 years - increased river temperatures, decreased dissolved oxygen, increased predation/competitiion. These are important context for why the population is so low right now and related some of the alternatives that would be like to lower river temperature and improve the dissolved oxygen situation. Please see the presentations and graphs of rainbow trout from the GCMRC Annual Review Meeting proceedings from Jan 23-25 2024 to get the necessary updated info that shows the updated and very low population levels, the information about the low dissolved oxygen levels and the increased temperatures. Or if needed I'm sure Brian Healy and Josh Korman could provide the best data and references. This information is critically important as some of the alternatives like the non-bypass may reduce rainbow trout recruitment and the currently low population level and stressors may prevent a compensatory response so your text as well as your analytical conclusions need to be updated with the current population and dyanmics in Lees Ferry. | The information on rainbow trout abundances is based on the most recent citable information available. Reclamation welcomes any additional references. |
| 50 | 79 | AQUA - Aquatic Resources | p. 3-76 Table 3-31 is probably very outdated. Please get updated distribution maps for the LCR from GCMRC or FWS. | Table 3-33 of the Final SEIS identifies the fish found throughout the Little Colorado River (not just near the inflow where GCMRC and the Service are sampling). Reclamation welcomes any new references regarding fish distribution. |
| 50 | 82 | AQUA - Aquatic Resources | p. 3-78 Given that you draw the conclusion on 3-78 that " these warmer temperatures will likely provide more suitable conditions for the proliferation of a number of fish parasites that could negatively affect native fish species (see Figure 3-34)." Then why is isn't this important factor addressed in table 2-2. It should state that parasites are much more likely to increase under No Action and Non-Bypass than under the action alternatives that cool summer temperatures. Please be sure this significant aquatic resource issue gets included in the table 2-2. | This issue has been addressed in Table 2-2 of the Final SEIS. |
| 50 | 80 | AQUA - Aquatic Resources | p. 3-78 there are extra characters in this sentence - fix to say improved humpback growth and survival I think. For example, the temperature of water released from Glen Canyon Dam increased during the trout removal study period to temperatures that may have improve humpback cub growth and survival | The Final SEIS has been updated per comment. |

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| 50 | 81 | AQUA - Aquatic Resources | p. 3-79 please add a paragraph that interactions between native fish and increasing numbers of SMB and GSF are likely to increase, and that these native fish will be subjected to much higher predation levels from warm water non-native fish as they get established. Increases in smallmouth bass, green sunfish, walleye and others would be very likely to greatly reduce young native fish survival levels. There is abundant evidence from the upper colorado river basin, (Johnson et al. 2008, Bestgen and Hill 2016, Martinez et al. 2014 and other references), that should be stated here to discuss this interaction of smb impacting native fish. | The following text was added: "Interactions between native fish and increasing numbers of smallmouth bass and green sunfish are likely to increase, and these native fish will be subjected to higher predation levels from warm water nonnative fish as they become established. Increases in smallmouth bass, green sunfish, walleye, and other nonnative species would likely reduce young native fish survival levels." |
| 50 | 83 | AQUA - Aquatic Resources | p. 3-79 see pdf letter for attached tables, row 62 in comment table The conclusion from this paragraph that rainbow trout won't be affected significantly by fluctuating flows is much less likely to be true now. Rainbow trout recruitment is likely to be affected, as it was prior to the MLFF. Given currently very low population size and other stressors from warmer temperatures, low do and more predators and competitors, there is much greater chance that extreme fluctuating flows such as the non-bypass 2000cfs to 27000cfs will affect the rainbow trout. If you look at figure 8 in the korman 2011 paper, you will notice that te compensatory response is happening when the reproducing population is in the > 2 million eggs part of the stock recuitment curve. however the current population size of rainbow trout is smaller than the 2006 population size which is at the far left of that graph less under a 1 mllion eggs level, so its much less likely there would be a compensatory response. Please include that figure in this LTEMP SEIS and check with GMRC experts like Brian Healy to help interpret why this may mean a compensatory response is a lot less likely. this is a very important consideration because the non-bypass alternative particularly presents this risk to rainbow trout population and to the rainbow trout fishery and this risk needs to be highlighted in this aquatic resources ipacts section and reflected in the table 2-2 summary. The flow spikes and HFEs are likely to have less impact because they don't drop as low beforehand and they remain higher for longer, and are much less frequent. This statement needs more context and updating with the current situation - this is only true with a larger and heatlhier rainbow trout population than exists right now. This is your text that needs to be updated: "The fluctuating flows were determined to have resulted in increasing the incubation mortality rate from 511 percent under normal flow conditions to 2349 percent under fluctuating flows (Korman et al. 2005; Korman et al. 2011; Korman and Melis 2011). However, no measurable reduction in age-0 abundance was observed, presumably due to increased survival of those rainbow trout that survived." | The following language was added: "This compensatory response may not occur under different flow conditions and rainbow trout population sizes. The present rainbow trout population is at its lowest level (Figure 3-44), and it may not be able to rebound from a flow scenario that would induce substantial mortality on the eggs and fry. Flow alternatives with particularly low dam releases would dewater spawning areas of trout and induce mortality to eggs and fry from which the low population may be unable to recover." |
| 50 | 84 | AQUA - Aquatic Resources | p. 3-80 Typo in middle of first para - ...a fe" brown trou" | The Final SEIS has been updated per comment. |
| 50 | 85 | AQUA - Aquatic Resources | p. 3-81 This is all very outdated. Removal efforts have continued and are ongoing. Published results are in Healy et al. 2018 and Healy et al. 2020; annual reports summarize data through 2022 | Additional citations were included as appropriate. |

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| 50 | 86 | AQUA - Aquatic Resources | p. 3-82 The paragraph beginning 'In 2017...' implies that the the proposed project of connecting the slough to to mainstem Colorado was actually done, which it wasn't. Suggest moving the last sentence (as modified below) above the information about the proposed connection project. Otherwise, the information on green sunfish is good for the time period covered, but a lot has happened in the last 3 years that this paragraph doesn't talk about. Green sunfish have increased in extent significantly in the last 3 years - again Melissa Trammell/Emily Omana/Jeff Arnold can provide catch data and Katherine Tucker can provide extent maps. Also there is information from Barrett Freissen (USU) study in the forebay of small green sunfish massing near the dam and good evidence to suggest that smaller green sunfish are entraining through the dam and you state that elsewhere in the plan. Would be good to update this sentence "Despite these efforts, green sunfish are regularly captured by fish monitoring efforts in the mainstem river." with a few sentences about these more recent findings. Melissa Trammell or Jeff Arnold could also provide #'s of GSF that were lethally treated during the last two years rotenone treatments in the slough. | We have added the following statement on the slough: "NPS is considering whether to mechanically modify the slough to allow the river to flow through the area and eliminate the effect of pooling water that provides a warm, low-velocity habitat for nonnative fish." |
| 50 | 88 | AQUA - Aquatic Resources | p. 3-84 Under Issue 1: It is possible that 'other mitigations' will not be present by 2027, or will not be sufficient to avoid establishment of SMB. To clarify this we suggest changing this sentence to say 'These alternatives were modeled through 2027, with the anticipation that other mitigation factors will be present by 2027; however, if such factors are not present or insufficient to avoid establishment of SMB, implementation of these alternatives may be extended past 2027." | The following text was added: "The alternatives proposed in this SEIS were modeled through 2027, with the anticipation that other mitigation factors will be present by 2027; however, if such factors are not present or insufficient to avoid establishment of smallmouth bass, implementation of these alternatives may be extended past 2027." |

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| 50 | 89 | AQUA - Aquatic Resources | p. 3-85 We have a few specific requests here for how to present the SMB lambda modeling results to be comparable to hydropower results for fair evaluation of all the alternatives: 1) The lambda results in appendix A should be inserted here directly given how important these results are to evaluting all the altenratives for purpose and need. The hydropower results are direclty in the text but hydropower is not part of the purpose and need but the efficacy of SMB populatipon reduction is. 2) the figure for the results needs some reformatting - the labels should be below the axis and the solid lines representing where the majority of runs landed should be dot like the other result locations. the level at which most of the results are coming out needs to be labeled (is it 90%, 92%, 95%? Also the figure legend needs to state more clear that lambda below 1 means a decreasing SMB population whereas a lamda over one means an increasing population and a lamba of 2 means the population is doublling. Also you need to state in the figure legend what percent of the runs didn't have any release temperatures over 15.5C - I suspect is 17% or close to that - that is really important to tell because that means that if no action and no bypass are maintaining lambda below 1 for 83% of the runs that is only because the temperatures never got high! so the action part of no bypass is not working to keep lambda below 1 for any runs. If that is true you need to provide the info for readers to understand that. The legend also needs to explain that reason effectiveness of lambda is higher in 2024 than 2027 is because the reservoir level may decrease in many of the runs by 2027 resulting in warmer outflow temps. That is a really important explanation. 2) you need a table of the average lambda results for only the years in which the release temperature was above 15.5C and for rm 15 and rm60 broken out. This should look just like table 3-25 in the hydropower section but should provide the average lambda in the summers in which temperature was over 15.5C. That way we can see how the tools in the alternatives are actually working in the years that they needed. This will show that the non-bypass isn't getting lambda below 1 whereas the the bypass alternatives are. But it will also provide a clear statistic that can be compared between all alternatives including those with spikes and without. It appears like the spikes aren't doing much, but if there are caveats to the modeling in that they can't fully tell us the results of the spikes then that should also be stated in the figure and table legends. This average lambda for the summers in which the temp was over 15.5C should then be included in the impact summary table at the top of the document. Ths is critically important to be able to evaluate the effectiveness of each alternative. | An updated explanation of lambda is provided in the document. Also, a table has been added that summarizes the percentages of 30 traces where lambda >1 for river miles 15 and 61 for each of the alternatives. The modeling for smallmouth bass propagule pressure and lambda population growth is described in Eppehimer and Yackulic (2024) as a chapter in the Modeling Impacts document of the USGS (Yackulic et al. 2024). |
| 50 | 91 | AQUA - Aquatic Resources | p. 3-86 For no action native fish section, you are missing the biggest issue - that these native fish will be subjected to much higher predation levels from warm water non-native fish as they get established. Increases in smallmouth bass, green sunfish, walleye and others would be very likely to greatly reduce young native fish survival levels. There is abundant evidence from the upper colorado river basin, (Johnson et al. 2008, Bestgen and Hill 2016, Martinez et al. 2014 and other references), that should be stated here to discuss this interaction of smb impacting native fish. This is the most important impact so please add a sentence specific to that here. Also you should mention that spring HFEs are very similar to the natural yearly peak flows that existed pre-dam that the native fish evolved with - that is quite an important fact when discussing the potential impact of spring HFEs. If native fish weren't able to deal with a spring HFE that would be very odd since it would the most like the hydrology that they experienced every year pre-dam. | Reclamation has reviewed the No Action section and made updates accordingly. Please see Section 3.5 for additional information. |

