Glen Canyon Dam/ Smallmouth Bass Flow Options Draft Environmental Assessment

US Department of the Interior
Bureau of Reclamation
Upper Colorado Basin Region
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February 2023

Mission Statements

The Department of the Interior (DOI) conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

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.

Glen Canyon Dam/Smallmouth Bass Flow Options
Draft Environmental Assessment

Proposed action:	Modify flows at Glen Canyon Dam for up to three years beginning in 2023 to disrupt smallmouth bass spawning. The flow may include the following options: Option A: Cool mix Option B: Cool mix with flow spikes Option C: Cold shock Option D: Cold shock with flow spikes
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Acronyms and Abbreviations

Acronym	Full Phrase
°C	degrees Celsius
APE	area of potential effects
Basin Fund	Upper Colorado River Basin Fund
CFR	Code of Federal Regulations
cfs	cubic feet per second
CRSP	Colorado River Storage Project
DOI	Department of the Interior
EA	environmental assessment
EIS	environmental impact statement
ESA	Endangered Species Act of 1973
GCD	Glen Canyon Dam
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
HFE	high-flow experiment
LTEMP	Glen Canyon Dam Long-Term Experimental and Management Plan
MW	megawatt
NEPA	National Environmental Policy Act of 1969
NHPA	National Historic Preservation Act of 1966
NHWZ	new high-water zone
NPS	National Park Service
NRHP	National Register of Historic Places
OHWZ	old high-water zone
PA	programmatic agreement
Reclamation	United States Bureau of Reclamation
RM	river mile
ROD	Record of Decision
SBAHG	Smallmouth Bass Ad Hoc Group
SHPO	State Historic Preservation Office
TCP	traditional cultural place
US	United States
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
WAPA	Western Area Power Administration

Chapter 1. Introduction

1.1 Introduction

The National Environmental Policy Act of 1969 (NEPA; 42 United States Code 4321 et seq.), the Council on Environmental Quality's regulations for implementing the procedural provisions of the NEPA (40 Code of Federal Regulations [CFR] 1500–1508), and the United States (US) Department of the Interior (DOI) NEPA regulations (43 CFR 46) require the DOI to consider the potential environmental impacts of a proposed action before making a decision. The Bureau of Reclamation (Reclamation) has prepared this environmental assessment (EA) to evaluate impacts that could result from the proposed action with options. The proposed action with options describes several options to change the temperature of the water released through Glen Canyon Dam (GCD) by changing where water is released through the dam's existing structure. The flow options are within the upper and lower bounds of water releases, as described and analyzed in the 2016 GCD Long-Term Experimental and Management Plan (LTEMP) Record of Decision (ROD; DOI 2016b).

The proposed action with options is a federal action subject to NEPA's procedural requirements. Should a determination be made that the proposed action would not result in significant environmental impacts, Reclamation would prepare a finding of no significant impact to document that determination.

1.2 Project Location and Background

Reclamation's Upper Colorado Basin Region in Salt Lake City, Utah, oversees operations of GCD, located in Page, Arizona (see **Figure 1-1**). GCD is situated along the Colorado River and creates the reservoir known as Lake Powell.

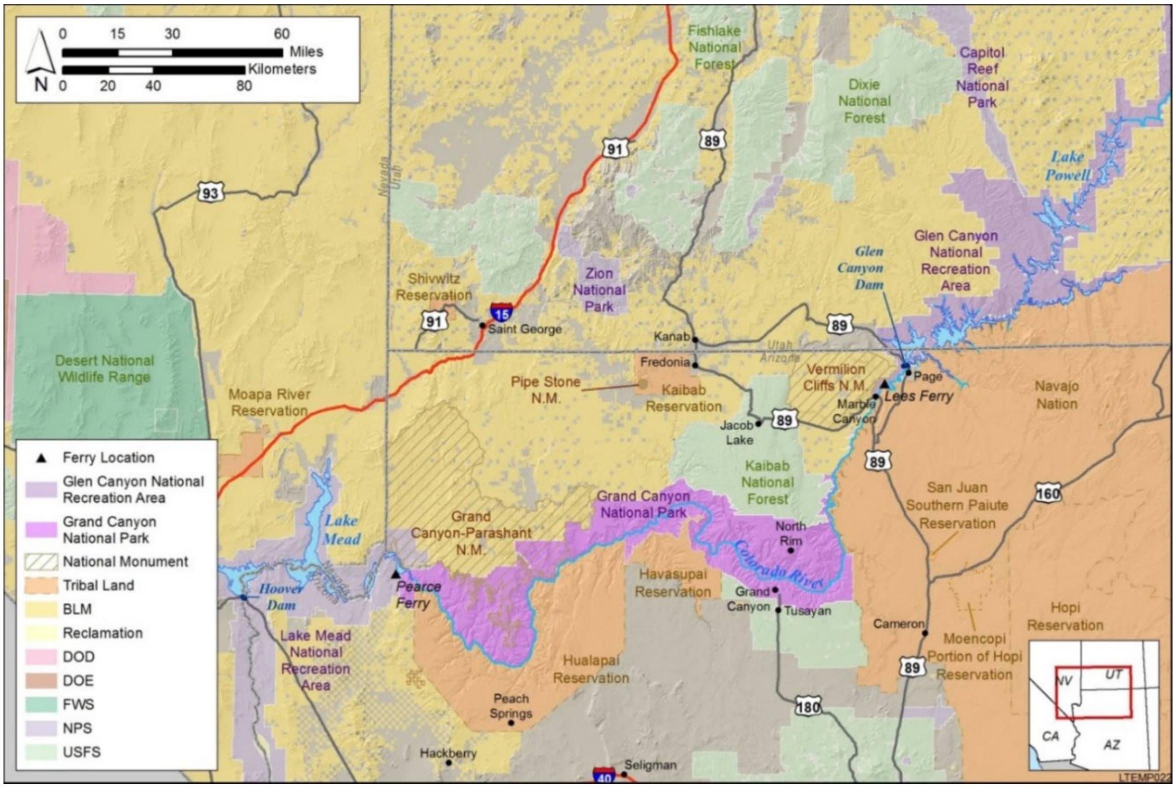
The Colorado River is mapped using river miles (RMs), with Lees Ferry marking RM 0 and GCD marking RM -15.84 (see **Figure 1-2**).

Lake Powell has a capacity of 25.0 million acre-feet and provides water storage for agriculture, municipal use, hydroelectric generation, and recreation, consistent with its authorizing legislation. Nonnative fish species, such as smallmouth bass (*Micropterus dolomieu*), are established in Lake Powell and are considered a sport fish. Native fish, including the federally protected humpback chub (*Gila cypha*), exist in the river downstream of GCD. The dam serves as an effective barrier to fish passage when lake elevations are high.

As the water elevation at Lake Powell has declined, the epilimnion[1] where most fish reside has become closer to the intakes for GCD. The drop in water elevation means that nonnative fish in Lake Powell are now more likely than in prior years to become entrained passing through the dam and into the Lees Ferry reach of the Colorado River. While some level of fish mortality occurs during passage through the turbines, some fish survive. As Lake Powell elevations decline, warmer water from the epilimnion is discharged, resulting in releases of water with warmer temperatures.

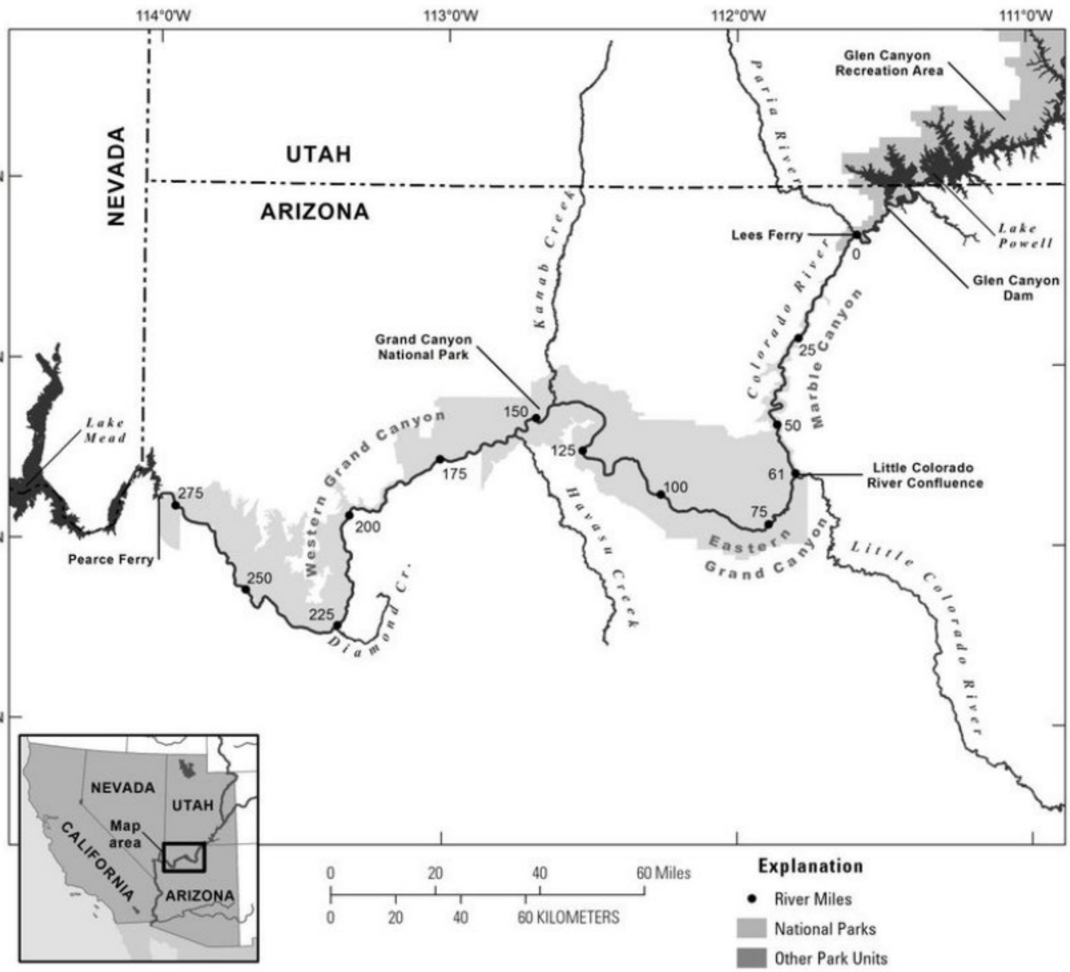
[1] The upper stratum of the water column of a reservoir that is generally warm, circulating, and turbulent.

Figure 1-1: Project Area and Surrounding Lands



Source: DOI 2016a

Figure 1-2: The Colorado River from Lake Powell to Lake Mead with River Miles



Source: Boyer and Rogowski 2017

Warm water temperatures below the dam amplify the risk of invasive fish establishing in the Colorado River (Dibble et al. 2021). This is a concern because smallmouth bass and other predatory fish pose a threat to federally listed fish species and other native fish downstream of GCD. To respond to the changing conditions, the Secretary of the Interior's designee directed Reclamation and the Grand Canyon Monitoring and Research Center (GCMRC) to work with the Adaptive Management Work Group to develop flow options at GCD to disrupt or prevent spawning of smallmouth bass and other invasive fish species that pass through the dam. Although invasive fish, including smallmouth bass, have been detected below the dam previously, the thermal conditions in the river (that is, warmer waters) are now conducive for smallmouth bass reproduction and establishment.