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| 50 | 92 | AQUA - Aquatic Resources | p. 3-86 For no action non-native fish section, you are missing the biggest issue - that the the non-native fish will increase in numbers and expand downstream in years when river temperature exceeds 15.5C. You need to provide the no action average lambda for the years that exceed 15.5C and you will see its generally over 2 meaning the population of SMB will more than double each year this happens. This is critical to state and to explain - its the biggest and most concening effect of no action and its why we are doing this SEIS and its not clearly stated in this section. Please add a few sentences talking about how Smallmouth bass, green sunfish, walleye and other invasive predators have been increasing, and predation on native fishes is expected to increase as a result, as the invasive predators become established. Increases in smallmouth bass, green sunfish, walleye and others would be very likely to greatly reduce young native fish survival levels (see references in above comment). This is the most important impact so please add a sentence specific to that here. | A figure has been added to the impact analysis that provides the average lambdas and ranges (maximum and minimum values) for the 30 traces at river mile 15 and 61 for each of the five alternatives and No Action. This figure shows the Cool Mix and Cool Mix with Flow Spikes are the least likely alternatives to allow smallmouth bass population growth (lambda>1). We have added language on other nonnative invasive fish species in the Grand Canyon. |
| 50 | 90 | EDIT - Editorial | p. 3-86 the citation (Summit Technologies Inc. 2022) is not included in the list of references. please add. | This reference was replaced in the Final SEIS. |
| 50 | 94 | AQUA - Aquatic Resources | p. 3-88 For coolmix native fish section, you are missing the biggest issue - that for this alternative there will be much less predation from warm water non-native species than no action - you talk about the effect on non-natives below it, but you need to draw the conclusion in the native fish section that the control of non-antives that this alternative would provide will avoid the much higher predation that would exist under alternatives that do not keep smb lambda under 1 (no action and non-bypass). You need to explain that here. | A figure has been added to the impact analysis that provides the average lambdas and ranges (maximum and minimum values) for the 30 traces at river miles 15 and 61 for each of the five alternatives and No Action. This figure shows the Cool Mix and Cool Mix with Flow Spikes are the least likely alternatives to allow smallmouth bass population growth (lambda>1). |
| 50 | 93 | AQUA - Aquatic Resources | p. 3-88 In the top section of cool mix, you state - "For river mile 15, predicted is > 1 for none of the traces in 2024-2027. For river mile 61, the model predicted is > 1 for none of the traces in 2024-2027. No uncertainty in model inputs, functional relationships, or outputs are described." While this is correct, you need to interpret that because this is one of the most important results in the plan. Firstly you should stated the inverse, that for all all traces, including all of those where release temp was > 15.5C, it kept the lambda less than 1. You should provide the average lambda for the years or months that exceeded 15.5C and it will show the lambda was < .96. You then need to explain that this result is showing that this would mean the SMB population would be declining - it would get smaller each year. This is versus alternatives like non action and non-bypass that have a lambda well over 1, often over 2 for years or months where temperature > 15.5C. That means those alternatives are allowing the SMB popuation to increase and in fact double when lambda > 2. Please interpret this result clearly for the public. And again, we can't say enought that you need to break out the lambdas for the month or years in the traces that exceeded 15.5C, otherwise you are aveaaging it with the 83% of traces where SMB would not be growing anyway. Hydropower broke out their results for those years so SMB impacts need to broken out that way as well - otherwise you aren't really stating how well the tool works when its needed. | The changes were made as requested, and an interpretation was provided for lambda for each alternative. |
| 50 | 95 | AQUA - Aquatic Resources | p. 3-88 For coolmix native fish section, you are missing the biggest issue - that for this alternative there will be much less predation from warm water non-native species than no action - you talk about the effect on non-natives below it, but you need to draw the conclusion in the native fish section that the control of non-natives that this alternative would provide will avoid the much higher predation that would exist under alternatives that do not keep smb lambda under 1 (no action and non-bypass). You need to explain that here. | A figure has been included in the impact analysis that displays the average lambdas and ranges (maximum and minimum values) for the 30 traces at river miles 15 and 61 for each of the five alternatives and No Action. This figure shows that the Cool Mix and Cool Mix with Flow Spikes Alternatives are the least likely to allow smallmouth bass population growth (lambda>1). Furthermore, we have provided an explanation and clarification of the lambda values for each alternative in the impact analysis. |

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| 50 | 96 | AQUA - Aquatic Resources | p. 3-88 For coolmix non-native fish section, you are missing the biggest issue - that this alternrative will not have growth of warm water invasive fish like SMB, GSF and walleye - those species would DECLINE with an avg lamdba <1 for years or months where relase temp exceeds 15.5C. That is in great contrast to no action and non-bypass that would have incresing populations in those years. Please state that clearly as well as how this altenative reduces predation pressure on native fish. | A figure has been included in the impact analysis that displays the average lambdas and ranges (maximum and minimum values) for the 30 traces at river miles 15 and 61 for each of the five alternatives and No Action. This figure shows that the Cool Mix and Cool Mix with Flow Spikes Alternatives are the least likely to allow smallmouth bass population growth (lambda>1). Furthermore, we have provided an explanation and clarification of the lambda values for each alternative in the impact analysis. |
| 50 | 97 | AQUA - Aquatic Resources | p. 3-89 Where you state "However, since smallmouth bass have been detected mainly in the Glen Canyon reach, implementation of this alternative could still be effective at reducing the likelihood of successful spawning of smallmouth bass where most fish have been found as of the end of 2023." It should also be stated that this is a reason not to delay the use of this tool, because if its not implemented in 2024, then the range of warm water invasives is likely to expand further and this tool would then be less effective. | The schedule for implementation of the selected alternative is a decision that will be made by Reclamation and its partners. Additional implementation language has been added to Chapter 2. |
| 50 | 100 | AQUA - Aquatic Resources | p. 3-91 for cold shock with flow spike - where you talk about lambda values, you need the average lambda for the years where release temp > 15.5C provided, you should again state the inverse of the way you do- when does it keep lambda < 1 because that is our goal, and you need to interpret and explain that that means the warm water invasive fish populations would be decreasing rather than increaseing. Again needs to be contrasted with no action and non-bypass where lambdas in those years is well over 1 and often well over 2. | A figure has been included in the impact analysis that displays the average lambdas and ranges (maximum and minimum values) for the 30 traces at river miles 15 and 61 for each of the five alternatives and No Action Alternative. This figure shows that the Cool Mix and Cool Mix with Flow Spikes Alternatives are the least likely to allow smallmouth bass population growth (lambda>1). Furthermore, we have provided an explanation and clarification of the lambda values for each alternative in the impact analysis. |
| 50 | 99 | AQUA - Aquatic Resources | p. 3-91 Once again where you state "For river mile 61, the model predicted is > 1 for 0 percent of the traces in 2024 but is predicted to be > 1 for 10 percent of the traces evaluated by 2027." you need to interpret this result for the public and you should state the inverse - under what conditions is it keeping lambda < 1. You also need to talk about not all traces, but what percentage of the traces where release temps > 15.5C. Those are the important years where the tools are needed. And again in the native fish section, you need to state the obvious effect that if warmwater non-natives aren't expanding as much as under no action that this alternative will have more successful native fish reproduction over time. This is so important to state and explain here as it is the reason these alternatives are even being considered. Please add it. | The changes were made as requested, and an interpretation was provided for lambda for each alternative. |
| 50 | 103 | AQUA - Aquatic Resources | p. 3-94 "Where you state ""For river mile 15, predicted is > 1 for none of the traces in 2024 but is predicted to be > 1 for 17 percent of the traces evaluated by 2027. For river mile 61 (confluence with the Little Colorado River), the model predicted is > 1 for 3 percent of the traces in 2024 but is predicted to be > 1 for 17 percent of the traces evaluated by 2027."" This needs to be reported as the average lambda for the years where river temp exceed 15.5C. That is important since that only occured in about 17% of the traces. You need to state that is where the 17% is coming from - its the traces where the river gets hot, that this tool doesn't work - just like no action. if you are averaging to include all the traces where this tool wasn't needed you are not showing its effect. If you do it this way, it will show that lambda is over 1 for all the years where we needed to try to control the SMB populations. You need to explain that its not working to prevent increase and expansion of SMB. This is the most critical result of this whole plan and its not intepreted here - you need to explain it. If this alternative is failing to make SMB less than one, then the SMB and other warm water populations will expand and impact native fish at very close to the levels that would occur uner no action. That is not clearly stated in the summary of this plan or in this section and you have to relay that information fairly based on these modeling results. We request that you do this clearly." | A figure has been included in the impact analysis that displays the average lambdas and ranges (maximum and minimum values) for the 30 traces at river miles 15 and 61 for each of the five alternatives and No Action Alternative. This figure shows that the Cool Mix and Cool Mix with Flow Spikes Alternatives are the least likely to allow smallmouth bass population growth (lambda>1). Furthermore, we have provided an explanation and clarification of the lambda values for each alternative in the impact analysis. |

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| 50 | 102 | AQUA - Aquatic Resources | p. 3-94 Where you state "The Non-Bypass Alternative consists of weekly flow spikes" you need to clarify more and distinguish from flow spikes in the other alternatives. These aren't just flow spikes - its a quick drop to 2000cfs followed by a flow spike - this matters because that drop increases that chances of impacting native fish. While an increase from a flow spike in spring is like a natural spring peak flow, this drop followed by an increase is not. This is important. Also you need to state how many of these are occuring under the warmer traces - when is the max# happening in a summer. The flow spikes for the other alternatives are limited to 3. These could occur much more - could be that they would occur every weekend May-Oct - I think that would 26 times - if that is occuring the traces, you need to state that because its VERY VERY different from the flow spikes in teh other alternatives. That is a huge frequency of a flow that would be likely to impact a lot of resources. That is NOT clear in any way from this text to the average reader. Please make it very clear. | The alternatives are described in detail in Chapter 2. Actual implementation would vary based on actual and future conditions. |
| 50 | 105 | AQUA - Aquatic Resources | p. 3-95 For the native and nonnative fish sections of the non-bypass, you are missing the most important effects. Based on the lambda modeling, this alternative will experience growth and expansion of SMB, GSF under years where temps are > 15.5C and there will be effects to young native fish from increasing predation from these warmwater invasives. This is not reflected in the text and its the most imprtant conclusion. The effects here to native and non-native should be decribed as very simliar to no-action based on the lambda modeling. This is critical since this alternative may have negative impacts to other resources, yet is not controlling SMB and preventing it from increasing and spreading. This needs to be clearly stated on this page as an impact to native fish and as the effect to the non-native fish population and contrasted with the alternatives that do control SMB. | A figure has been added to the impact analysis that provides the average lambdas and ranges (maximum and minimum values) for the 30 traces at river miles 15 and 61 for each of the five alternatives and No Action Alternative. This figure shows the Cool Mix and Cool Mix with Flow Spikes are the least likely alternatives to allow smallmouth bass population growth (lambda>1). The language has been revised in the text to reflect the potential expansion of smallmouth bass from some alternatives and the consequence on native fish populations. |
| 50 | 104 | AQUA - Aquatic Resources | p. 3-95 Where you state "For frequency, releases would be weekly to keep bass from successfully renesting." you should again state how many of these possible in a summer - from my count it ran from May 1-Oct 31 that would be 26 times - that is huge and important to provide. If its less than that given the occurances in the traces then just provide the average and max in years that have temps over 15.5C. | The alternatives are described in detail in Chapter 2. Actual implementation would vary based on actual and future conditions. |
| 50 | 106 | AQUA - Aquatic Resources | p. 3-95 Where you state "The native Colorado River Basin fish evolved in a highly variable flow environment, and assessments of how juvenile humpback chub use different habitats or their survival rates did not vary during a transition from fluctuating to steady flows below the Little Colorado River (Gerig et al.2014)." but again we would point out that these aren't just flow spikes or hfes that might resemble a natural spring peak... these are fluctations that start with a quick drop to 2000cfs followed by a big flow spike and these would occur at a very high freuqency of every weekend and could occur all the way from May-Oct - which might be a max of 26 times - if that is occuring in any of the traces, you need to state that because its VERY VERY different from the flow spikes in the other alternatives and very different from a natural spring peak. We don't feel like these references or this analysis is complete. We would ask for more input from GCMRC on the effects on native fish in marble canyon from these flows. Particularly the 30 mile aggregation of humpback chub of concern for us with these 26 big fluctations throughout the summer. The waves from these fluctuations do not really substantially ameliorate by the time they reach the LCR, or even Pumpkin springs according to the figure included. | The text has been revised to: "The native Colorado River Basin fish evolved in a highly variable flow environment of flow, turbidity, and temperature variation. Under the Non-Bypass Alternative, a high short-term release would be followed by a low short-term release. This flow variability is not characteristic of Colorado River hydrology that is better described as increasing flows in late winter and early spring to peak flows in spring then a declining hydrograph, all taking place generally from about April to mid-June. Monsoonal floods in summer may be akin to the high releases of this alternative, but they are not generally followed by an extremely low flow (2,000 cfs). Hence, the response by the native fish to the hydrology of this alternative is uncertain, but the contrast in hydrology between high and low flows could displace and stress some fish, especially younger fish. Also, the extremely low flows of 2,000 cfs is likely to dewater shallow and shoreline habitats. Although these flow variations are expected to ameliorate downstream, effects on habitat and fish displacement could be experienced by the humpback chub aggregation at river mile 30 and possibly further downstream to the mouth of the Little Colorado River at river mile 61." |

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| 50 | 107 | AQUA - Aquatic Resources | p. 3-95 In the non-native fish section of non-bypass, it talks about the mechanism for how this *MIGHT* work but doesn't include and discuss the modeling results for SMB lambda, that suggest it doesn't work to reduce lambda below 1. The lambda values need to included and talked about here. Also when discussing the mechanism for how the flucutations might impact, it states "For smallmouth bass, rising water would flush solar-warmed shoreline nest areas with water at the temperature of main river, potentially causing nest desertion and halting embryo development if the main river temperatures are significantly lower." it says that the temperature difference is what might make this work, but we would stress that this tool will only be used when river temps are over 15.5C and warmer. So the main river temperatures would NOT be significantly lower unless bypass was used. Again, this is really important to provide some clear interp here or more info on how much of a temperature difference is needed. It seems to us this statement indicates why flow spikes paired with bypass cooling might have this effect more than this tool that is used instead of bypass. Please try to evaluate these effects for the flow spike alterantives and explain the mechanism there like you do here. | The modeled lambda values for this and all the alternatives are now summarized in a new table. These modeling results are for the sum of all elements contained in each of the alternatives and have not been parsed for flow spikes individually. |
| 50 | 108 | AQUA - Aquatic Resources | p. 3-95 We are very concerned that it doesn't appear these very frequenct fluctuations with a drop to 2000 then a spike that may be used up to 26 times a summer don't appear like they dissipate by river mile 30 where an aggregation of HBC has persisted for many years. We will like impact to the humpback there and in the upper parts of Marble canyon that would be effected by these fluctuations to be fully addressed. | The number of high releases for the Non-Bypass Alternative is not determined. As with the other flow-prescribed alternatives, actual implementation would be determined during the planning and implementation process and would vary based on current and future conditions. |
| 50 | 110 | AQUA - Aquatic Resources | p. 3-96 For the discussion on no-bypass effects to aquatic food base, 1) we are concerned that this section uses a reference (Blinn et al 1999) that study that evaluated an early spring high flow and that information is is likely not applicatable to these flows that are drop much lower and run throughout the whole summer. The argument that the dessication is occuring at night is problematic given that the dessication would occur during the hottest parts of the summer when temperatures are much higher at night than during the 1996 spring flow that Blinn considered in this paper. 2) Also with the propagation of the fluctations downstream it won't be at night by the time the fluctuation propagates to the LCR and from figure 2-6 it looks like it doesn't dissipate very much by the time it gets there so it will be happening in daylight in july/aug heat down further. 3) Again, we would highlight that these fluctuations go low before they go high and the frequency and timing are very different than a natural spring peak flow - these are occuring every weekend, potentially all summer so possibly as many as 26 times. The bug flow experiments in the last few years lasted only a few weeks but showed definite changes to macroinvertebrastes, so it seems very challenging to believe that we would conclude these have no impacts. 4) this section seems very incomplete/incorrect regarding food base/macroinvert effects and you need input from Ted Kennedy at GCMRC specifically on these sections. | This discrepancy was addressed in the Final SEIS. |
| 50 | 109 | AQUA - Aquatic Resources | p. 3-96 The effects to rainbow trout discussed here at the top of this page appear to us to be correct, but they don't match your conclusions on the previous section specific to trout or in the summary of effects at the top of the plan. These conclusions are right and need to be used to update the other sections. This section shoudl also note that this non-bypass alternative would be likely to expertince more low DO events and more warm river temperatures that will continue to stress what is already a low population level of rainbow trout that is in poor health condition whereas the bypass alternatives would reduce the temperature and low DO stressors for the rainbow trout. | The following text was added to the paragraph: “The No Action Alternative and Non-Bypass Alternative are expected to result in warmer water temperatures and lower dissolved oxygen in the Lees Ferry Reach that could be detrimental to rainbow trout.” |

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| 50 | 113 | AQUA - Aquatic Resources | p. 3-97 You state "Generally, the five alternatives are not expected to have a negative population-wide effect on native fish, as these species have adapted to a large range of flows and temperatures in the Colorado River. However, all alternatives assume that establishment of smallmouth bass will have impacts on native fish populations, which is consistent with the recommendations of the Smallmouth Bass Ad Hoc Group report (2023)." You need to add these two statements together - because if smallmouth bass will have impacts on native fish populations, then that first sentence is not true - the alternatives that don't control SMB (avg lambda in years > 15.5C) such as no action and no bypass will have a big negative impact on native fish compared to the alternatives that use bypass and control SMB. Or if you look at in comparision to no action then the no bypass will have the same negative impacts as no action but the bypass altenraives will have a positive impact on native fish by comparision. | These distinctions between alternatives have been noted in the text. |
| 50 | 111 | AQUA - Aquatic Resources | p. 3-97 You state that "Previous flow experiments below GCD to interrupt rainbow trout spawning caused mortality of rainbow trout eggs and fry, but recruitment did not decline because of compensatory survival of the remaining young rainbow trout (Korman et al. 2011)." but Korman's work was at time of a much larger and healtheir population of rainbow trout. As we commented on p 3-79, given current rainbow trout population size, and given current health and stressors (low DO, high temp, increasing preadtors), this work is likely not applicable to this situation. Please see our comments up on 3-79 and please contact Brian Healy from GCMRC for more perspective on why comprensatory response is unlikely | The following language was added: "This compensatory response may not occur under different flow conditions and rainbow trout population sizes. The present rainbow trout population is at its lowest level (Figure 3-44), and it may not be able to rebound from a flow scenario that would induce substantial mortality on the eggs and fry. Flow alternatives with particularly low dam releases would dewater spawning areas of trout and induce mortality to eggs and fry from which the low population may be unable to recover." |
| 50 | 112 | AQUA - Aquatic Resources | p. 3-97 This statement needs more qualification "The five alternatives each have the potential to disrupt smallmouth bass spawning by either desiccating or inundating nesting areas, creating unsuitable water temperatures, or both." As you say just above this the lambda values for the bypass options are below one, but for the non-bypass its not showing that it performs differently from no action - again you have to get lambda values for the summers in which temperature > 15.5C and see what % of those non-bypass and no action are able to keep lambda less than one - I think it will be zero or nearly zero. these statements that indicate non-bypass actually controls smb are inaccurate, so please edit and qualify those wtih the modeling results. | The smallmouth bass model is based on a 16-month period for generating Lambda values so that winter mortality is considered (Eppehimer and Yackulic 2024). The time step for the model is 12 months, and lambdas for shorter time periods are not available or possible. |
| 50 | 114 | AQUA - Aquatic Resources | p. 3-97 You state, "These alternatives are not expected to have long-term negative effects on rainbow trout in the Lees Ferry reach." but see the comments above about how the rainbow trout popuation in a very different situation then it was for Korman's 2011 study and how assuming compensatory response may not be appropriate. Also alternatives that don't control SMB will likely have added predation affecting rainbow trout at the population level - that may be an important impact to add. | The following language was added: "This compensatory response may not occur under different flow conditions and rainbow trout population sizes. The present rainbow trout population is at its lowest level (Figure 3-44), and it may not be able to rebound from a flow scenario that would induce substantial mortality on the eggs and fry. Flow alternatives with particularly low dam releases would dewater spawning areas of trout and induce mortality to eggs and fry from which the low population may be unable to recover." |
| 50 | 121 | WILDLIFE - Wildlife | p.3-107 Under Mammals: Include that GRCA has the highest diversity of bat species in all NPS units | We have added text to the mammals subsection in the Affected Environment section indicating the high level of bat biodiversity in the Grand Canyon National Park. |
| 50 | 150 | REC - Recreation | p.3-191 For impacts to recreation from the non-bypass alterantive in Glen Canyon, please include a statements that this alternative may have flows every weekend from May-Oct so up to 26 times a summer if conditions call for it. This would require concessions to shut down for those days, which is a much great impact than HFEs once a year or flow spikes 2-3 times a year. This should be clearly stated in this section as the impact could be 20x greater in terms of financial impacts to these small businesses. | The frequency of non-bypass flows has been added to the analysis.<br>The potential economic impacts under the Non-Bypass Alternative are already addressed in Section 3.15.2. |

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| 50 | 151 | REC - Recreation | p.3-192 The non-bypass flow would create flows below 5000cfs that would not allow for motor boats during the current motor season and would be of such high and low extremes to significantly disrupt river users and cause erosion to beaches. It appears that flows lower than 5000cfs persist down past the LCR and as the flows propigate downstream they will change from happening at night into daytime. Analysis of beach erosion from extreme high and low flows was not sufficiently analyzed in the document. Again sediment metrics need to evaluated for the years or months in which the non-bypass alterantive is occuring to tease out the actual impacts to sediment (erosion and loss of sandmass balance leading to less and shorter HFEs) from the large number of these flucutations (potentiall up to 26) that may occur in a summer. Camping opportunities could be drastically affected due to beach erosion and access issues/boat stranding due to the low volume. for beach erosoin - again please look at HFE, sand mass balance and other sediment stats after they are broken out for the years or months this non-bypass tool is used and we are pretty sure it will show that this tool is having a marked impact on beaches. | Sediment modeling has been updated in the Final SEIS to better capture impacts during the years HFEs would be implemented.<br><br>Recreational impacts would be considered during the planning and implementation process. Adequate lead time will be given prior to implementation to allow for planning of safe river travel. |
| 50 | 98 | AQUA - Aquatic Resources | p.3-90 For cool mix native fish and non-native fish sections, again the obvious most important impact of controlling the SMB and other warm water fish needs to be stated hear and the average lambda for years or months that exceed 15.5C should be stated. The biggest impact on native fish is that their young won't be preyed upon by expanding warm water invasive fish. The biggest impact on non-native fish is that they won't be expanding and in in fact their populations will be decreasing over time. It should also be noted that flow spikes are very much like the naturally timed peak flows that were there every predam in May and June that the native fish evolved with. | A figure has been included in the impact analysis that displays the average lambdas and ranges (maximum and minimum values) for the 30 traces at river miles 15 and 61 for each of the five alternatives and No Action Alternative. This figure shows that the Cool Mix and Cool Mix with Flow Spikes Alternatives are the least likely to allow smallmouth bass population growth (lambda >1). Furthermore, we have provided an explanation and clarification of the lambda values for each alternative in the impact analysis. |
| 50 | 1 | SCOPE - Scope of the Analysis | page 2: Currently, this SEIS states that SMB operations would end in 2027. That is assuming that other approaches such as a thermal curtain may be available and effective by then. However, given uncertainties, NPS recommends extending the timeframe for the SMB operations beyond 2027 through the lifetime of the original LTEMP, in case other tools (temperature curtain or higher Powell elevation) are not available or prove ineffective by 2027. If that happens, and if the elevation of Lake Powell falls lower and release temperatures return to over 15.5C, these bypass flow tools would need to be continued to address the mandates of the GCPA and the Endangered Species Act (ESA). | Reclamation has considered extending the timeline but will continue to work to implement long-term solutions by 2027. Supplemental NEPA efforts could be an option if long-term solutions are not implemented by 2027. |
| 50 | 2 | ALTBYPASS - Alternatives - Non-Bypass | Page 2: NPS believes the Non-Bypass alternative does not meet the purpose and need of the SEIS based on the 2022 evaluation of the USFWS-led multiagency SMB Task Force, the subsequent analysis performed in the development of the Reclamation SMB Environmental Assessment (EA), and the modeling analysis presented in this LTEMP SEIS document. The need for the SEIS is to disrupt the establishment of smallmouth bass below Glen Canyon Dam by limiting additional recruitment, which could threaten populations of threatened humpback chub below the dam; however, based on SMB population growth modeling (lambda), the Non-Bypass alternative is not effective. The purpose of the plan is to prevent the SMB population from growing and expanding during summers when dam release water temperatures are over 15.5C. A lambda less than 1.0 would indicate the alternative is creating conditions for the SMB population to decline whereas a lambda greater than one indicates the alternative is failing to prevent the growth of the population. This Non-Bypass alternative fails to achieve a lambda less than 1 in warmer water summers and instead shows growth of the population with a lambda factor of about 1.5-2.0. The current analysis in the plan lumps all the results together for both warm and colder water summers, but when these results are split out, it is clear this alternative does not perform significantly different from no action, which also fails to stop the SMB from reproducing. Reclamation has evidence in this SEIS for dismissal of this alternative as it does not meet the published purpose and need. | Per NEPA requirements, Reclamation is required to analyze reasonable action alternatives. The Non-Bypass Alternative represents an alternative that was deemed reasonable for analysis. While temperature has been found to be effective at disrupting smallmouth bass spawning, there are additional options that should be considered. Reclamation has decided to include the Non-Bypass Alternative to analyze other strategies for disrupting recruitment. While it does not perform as well as the other action alternatives within the SMB model, it does show improvement over the No Action Alternative. Due to the modeling results and analysis, it was not deemed the environmentally preferred alternative and will not be implemented in 2024. |