The flow options presented and analyzed in this EA combine cold-water releases through the bypass tubes[2] (also referred to as jet tubes, outlet works, or river outlets) and water released through the penstock[3] intakes to disrupt smallmouth bass and other cool-water and warmwater invasive fish from establishing below the dam. If smallmouth bass, which are a predaceous fish, establish below the dam,

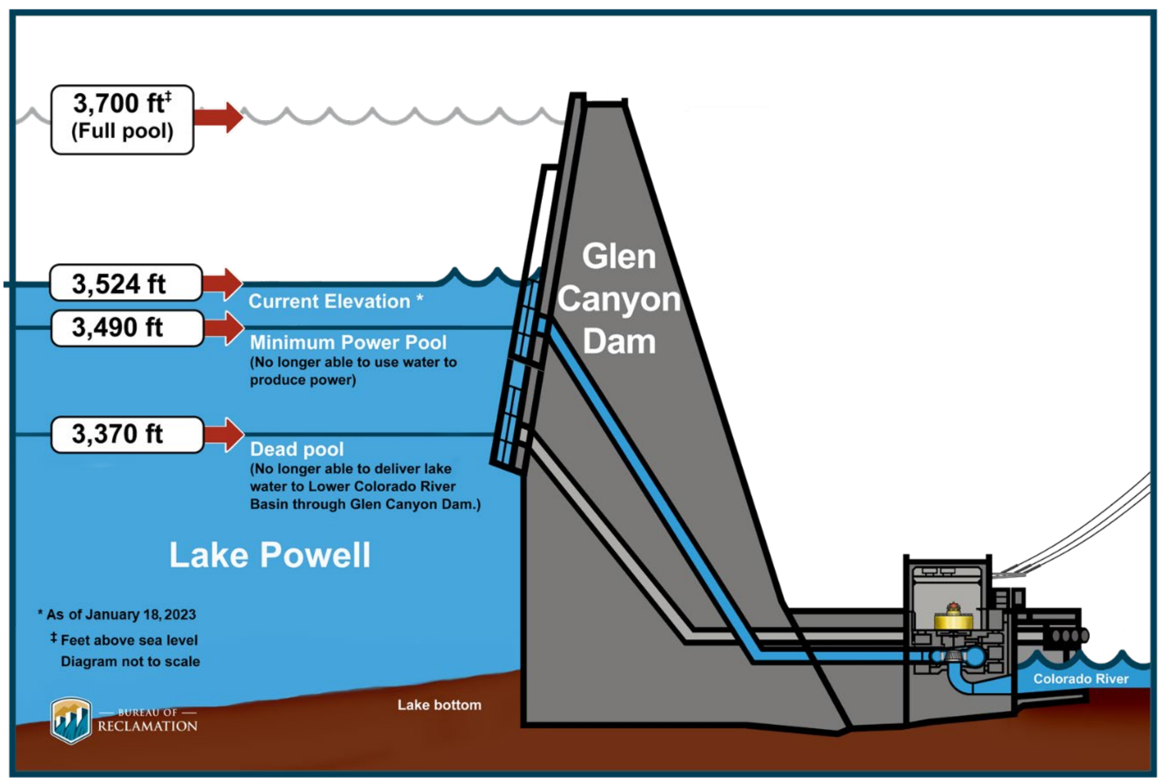
[2] Dam structures that conduct water from the reservoir to the river without passing through a power plant
[3] Dam structures that conduct water from the reservoir through the dam to the turbines of a power plant

removal efforts to protect federally listed species could be difficult and expensive. Furthermore, 20 years of mechanical removal of smallmouth bass upstream of GCD in the Upper Colorado River Basin have had limited success at reducing smallmouth bass densities to benefit native fish populations (Dibble et al. 2021; Bestgen and Hill 2016).

The flow options evaluated in this EA were developed collaboratively by the GCMRC and technical experts from various agencies using existing research and monitoring data within the Glen Canyon Dam Adaptive Management Program (GCDAMP). The goal of the flow options is to disrupt and prevent smallmouth bass from reproducing in the Colorado River in the area directly below the dam down to the confluence of the Little Colorado River, approximately 76 miles below GCD (RM 61), an important area for federally listed humpback chub.

The flow options incorporate releasing water from either the penstocks or the bypass tubes during certain months based on when temperatures at the Little Colorado River confluence reach or exceed 16 degrees Celsius (°C) and smallmouth bass would be expected to initiate spawning (Bestgen and Hill 2016). The penstocks are used for water releases and power generation. Because the bypass tubes are lower in the water column than the penstocks, water released from the bypass tubes is typically colder than water released through the penstocks. When water is released through the bypass tubes, no hydroelectric power is generated. See **Figure 1-3** for an operations guide to GCD.

Figure 1-3: Glen Canyon Dam Operations Guide



Source: Reclamation 2022a

Note: This diagram shows the current water elevation at Lake Powell, along with the elevation of the penstock and bypass tubes. The penstocks direct water through the hydropowered generator before being released to the Colorado River. Based on the current elevation, water is pulled from the warmer epilimnion. The bypass tubes release water directly to the Colorado River from the cold hypolimnion layer.

1.3 PURPOSE AND NEED

Reclamation has determined that a targeted EA is necessary to pursue implementation of flow options at GCD to respond to invasive smallmouth bass recently detected directly below the dam. The proposed action's purpose and need are to prevent the establishment of smallmouth bass below the GCD, which could threaten core populations of humpback chub in and around the Little Colorado River and its confluence with the mainstem.

Water levels in Lake Powell continue to decline to historically low levels, which has contributed to record high water temperature releases through GCD. Below the dam, these warmwater releases are creating ideal spawning conditions for smallmouth bass, a predatory invasive fish species. If smallmouth bass successfully spawn and establish below GCD and expand downstream into the Grand Canyon, they may threaten the federally protected humpback chub and other native fish (Dibble et al. 2021).

To respond to the threat of smallmouth bass establishment below GCD, this targeted EA identifies various GCD flow options designed to disrupt and prevent smallmouth bass from spawning in the Colorado River between GCD and the confluence of the Little Colorado River. A mix of water releases would be needed to disrupt smallmouth bass spawning behavior, which is expected to begin when water temperatures reach 16°C (Bestgen and Hill 2016). Reductions in water temperature combined with changes in flow velocity would be used to prevent smallmouth bass from successfully spawning and establishing downstream of GCD.

1.4 SELECTED AUTHORITIES CONCERNING GLEN CANYON DAM OPERATIONS

There is an extensive list of laws and executive orders that provide context for the management of the Colorado River and GCD. The list of these laws and executive orders is provided in the LTEMP Final EIS and is incorporated by reference (DOI 2016a, p.1.20). Selected authorities are described below.

Colorado River Compact (1922) – In 1922, the Colorado River Basin was divided into an upper and lower basin. The states of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming entered into an agreement to divide the waters of the Colorado River System. The compact provided the baseline management for future acts.

Colorado River Storage Project (CRSP) Act (April 11, 1956) – In 1956, the Secretary of the Interior authorized the construction of four major storage projects along the Colorado River Basin: the Wayne N. Aspinall Unit, the Flaming Gorge Unit, the Navajo Unit, and the Glen Canyon Unit. This created additional storage and allowed for long-term regulatory storage of water in the basin. The act also established the Upper Colorado River Basin Fund (Basin Fund), which is funded by sales of hydroelectric power and transmission. Funds are used to pay operations and maintenance costs of the storage projects; the funds are also allocated to other related programs.

Grand Canyon Protection Act of 1992 – This was enacted to "protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park (GCNP) and Glen Canyon National Recreation Area (GCNRA) were established." It paved the way for the Operation of GCD Environmental Impact Statement (EIS) and long-term operations and monitoring of GCD, complete in 1996.

Glen Canyon Adaptive Management Program (1997) – Established following the Grand Canyon Protection Act and GCD Final EIS 1995 and ROD 1996, the program created an interdisciplinary group to help organize and coordinate dam operations and future monitoring and research and protect and manage downstream resources.

Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead Final EIS (November 2007) and ROD (December 2007) – Reclamation prepared this EIS and ROD to establish guidelines and management strategies for Lake Powell and Lake Mead under drought and low reservoir conditions (Reclamation 2007a, 2007b).

GCD Long-Term Experimental and Management Plan EIS (October 2016) and ROD (December 2016) – This EIS provided a comprehensive framework for managing GCD in a manner consistent to the Grand Canyon Protection Act. It updated and superseded scientific data and monitoring that was established in the 1995 Operation of GCD EIS (DOI 2016a, 2016b).

1.5 Regulatory Compliance

Various laws and regulations apply to the proposed action. Compliance with selected requirements is summarized below:

- **National Environmental Policy Act of 1969 (NEPA)**, as amended, requires that the action agency use a public disclosure process to determine whether there are any environmental impacts associated with proposed federal actions. If there are no significant environmental impacts, a finding of no significant impact can be signed to complete the NEPA compliance.
- **Endangered Species Act of 1973 (ESA)**, as amended, requires all federal agencies to ensure their actions do not jeopardize the continued existence of listed species, or destroy or adversely modify their critical habitat. As part of the ESA's Section 7 process, an agency must coordinate with the US Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service on whether threatened and endangered species exist within or near the action area and evaluate the impacts on the species, if present.
- **National Historic Preservation Act of 1966 (NHPA)**, as amended, requires federal agencies to consider the effects of their undertakings on historical properties eligible for or listed on the National Register of Historic Places (NRHP). Federal agencies must determine whether there are historical properties in the project area, the effects of the project on those properties, and the appropriate mitigation for adverse effects. In making these determinations, federal agencies are required to consult with the State Historic Preservation Office (SHPO), Native American tribes with traditional or culturally significant religious interest in the project area, and the interested public.

The United States also has an Indian trust responsibility to protect and maintain rights reserved by or granted to Indian tribes or Indian individuals by treaties, statutes, and executive orders, such as Executive Order 13175 (Consultation and Coordination with Tribal Governments). These rights are sometimes further interpreted through court decisions and regulations. This trust responsibility requires that officials from federal agencies, including Reclamation, consult with tribal governments and take all actions reasonably necessary to protect Indian Trust Assets when administering programs under their control. Indian Trust Assets are legal interests in property held in trust by the US Government for Indian tribes or individuals. Examples of such resources are lands, minerals, or water rights.

There is an extensive list of laws and executive orders that provide context for the management of the Colorado River and GCD. The list of these laws and executive orders is provided in the LTEMP Final EIS and is incorporated by reference (DOI 2016a, p. 1.29).

1.6 Long-Term Experimental and Management Plan EIS and EA Tiering

The LTEMP Final EIS (DOI 2016a) was developed to better operate GCD in a manner to improve and protect important resources identified by the GCDAMP while maintaining compliance with relevant laws. The LTEMP Final EIS created adaptive management practices using the best current scientific information to guide dam operations and experimentations for 20 years following the ROD. Several key issues and goals were identified in the LTEMP Final EIS, including protecting humpback chub and other native fishes. The complete list of goals in the LTEMP ROD is incorporated by reference (DOI 2016b p. 6). The LTEMP ROD represents the most recent plan guiding operations of GCD.

The flows analyzed in this EA are tiered from the LTEMP analysis and fall within the scope of release parameters addressed in the LTEMP. Though the LTEMP addresses a wide range of GCD releases, its release parameters address sub-annual releases: hourly, daily, and monthly releases, including experimental releases that vary from base operations on hourly, daily, and monthly timescales.

The release parameters addressed in the LTEMP and in this EA do not and cannot affect annual releases from GCD. The 2007 Interim Guidelines govern annual releases, and the LTEMP is constrained by the 2007 Interim Guidelines and the underlying authority for the 2007 guidelines, including, but not limited to, the 1968 Colorado River Basin Project Act and the 1970 Long-Range Operating Criteria. The sub-annual GCD release parameters addressed in the LTEMP and in this EA are applied within the boundaries of the annual volume determinations of water prescribed by the Law of the River, and the LTEMP does not determine those annual volumes. The LTEMP ROD describes the decision-making sequence where first an annual volume is determined under the 2007 Interim Guidelines and then, once the annual volume is determined, the monthly and other sub-annual releases are determined pursuant to the LTEMP ROD.

The 2007 Interim Guidelines are scheduled to be in effect until 2026. Operational rules to apply after 2026 are being developed as the EA is underway.[4] Also, as this EA is underway, the DOI is reviewing the 2007 Interim Guidelines for the remainder of the operational period (through 2026) to supplement the 2007 Interim Guidelines to address historical drought and low runoff conditions in the Colorado River Basin.[5] Both processes related to the current 2007 Interim Guidelines could affect annual releases from GCD. Any sub-annual releases being addressed in this EA must be consistent with annual release requirements.

1.7 Operational Guidelines

As stated in the LTEMP ROD (Reclamation 2016b, Section 1.2), "Reclamation retains the authority to utilize operational flexibility at GCD because hydrologic conditions of the Colorado River Basin (or the operational conditions of Colorado River reservoirs) cannot be completely known in advance." Reclamation will make specific adjustments using the best available scientific and technological data, and in consultation with the GCDAMP partners. Should conditions warrant, Reclamation would seek to expedite

[4] https://www.federalregister.gov/documents/2022/06/24/2022-13502/request-for-input-on-development-of-post-2026-colorado-river-reservoir-operational-strategies-for

[5] https://www.federalregister.gov/documents/2022/06/23/2022-13394/notice-of-intent-to-prepare-a-supplemental-environmental-impact-statement-for-the-colorado-river

the decision-making process and would consider impacts to water quality and water delivery, humpback chub, sediment, riparian ecosystems, historical properties and traditional cultural properties, tribal concerns, hydropower production and the status of the Basin Fund, the rainbow trout fishery, and recreation.

1.8 CONSULTATION, COORDINATION, AND OUTREACH

For more than a year, Reclamation has coordinated with stakeholders in exploring, discussing, and developing various flow options for operations at GCD. Reclamation was a participant in the Smallmouth Bass Task Force, a sub-group comprised of the agencies that are members of the Adaptive Management Work Group. The task force met weekly starting in January 2022 to develop some initial information related to smallmouth bass. After the Secretary of the Interior's designee created several directives to respond to invasive fish in the Colorado River, the Smallmouth Bass Ad Hoc Group (SBAHG) was created to discuss approaches for dealing with smallmouth bass in the short, mid-, and long term. The SBAHG was formed as a sub-group of the Technical Work Group. The SBAHG involved participation from the member agencies of the GCDAMP. Reclamation participated in the SBAHG and provided feedback at regular intervals. The GCMRC conducted modeling and created initial ideas for flow options, which were discussed with the Smallmouth Bass Task Force and further refined during regular meetings with the SBAHG.

On December 1, 2022, Reclamation also hosted a virtual information session for GCDAMP stakeholders. The purpose of the session was to provide information to GCDAMP stakeholders on the EA process, discuss Reclamation's NEPA procedures, review current conditions, review the development and description of the flow options, and provide an opportunity for stakeholders to submit their written input to Reclamation by December 15, 2022.

Approximately 70 stakeholders attended the 90-minute information session. Reclamation received 10 stakeholder written input letters (included in **Appendix A**) and considered these in the preparation of the draft EA.

Reclamation has also coordinated closely with the USFWS throughout the EA process regarding implementation of the proposed flow options to disrupt smallmouth bass spawning. The USFWS agrees that the proposed flow options comply with the Biological Opinion issued by the USFWS for the LTEMP (see **Appendix C**). These flow options are designed to prevent a potential future decline in humpback chub that would occur if smallmouth bass are allowed to establish. An attempt to remove smallmouth bass once they become established has a reduced chance of success and would likely be more expensive.

Chapter 4 provides a list of technical specialists, subject matter experts, and other federal agencies and entities that contributed to or were conferred with in preparation of this EA.

1.8.1 Tribal Consultation and Coordination

This targeted EA tiers to the LTEMP Final EIS analysis in which Reclamation coordinated with Native American tribes, including the Hopi Tribe, Hualapai Tribe, Navajo Nation, Pueblo of Zuni, and Southern Paiute Consortium (Kaibab Band of Paiute Indians and Paiute Indian Tribe of Utah). In addition to the LTEMP's tribal consultation and coordination, Reclamation initially spoke with the tribes about the EA on October 25, 2022. Follow-up consultations occurred on November 18, November 21, and December 1, 2022, and on January 18, 2023. Tribes have also been involved in regular GCDAMP updates and meetings throughout this timeline as issues concerning smallmouth bass have been addressed. Additional consultation will continue throughout the EA process.

Coordination with the tribes also includes regular monthly and quarterly meetings and an annual LTEMP Programmatic Agreement[6] (PA; Reclamation 2017) report with annual follow-up meetings every April. These meetings provide additional tribal opportunities for updates and coordination on Upper Colorado Basin projects and processes. Reclamation's GCDAMP Tribal Liaison also participates in the meetings and helps facilitate additional discussion and coordination with the tribes.

[6] The PA is titled Programmatic Agreement Among US Department of the Interior Bureau of Reclamation and National Park Service, Western Area Power Administration, the Advisory Council on Historic Preservation, the Hualapai Tribal Historic Preservation Officer, the Navajo Nation Tribal Preservation Officer, the Hopi Tribe, the Kaibab Band of Paiute Indians, the Paiute Indian Tribe of Utah, the Pueblo of Zuni, and the Arizona State Historic Preservation Officer Regarding the Glen Canyon Dam Operations and Non-flow Actions Identified in the Long-Term Experimental and Management Plan Environmental Impact Statement and Record of Decision.

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Chapter 2. Proposed Action and Alternatives

As previously discussed, the proposed action with flow options was developed collaboratively by GCMRC and the Smallmouth Bass Task Force with input from numerous stakeholders, including the SBAHG, using existing research and monitoring efforts within the GCDAMP (see **Chapter 1**). This targeted EA analyzed the following:

- No action alternative
- Proposed action with several flow options:
  - Flow Option A—Cool Mix
  - Flow Option B—Cool Mix with Flow Spikes
  - Flow Option C—Cold Shock
  - Flow Option D—Cold Shock with Flow Spikes
- Alternatives considered but not analyzed in detail:
  - Flow Option E—Penstock Only Release

2.1 No Action Alternative

Reclamation analyzed the no action alternative, as it provides an appropriate basis by which to compare the effects of the proposed action. Under the no action alternative, there would be no change to water release operations at GCD. Operations at GCD would continue within the range of flows, as described in the LTEMP ROD (DOI 2016b).

The no action alternative would result in continued warming of water in the Colorado River below GCD if low elevations at Lake Powell persist. Warmer water temperatures would likely encourage smallmouth bass spawning and would likely result in new population establishment downstream of GCD. Smallmouth bass are predatory and invasive and would likely prey upon the federally protected humpback chub and eventually impact the humpback chub population status. This alternative does not meet the project's purpose or need.

2.2 Proposed Action with Flow Options

The proposed action with flow options provides Reclamation with flexibility to adaptively manage water releases from GCD to target smallmouth bass. Reclamation would utilize a flow option based on conditions at the time of implementation. Reclamation could switch to another flow option, as described below, to better match changing conditions.

2.2.1 Assumptions for All Flow Options

Under all flow options, Reclamation would adhere to operational and regulatory constraints, as outlined in the LTEMP Final EIS (DOI 2016a). Operational flow actions would occur for up to 3 years, starting in water year 2023. The following are the operations and constraints assumed for all flow options (USGS 2022):

- A minimum of 40 megawatts (MW) of generation must be maintained to stabilize electrical grid requirements. Water requirements to maintain 40 MW change, depending on the water surface elevations at Lake Powell. Current conversion estimates to maintain 40 MW correspond to 1,300 cubic feet per second (cfs) minimum discharge released through the penstocks for down-regulation[7] requirements held at GCD.

- The maximum non-experimental discharge that could be released through the penstocks under LTEMP is 30,000 cfs, but release capacity depends on the elevation of Lake Powell. Representative hydrographs were developed assuming that a maximum of approximately 18,000 cfs would be available. The 18,000 cfs maximum discharge is due to drought conditions, lower release volumes, and reduced unit availability based on the maintenance schedule at GCD in 2023. However, in future years, capacity could be higher; if so, the maximum discharge and magnitude of flow spikes would be expected to increase.
- The maximum discharge that could be released through the bypass tubes is 15,000 cfs; however, due to drought conditions and lower release volumes caused by decreased pressure with lower reservoir water surface elevations, it is likely that around 14,000 cfs maximum would be available, with 3,500 cfs released per bypass tube. Representative hydrographs were developed based on the assumption that 14,000 cfs would be available. However, depending on hydrologic conditions in future years, the discharge could be higher.
- Bypass tubes can be operated at half-tube increments (that is, 1,750 cfs, assuming 3,500 cfs per bypass tube) to minimize the amount of water released through the bypass tubes that would be required to reach a particular target temperature.
- Maintenance of penstocks or bypass tubes could impact the number of valves that could be discharged from at one time.
- Consistent with the water releases, as described and analyzed in the LTEMP ROD (DOI 2016b), the total discharge would not exceed a maximum ramp rate of 4,000 cfs per hour when increasing flows, and 2,500 cfs per hour when decreasing flows.
- Consistent with the water releases described and analyzed in the LTEMP ROD (DOI 2016b), Reclamation would maintain a minimum of 8,000 cfs total discharge during the day (7 am to 7 pm) and a minimum of 5,000 cfs at night (7 pm to 7 am).
- If temperatures at the Little Colorado River are below 16°C, it is not necessary to implement the proposed action. Dam operations would allow for the emergency exception criteria to continue as needed and as outlined in the LTEMP FEIS (DOI 2016a).
- Monthly volumes will not be adjusted specifically to implement the flow options.
- In order to determine when the flow action is triggered, a daily temperature model that was adapted from a monthly temperature model developed by Dibble et al. 2020 will be used to predict when the temperature at the Little Colorado River reaches 15.5°C. The trigger will be 15.5°C to account for error in the model. The model uses discharge, water temperature, air temperature, and solar radiation in a heat balance equation to describe changes in water temperature over the length of the Colorado River from RM -15 (GCD) to RM 281. To estimate the date that the temperature threshold will be met, the model is applied using projected daily

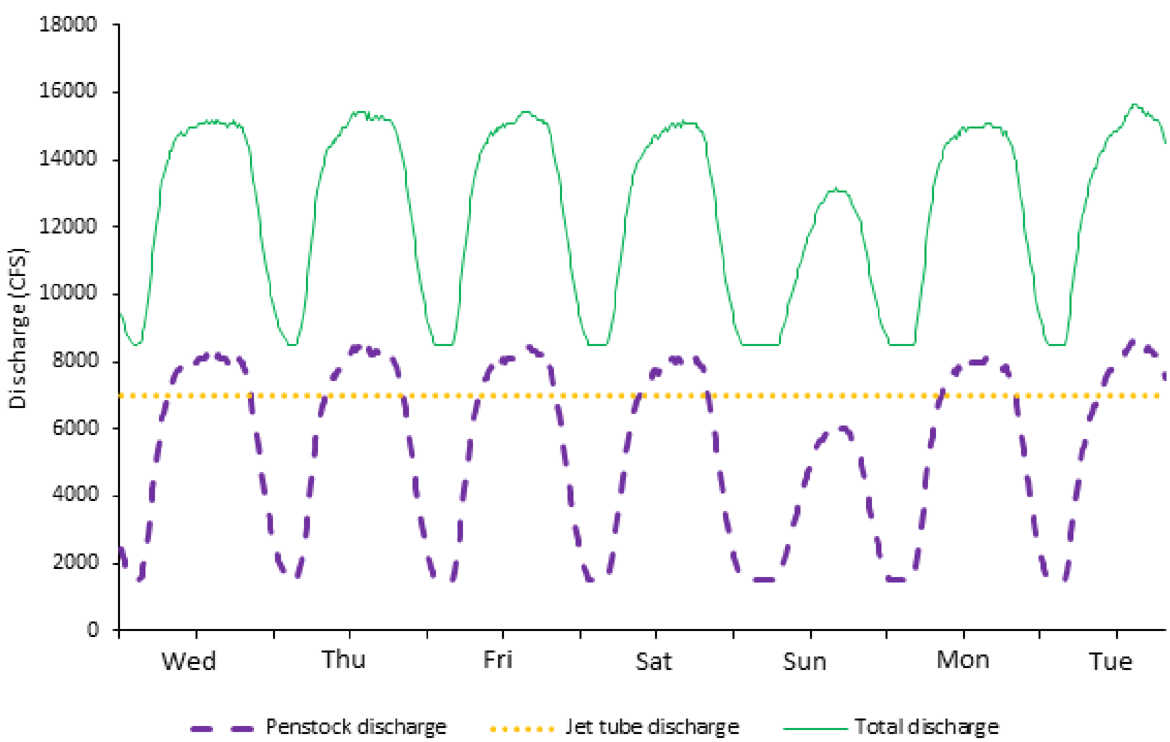
[7] In addition to daily scheduled fluctuations for power generation, the instantaneous releases from GCD may also fluctuate to provide 40 MW of system regulation. These instantaneous release adjustments stabilize the electrical generation and transmission system and translate to a range of approximately 1,300 cfs 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.

releases and water temperature from GCD, mean daily air temperature from Page, Arizona, and mean solar radiation from Williams, Arizona. These sites produce a stable model and minimize error.

2.2.2 Flow Option A—Cool Mix

For Flow Option A, with a goal of disrupting smallmouth bass spawning, water would be released from both penstocks and bypass tubes to maintain a daily average water temperature below 16°C from below the dam to the Little Colorado River (RM 61). The amount of water released through the bypass tubes would be based on predicted temperatures at the bypass tubes and penstocks at the time of the flow; the minimum amount of water to meet the water temperature goal would be released through the bypass tubes. The amount of water released through the bypass tubes would vary over the course of the year, depending on monthly volumes of water available and the temperature. A conceptual hydrograph is provided for this flow option in **Figure 2-1** (USGS 2022).

Figure 2-1: Conceptual Hydrograph for Flow Option A



Source: USGS 2022
Note: This conceptual hydrograph for Flow Option A assumes that a monthly volume of about 740,000 acre-feet is being released. The hydrograph begins on the midnight between Tuesday and Wednesday and illustrates a full week of operations.

The amount of water released through the bypass tubes and penstocks would vary based on the elevation of Lake Powell and the distribution of water temperatures through the water column. These factors determine the temperature of the water released into the Colorado River. The released water temperature and the time of year (air temperature and solar radiation) determine how quickly the water warms as it travels downriver (Dibble et al. 2021; Mihalevich et al. 2020).