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| 50 | 9 | ALTBYPASS - Alternatives - Non-Bypass | page 3 Engineering constraints and remodeling: The Non-Bypass Alternative was designed with low flows down to 2,000 cfs. NPS understands there may be new potential operational restrictions of maintaining penstock flows of at least 3,000 cfs or perhaps even 3,500 cfs; If this alternative is not dismissed then it may require further analysis in the SEIS to show how those guidelines may affect the modeled lambdas. | Language regarding operational constraints has been added to Chapter 1. |
| 50 | 7 | AQUA - Aquatic Resources | page 3 regarding Non-bypass alt Rainbow Trout Fishery Impacts: Non-bypass fluctuations are also likely to impact the rainbow trout fishery in Lees Ferry which is already at very low population levels and facing more stressors than it ever has. This alternative fails to prevent the low dissolved oxygen levels and elevated temperatures that occur in the worst 17-20% of the traces run in the modeling scenarios, which will increasingly stress the rainbow trout. | The low flow (2,000 cfs) element of the Non-Bypass Alternative will dewater margins and shallow habitats, negatively affecting young trout and their food base. This is acknowledged in the Draft SEIS. |
| 50 | 4 | REC - Recreation | page 3 regarding Non-bypass alt Recreation impacts: While the plan currently mentions some impact to recreation from the non-bypass flows, it fails to articulate that these flows might occur on a weekly basis. For guided boating in the Glen Canyon National Recreation Area (NRA), this would likely mean shutting down concessions during those days. While that is similar to the impacts of an HFE, an HFE occurs once a year, whereas these may occur more than 20 times a summer, which is a more significant impact. | The Non-Bypass Alternative analysis has been expanded to include the increased significance of impacts due to the more frequent implementation of flows. |
| 50 | 3 | GEOSEDI - Geomorphology and Sediment | Page 3 regarding Non-bypass alt Sediment impacts: When the effects of the Non-Bypass alternative are split out for those months or years in which the Non-Bypass tool is actually used, they show increased sand mass balance and beach erosion and decreases in the frequency of High Flow Experiments (HFEs). These effects will decrease the natural aeolian transport processes in the canyon, threaten the protection of archeological sites, and reduce the area of recreational camping beaches, while also directly impacting the rafting recreation with flows lower than what are currently allowed under the 2016 LTEMP EIS. | Language, figures, and tables have been added to Section 3.4.2 regarding effects of alternative flow options during periods when those flow options would be implemented. |
| 50 | 8 | AQUA - Aquatic Resources | page 3, regarding Non-bypass alt Ineffective at preventing the establishment of SMB. This alternative also fails to reduce the growth and distribution of the warm water invasive fish populations that threaten native aquatic resources. These types of impacts are what led to the 1995 EIS that moved dam operations away from large daily fluctuations to comply with the GCPA. NPS encourages Reclamation to consider dismissal of this alternative given its inconsistency with the intent of the GCPA. | Thank you for your comment. Reclamation is using the best available science to direct the development and implementation of alternatives. This is just one of many steps Reclamation is taking to reduce the threat of nonnative, predatory invasive species. |
| 50 | 6 | AQUA - Aquatic Resources | page 3: regarding Non-bypass alt Food base and direct Native Fish Impacts: According to the SEIS routing chart, these frequent and large river fluctuations under the non-bypass alternative persist down to the Little Colorado River (LCR) and beyond, and may result in desiccation of macroinvertebrate resources, ultimately impacting food base in the system. These significant fluctuations during the summer through Marble Canyon would also be likely to impact native fish, including the humpback chub aggregation at river mile 30. | The SEIS considers these potential impacts and states that the Non-Bypass Alternative is "not expected to negatively affect the food base in the Lees Ferry reach or farther downstream." Minimizing impact with short-duration low flows at night when drying is minimized is part of the alternative, which is supported by Blinn et al. (1999). The native Colorado River fish evolved in a highly variable flow environment. The effects on juvenile humpback chub and their decrease in survival rates have been assessed (Gerig et al. 2014) with no variation found. |

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| 50 | 10 | ENERGYPOW - Energy and Power | page 4 Hydropower modeling transparency: NPS understands that much of the hydropower modeling in this document was performed by the Grand Canyon Monitoring and Research Center (GCMRC). The assumptions and methods appear very clear and transparent, but there has been substantial criticism of this work from hydropower interests. NPS understands that much of this controversy is because GCMRC adjusted future energy costs to be more realistic. The Argus Forward Mid-Market projections for the Palo Verde hub are used by Western Area Power Administration (WAPA) and were also used by GCMRC, but because these projections include a risk premium, these were adjusted to be more representative of the marginal cost of energy by GCMRC using actual prices from February 2000 through November 2023 and the Argus Forward Mid-Market projections. NPS encourages Reclamation to continue to use these estimates from GCMRC to ensure that cost impacts to hydropower are fairly and objectively estimated. NPS understands WAPA will be submitting another cost estimate during this comment process using a different method, and hope this estimate is provided with sufficient time for review and with a clear and transparent set of assumptions, that it is peer reviewed to ensure objectivity, and can be weighed in relation these estimates from GCMRC. To be objective information for this SEIS, we hope any new analysis includes similar adjustments to the GMCRC analysis to be more representative of the marginal cost of energy using methods to correct the Argus Forward Mid-Market projections. | Additional analysis from WAPA, NREL, and Argonne has been added to the Final SEIS.<br><br>The GCMRC report (GCMRC 2024) was internally peer reviewed and published after the Draft SEIS was published. |
| 50 | 13 | SCOPE - Scope of the Analysis | page 5 Not all resources are being compared the same way and this may cause inconsistent comparisons that underestimate the impacts of some alternatives on some resources. NPS understanding of the modeling is that there were 30 traces used; approximately 6 of the traces had years where release temperatures were greater than 15.5C and about 24 traces where temperatures stayed below 15.5C. Resources were analyzed to look at the effects of the alternative as averaged over all traces. Since the alternatives have tools that are only used in months where the temperature exceeds 15.5C, averaging across all the traces means we are averaging out the actual effects with 83% of the runs that didnt use the tool. That would mean we are only really seeing about 1/5 of the impact, rather than the actual impact that would be experienced if the future was actually a trace where release temperature was hotter. In years where these tools arent needed, the costs and impacts of the tools is zero because this would be no action. For hydropower, the analysis broke out the effects for the months where the tools were used to show the real impact of use of those tools in Table 3-26. NPS believes this to be the correct way to look at all impacts. | Some resources analysis is limited by the available modeling. Reclamation has included the best available science in the Final SEIS. Additional analysis to look at traces with experiments has been added where feasible. |
| 50 | 11 | ALTRANGE - Inadequate Range of Alternatives | page 5 Possible combination of alternative options: NPS understands that, due to discussions occurring, it may make sense to combine a suite of alternatives into an umbrella or menuoriented alternative where a particular option could be chosen to fit the conditions of a specific year. NPS is not opposed to this approach as it may increase flexibility; however, we would strongly suggest that only tools that are able to meet the purpose and need of discontinuing the establishment of SMB are combined into an umbrella alternative. This would include the 4 alternatives that use bypass. If tools do not reduce lambda below 1, then they are not effective and should not be considered at this point in the invasion curve. | Reclamation appreciates this perspective and will consider it when drafting the ROD. |
| 50 | 17 | WATERQUAL - Water Quality | Page 5 on regarding impacts Dissolved Oxygen: NPS recommends this data and graph be broken out to show the effects to dissolved oxygen for the years in which the tools are used, otherwise this is mostly comparing the effects of no action to no action. NPS believes there will be a more distinct difference that will emerge on the alternatives with bypass cooling versus those without. Again, that is a fair way to compare similar to the hydropower table 3-26, because we dont actually experience the average of the traces in the future, rather, it is only the future trace that occurs. | The figures have been updated in the Final SEIS to only compare years where an experiment was implemented. |

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| 50 | 15 | WATERQUAL - Water Quality | Page 5 regarding impact analysis Frequency and Duration of HFEs: NPS recommends this be in table form, again broken out for the years when the tools are used only because in the years they arent used, it would look and function exactly like no action. Currently, the way it is presented, it looks like there are no differences in HFEs amongst the alternatives, but NPS thinks that when this is split out clearly based on the years the tools are used, it will show some marked differences. | The change has been made as requested. HFE frequency and duration have been provided for for all years and years in which tools are used |
| 50 | 16 | GEOSEDI - Geomorphology and Sediment | page 5 regarding impacts Sand Mass Balance and Beach Building metrics: both need to be split out for the months or at least the years in which the tools are used (temp>15.5C), which would show the full effects of the alternatives on these metrics. GCMRC may have to advise whether months or years would be more appropriate, and if years whether those should start and end July 1 because of the HFE accounting window. | Language, figures, and tables have been added to Section 3.4.2 regarding effects of alternative flow options during periods when those flow options would be implemented. |
| 50 | 14 | AQUA - Aquatic Resources | page 5, regarding impacts Lambda for SMB population growth: this should be expressed in table form similar to 3-26, as an average lambda for the months in which the tools are used (when temp > 15.5C). This should be considered as months because even years that the tools are used may vary significantly if the tool is only used for one month vs. when it is used for 5 months; however, GCMRC may have reasons why they believe year might be more appropriate. In either circumstance, NPS would strongly suggest not doing this by trace, which would lump together 4 years when in fact the tool might only be used in one year of the four. | The smallmouth bass model computes lambda for a 16-month period to include winter survival. The output is a 12-month timestep. Lambda cannot be computed for shorter timesteps. A table that summarizes lambda values for the alternatives has been added with an explanation of lambda. |
| 50 | 20 | HYDROLOGY - Hydrology | page 6 Trace graphs to accompany lambda graph: Another two graphs that would be very useful to be presented in the same section accompanying the lambda values would one with the Lake Powell elevation over years and one with the release temperature over years showing all 30 traces. This would illustrate how many traces did not exceed 15.5C and explain why based on reservoir levels. That is an important part to relay. Again, current graphs in section 3.2.1 appear to show the averaging of all the traces for temperature and lake Powell elevation but seeing the 30 individual traces and seeing them right next to the lambda graph would be much more useful for comprehension of what is happening. | Additional figures have been added to the Final SEIS. Please see Section 3.2 for more information. |
| 50 | 19 | EDIT - Editorial | page 6 Lambda graphic: Currently, this graphic is in an appendix and since it is the most important modeling result it should be moved to the main text. It needs some reformatting as its very confusing. The labels should be moved below the axis, the thick lines where most of the results are falling needs a tick off to the side (is it 90%, 92%, 95%?) and should be a dot rather than a line like the other locations. Again, this graphic would be much more useful if it showed only the traces in which temperature exceeds 15.5C as those are the traces in which the tools are used. Also as suggested above, a table format presentation with the breakout for the months where 15.5 was exceeded with average lambda values would be even more useful. | The Final SEIS has been updated to include additional analysis of the lambda results, including incorporating by reference the GCMRC report (GCMRC 2024). Please note that the original Appendix A has been removed and replaced with the GCMRC report. |
| 50 | 18 | HYDROLOGY - Hydrology | page 6 Representative Summer-Long Releases for each Alternative: In chapter 2, NPS sees the need for a graph showing the alternative releases for the entire summer (May1-Oct 31) using a representative trace with higher release temperatures where the tools are used for most of the summer. Currently you are only showing a representative week, but there are important differences with frequencies and timing of these flows throughout the summer. For the alternatives with flow spikes that would show the 3 spikes occurring from June to mid-July. For the Non-Bypass our understanding is that might show 26 fluctuations between May to October. We think that it is not clear to most readers how frequent these flows might be occurring in a hot summer. The graphs in 3.2.1 appear to show monthly volumes over time, but not the actual spikes. | Additional figures have been added to the Final SEIS. Please see Section 3.2 for more information. |