When all four bypass tubes are available and daily total discharge (that is, the sum of water released through the penstocks and bypass tubes) is greater than 16,860 acre-feet per day (8,500 cfs), the target temperature of 16°C at the Little Colorado River is almost always achievable (USGS 2022).

If monthly volumes are below 476,000 acre-feet for 30-day months and 492,000 acre-feet for 31-day months, and water temperatures at the depth of the penstocks are greater than 23°C, it may not be feasible to maintain daily average water temperatures below 16°C. It may only be possible to maintain those temperatures from below the dam through RM 45 in Marble Canyon. Smaller water volumes warm more quickly, and it is not always possible to release enough cold water to overcome this warming (USGS 2022). However, since smallmouth bass were detected in the Glen Canyon reach in 2022, no smallmouth bass have been detected below RM 0. This means that even if it is only possible to change the temperature down to RM 45, implementation of the flows would still be effective at preventing spawning of smallmouth bass.

If only two bypass tubes are available and daily total discharges are high, the target temperature may also only be achievable in upper Marble Canyon (for example, if the daily total discharge is 20,826 acre-feet per day [10,500 cfs], the water temperature at the penstock is 20°C, the water temperature at the bypass tubes is 11°C, and only two bypass tubes are available for use; the water temperature in June is expected to remain below 16°C through RM 40) or not achievable at all (for example, if the daily total discharge is 27,769 acre-feet per day [14,000 cfs], the water temperature at the penstock is 21°C and the water temperature at the bypass tube is 11°C) (USGS 2022).

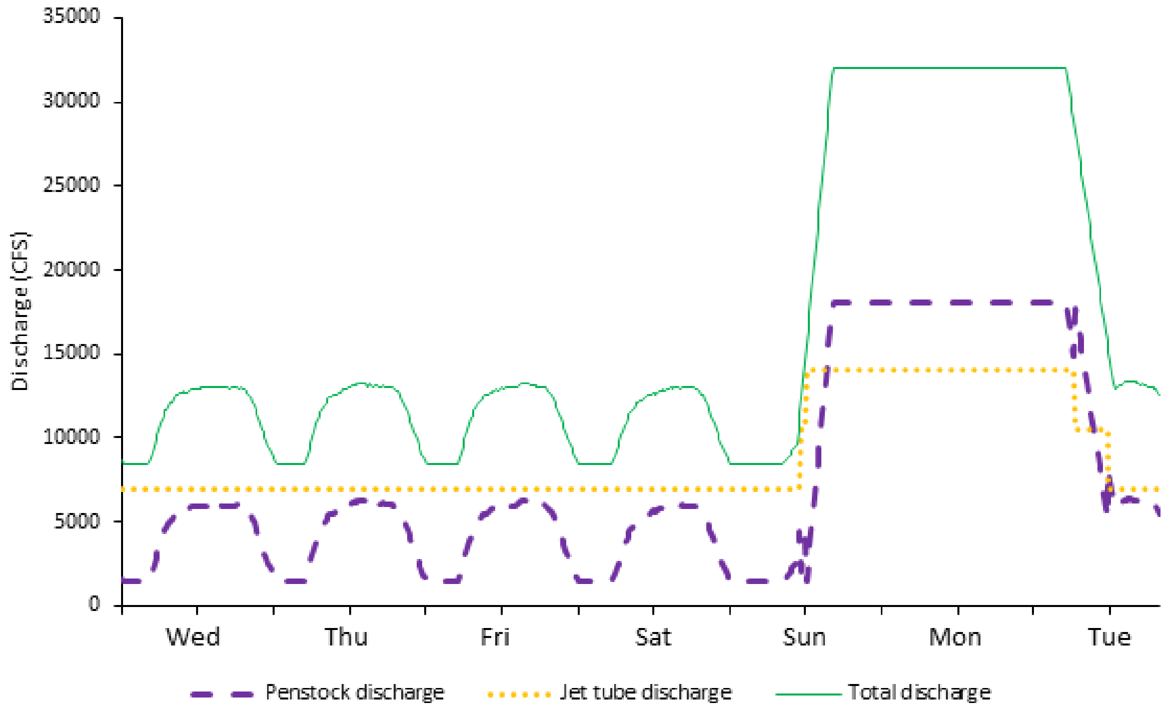
2.2.3 Flow Option B—Cool Mix with Flow Spikes

For Flow Option B, water would be released through the penstocks and bypass tubes to maintain a daily average water temperature below 16°C from below the dam to the Little Colorado River (RM 61), with the goal of disrupting smallmouth bass spawning. In addition, up to three 36-hour flow spikes would be added between late May and mid-July if sufficient water is available. The flow spike would likely disrupt spawning in margin habitats that may be warmer than the main stem river. During a flow spike, as much water as possible (up to 45,000 cfs) would be released through the penstocks and bypass tubes. The amount of water released through the bypass tubes during the cool mix portion of the hydrograph is based on predicted temperatures at the bypass tubes and penstocks at the time of the flow. The minimum amount of water would be released through the bypass tubes to meet the water temperature goal. The amount of water released through the bypass tubes would vary over the course of the year, depending on monthly volumes. A conceptual hydrograph is provided for this flow option in **Figure 2-2** (USGS 2022).

The amount of water needed to be released through the bypass tubes and the penstocks would vary based on the elevation of the lake and the distribution of water temperatures through the water column. The temperature of the water released and the time of year (air temperature and solar radiation) determine how quickly the water warms as it travels downriver (Dibble et al. 2021; Mihalevich et al. 2020).

When all four bypass tubes are available and daily total discharge (that is, the sum of penstock and river outlet releases) is greater than 16,860 acre-feet per day (8,500 cfs), 16°C at the Little Colorado River is almost always achievable (USGS 2022).

Figure 2-2: Conceptual Hydrograph for Flow Option B



Source: USGS 2022
Note: This conceptual hydrograph for Flow Option B assumes a monthly release volume of approximately 740,000 acre-feet. The hydrograph begins on the 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 acre-feet of water would be required. Alternatively, the average daily discharge on non-flow 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 acre-feet.

If monthly volumes are below 476,000 acre-feet for 30-day months and 492,000 acre-feet for 31-day months, and water temperatures at the penstocks are greater than 23°C, it may only be possible to maintain daily average water temperatures below 16°C from below the dam through RM 45 in Marble Canyon. Smaller water volumes warm more quickly, and it might not always be possible to release sufficient cold water to overcome this warming (USGS 2022). However, since smallmouth bass were detected in the Glen Canyon reach in 2022, no smallmouth bass have been detected below RM 0. This means that even if it is only possible to change the temperature down to RM 45, implementation of the flows would still be effective at preventing spawning of smallmouth bass.

If only two bypass tubes are available and daily total discharges are high, the target temperature may also only be achievable in upper Marble Canyon (for example, if the daily total discharge is 20,826 acre-feet per day [10,500 cfs], the water temperature at the penstock is 20°C, the water temperature at the bypass tube is 11°C, and two bypass tubes are used, then the water temperature in June is expected to remain below 16°C through RM 40) or not achievable at all (for example, if the daily total discharge is 27,769 acre-feet per day (14,000 cfs), the water temperature at the penstock is 21°C, and the water temperature at the bypass tube is 11°C) (USGS 2022).

Flow spikes would likely be most effective if timed earlier in the potential reproductive cycle of smallmouth bass (late May through mid-July) (USGS 2022).

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

2.2.4 Flow Option C—Cold Shock

For Flow Option C, water would be released for at least 48 hours through the bypass tubes, releasing the minimum amount of water required to create a cold shock all the way down to the Little Colorado River (RM 61) 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 or below (Henderson and Foster 1957; Rawson 1945; Latta 1963). This option would begin as soon as daily water temperatures near the Little Colorado River reached 16°C; after this, weekly use of the bypass tubes, anticipated to occur during weekends, would be initiated and would last for up to 12 weeks.

The amount of water released through the bypass tubes during the cold-shock portion of the hydrograph would be based on predicted temperatures at the bypass tubes and penstocks at the time of the flow. The minimum amount of water required to meet the water temperature goal would be released through the bypass tubes and depends on constraints due to maintenance. The discharge volume released through the bypass tubes would vary over the course of the year based on water temperatures at the depths of the bypass tubes and penstocks. Releases on other days of the week would be primarily determined by the monthly volume. A conceptual hydrograph is provided for this flow option in **Figure 2-3** (USGS 2022).

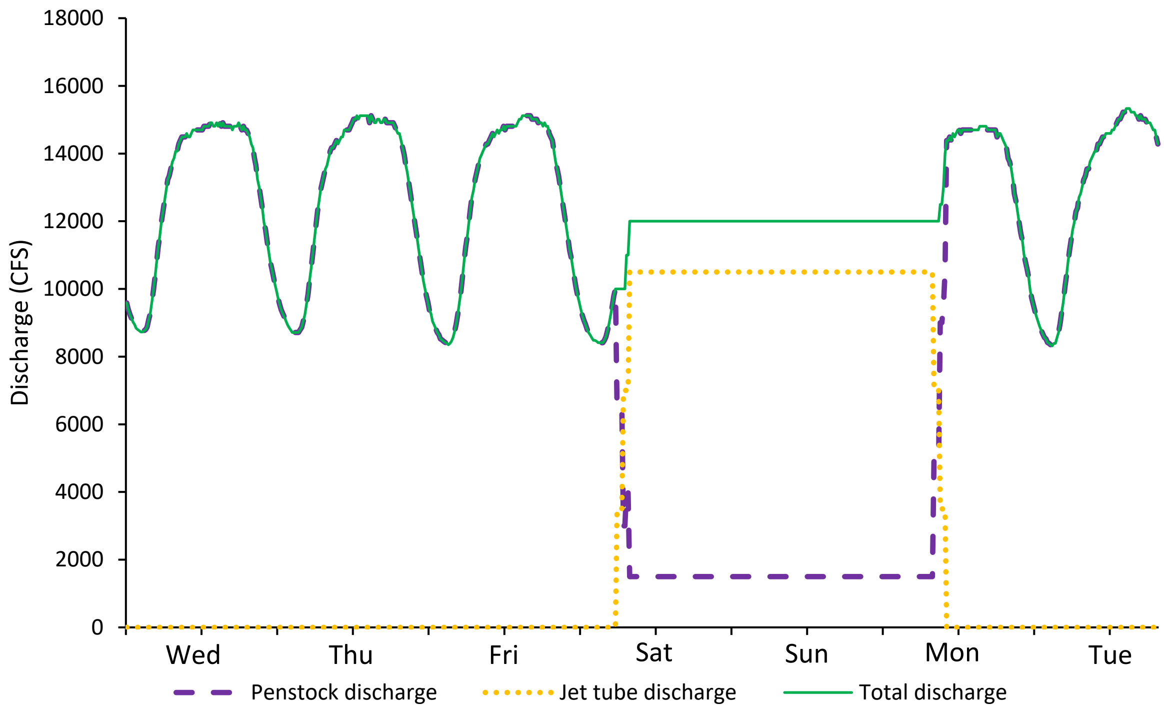
The amount of water released through the bypass tubes and the penstocks to meet the water temperature release goal of 13°C would vary based on the elevation of the lake and the distribution of water temperatures through the water column. The temperature of the water released and the time of year (air temperature and solar radiation) determine how quickly the water warms as it travels downriver (Dibble et al. 2021; Mihalevich et al. 2020).

If water temperatures at the depth of the penstocks are greater than 23°C and only two bypass tubes are available, it is likely impossible to achieve a cold shock daily average water temperature below 13°C through Lees Ferry (RM 0) (USGS 2022).

If water temperatures at the penstock depth are greater than 23°C and three bypass tubes are available, it may be possible to achieve a cold shock daily average water temperature below 13°C from the dam through RM 15 in upper Marble Canyon (USGS 2022).

Since smallmouth bass were detected in summer 2022, no smallmouth bass have been detected below RM 0. This means that achieving a cold shock down to RM 0 or RM 15 would still be effective at disrupting spawning.

Figure 2-3: Conceptual Hydrograph for Flow Option C



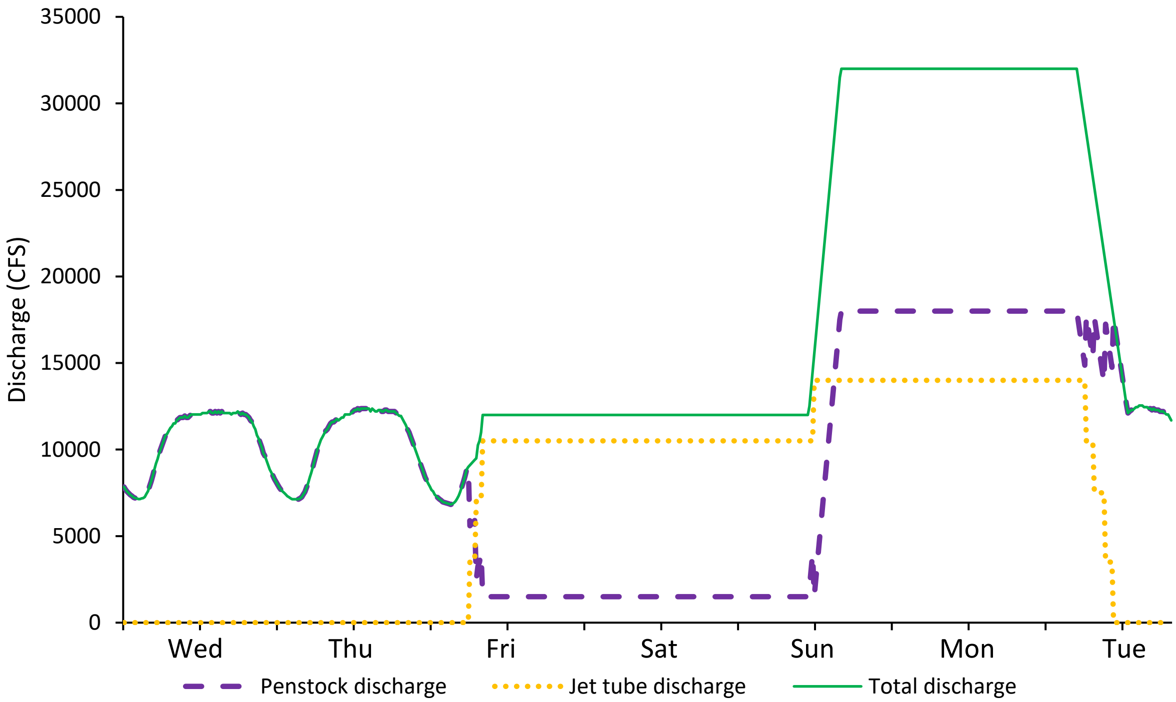
Source: USGS 2022
Note: This conceptual hydrograph for Flow Option C assumes that approximately 740,000 acre-feet and at least three bypass tubes are available in June. The hydrograph begins on the midnight between Tuesday and Wednesday and illustrates a full week of operations. Operations would be the same for all weeks in the month.

2.2.5 Flow Option D—Cold Shock with Flow Spikes

For Flow Option D, water would be released for at least 48 hours through the bypass tubes for the minimum amount of time required to create a cold shock all the way down to the Little Colorado River (RM 61) to disrupt smallmouth bass spawning. In addition, up to three 36-hour flow spikes would be added between late May 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. As much water as possible (up to 45,000 cfs, depending on water availability) would be released through the penstocks and bypass tubes during flow spikes. This option would begin as soon as daily water temperatures near the Little Colorado River reach 16°C. This option would provide weekly 48-hour cold-shock releases and at least one 36-hour spike flow, and it would last for up to 12 weeks.

The amount of water released through the bypass tubes during the cold-shock portion of the hydrograph is based on predicted temperatures at the bypass tubes and penstocks at the time of the flow. The minimum amount of water required to meet the water temperature goal would be released through the bypass tubes and depends on constraints due to maintenance. The amount of water released through the bypass tubes could vary over the course of the year, based on the water temperatures at the depths of the bypass tubes and penstocks. Releases during other days of the week would be primarily determined by the monthly volume. A conceptual hydrograph is provided for this flow option in **Figure 2-4** (USGS 2022).

Figure 2-4: Conceptual Hydrograph for Flow Option D



Source: USGS 2022
Note: This conceptual hydrograph for Flow Option D assumes approximately 740,000 acre-feet are available in June, all four bypass tubes are available, and there is one flow spike per month. 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.

The amount of water that would need to be released through the bypass tubes and the penstocks to meet the temperature goal would vary based on the elevation of the lake and the distribution of water temperatures through the water column. The temperature of the water released and the time of year (air temperature and solar radiation) determine how quickly the water warms as it travels downriver (Dibble et al. 2021; Mihalevich et al. 2020).

If water temperatures at the penstock depth are greater than 23°C and only two bypass tubes are available, it would likely be impossible to achieve a cold shock daily average water temperature below 13°C through Lees Ferry (RM 0) (USGS 2022). Even if it is not possible to achieve a temperature of 13°C, the flow would likely disrupt spawning, even though data from the Yampa and Green Rivers suggests that smallmouth bass can continue to spawn when temperatures drop to 13.9°C (Bestgen and Hill 2016).

If water temperatures at the penstock depth are greater than 23°C and three bypass tubes are available, it may be possible to achieve a cold shock daily average water temperature below 13°C from the dam through RM 15 in upper Marble Canyon (USGS 2022). Even if it is not possible to achieve a temperature of 13°C, the flow would likely disrupt spawning even though data from the Yampa and Green Rivers suggests that smallmouth bass can continue to spawn when temperatures drop to 13.9°C (Bestgen and Hill 2016).

2.3 Alternatives Considered but Not Analyzed in Detail

Flow Option E – Penstock Only Release, as described below, was developed by the same team that developed the proposed action flow options. Flow Option E was not analyzed in detail because it does not meet the project's purpose and need of preventing establishment of smallmouth bass below GCD.

As soon as water temperatures reach 16°C at the confluence with the Little Colorado River, once a week for 3 months, GCD discharge through the penstocks would be lowered to 2,000 cfs and then increased to 25,000 cfs. This change in flows may create the maximum amount of disturbance to spawning habitat without the use of the bypass tubes. Since all the water is released through the penstocks, water temperature would not be changed by Flow Option E.

Flow Option E would disturb smallmouth bass spawning and rearing by dewatering habitat under low flows and increasing velocities under elevated flows. This would cause males to abandon nests, resulting in high mortality of offspring (Winemiller and Taylor 1982, Lukas and Orth 1995, Knotek and Orth 1998). Spawning habitat disturbance was estimated using a discharge-velocity model developed for Lees Ferry with 5-by-5-meter resolution (Kaplinski et al. 2022a, 2022b; Nelson et al. 2016).

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Chapter 3. Affected Environment and Environmental Consequences

3.1 INTRODUCTION

This chapter describes existing physical, biological, social, and cultural resources that could be affected by the no action alternative and the proposed action, as described in **Chapter 2**. It also identifies potential environmental consequences—beneficial or adverse—to those resources that could result from implementing either of the two alternatives. The affected environment sections describe the existing environment upon which the alternatives could have an effect. More specifically, this is the Colorado River Ecosystem, as described in the LTEMP Final EIS (DOI 2016a, p. ES-1), which includes the Colorado River mainstream corridor and interacting resources in associated riparian and terrace zones, located primarily from the forebay[8] of GCD to the western boundary of GCNP. The environmental consequences sections describe the potential direct, indirect, and cumulative effects of those alternatives, if implemented, on the resources evaluated. **Section 3.11**, Anticipated Effects on LTEMP Resource Goals, includes a summary of anticipated effects on resource goals below GCD, as described in the LTEMP ROD (DOI 2016b, Attachment A).

3.2 AQUATIC ECOLOGY

3.2.1 Affected Environment

Fisheries

This section provides information on the fisheries resources and affected environment for the Colorado River from GCD to the confluence with the Little Colorado River, which is the principal area evaluated for the environmental effects of the action. Though the scope of this analysis does not extend downstream of the Little Colorado River confluence based on the limitations to affect temperatures beyond that point, the migratory nature of fish within the affected environment warrants consideration of the fisheries downstream of the confluence with the Little Colorado River to the inflow of Lake Mead at Pearce Ferry if those fish migrate to the Little Colorado River confluence. Habitat within the affected environment includes the mainstem Colorado River, where perennial waters occur, to the confluence of the Little Colorado River and selected locations downstream of this confluence, such as at the confluences of other tributaries (for example, at Bright Angel, Shinumo, Havasu, and Tapeats Creeks).

Federally Listed Fish

The native fish assemblage includes two ESA-listed species: humpback chub (*Gila cypha*) and razorback sucker (*Xyrauchen texanus*). The Little Colorado River (at Colorado River RM 61) hosts the core population of humpback chub (**Figure 3-1**) below GCD and serves as important habitat for humpback chub, both for migrating adults for spawning and for rearing habitat for young-of-the-year.[9] More recently, a population of humpback chub has been observed in the western section of Grand Canyon (approximately RM 180–280), although the dynamics of that population are not fully understood.

[8] The area of Lake Powell that is immediately upstream of the GCD face.

[9] All of the fish of a species younger than one year of age.

Figure 3-1: Humpback Chub

Photograph courtesy of Rich Valdez, SWCA Environmental Consultants.

Razorback suckers were thought to be extirpated in the Grand Canyon until they were observed in 2012 (Albrecht et al. 2013). Although larval fish have been identified in the Grand Canyon, the last detection was in 2019 and small-bodied fish have not been captured. This suggests either poor survival of larval fish or downstream export to Lake Mead. Radio-tagged razorback suckers have been released in the Grand Canyon to better understand their movements (Albrecht et al. 2017).

Other Native Fish

The other native fish in the Grand Canyon include speckled dace (*Rhinichthys osculus*), flannelmouth sucker (*Catostomus latipinnis*), and bluehead sucker (*Catostomus discobolus*). The Colorado pikeminnow (*Ptychocheilus lucius*), bonytail (*Gila elegans*), and roundtail chub (*Gila robusta*) are native to the Colorado River through the Grand Canyon, but they have been extirpated since about the 1970s (Valdez and Carothers 1998).

Rainbow Trout

A Blue Ribbon[10] rainbow trout (*Oncorhynchus mykiss*) recreational fishery exists in the Lees Ferry reach of the Colorado River, which extends from the GCD tailwater to the Paria River confluence (DOI 2016a; see **Section 3.3**, Recreation). The annual value of angling in the Lees Ferry reach totaled $2.7 million at 2014 visitation levels (Bair et al. 2016; see **Section 3.7**, Socioeconomics and Environmental Justice). The LTEMP ROD (DOI 2016b) specifically aims to create and maintain a "high-quality" fishery while also

[10] Designation given to trout fisheries that are extremely high quality for anglers and wildlife enthusiasts. It was designated this status by Arizona Game and Fish Department in 1981.

limiting downstream migration of the nonnative species that could affect federally listed fish farther downstream.

The interaction of dam releases, water temperature, and sediment drives the presence and abundance of nonnative species, primarily rainbow trout and brown trout (Melis 2011). Cold, clear, hypolimnetic releases from the dam to the Paria River favor trout species whose populations can extend downstream to the confluence of the Little Colorado River and in and near the mouth of several cold-water tributaries (for example, Bright Angel, Deer, and Shinumo Creeks), where clear, cold flows provide local, suitable conditions for these species (Coggins et al. 2011; Runge et al. 2018). Sediment can also be a factor by impeding sight feeders, such as trout, when large floods occur in tributaries such as the Paria River and the Little Colorado River (Melis et al. 2011; Korman et al. 2021).

Nonnative Fish

Although native fish dominate the Colorado River from the Little Colorado River to Pearce Ferry, several nonnative fish occur in small numbers or as localized populations (DOI 2016a). Most of these nonnative fish are warmwater species that depend on water temperatures greater than 16˚C for spawning, egg incubation, and rearing (Valdez et al. 2015). There have been sporadic detections of various nonnative fish species below the dam since it was completed, showing that fish are capable of surviving in reservoir releases. Other sources of nonnative fish are the tributaries that support upstream populations. The principal nonnative species in the Grand Canyon include common carp (*Cyprinus carpio*), red shiner (*Cyprinella lutrensis*), fathead minnow (*Pimephales promelas*), plains killifish (*Fundulus zebrinus*), rainbow trout, brown trout (*Salmo trutta*), black bullhead (*Ameiurus melas*), channel catfish (*Ictalurus punctatus*), green sunfish (*Lepomis cyanellus*), striped bass (*Morone saxatilis*), smallmouth bass, largemouth bass (*Micropterus salmoides*), walleye (*Sander vitreus*), northern pike (*Esox lucius*), and western mosquitofish (*Gambusia affinis*) (Valdez and Carothers 1998).

Although water temperatures below the dam have historically been cold enough to deter the establishment of these warmwater species, warmer releases have occurred as a consequence of Lake Powell's lower levels starting in about 2004 (Valdez et al. 2015). Species such as smallmouth bass have been detected sporadically in the Colorado River below GCD. The smallmouth bass is a predaceous fish that has had a large impact on federally listed fish in the Upper Colorado River Basin (Breton et al. 2015); it is of concern as a predator and competitor in the Colorado River through the Grand Canyon.