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| 50 | 21 | ALTBYPASS - Alternatives - Non-Bypass | page 6: Improved Routing map in Figure 2-6: This routing map for the Non-Bypass should be relabeled as the term collapsing trough is a bit subjective. We actually dont see the trough collapsing by the LCR, it appears to still be a trough at that point. It would be helpful to have stage on the right axis (we think that was intended but it shows as all zeros on the right axis) and a gridded and more clear set of labels and tics on the left-hand axis so we can tell what the minimum flows actually are at the LCR. On the X axis it would be helpful to have time, because one of the assertions of the Non-Bypass alternative is that it wont desiccate invertebrates because its dropping at night but as that wave propagates down it wont be at night but may be in direct sunlight in august daytime temperatures. | The figure was provided by an outside source and could not be updated for the Final SEIS. The qualitative analysis of the figure has been updated to better describe the collapsing trough (by river mile 213). |
| 50 | 22 | GEOSEDI - Geomorphology and Sediment | Page 6-7: Sediment graphics showing HFEs: NPS recommends breaking these out to show representative trace years in which fall season HFEs occurred vs. those with spring HFEs, as well as for those in which other tools were used (the flow spikes vs. Non-Bypass fluctuations vs. those without any). Currently, these graphics are misleading both in terms of the averaging problem (stated above) but also it makes it looks like there will be two HFEs a year. This may create concerns for some stakeholders thinking that HFE frequency is increasing when in fact the frequency may decrease slightly from the original LTEMP using the modeling assumptions. We suspect if this is broken out, the frequency of HFEs would decrease the most under Non-Bypass in the years when that tool is used. | Language, figures, and tables have been added to 3.4.2 regarding effects of alternative flow options during periods when those flow options would be implemented. We clarified in captions for sandbar volume and mass balance figures that HFEs would not be implemented in both fall and spring within individual years. |
| 50 | 23 | AQUA - Aquatic Resources | page 7 Fully incorporating the implications of the lambda results In both Table 2.12 (impact summary table) and section 3.5 (aquatic resources) the lambda modeling results treated separately and almost as if they are an unrelated issue with respect to effects of the alternatives to native and non-native fish. Those results are the best available science for whether the alternative actually meets the purpose and need to either: (1) control the growth and expansion of the warmwater invasive fish populations or not, and (2) minimize impacts of predation on native fish populations or not. Those results are not fully interpreted when they are presented and arent carried through into the subsections to relay the potential impacts of the alternatives in comparison to no action and each other. For example, the lambda results show that cool mix is keeping lambda well under 1.0 in the warmest years, whereas no action has lambdas well over 1.0 or even over 2.0 in those warmest years. NPS recommends this be interpreted to explain that these results indicate smallmouth bass and other warmwater invasive populations would decline under Coolmix and native fish would then not face increasing predation, whereas under no action, smallmouth bass and other warmwater invasive populations would increase and possibly double each year. After a time delay, native fish would be subject to an expanding wave of predation from these fish that would likely impact them at the population level. The most important place to fully incorporate these results is on pages 3-133 and 3-134 for the effects of NonBypass alternatives in terms of how SMB and GSF populations would expand and impact HBC and RBS under no action and Non-Bypass. | The Final SEIS has been updated to include additional analysis of the lambda results, including incorporating by reference the GCMRC report (GCMRC 2024). The language has been modified and added to the text to reflect your comment. |
| 50 | 24 | AQUA - Aquatic Resources | Page 7: Updating non-native information from 2018-2024 in section 3.5 Much of the non-native presence and distribution information is cited before 2018. Given the increased river temperatures and presumed entrainment in the last few years, NPS recommends inclusion of literature from 2018-2024 including information presented at the GCMRC Annual Review Meetings. NPS can supply an appendix to the 2019 NPS Expanded Aquatic Non-native Species Management Plan to help, and the Annual Review Meeting (ARM) information should be readily available from GMCRC. GCMRC can also provide access to a shared non-native database and new mapping information for the distributions of non-native fish that should be used in this document, particularly for smallmouth bass, green sunfish, walleye and brown trout. NPS will provide a presentation from the last AMWG that summarizes much of that data and provides details of NPS rapid response efforts. | Reclamation used the best available information to develop the nonnative fish information. Reclamation welcomes any new resources that were not included in this analysis. Any new information can be considered in the ROD or during the planning and implementation process. |

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| 50 | 26 | AQUA - Aquatic Resources | page 8 Rainbow trout population effects from Non-Bypass alternative Several sections of the plan conclude that rainbow trout population would not likely be affected by the Non-Bypass fluctuations despite expected increased mortality in young rainbow trout. The conclusion appears to be based primarily on the Korman 2011 study that found compensatory responses to flows that impact rainbow trout reproduction. However, the current rainbow trout population is at a much lower population than any of the data points that Korman 2011 considered with fewer total reproducing fish. There are also major stressors on the population, including occasional high river temperatures (which vary with alternative), low dissolved oxygen situations (which vary with alternative), increased brown trout predation and competition, and the potential for significantly increased predation from warm water predators (which varies with alternative). Also, the health of the trout population is a recent concern this spring (2024), which may have to do with some impacts from these stressors. NPS recommends these factors be taken into consideration, as assuming a compensatory response no longer seems like a reliable conclusion. | The low-flow (2,000-cfs) element of the Non-Bypass Alternative would dewater margins and shallow habitats, negatively affecting young trout and their food base. This information was added to the Final SEIS. Please see Section 3.5 for additional information. |
| 50 | 5 | WILDLIFE - Wildlife | regarding Non-bypass alt Impacts to Native Amphibians and invertebrates: The current analysis fails to mention impacts to native amphibians. In locations such as the river mile-12 slough, we may already be seeing SMB prey upon native salamanders and other amphibians and invertebrates, and based on research in other river systems where SMB have invaded, these impacts would be likely to increase throughout the system below the dam if alternatives fail to prevent the establishment of SMB (Sanderson et al. 2009, Kiesecker and Blaustein 1998, Hayes and Jennings 1986; Dill and Cordone 1997). | We have revised text to the description of the Non-Bypass Alternative in the Environmental Consequences section to address the potential impacts of increased predation of amphibians by non-native invasive fish species. |
| 50 | 28 | EDIT - Editorial | Section 1.1, page 1: 2nd paragraph. Reclamation and NPS, not just Reclamation, developed LTEMP. It is correct in the 4th paragraph but not the 2nd. | We have revised the text based on your suggestion. |
| 50 | 27 | EDIT - Editorial | section 1.1, page 1: In the opening section, please edit to recognize that the Colorado River meanders through many more rocks types than sandstone. The river cuts through sandstone cliffs in the 15 miles below Glen Canyon Dam, and quickly downcuts through the entirety of the Grand Canyon strata, from limestone through schist and granite. | We have revised the text based on your suggestion. |
| 50 | 29 | EDIT - Editorial | section 1.2, p. 1-4 2nd complete paragraph references LTEMP FEIS also includes a proposal Should this not reference the current SEIS? | This paragraph correctly sites the 2016 LTEMP FEIS as a source for information on HFEs. |
| 50 | 30 | EDIT - Editorial | section 1.5, P. 1-6 end of page, NPS is the only agency not spelled out with abbreviation in ( ) | NPS was spelled out earlier in the text, unlike the other agencies in that list. |
| 50 | 31 | EDIT - Editorial | section 1.5, p. 1-7 Under the "NPS administers" paragraph, delete Baaj Nwaajjo I'tah Grand canyon National Monument. BLM and FS administer those areas | We have revised the text based on your suggestion. |
| 50 | 33 | ALTBYPASS - Alternatives - Non-Bypass | section 2.1, p. 2-17 and 2-18 First para in section 2.10 states that 'The design of this alternative is such that the short-duration, low-flow and high-flow releases are largely attenuated by the time the flow wave reaches the confluence with the Little Colorado River." but in para 2 on page 2-18 it says 'The fluctuations shown in Figure 2-5 were designed to disrupt the smallmouth bass spawning at river mile 61.' If the flows dissipate by the LCR, they can't also be designed to disrupt spawning in the same location (RM61). Also, as stated in following comment, the trough is not in fact attenuated by the time the flow wave reaches the LCR (RM 61). Please delete the first quoted sentence above. | The Final SEIS has been updated to better describe the attenuation of flows. |