There have been sporadic detections of smallmouth bass below GCD since 2000 (Rogowski et al. 2017). Smallmouth bass are a highly predatory fish that have caused serious population declines of native fish in upper sections of the Colorado River, including humpback chub (Breton et al. 2015; Valdez et al. 2021). Smallmouth bass were first detected below GCD in April 2003 and April 2004, when an adult and a juvenile, respectively, were captured within 5 miles of the base of the dam, likely a result of illegal stocking at Lees Ferry or passage through the dam (Hilwig et al. 2009). In summer 2022, some smallmouth bass were found at the -12-mile slough (including fish <20 mm in total length), and over 250 juveniles were found throughout the Glen Canyon reach over the next few months. This large number of young fish suggests successful spawning occurred in Lees Ferry.

Aquatic Food Base

A healthy aquatic ecosystem depends on a functional balance between producer and consumer groups and the interactions between trophic levels.[11] River flow, nutrient, and temperature regimes influence these groups. This section describes the aquatic food base, including primary producers and consumers and native and nonnative fish and their habitats, as well as the effects of flow and temperature regimes on these groups.

Hourly and daily fluctuations that result from dam releases occur in response to hydropower and load-following flows from GCD. These flow regimes cause artificial wet and dry periods along channel margins below GCD that alter the water depth, width, and clarity and, thus, primary production (Deemer et al. 2022). Water depth and shear stress (or force per unit area) at the sediment-water interface increase during periods of elevated flow, leading to nonlinear increases in turbidity levels and altering habitat suitability for several aquatic species.

Many fish, amphibious species, and macroinvertebrates occupy shallow water habitat along the shorelines for protection against predators and to lay eggs. When the water level subsides, early life stages of fish and macroinvertebrates are exposed to desiccation, leading to an overall decrease in species diversity and biomass (Angradi and Kubly 1993; Kennedy et al. 2016; Young et al. 2011).

Fluctuating hourly and daily releases limit the abundance of macroinvertebrates and reduce the overall availability of prey for fish, potentially causing food limitation for fish populations (Kennedy et al. 2013). Aquatic insect abundance depends on a basic life-history trait—adult egg-laying behavior—such that open water taxa are unaffected by hourly and daily fluctuations (Kennedy et al. 2016). Some taxa of macroinvertebrates, particularly Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddis flies), lay their eggs along the river edge and have been negatively impacted by hourly and daily fluctuations (DOI 2016a). Mayflies have largely disappeared in areas below GCD (Kennedy et al. 2016).

Primary production is also correlated with light availability and turbidity levels (Stevens et al. 1997). When turbidity levels are high, there is less light available for primary production (Hall et al. 2015; Deemer et al. 2022). The segment between GCD and the Little Colorado River is often clear and supports high abundance of primary producers. In contrast, river segments downstream of the Little Colorado River often experience elevated sediment inputs. Sediment, in turn, increases turbidity, which lowers the number of primary producers downstream of GCD (Stevens et al. 1997). Further, nonlinear increases in turbidity during elevated flows result in fewer primary producers, whereas a steady flow regime will have lower turbidity and result in more primary producers.

The effects of water temperature fluctuations and the temperature threshold that organisms in the aquatic food base can sustain are not as well understood. Before dam operations began, the Colorado River corridor between GCD and the western edge of GCNP was seasonally warm and turbid, with large seasonal flow variations. Temperatures in this corridor fluctuated between 0˚C in winter months and 30˚C during the summer, creating a warmwater habitat (Gloss and Coggins 2005). Generally, warmer temperatures increase the growth and reproduction of primary producers in aquatic ecosystems but do not necessarily increase biodiversity (EPA 2022). After the installation of GCD, water temperatures became colder, with water temperatures in the reach through the Little Colorado River confluence rarely exceeding 12˚C (Gloss and Coggins 2005). Since the early 2000s, temperatures have warmed, with 12˚C

[11] Trophic level refers to the place of an animal in the food chain.

often exceeded near the Little Colorado River confluence for multiple months. This warming accelerated dramatically in 2021 and 2022 as the elevation of Lake Powell declined.

Many fish, insects, zooplankton, phytoplankton, and other aquatic species have a preferred temperature range (DOI 2016a). As temperatures get too far above or below this preferred range, the physiology becomes disrupted; this can result in modifications in the macroinvertebrate community structure and alterations in trophic interactions within the aquatic food web (Bonacina et al. 2022). Water temperature regimes below GCD become less influenced by dam releases the farther water moves downstream (DOI 2016a; Mihalevich et al., 2020).

3.2.2 Environmental Consequences

No Action Alternative

Fisheries, Including Federally Listed Fish, Other Native Fish, Rainbow Trout, and Other Nonnative Fish

Considering the warmer dam releases due to the low elevation of Lake Powell resulting from a 20-year drought (Reclamation 2022b), the no action alternative could allow for an expanded range of invasive fish in the Colorado River below GCD. It also could increase interactions between predatory invasive species and native species (Coggins et al. 2011). The lower lake elevation means the penstocks withdraw warmer water from the epilimnion and mesolimnion,[12] rather than deeper, colder water from the hypolimnion[13] (see **Figure 1-3**).

No flow-based actions under LTEMP would be taken to prevent the spawning of smallmouth bass downstream of GCD. The population could continue to grow and expand in the Lees Ferry reach and potentially downstream.

Native fish interactions with invasive piscivorous fish like smallmouth bass would likely increase, resulting in increased predation and competition (Coggins et al. 2011). Assuming smallmouth bass and other invasive fish become established, despite management actions to prevent further distribution, it is likely that the no action alternative would detrimentally affect native species (including ESA-listed fish). This is largely because of continued regional drought conditions, the potential for continued decline in Lake Powell's elevation, and the consequential potential increase in nonnative fish entrainment and passage and warm-water releases conducive to spawning (Summit Technologies Inc. 2022).

Aquatic Food Base

Under the no action alternative, flow regimes would remain similar to the conditions modeled in the LTEMP Final EIS (DOI 2016a). Low reservoir volumes above the dam would continue to provide low-nutrient, concentrated water to areas below the dam. The decreased sediment load and increased light availability would continue to cause high productivity levels directly below the dam; however, 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 remain limited to support native and desired nonnative fish populations (DOI 2016a; Kennedy et al. 2013). Macroinvertebrate production flows (bug flows) were conducted in 2018,

[12] The thermally stratified layer of a reservoir characterized by a rapid change in temperature with depth, that effectively isolates the waters of the epilimnion from those of the hypolimnion during the period of stratification.

[13] The lower stratum of the water column of a reservoir where the water temperature is cold.

2019, 2020, and 2022 in an attempt to improve productivity and diversity of the aquatic food base and to learn more about the response of the food base to these flows.

Proposed Action with Options

Federally Listed Fish

While all flow options under the proposed action would aim to reduce water temperatures, native fish naturally experience water temperatures colder than those expected from each flow option. The temperatures proposed in the flows would be consistent with the conditions present when the analysis for the LTEMP Final EIS (DOI 2016a) was conducted. In other words, impacts to humpback chub would not likely be different from those analyzed in the LTEMP Final EIS.

Cold shocks under Flow Options C and D, and the flow spikes under Flow Options B and D would be of short duration. Also, the cold temperatures would reach downstream to the confluence of the Little Colorado River where humpback chub habitat begins. A range expansion of humpback chub has occurred recently, but it is downstream of the Little Colorado River in the western Grand Canyon (Rogowski et al. 2018); water temperatures and flow volumes from the proposed flow options would moderate with distance from the dam and before reaching this population.

There are no recent reports of razorback suckers in the affected reach of the Colorado River (from GCD to the confluence with the Little Colorado River). However, water temperatures and flow volumes from the proposed flow options could affect downstream reaches occupied by adult razorback suckers moving into the lower Grand Canyon from Lake Mead. Also, the few larvae and juveniles produced in the lower Grand Canyon could be affected as flow changes inundate or desiccate backwaters used by juveniles. However, the effects would be minor because flow characteristics would moderate with distance from the dam.

Flow Option A would likely have minor effects on federally listed fish. The conditions of the flow and water temperature under this flow option would be the same as those analyzed in the LTEMP Final EIS (DOI 2016a). In addition, the flows are designed to disrupt spawning of smallmouth bass and prevent establishment. Smallmouth bass would likely have a negative impact on humpback chub and other native fish.

Other Native Fish

It is unlikely that any of the flow options would negatively affect native fish species because these species are adapted to flooding and have existed in this cold-water system since completion of the dam (Melis 2011; Robison and Childs 2001; Yackulic et al. 2014). Native fish species below GCD routinely encounter temperatures colder than the target temperatures for all flow options (Yackulic et al. 2014).

Flow Option A would likely positively affect native fish species. The conditions of the flow and water temperature under this flow option would be the same as those analyzed in the LTEMP Final EIS (DOI 2016a). In addition, the flows are designed to disrupt spawning of smallmouth bass and prevent establishment, which would benefit native fish populations.

Flow Options B and D would include flow spikes, which mimic pre-dam river hydrology, and would likely not negatively impact native fish (Propst and Gido 2004; Olden et al. 2006; Tonkin et al. 2021; Pennock et al. 2022). The flow spikes would disrupt spawning in margin habitats that are typically lower velocity and warmer than the mainstem river, potentially causing nest abandonment by guarding males and/or displacing newly hatched larvae downstream with subsequent low survival. Since most native fish reside below the affected area, the flow would not likely have more than minor effects.

Although the cold shock in Flow Options C and D could negatively affect some native fish species, most native fish in the affected environment reside near and below the Little Colorado River confluence. This means that only the fish near the Little Colorado River confluence would be affected. Native fish species typically spawn in spring or summer, which means that cold shocks could negatively affect the survival of eggs and newly hatched larvae of native species if they spawn in the affected reach during the flow option's implementation.

Rainbow Trout

None of the flow options would likely significantly affect adult rainbow trout population size; however, the cold shocks (Flow Options C and D) and flow spikes (Flow Options B and D) could displace young rainbow trout from shoreline habitats and increase downstream displacement (Avery et al. 2015; Korman and Campana 2009). Downstream displacement of rainbow trout could lead to increases in interactions with other rainbow trout and humpback chub (Avery et al. 2015).

While colder water temperatures may negatively affect warmwater nonnative fish species, such as smallmouth bass, they may beneficially affect cold-water nonnative fish species, such as the recreational trout fishery in Lees Ferry. Flow Options C and D are meant to create a cold shock to quickly reduce water temperatures to below 13˚C. It is unclear how this change 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 16˚C–18˚C optimal growth range for rainbow trout (Mishra et al. 2021). Reduced feeding behavior may result in lower catch rate by anglers during cold shocks (see **Section 3.3**, Recreation, for more information on the rainbow trout fishery). Additionally, spike flows under Flow Options B and D could create spawning and rearing habitat for rainbow trout on high-elevation cobble and gravel bars (USGS 2011a). 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).

Nonnative Fish

All flow options are designed to inhibit smallmouth bass spawning, displace male smallmouth bass from guarding nests, or both. Flow Options A and B are designed to accomplish this using prolonged water releases below ideal temperatures for smallmouth bass spawning. Cool water temperatures under Flow Option A would likely disrupt or prevent spawning of smallmouth bass and other nonnative, invasive warmwater fish species. Additionally, Flow Options B and D would provide added flow spikes to disrupt spawning in areas where water temperatures may be higher than the water released from GCD, especially along shorelines and backwaters where local warming may occur. Flow Option B would reduce the water temperature to below 16°C in the mainstem Colorado River, and the flow spikes would push cold water into the backwater habitats to prevent spawning or push male smallmouth bass off nests, if spawning has already occurred. For these reasons, this option is most likely to meet the purpose and need.

Cold shocks under Flow Options C and D would disrupt spawning in shoreline or backwater habitats that may be warmer than the mainstem river. This would also likely result in population decreases for cold-water and warmwater nonnative fish species, including smallmouth bass, which are spawning at the time of these releases. Smallmouth bass usually spawn from May to mid-July, and a cold shock would serve to move males off the nest, decreasing the survival of eggs and newly hatched fry or larvae. Other nonnative fish could be similarly affected if they spawn at the time of the flow.

Smallmouth bass are managed as a sport fish in Lake Powell, and there is a higher risk of entrainment through GCD whenever the epilimnion aligns with the dam's penstocks (see **Figure 1-3**, Glen Canyon Dam Operations Guide). Although this could happen during flow option implementation, smallmouth bass could also pass through GCD if no action were taken, particularly when Lake Powell elevations are between 3,490 and 3,530. During implementation of flow options, the velocity around the penstock intakes would increase, but smallmouth bass would likely outswim the intake velocities, regardless of the flow (Webb 1998, Peake 2004). Smallmouth bass spawning typically occurs from May through July, and the area where the penstock intakes are does not include suitable habitat for spawning. This means that juvenile fish are unlikely to move up into this area until they are larger.

Fish dispersal is an important consideration for establishment. The flow spikes under Flow Options B and D would coincide with times when many nonnative fish fry and larvae are present in the system (May through July), potentially resulting in downstream displacement. However, fish that are displaced at early life stages generally have very low survival (Harvey, 1987; Miller and Brewer, 2020).

Most literature on smallmouth bass movement in rivers focuses on seasonal movement between winter and summer habitat (Todd and Rabeni 1989, Westhoff et al. 2016, Humston et al. 2021), including movement between tributaries and mainstem rivers (Schall et al. 2019). Movement is often tied to spawning behavior (Rubenson and Olden 2017), with individuals often displaying site fidelity (Todd and Rabeni 1989), but localized movement can also be in response to changes in flow (Lyons and Kanehl 2002) or temperature (Dauwalter and Fisher, 2008).

In regulated rivers, operational flow fluctuations showed no impact on black bass (includes largemouth and smallmouth bass) dispersal (Earley and Sammons 2015, Sammons and Earley 2015). There is no literature on smallmouth bass movement in response to flow spikes or cold-water releases. Furthermore, there have been no reports of population level movement from the flow spike experiments below Flaming Gorge Dam.

Green sunfish already occur throughout the Grand Canyon in low numbers, so any potential additional impacts from dispersal are expected to be minimal. There is an overall lack of quantitative research on green sunfish movement or dispersal in response to flows. However, studies indicate that floods can result in significant drift rates of small green sunfish larvae (up to about 0.4-inch total length) often resulting in high morality, but larvae between 0.4-inch and 1-inch in length showed greater ability maintain position during flood flows (Harvey 1987).

Aquatic Food Base

Under all four proposed flow options, the range of potential discharge volumes would remain within the existing range of flows outlined in the LTEMP Final EIS (DOI 2016a).

Flow Option A is similar to routine operations that occurred for decades under the 1996 EIS (Reclamation 1996) and more recently the LTEMP Final EIS and ROD (DOI 2016a, 2016b). Bypass releases that are characteristic of Flow Option A would likely increase dissolved nutrient concentrations, potentially stimulating food-base productivity. Cold and relatively constant water temperatures would be expected to favor cold-water-adapted algae and macroinvertebrate species, such as midges and blackflies.

Under Flow Option B, releases that exceed the penstock capacity of about 30,000 cfs would likely scour the substrate of the Lees Ferry reach and have negative short-term effects on primary production and macroinvertebrate populations. High-flow experiments (HFEs), which are other flow experiments conducted within the GCDAMP, have occurred in either spring (March–April) or fall (October–November). A high-scouring flow event in May or June would temporarily reduce the food-base abundance and biomass; however, due to relatively high nutrient and light availability at this time of year, recovery of the food base could be rapid. Indeed, food-base recovery following the spring HFE in March 2008 was rapid and likely responsible for contributing to high rates of rainbow trout recruitment and growth in that year (Cross et al. 2013).

Flow Option C would have the smallest range of discharges, which could provide modest benefits to sensitive macroinvertebrate species that have egg-laying habits on the river edge. However, the recurring cold shocks could lead to high accidental and behavioral drift of macroinvertebrates (Carolli et al. 2012). Also, these cold-water pulses would likely disrupt macroinvertebrate development and life cycles in the same way they are intended to disrupt development and spawning of smallmouth bass.

Flow Option D would involve recurring cold shocks and recurring flow spikes. Similar to Flow Option C, the cold shocks of Flow Option D could lead to high rates of macroinvertebrate drift and potentially disrupt macroinvertebrate development and life cycles. The flow spikes of Flow Option D represent a disturbance that would scour benthic substrates and reduce the food-base abundance and biomass. An appropriately timed flow disturbance can stimulate food-base productivity, similar to that observed after the 2008 spring HFE (Cross et al. 2013). The timing of the flow events would be consistent with pre-dam flooding events, potentially allowing for a more natural disturbance flow regime that may stimulate food-base productivity and abundance.

Cumulative Impacts

Fisheries, Including Federally Listed Fish, Other Native Fish, Nonnative Fish, and Rainbow Trout

Overall, cumulative impacts on native and federally listed fish would likely be temporary and beneficial overall. This is because the flow options are meant to disrupt or prevent 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. In addition, rainbow trout thrive in colder waters and would likely benefit from the reduced water temperatures created by the flow options. However, impacts to young rainbow trout from options that include cold shocks and/or flow spikes would likely be negative because they would be displaced from shoreline habitats by changing flow volumes and temperatures (Korman and Campana 2009).

Aquatic Food Base

The cumulative impacts to the aquatic food base from the four flow options would 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 four flow options would operate within the spatial and temporal bounds and under the assumptions of the existing analysis conducted in the LTEMP Final EIS (DOI 2016a). Therefore, cumulative impacts on organisms of the aquatic food base would not differ substantively from those included in the LTEMP Final EIS.

3.3 RECREATION

3.3.1 Affected Environment

The description of recreational resources in this section focuses on resources and activities found in the Colorado River corridor from just below GCD downstream to the confluence of the Little Colorado River at RM 61 (recreation analysis area). Recreational resources of concern include the Blue Ribbon rainbow trout fishery, boating (such as kayaking, rafting, and canoeing) from GCD to Lees Ferry, boating through a portion of the Marble/Grand Canyon (upper reach) of the Grand Canyon from Lees Ferry (RM 0) to the confluence of the Little Colorado River (RM 61), and camping opportunities throughout the recreation analysis area. Recreation economics are discussed in **Section 3.7**, Socioeconomics and Environmental Justice.

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 GCD and Lees Ferry, Arizona. Recreational activities of concern in this area include rainbow trout fishing, day-rafting, boating, 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 angling is done from boats or is facilitated by boat access, often provided by guide services. Some anglers also fish by wading or from shore. Fish in all waters within the GCNRA and GCNP are managed by the National Park Service (NPS), in coordination with the Arizona Game and Fish Department and the USFWS. The condition of the fishery within the GCNRA can be affected by the operations of GCD, which is operated by Reclamation.

Dam operations and fishery management may affect the size and quality of the rainbow trout fishery and angler experience. Since completion of the dam and 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. Recent drought conditions have resulted in warming water temperatures below GCD, which could impact rainbow trout energetics and survival (Rogers 2015; Korman et al., 2022). While there is a strong interest in maintaining the highly valued rainbow trout fishery in the Glen Canyon reach, there is also a concern about the migration of rainbow trout to downstream areas, particularly near the confluence of the Little Colorado River, where there is an important aggregation of federally listed humpback chub. Increased rainbow trout densities near the Little Colorado River confluence are associated with moderate declines in juvenile humpback chub survival (Yackulic et al., 2018).

Fishing in the Glen Canyon reach occurs year-round. Peak usage is in April and May; however, substantial fishing has occurred from March through October in most years (Rogowski and Boyer 2020). An estimated total of 7,653 anglers used the rainbow trout fishery in 2019; of these, 5,469 were boat anglers and 2,185 were walk-in anglers (Rogowski and Boyer 2020).

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 to 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. Most anglers elect not to fish in the Glen Canyon reach during HFEs.

Day-Rafting, Boating, and Camping in the Glen Canyon Reach

In addition to fishing, the Glen Canyon reach supports recreational activities that include river floating, camping, and recreational boating. The NPS estimated that 26,000 commercial angler and water-based recreation 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.[14]

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 3-2** shows the general location of the six designated campsite areas. Releases of 40,000 cfs to 45,000 cfs can create steep banks in some portions of the river that make 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, Colorado River Discovery, to operate in the Glen Canyon reach. The concessionaire's most popular service is a half-day guided trip that originates at GCD. 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 3-1**). 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.

Table 3-1: 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

[14] Zoom call between Lucas Bari, NPS, and Noelle Crowley, EMPSi, on January 13, 2023.

*Lower visitation in 2020 and 2021 compared to previous years is likely attributed to the COVID-19 pandemic.

Figure 3-2: Designated Campsite Areas in the Glen Canyon Reach

Source: Reclamation 2011
Map showing designated sites on the Colorado River between GCD and Lees Ferry; boat closures are indicated by cables across the river.

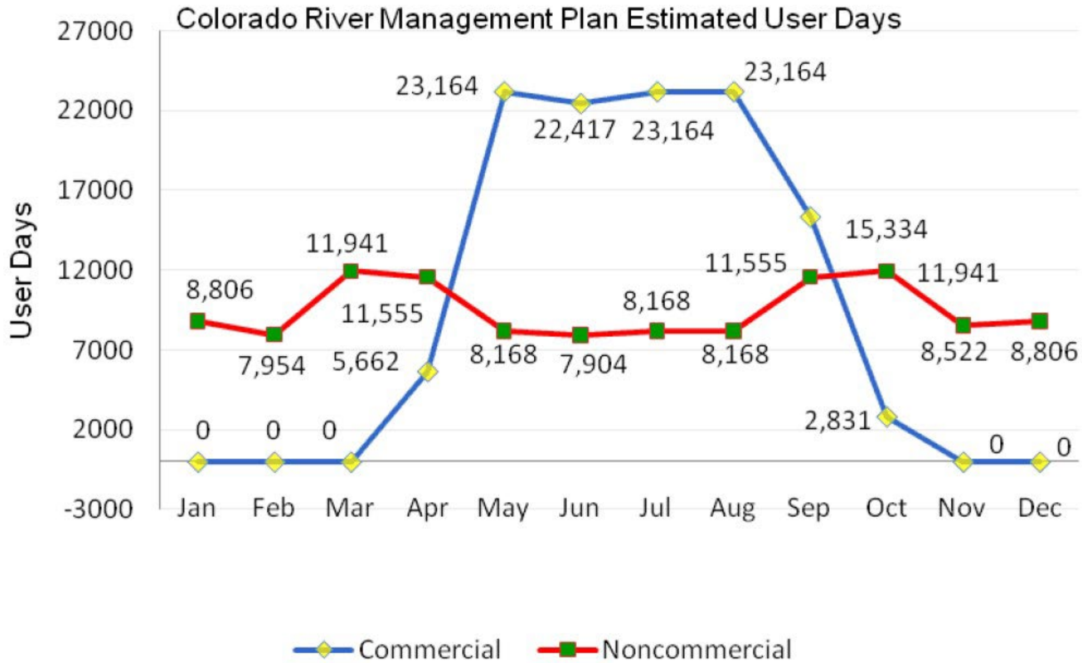
The Colorado River in Grand Canyon National Park

Boating in Grand Canyon National Park

Boating in the reach below Lees Ferry and through the Grand Canyon is internationally renowned. Use is regulated by the NPS under the Colorado River Management Plan (NPS 2006) with a lottery system. The Colorado River Management Plan for boating through GCNP governs use in both the reach from Lees Ferry (RM 0) to Diamond Creek (RM 226) and the reach from Diamond Creek down to Lake Mead (RM 277). The recreation analysis area in GCNP for this EA only includes from Lees Ferry to the confluence of the Little Colorado River (RM 61). Higher-use months for commercial operations extend from May through September, but there is relatively consistent use throughout the year for noncommercial boating. **Figure 3-3** shows the expected maximum amount of use allowed by the Colorado River Management Plan, as measured in user days.

The Colorado River Management Plan (NPS 2006, 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, not all available noncommercial trips have been taken, and not all available trips have been filled to capacity.

Figure 3-3: Anticipated Annual Boating Use in the Grand Canyon by Month



Source: NPS 2006; Reclamation 2011
Anticipated annual boating use in the Grand Canyon estimated in 2006

3.3.2 Environmental Consequences

No Action Alternative

Under the no action alternative, Reclamation would not make any changes to operations of GCD. Therefore, water would continue to be released, as described in the LTEMP Final EIS (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; therefore, there would likely be no change to angler satisfaction with flow levels and daily fluctuations in the short term. In the long term, drought conditions could result in increasingly warm water temperatures that 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

Under the no action alternative, boaters and campers in the Glen Canyon reach would continue to have the same level of access as they currently have.

Impacts on Boating in the Grand Canyon

Under the no action alternative, boaters in the Grand Canyon would continue to have the same level of access as they currently have.

The exact impacts on recreation would continue to depend on water availability for releases.

Proposed Action with Flow Options

Under the proposed action, the volume of water discharged during the flow actions would have the greatest potential to impact recreation. These impacts would all be temporary, because flow actions would only be implemented for a limited time. The range of volumes of potential discharges under the proposed flows would be within the range of operations, as outlined in the LTEMP. Therefore, recreation conditions within the recreation analysis area would remain within the range described in the LTEMP Final EIS (DOI 2016a).