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| 50 | 34 | ALTBYPASS - Alternatives - Non-Bypass | section 2.10, figure 2-6, P. 2-19 The axis titles on the figure 2-6 are too small to read, and the right axis is probably supposed to be stage but says all 0's. Objectively, this figure does NOT show the fluctual trough dissipating by the LCR. WAPA has been saying it would 'collapse' by the time the trough reaches the LCR ('collapse is in the title of the figure) but this figure appears to show there is still a large variation in flow at the LCR, and even at Pumpkin Springs, and flows are still dropping below 5000cfs at the LCR. The amount of time flows are below 5000 cfs is shown as shorter, but it is impossible to tell how long from this figure. The scale should be better with a higher resolution, so you can actually read the graph. Also we can't tell time of day the trough reaches the LCR or Pumpkin Springs, and that is important to how the flows impact macroinverts, as impacts are higher during daylight hours especially in summer heat. please add a figure that shows only a two-day time period or add a table to show what hour of day the trough is low. | The figure was provided by an outside source and could not be updated for the Final SEIS. The qualitative analysis of the figure has been updated to better describe the collapsing trough (by river mile 213). |
| 50 | 35 | ALTASSUMP - General Assumptions Common to All Alternatives | section 2.12, table 2-1, p. 2-20 and 2-21 The tables 2-1 and 2-2 are incomplete in summarizing important effects to GCPA resources and LTEMP goal effects. For no action - should restate as stated in the intro that HFEs are likely to happen at a lower frequency than was estimated in the LTEMP if we remain in lower water conditions under no action. Should also state the warmer river and dissolved oxygen are likely to negatively impact the rainbow trout fishery (this is stated elsewhere in the plan multiple times). For the non-bypass alternative it should state that it may have negative impacts on native fish because of the spread of warm water non-natives (because lambda results are very simliar to no action and that is the conclusion for no action). Also see new GCMRC report (to be released soon) and presentation (Yackulic, C.B., Bair, L.S., Eppehimer, D.E., Salter, G.L., Butterfield, B.J., Caster, J.J., Deemer, B.R., Fairley, H., Grams, P.E., Kasprak, A., Palmquist, E.C., and Sankey, J.B., 2024, Modeling the impacts of Glen Canyon Dam operations on Colorado River resources [presentation], LTEMP SEIS meeting (virtual), January 31, 2024: Flagstaff, Ariz., US Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center, https://www.usgs.gov/centers/southwest-biological-science-center/science/modeling-impacts-glen-canyon-dam-operations), because we expect there would be impacts to native fish larvae/yoy in marble canyon if "non-bypass" implemented in spring or early summer, and it may have negative impacts to foodbase and to the rainbow trout fishery, and the larger and much more frequent fluctuations compared to flow spikes may increase sediment erosion and deplete sand mass balance resulting in less frequent HFEs. Again - we hope these effects are summarized better based on the new GCMRC report coming out soon. Please see all the edits and refrences below to suppport this and then come back to these summaries and edit them to fully reflect the information in chap 3 after those revisions. | Tables 2-1 and 2-2 are summary tables and do not contain comprehensive analysis of impacts. We reviewed Tables 2-1 and 2-2 to ensure they accurately summarize effects on Grand Canyon Protection Act resources and LTEMP goals. We clarified in the No Action Alternative that HFEs are likely to occur less frequently than estimated in the LTEMP FEIS under lower water conditions. Additionally, we noted the negative impacts of warmer river temperatures and dissolved oxygen on the rainbow trout fishery.<br><br>Regarding the Non-Bypass Alternative, we added that it may negatively impact native fish due to the spread of warmwater nonnatives. This is supported by lambda results similar to the No Action Alternative, which indicates potential negative impacts on native fish.<br><br>The new GCMRC report has been incorporated by reference. These findings will be incorporated in Chapter 3. Thank you for highlighting these areas for improvement. |
| 50 | 37 | ALTASSUMP - General Assumptions Common to All Alternatives | section 2.12, table 2-2, p. 2-25 Please include the lambda statistic in this summary - it is critical for quantitive comparision and currently you are only reporting quantiative model results for hydropower - you need to do so for this - very important edit. The effects of the no-bypass alternative for aquatic resource suggest that alternative is effective for SMB reduction, but this summary should include the lambda and state that its effecitveness is not significantly different from no action but is significantly different from the bypass alternatives. This is a critical update to this table. Otherwise decision makers will not understand that this alternative actually fails to reduce the SMB population and merely slows population growth. That does apear to be the case - its not any more effective than no action, so this summary is currently very misleading. Please include lambda results in this table, and in the affected environment section (not just the appendix) and interpret them with statistical signficance. Please see all the edits and refrences below to suppport this and then come back to these summaries and edit them to fully reflect the information in chap 3 after those revisions. | Table 2-2 has been updated with additional details on the analysis. These changes reflect changes that have also been made in Section 3.5. |

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| 50 | 36 | ALTASSUMP - General Assumptions Common to All Alternatives | section 2.13, table 2-2, p. 2-25 Please include the key quantitative sediment metrics here in this summary for comparison and please split them out for the average of the runs where the tools were actually employed versus the runs where the tools were not used because currently the lumped average results are obscuring the effects of the flow spikes (max of 3) and the non-bypass fluctuations (every weekend so as many as 26) so we aren't really seeing the effects to the sediment that we are certain are there in the years when the tool is used. Hydropower has quantitative results summarized here split out finely to understand the impacts and that is needed here for sand mass balance, the amt of sediment deposited and the frequency and duration of HFEs were all modeled - please report all those stats here for comparison. This is critically important. | Table 2-2 has been updated with additional details on the analysis. These changes reflect changes that have also been made in Section 3.4. |
| 50 | 40 | AQUA - Aquatic Resources | section 2.13, table 2-2, p. 2-26 For aquatic resources there is no discussion of aquatic parasites, yet page 3-78 points out that warmer temperatures are much more likely to increase proliferation of fish parasites, so that statement should be included for No Action and Non-Bypass alternatives in contrast to the bypass cooling alternatives. | Continued warmer releases under the No Action Alternative and Non-Bypass Alternative are likely to increase the infestation rates of certain fish parasites, including the Asian tapeworm and the lernaean copepod. This language has been included under each alternative. Please see Section 3.5 for additional information. |
| 50 | 41 | WILDLIFE - Wildlife | section 2.13, table 2-2, p. 2-26 special status species - northern leopard frog is not listed as endangered or threatened. it is a species of concern in Arizona (correctly identified elsewhere in the document) | Table 2-2 has been updated accordingly. |
| 50 | 38 | AQUA - Aquatic Resources | section 2.13, table 2-2, p. 2-26 The effects of no-bypass alternative for aquatic resources indicate little impact to native fish and don't mention food base. Large fluctuations every weekend (up to 26 total compared to a max of 3 for flow spikes) would continue down to the LCR and even down to Pumpkin Springs with little amelioration according to Figure 2-6, so within GRCA that impacts locations like the 30 mile aggregation of HBC and native fish in Marble canyon. If the fluctations are in late spring or early summer they could impact recruitment or survival of yoy for native fish or HBC. They may also negatively impact GPP and macroinvertebrates. This also fails to state the biggest impact to native fish that is stated in the no action - that the SMB will prey upon them - if this no-bypass alternative has close to the same lambda values as no action (with lambda above 1 in most years), then the effects of increasing warmwater non-natives should also be the same and so that is critical that that is stated here in the summary. This is currently stated in a way that suggests this language was written before the analysis in chp3 and the appendix was submitted based on what is intended in the design of this alternative, but it appears this table wasn't updated based on the performance of the modeling of lambda, which shows its doesn't accomplish the goal based on those lambda results - the lambda results show performance very comparable to no action - please update these summary statements to be fully consistent with the lambda modeling results. New Corrected Summary language: The Non-bypass Alternative could disrupt some SMB spawning by changing the water velocity. This may reduce SMB population growth rate (lambda) compared to no-action, but will not stop population growth. Native fish may be affected due to continued population growth of SMB, and because flow fluctuations do not attenuate substantially at the confluence of the LCR or Pumpkin Springs, and because large flow fluctuations would be more frequent than the no-action, or flow spike alternatives. Please see all the edits and refrences below to suppport this and then come back to these summaries and edit them to fully reflect the information in chap 3 after those revisions. | The language under the food base section has been revised for the Final SEIS. Please refer to Section 3.5 for additional information. |

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| 50 | 44 | REC - Recreation | section 2.13, table 2-2, p. 2-27 recreation no bypass alternative - non-bypass alternative - Currently this is missing the short term impacts to recreational camping in marble given large stage change during implementation days (will require moving boats on shore multiple times). Also doesn't address long term impacts to camping in Marble canyon from the sandbar/beach erosion and the reduced number of HFEs we would expect from loss of sandmass balance reducing chances of triggering HFEs when compared to other action alternatives. This also doesn't include longterm impacts to recreational rainbow trout fishery from the increased predation impacts from warm water predators we would expect given the lambda values we expect with this alterantive compared to other bypass action alternatives. | Impacts to rainbow trout resulting from increased potential from warmwater predators have been added. Impacts to camping beaches are described under Issue 2 for recreation. |
| 50 | 42 | WILDLIFE - Wildlife | section 2.13, table 2-2, p. 2-27 special status species - no action - this alternative will not reduce SMB so SMB is likely to reduce populations of northern leopard frog as they feed on tadpoles. no bypass alternative - this alternative reduces lambda compared to no-action but does not stop SMB population growth based on the lambda values, so under this alternative we would expect more impact to northern leopard frog from direct predation on tadpoles than from the other alternatives. We would direct you toward these references from Keisecker and Blaustein 2008 in conservation biology https://doi.org/10.1111/j.1523-1739.1998.97125.x The introduction of several species of nonnative predatory fish, including smallmouth bass (Micropterus dolomieu), may also contribute to population declines of ranid frogs (Hayes & Jennings 1986). Smallmouth bass are known to prey on larval amphibians, including red-legged frog larvae (Scott & Crossman 1973;Kruse & Francis 1977; J. M. K., personal observation). Historically, smallmouth bass were restricted to central and eastern North America, but they have since been introduced throughout western North America (Lee et al. 1980;Minckley & Deacon 1991). Predation by nonnative fish can have negative effects on native frog populations (Bradford 1989;Bradford et al. 1993). Furthermore, exotic fish may exert indirect effects by introducing pathogens that can be transmitted to amphibians (Blaustein et al. 1994b;Kiesecker & Blaustein 1995, 1997a). | Substantial revisions have been made to the description of the impacts in the Environmental Consequences section to state that potential impacts include increased predation of native species of invertebrates, small mammals, reptiles, and amphibians and to acknowledge the potential for introductions of pathogens that may spread to amphibian species. |
| 50 | 43 | CRTRIBE - Cultural and Tribal Resources | section 2.13, table 2-2, p. 2-27 tribal resources - no action alternative - because no action won't reduce SMB and other warmwater invasive reproduction, then there will have to be more rapid response mech and chemical treatment to try to address these populations, thus increasing fish mortality over time. no bypass alternative - because nonbypass won't effectively reduce SMB lambda less than 1, then SMB and other warmwater invasive populations will continue to expand and there will have to be more rapid response mech and chemical treatment to try to address these populations, thus increasing fish mortality over the cooling alternatives. | Text in Table 2.2 (Tribal Resources) was changed to: "Operations at Glen Canyon Dam would not change, and there would be no change in fish mortality from what is analyzed in the LTEMP FEIS, which does include management activities to prevent the spread of nonnative fish. There would be no additional impacts on archaeological or sacred sites than those analyzed in the LTEMP FEIS. Riparian vegetation would follow current trends." |
| 50 | 32 | EDIT - Editorial | section 2.3, p. 2-2 "Strike the extra 'the' - This document provides detailed changes to the both the sediment account period and implementation window. " | We have revised the text based on your suggestion. |
| 50 | 87 | ALTASSUMP - General Assumptions Common to All Alternatives | section 2.4, p. 2-4 Would actions be initiated as soon as temperatures hit these triggers, or after XX hours above this temp, or after XX days? Temps fluctuate throughout the day. Define the trigger more specifically. It matters how long the river is at this temp and SMB may actually breed when the temp is slightly below 16C. Will there be seasonal limits to target just the spawning season, or any time the temp trigger is met? We are assuming it would be based on temperature projections and the operations would be carried out for the full month of when the 15.5C temperature trigger is reached, but it should be clarifiied | Additional implementation language has been added to Chapter 1 of the Final SEIS. Additional details will be provided in the ROD. |
| 50 | 154 | CRTRIBE - Cultural and Tribal Resources | section 3.12 Other information: East, A.E., Collins, B.D., Sankey, J.B., Corbett, S.C., Fairley, H.C., and Caster, J., 2016, ** East, A.E., Sankey, J.B., Fairley, H.C., Caster, J.J., and Kasprak, A., 2017** Kasprak, A., Sankey, J.B. and Butterfield, B.J., 2021. ** Mueller, E.R. and Grams, P.E., 2021. **Sankey, J.B., Caster, J., Kasprak, A. and East, A.E., 2018. **Sankey, J.B., Caster, J., Kasprak, A. and Fairley, H.C., 2022. | Thank you for providing the references. |

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| 50 | 152 | CRTRIBE - Cultural and Tribal Resources | section 3.12, p. 3-166 3.12.1 Affected Environment, first sentence should read "The history and importance of Glen Canyon, Marble Canyon, and Grand Canyon..." | The change has been made as suggested. |
| 50 | 156 | CRTRIBE - Cultural and Tribal Resources | section 3.12.1, p. 3-166 Grand Canyon has perhaps the most well know Late Archaic material culture within the study area, including the so called Split Twig Figurine Complex and Grand Canyon Polychrome pictographs. The STFC appears limited to eastern Grand Canyon, while the Grand Canyon Polychrome sites are focused in western Grand Canyon. | Language has been added to Section 3.12.1 Affected Environment. |
| 50 | 155 | CRTRIBE - Cultural and Tribal Resources | section 3.12.1, p. 3-166 Two confirmed Paleoindian points, a fragmentary Clovis point, and a partial Folsom point have been identified at the Grand Canyon. | Language has been added to Section 3.12.1 Affected Environment. |
| 50 | 161 | CRTRIBE - Cultural and Tribal Resources | section 3.12.1, p. 3-167 Grand Canyon also has a significant early EuroAmerican History. Why isn't it included? | Paragraph revised to: "The Historic period (AD 1776–1970s) began with the arrival of the Domínguez-Escalante Expedition in 1776 at what is now Lees Ferry along the Colorado River and Fr. Francisco Garces expedition up the Lower Colorado River and then overland to the western Grand Canyon area. Other Spanish and then American expeditions, such as the Powell expedition and the Stanton expedition, visited the Colorado River area in the 18th and 19th centuries. More European and American settlers moved into the Colorado River corridor, putting pressure on Indigenous groups in the 19th century. Indigenous groups moved into smaller territories and more remote areas. The Hualapai stayed in the western Grand Canyon area, and the Southern Paiute lived in the western and northern Grand Canyon area. The Havasupai lived in Grand Canyon. The Diné lived along the south, east, and north rims of and with the canyons. Native American archaeological sites from this period contain a mix of Indigenous and non-Native artifacts." |
| 50 | 163 | CRTRIBE - Cultural and Tribal Resources | section 3.12.1, p. 3-167 Grand Canyon has documented over 500 ethnographic resources within the park, including the river and specific locations within it. We will never know all such resources due to their sensitivity from a tribal perspecitive. | We added the following to Section 3.12.1, Traditional Cultural Places and Ethnographic Resources: "The GCNP has over 500 documented ethnographic resources within the park including the river and specific locations within the river. Because these resources are sensitive from a tribal perspective, the full number and nature of them is and will remain unknown to the agencies." |
| 50 | 162 | CRTRIBE - Cultural and Tribal Resources | section 3.12.1, p. 3-167 The Grand Canyon has 16 cultural Landscapes, including the Canyon itself and the Cross Canyon Corridor (major trails between the North and South Rims in the inner canyon) | We added the following to 3.12.1 Cultural Landscapes: "The Grand Canyon has 16 documented cultural landscapes, including the Canyon itself and the Cross Canyon Corridor, which encompassed the major trails between the North and South Rims in the inner canyon." |
| 50 | 160 | CRTRIBE - Cultural and Tribal Resources | section 3.12.1, p. 3-167 The Havasupai, Hualapi, Navajo, and Southern Paiute all were present in and near the Grand Canyon. Tha Havasupai still live within it. | Paragraph revised to: "The Historic period (AD 1776–1970s) began with the arrival of the Domínguez-Escalante Expedition in 1776 at what is now Lees Ferry along the Colorado River and Fr. Francisco Garces expedition up the Lower Colorado River and then overland to the western Grand Canyon area. Other Spanish and then American expeditions, such as the Powell expedition and the Stanton expedition, visited the Colorado River area in the 18th and 19th centuries. More European and American settlers moved into the Colorado River corridor, putting pressure on Indigenous groups in the 19th century. Indigenous groups moved into smaller territories and more remote areas. The Hualapai stayed in the western Grand Canyon area, and the Southern Paiute lived in the western and northern Grand Canyon area. The Havasupai lived in Grand Canyon. The Diné lived along the south, east, and north rims of and with the canyons. Native American archaeological sites from this period contain a mix of Indigenous and non-Native artifacts." |

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| 50 | 158 | CRTRIBE - Cultural and Tribal Resources | section 3.12.1, table/ line 1&2, p. 3-166 It would be good to acknowledge that Ancestral Puebloan people retained their ties to the Canyon and returned for many reasons (resources, trade, ceremony, etc). | Language has been added to Section 3.12.1 Affected Environment. |
| 50 | 46 | EDIT - Editorial | section 3.2.1, p. 3-2 It says "Long-term and annual release volumes from Lake Powell are detailed in the LTEMP FEIS (Department 2016a)." but this may be misleading to readers as the LTEMP does not set annual releases - annual releases are determined under the 2007 Interim Guidelines and the LROC, not by LTEMP. | We have revised the text based on your suggestion. |
| 50 | 45 | HYDROLOGY - Hydrology | section 3.2.1, p. 3-2 Please change the sentence "Monthly release volumes are based on anticipated power demands, forecasted inflows, and other factors such as storage equalization between Lake Powell and Lake Mead" to say, "Monthly release volumes are based on the monthly pattern of the 2016 LTEMP ROD which takes into account GCPA resource concerns and anticipated power demands, forecasted inflows, and other factors such as storage equalization between Lake Powell and Lake Mead". The monthly volumes ARE NOT based on only hydropower. | We have revised the text based on your suggestion. |
| 50 | 47 | EDIT - Editorial | section 3.2.1, p. 3-3 It says "Releases can also fluctuate beyond those scheduled in accordance with ROD section 1.2B (DOI 2016b)." please add these additional words "Releases can also fluctuate beyond those scheduled under certain allowed circumstances in accordance with ROD section 1.2B (DOI 2016b)." | We have revised the text based on your suggestion. |
| 50 | 48 | EDIT - Editorial | section 3.2.2, p. 3-3 Please accept the tracked change shown that left in the text for the tempertaure of 15.5 degrees Celsius not 15.6 | We have revised the text based on your suggestion. |
| 50 | 51 | ENERGYPOW - Energy and Power | section 3.2.2, table 3-12, p. 3-16 The way the # of HFEs statistics have been compiled doesn't allow for a fair comparison to hydropower results. They should be tabulated for only the years in which the alternative tools were used - in the years when temperature was greater than 15.5 C. This was done in the hydropower section in table 3-25 and we need apples to apples comparison of effects when the alternative tools are actually used. Otherwise for alternatives like the non-bypass that are likely reducing the # of HFEs by eroding the sand mass balance in the 17% of the runs in which the tool is being used, we can't see that effect because its being averaged out with the 83% of runs in which the tool wasn't used and it was just no action operations. We strongly suspect when this is run it will show a markedly lower number of HFEs. If that is correct, then those statistics and this big impact of that alternative need to be included in that top summary table. | Section 3.4 Geomorphology/Sediment has been updated to include analysis of HFEs during months when experiments are triggered. |
| 50 | 50 | HYDROLOGY - Hydrology | section 3.2.2, table 3-12, p. 3-16 under Cumulative Effects - sentence 2 - end of sentence 'Overall elevation changes in Lake Powell under the action alternatives are relatively minor, and water.' '...and water.' does not make sense, please correct. | The Final SEIS has been updated based on your comment. |
| 50 | 52 | ENERGYPOW - Energy and Power | section 3.3.1, p. 3-18 and 3-19 Under the description of the Basin Fund it says it is used to support environmental and salinity funds - is this true as our understanding is that for the last 3 or 4 years WAPA has not transferred any money from the Basin Fund to environmental programs, and is unlikely to do so in the near future. Please correct if this is no longer true. Kathy Callister would know the most precise answer to this. | The Basin Fund can be used for that purpose; however, it has not been accessed since Fiscal Year 2021. Reclamation does not anticipate receiving funding in the near future. |

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| 50 | 53 | ENERGYPOW - Energy and Power | section 3.3.1, p. 3-19 In this paragraph "By bypassing the electrical generators at Glen Canyon Dam, the experiment will reduce hydropower generation. Accordingly, WAPA will be required to purchase replacement power to fulfill its contractual obligations to customers. The experiment would markedly increase the amount of non-reimbursable costs drawn from the Basin Fund and returned to the Treasury." It is unclear which experiment is being referred to - I would replace the word 'experiment' which is both unclear and not applied to this document, with "bypass alternatives". Also the statement that it will markedly affect the basin fund is not true under many scenarios for the bypass alternatives - it is entirely dependent on the hydrologic conditions as to how much the affect would be, so this statement is inaccurate and needs to be changed because it would only be correct under more severe hydrologies. Please make this paragraph consistent with the statement later in the plan on p3-27 that says "The action alternatives would have financial impacts that would vary to a large extent based on reservoir elevation and temperature conditions, as well as which river mile is targeted for cooling, based on the distribution of smallmouth bass." | Section 3.3 has received substantial updates for the Final SEIS. Please see this section for additional information. |
| 50 | 54 | ENERGYPOW - Energy and Power | section 3.3.1, p. 3-19 In the discussion of the Basin Fund it would be helpful to provide readers perspective that the biggest impact to the Basin Fund in recent years has NOT been from bypass operations but rather from the level of lake powell - the lower levels of powell have significantly impacted hydropower head and hydropwer production and revenue - please include a statement about this very improtant fact that provides perspective to the public. Also paragraph 5 implies that the basin fund is used to fund the GCDAMP, and Upper Colorado River Recovery Implementation Program - which it no longer funds, except for costs (and benefits) from experimental flows. | Section 3.3 has received substantial updates for the Final SEIS. Please see this section for additional information. |
| 50 | 55 | ENERGYPOW - Energy and Power | section 3.3.1, table 3-20 It says "WAPA will continue to operate under the emergency exception criteria, as stipulated under the 1996 ROD", but I thought the 2016 LTEMP ROD replaced the 1996 ROD and I think it restated the emergency exception criteria in the 2016 ROD (could be wrong, but you might want to doublecheck). I would guess Rod Smith would know the definitive answer on that. | The Final SEIS has been revised to reference the 2016 LTEMP FEIS ROD. |
| 50 | 56 | ENERGYPOW - Energy and Power | section 3.3.2, p. 3-21 Under Methodology for GMCRC, it might be important to explain how this methodology corrects for overestimation of future prices - this sounded from the AMWG Lucas Bair presentation like an important difference between this methodology and the WAPA methodology that might be important for readers to understand. Lucas Bair could provide exact language for that. | For further details on modeling assumptions, please refer to the GCMRC report (2024). |

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| 50 | 58 | GEOSEDI - Geomorphology and Sediment | section 3.4.1, figure 3-22, p. 3-46 Figures 3-18 thru 3-22 all obscure the actual affects of the spike flows and the non-bypass alternative because they lump together results of 30 runs and show only an average. These need to broken out to show the sediment impacts in only the years when release temperature was over 15.5C and the tools were actually used. This would breakout make these results comparable to hydropower results in table 3-25. Without this its not a fair comparision. Averaging over all runs is problematic because we don't get to experience all of those futures - we may either have a future with lower reservoir elevations in which case the tools will be used more, or futures where the reservoir is higher and the tools aren't used. Those divergent futures will have very different results on the number of HFEs, the sand mass balance and the beach building and can't be lumped together without diluting those impacts. Also showing the results of these lumped situations in figures like 3-22 makes it appear that action action alternatives are doing twice as many HFEs as no action and that is not the case. That is greatly misleading and we need to separate out these graphs to that is more clear to readers. If this graph will be used, then it will need to be in addition to graphs that split out runs where the tools are used versus where they aren't used and to explain a great deal more in the legends. We request contrasting in one year each of these strategies for the total effects from july 1 to june 30 for sand mass balance, beach building and # and duration of HFEs. Table presentation of all the statistics are needed so everything can be compared - the text currently only presents some of the information for some alternatives but not others (like HFE duration and HFE frequency). And figures like 3-22 need a very big caveat in the legend that these are based on the Mueller model which only considers building of beaches but not erosion - that is a critical issue when some alternatives like non-bypass are doing to be eroding the beaches with flows every weekend. This is simply very misleading as currently presented and needs the appropriate caveats and the appropriate groupings of runs to effectively present the impacts to sediment. | Language, figures, and tables have been added to Section 3.4.2 regarding effects of alternative flow options during periods when those flow options would be implemented. We clarified in captions for sandbar volume and mass balance figures that HFEs would not be implemented in both fall and spring within individual years. |
| 50 | 57 | GEOSEDI - Geomorphology and Sediment | section 3.4.1, p. 3-43 The reported durations of hfes are hard to put in context without a table that shows the avg duration of HFEs for both spring and fall HFEs - please provide that so we can completely compare. | The change has been made as suggested. |
| 50 | 59 | GEOSEDI - Geomorphology and Sediment | section 3.4.1, p. 3-47 Statements like this summary of the non-bypass alternative really need quantitative numbers to understand the differences - need % differences between alternatives for sand mass balance, for beach volumes and for # and durations of HFEs to be clearly reported in tables. Without stats its very difficult to interpret the level of differences... "Compared to other action alternatives, the Non-Bypass Alternative would cause the greatest reductions in mass balance starting in Spring 2025. This alternative would generally produce the second-smallest sandbars, slightly surpassing volumes that would be generated under alternatives without flow spikes." The differences need to then be relayed quantitatively in the summary table at the top of the document - this is very important. That is how it is being done for hydropwer and if we have quantitaitve results, that should also be done for fish and sediment results. | We added percent differences for sand routing to Section 3.4.2 and summary table. |
| 50 | 61 | AQUA - Aquatic Resources | section 3.5.1, p. 3-48 Strike the 'and' and add a comma after backwaters - "along shorelines, and in backwaters, and tributary mouths. The aquatic food base for fishes also includes vertebrates, such as other fishes, which should be added to the first sentence under the "Aquatic Food Base" title. | The Final SEIS has been updated based on your comment. |

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| 50 | 60 | AQUA - Aquatic Resources | section 3.5.1, p.3-48 What does this mean - "Flow spikes that occur outside of the sediment accounting period would increase the likelihood of HFE deferral due to increased sediment export." Does this mean that flow spikes or nonpbyass flucturations happening after hfes in the spring windows (may-july) aren't accounted for because of the july 1 reset of sand mass balance? If so, we may be masking the loss of a lot of real sediment in each summer and that may be why we are seeing a lot less differences between alts with spikes and without or those with big fluctuations vs. those without. If this is the case we may need a true sand mass balance loss stat that is indepened of the sediment windows as a measure of what is being exported over the whole summer to compare between alternatives. And in the Summary seciton , we really need clearly quantitative results - for instance how much more sand mass balance was lost in a year where flow spikes or non-bypass flucutations were used when compared to coolmix or coldshock with no spikes. That would be a very useful number to see. How many HFEs of what duration were run with those same comparisons -we are quite confident there will be some clear differences if you make those explicit comparisions and show probabilities. | The HFE language was updated based on your comment. Please see Section 3.4 for additional information.<br><br>GCMRC provided sand mass balance summary statistics, which have been incorporated into the section. |
| 50 | 71 | AQUA - Aquatic Resources | table 3-30, p. 3-63 Brown trout are incredibly abundant from Glen Canyon Dam to Lees Ferry; Channel catfish fairly abundant near and in Little Colorado River; Bluegill are becoming more abundant and captured in electrofishing surveys close to Glen Canyon Dam and from the dam to Badger Rapid in Grand Canyon; Largemouth bass individuals have been recently captured (2022) in Glen Canyon below the dam; Smallmouth bass found in increasing numbers in Glen Canyon from the dam to Marble Canyon. See R. Billerbeck's comment below please. Also, please add updated distribution maps or data tables from Katherine Tucker (BOR on detail to GCMRC) or from Melissa Trammell at NPS. This table is grossly outdated and misleading - sorry but you really need up to date info because so much has changed in the last few years. This is very important. should be a more effective way to do this broken into more relvant sections of the river. | The most recent information we can find on brown trout in Lees Ferry is from the GCMRC Annual Reporting Meeting. We have added the figure that shows the index of brown trout abundance from electrofishing for 1992–2023.<br>We cited this as Rogowski et al. (2023) from the GCMRC Annual Reporting Meeting. We have also revised the language in the document to reflect an increased abundance of brown trout in Lees Ferry by about fourfold, based on the electrofishing index. |
| 50 | 165 | ALTBYPASS - Alternatives - Non-Bypass | The effects of no-bypass alternative for cultural resources and sediment fail to include the effect of the large fluctuations themselves. It appears that no-bypass may have a lower number of HFEs in the runs when it is actually employed, but that difference is being lost when averaged over all 30 runs many of which don't use the tool. | Thank you for your comment. Please refer to the respective analyses for cultural/tribal resources and sediment. |
| 50 | 12 | ALTBYPASS - Alternatives - Non-Bypass | The Non-Bypass alternative, when lambda results are averaged for the months or years when the tool is actually needed and used (when release temperatures are greater than 15.5C) does not reduce lambda below 1, so it does not in fact disrupt the establishment of smallmouth bass. For this reason, this alternative should not be included. It is critical, particularly in the summer of 2024, to use the most effective tools available while SMB is still limited in distribution to Lees Ferry and the most eastern portion of Marble Canyon. Many of these tools will be less effective if the population expands during this early phase in the invasion curve. NPS recommends prioritizing the use of tools that will be the most effective the earliest in the process based on the lambda values. If there is the possibility that Reclamation may not choose to use the most effective tool during the first year (2024), then this SEIS should include a cost analysis of how much more bypass cooling might cost in the 2nd year (2025) if SMB distribution expands further downriver. | Per NEPA requirements, Reclamation is required to analyze reasonable action alternatives. The Non-Bypass Alternative represents an alternative that was deemed reasonable for analysis. While temperature has been found to be effective at disrupting smallmouth bass spawning, there are additional options that should be considered. Reclamation has decided to include the Non-Bypass Alternative to analyze other strategies for disrupting recruitment. While it does not perform as well as the other action alternatives within the smallmouth bass model, it does show improvement over the No Action Alternative. Due to the modeling results and analysis, it was not deemed the environmentally preferred alternative and will not be implemented in 2024. |
| 51 | 1 | PROPACTION - Proposed Action | As a member of Utah Associated Municipal Power Systems (“UAMPS”) Logan City Light and Power supports the comments submitted UAMPS. In particular, UAMPS joins CREDA’s comments addressing the several issues, Logan City is particularly concerned about:<br>1. Insufficient data on which to base decision:<br>2. Costs to Logan City Light and Power’s customers | Thank you for your comment. The Final SEIS has been substantially updated with new hydropower analysis. Please see Section 3.3 for more information. |

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| 51 | 1 | PROPACTION - Proposed Action | Logan City Light and Power Supports UAMPS' Comments : As a member of Utah Associated Municipal Power Systems ("UAMPS") Logan City Light and Power supports the comments submitted UAMPS. In particular, UAMPS joins CREDA's comments addressing the several issues, Logan City is particularly concerned about: 1.Insufficient data on which to base decision: 2.Costs to Logan City Light and Power's customers | Thank you for your comments. The Final SEIS has been updated to better analyze impacts to customers. Additional modeling data have also been added to the Final SEIS. |
| 52 | 1 | PROPACTION - Proposed Action | The Upper Colorado River Commission ("UCRC") is a Cooperating Agency in this process. The UCRC endorses and supports the comments from the Upper Division States of Colorado, New Mexico, Utah, and Wyoming regarding the Draft SEIS, which are incorporated herein by reference. The Upper Division States's comments will also guide the UCRC's participation as one of the Cooperating Agencies in the development and preparation of the Final SEIS. | Thank you for your comment. Reclamation considered this during the development of the Final SEIS. |
| 53 | 2 | POLICYGOV-Policy and Governance | Through our membership in the Colorado River Energy Distributors Association (CREDA), St. George has participated in all NEPA processes associated with LTEMP and DSEIS. It is our position that the DSEIS is legally inadequate to allow the decision maker and the public to understand what is proposed or to make a reasoned choice among alternatives. The DSEIS should be revised to include ALL necessary information and analyses and reissued for public comment prior to issuance of a final SEIS, Record of Decision, or Implementation of any experiments. | The Final SEIS has been substantially updated to include additional data and science. The Final SEIS will be available for a 30-day public review period before the ROD is signed. |
| 53 | 1 | AQUA-Aquatic Resources | The fundamental premise behind the proposed action is based on the smallmouth bass data and models. Although data has been collected it has not been analyzed. The DSEIS states "(s)pecific data on these fish have been collected but are not available or citable at this time" (p.3 -68). Based on the relationship and hypotheses related to smallmouth bass, humpback chub and temperature, it is important that the tools used to analyze impacts and make decisions be linked with the results disclosed in the DSEIS. It is critical that a technical review of the preliminary model and the assumptions is done prior to issuance of the final SEIS. | The smallmouth bass model has not been peer reviewed for coding and parameterization. GCMRC will continue to work on the model to refine data input and parameters to help inform the post-2026 EIS. |
| 55 | 1 | PN-Purpose and Need | Please know that I feel the S.M.bass will be a improvement to the river system. Let them "stay" | Thank you for your comment. We have considered these points while developing the Final SEIS. |
| Form Letter 1 | 3 | SOC - Socioeconomics | BOR should always consider economic values of recreation in any decisions regarding Lake Powell. Glen Canyon National Recreation Area is a significant national treasure as well as a spectacular generator of economic growth. GCNRA averages $250 million to $450 million in annual revenue. It gives rise to over 5000 jobs. Its economic multiplier is 10, giving rise to somewhere between $2 - $4 billion in direct economic value to its surrounding and regional areas. The latest economic impact report from the National Park Service shows that Glen Canyon lost $207 million in economic activity during low water years of 2022 and 2023. Lake Mead lost $114 million to low water levels. I would like to see BOR analyze whether the timing of holdbacks and releases will affect recreation amenities such as The Cut. Language should be incorporated providing a recreation time buffer to consider the timing of the year and when releases would occur to continue to provide maximum recreation opportunities. These are not inconsequential losses, and they suggest that outdoor recreation on these reservoirs is one of the other important interests that needs to be a stakeholder in this process. | Thank you for your comment. Impacts to recreation in Lake Powell (and related economic contributions) are anticipated to be negligible, as elevation reductions are not anticipated to result in changes that would go below the critical thresholds at which impacts to recreation impacts would occur. In addition, as discussed in Section 3.2, Hydrology, changes to reservoir levels would be temporary in nature and would be negligible, compared with elevation changes as a result of non-project activities. |
| Form Letter 1 | 1 | SOC - Socioeconomics | As water levels have decreased in the recent past in reservoirs in the Colorado Basin I am concerned with the future of Lake Powell and communities that rely on the economic opportunity and social value that recreation brings. | Thank you for your comment. Impacts to recreation in Lake Powell (and related economic contributions) are anticipated to be negligible, as elevation reductions are not anticipated to result in changes that would go below the critical thresholds at which impacts to recreation impacts would occur. In addition, as discussed in Section 3.2, Hydrology, changes to reservoir levels would be temporary in nature and would be negligible, compared with elevation changes as a result of non-project activities. |

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| Form Letter 1 | 2 | WATERQUAL - Water Quality | High flow releases and cold shocks are based on predictions of water temperatures and unknowns. The non-bypass alternative will treat nests to prevent the spawning of small mouth bass. Its crucial BOR adapts plans on weekly changes as water conditions and temperatures can change rapidly. BOR should not be making long term decisions based solely off predictions but real time data. I also believe BOR needs to use mile 15 to gauge temperatures rather than mile 61 along the Colorado River. | Reclamation will use adaptive management strategies during the planning and implementation process to incorporate observed conditions into its decision-making. |