Impacts on Fishing in the Glen Canyon Reach

Compared to the no action alternative, all four flow options would reduce water temperatures of the Colorado River below GCD during and after releases. This would benefit the rainbow trout fishery because rainbow trout are cold-water species and thrive when water temperatures are colder. Flow Options B and D include cold shocks which would temporarily reduce catchability, which may reduce angler satisfaction in the short term. However, all flow options would likely result in higher angler satisfaction in the long term than the no action alternative. More information on the impacts on the water temperature and rainbow trout are described in **Section 3.2**, Aquatic Ecology, and **Section 3.4**, Water Resources.

Flow Options A and C would continue to operate flows within the range of operations, as outlined in the LTEMP; therefore, the impacts to fishing in the Glen Canyon reach resulting from the volume of water discharged would be the same, as described under the no action alternative. Flow Options B and D include flow spikes, which would create a temporary increase in the amount of discharge. The flow spikes would occur between May and July. They would overlap with one of the peak fishing months (May) (Rogowski and Boyer 2020) and would disrupt fishing during the 36-hour period of the spike flow.

Flow Options B and D have a greater potential to result in negative short-term impacts by disrupting fishing during one of the most popular months; however, those options could benefit the rainbow trout fishery in the long term by improving the water quality. More information on the impacts on rainbow trout is described in **Section 3.2**, Aquatic Ecology.

Impacts on Boating and Camping in the Glen Canyon Reach

All four flow options would produce flows that would temporarily disrupt boating within the Glen Canyon reach. Impacts to recreational boating and the rafting concessionaire during the implementation of the flow options would be increased under the proposed action due to the implementation of the flow options during the spring and summer months when there is higher visitor use. The elevated flows in Options B and D could make certain areas or boating types (for example, commercial rafting day-trips) temporarily inaccessible. Flow Options B and D include flow spikes that could cause erosion or deposition of sand bars along camping areas with terraces in the Glen Canyon reach, depending on the volume of the flow released and the amount of sand in the system. Flow Options A and C would not likely have as large an impact on boating or camping, depending on the volume of water released.

Impacts on Boating in Grand Canyon National Park

All four flow options would affect a relatively small portion of the Colorado River used by boaters in the Grand Canyon. On this stretch, Flow Options B and D would produce flows that would likely improve boater navigability in the Grand Canyon, yielding impacts on boating in the Grand Canyon similar to those described under the no action alternative. The steadier flows of Flow Options A and C would minimally impact boaters in a positive direction.

Flow Options B and D include flow spikes, which could temporarily limit the usability of beaches for camping. However, these flow options would also have the greatest potential for sandbar growth, which would result in more campsite area than under Flow Options A and C and the no action alternative.

Cumulative Impacts

Impacts on recreation from the proposed action with options would be temporary in nature and would not have major impacts on recreation in the recreation analysis area. All proposed flow options would operate within the spatial and temporal bounds and under the assumptions of the existing analysis conducted in the LTEMP Final EIS. There would be no cumulative impacts on recreation beyond those included in the LTEMP Final EIS.

3.4 WATER RESOURCES

3.4.1 Affected Environment

This section provides information about the water resources of the analysis area, including Lake Powell and the Colorado River, from GCD to the confluence with the Little Colorado River. Information is organized into broad categories focused on hydrology and water quality.

The hydrology of Lake Powell and the Colorado River, as discussed in this EA, refers to water volume and flow rates; water quality refers to biological and chemical properties, and temperatures. This section will focus on temperature, salinity, conductivity, turbidity, and dissolved oxygen. These aspects of the system could be affected by the proposed action with flow options at GCD.

The Colorado River is monitored for several other physical and chemical properties, such as nutrients, bacteria, and pathogens. However, it is unlikely the proposed action would affect these water quality characteristics; therefore, they are not pertinent to this EA. Information on these water quality characteristics is available in the LTEMP Final EIS Section 3.2.2 and is incorporated by reference (DOI 2016a).

Hydrology

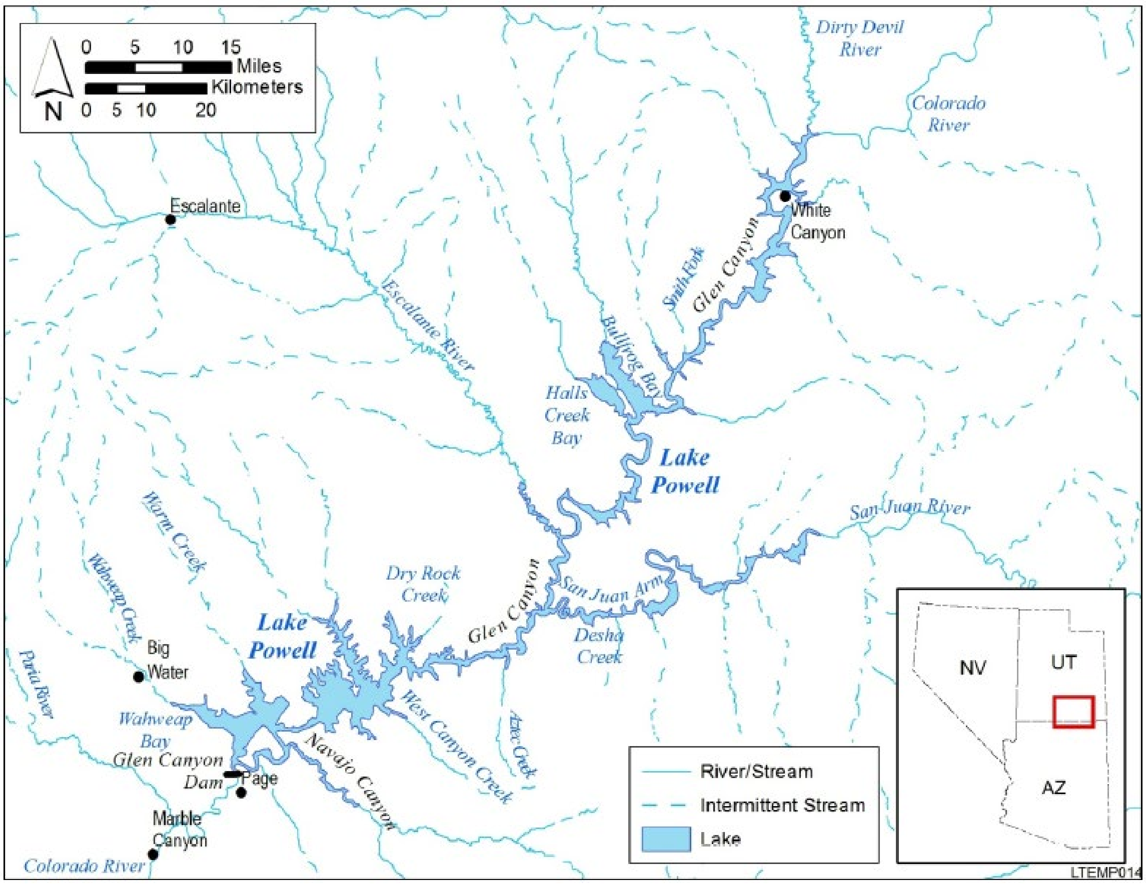
The primary source of water in the system originates as snowmelt from the Rocky Mountains in the Upper Colorado River Basin. Snowmelt peaks in the spring, resulting in peak flows in the Colorado River in late spring to early summer. However, regulatory structures in the Upper Colorado River Basin, such as dams and diversion structures, may alter the system's water availability. The snowmelt converges into several large rivers that supply the area with water, including the Colorado, Green, and San Juan Rivers (DOI 2016a).

The Colorado River Basin is experiencing the worst drought conditions in the region's recorded climatic history. The region is experiencing hotter and drier conditions, with lower annual precipitation totals, fewer wet days, and greater fluctuations in multiple precipitation characteristics, such as timing, frequency, and magnitude (Zhang et al. 2021). These climatic changes have resulted in lower water levels in Lake Powell and less water availability for GCD operations.

Lake Powell Hydrology

After Lake Mead, Lake Powell is the second-largest human-made reservoir on the Colorado River. It was created following the construction of GCD in 1963 under the CRSP Act of 1956. Lake Powell has a maximum storage capacity of approximately 25.0 million acre-feet. When storage is maximized, it has an average depth of approximately 165 feet, with a maximum depth of 560 feet near GCD. The reservoir is long and narrow, with a multitude of side canyons and tributaries. **Figure 3-4** shows the reservoir and major tributaries.

Figure 3-4: Lake Powell and Major Tributary Rivers



Source: DOI 2016a

The hydrology of Lake Powell is primarily influenced by basin-wide conditions and inflows, which are beyond the scope of this targeted EA. These inflows dictate the volume and water quality characteristics of releases from GCD. Inflows to Lake Powell dictate water levels, water mixing, and water quality such as temperature. The LTEMP Final EIS Section 3.2.1.1, Lake Powell Hydrology, provides additional information on the inflows and how they influence the hydrology of Lake Powell; the information is incorporated by reference.

Releases from GCD can impact the hydrology of Lake Powell by changing the way water mixes within the reservoir and by altering the water elevation of the reservoir. Increasing the volume released would reduce the water's surface elevation. Altering the location and volume of releases can change how water is mixed within the reservoir. Mixing occurs when water is added (inflows) or removed (dam releases) from the reservoir. Additional mixing can occur due to climatic conditions such as wind. Mixing can change the reservoir's water quality, and is discussed further in Lake Powell Water Quality, below.

Colorado River Hydrology

The hydrology of the Colorado River below GCD is directly related to the dam operations, including the timing and volume of releases. Long-term and annual release volumes are outlined in **Section 1.6**, detailed in the LTEMP Final EIS, and incorporated by reference (DOI 2016a).

Colorado River flows at Lees Ferry, RM 0, have been monitored since May 1921, prior to the dam's construction (DOI 2016a). As such, they provide an outlook on pre-dam conditions and unique post-dam conditions, as this stretch of river is mostly unaffected by the presence of tributary inflows. The average pre-dam annual discharge was approximately 92,000 cfs. Evidence of historical flooding has shown significantly higher peak discharges. However, since the installation of the dam, peak discharges have been reduced significantly. In addition to the reduction of peak flows, there has been a significant decrease in the frequency of very low flows (DOI 2016a).

Water Quality

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 EA, the focus is mainly on the vertical stratification near GCD, which acts as the release point for water into the Colorado River (DOI 2016a).

The reservoir is thermally stratified during the spring, summer, and early fall, with cooler waters lower in the water column and warmer waters toward the surface (DOI 2016a). The penstocks are 15 feet in diameter with a centerline elevation of 3,470 feet, and up until recently, the penstock intakes have aligned with the upper hypolimnion layer of cooler water around 10˚C to 12.2˚C. The bypass outlets are located at an elevation of 3,374 feet and typically fall within the lower hypolimnion layer, which usually consists of cold water from around 6.1˚C to 8.9˚C. Due to the lower lake elevation, the warm epilimnion layer is found closer to the penstocks, which means that water released through the penstocks is warmer than historical values.[15] The ongoing drought has led to continued and increased warming throughout the reservoir, particularly during the spring, summer, and early fall months.

Salinity and conductivity are stratified with temperatures. The lower, cooler waters tend to have higher salinity and conductivity values (Boehrer and Schultze 2008). The difference in salinity and conductivity values between the penstocks and bypass tubes is typically negligible.

Dissolved oxygen[16] can vary within the reservoir due to variations in inflows, water temperatures, mixing, and biological processes. The dissolved oxygen concentrations in Lake Powell do not typically correlate

[15] Internet website: http://gcdamp.com/index.php/TEMPERATURE

[16] Dissolved oxygen is the measure of how much oxygen is dissolved in water and is perhaps the most commonly employed measurement of water quality. Low dissolved oxygen levels adversely affect fish and other aquatic life. The ideal dissolved oxygen for fish life is between 7 and 9 milligrams per liter; most fish cannot survive when the dissolved oxygen level falls below 3 milligrams per liter.

with dissolved oxygen concentrations in the Colorado River. This is because the water released from the dam becomes aerated during discharge and in the rapids below the dam, raising dissolved oxygen concentrations (DOI 2016a).

Other chemical and biological processes within Lake Powell can vary, depending on inflow, precipitation, and other environmental conditions (DOI 2016a).

Colorado River Water Quality

Apart from dissolved oxygen, 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 bypass tubes. Typically, the water discharged from the dam is characterized as cold, clear, below saturation in dissolved oxygen, and low in nutrients. However, due to the recent drought conditions, the discharged water is released from higher in the water column and is warmer with less dissolved oxygen and higher salinity. 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).

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).

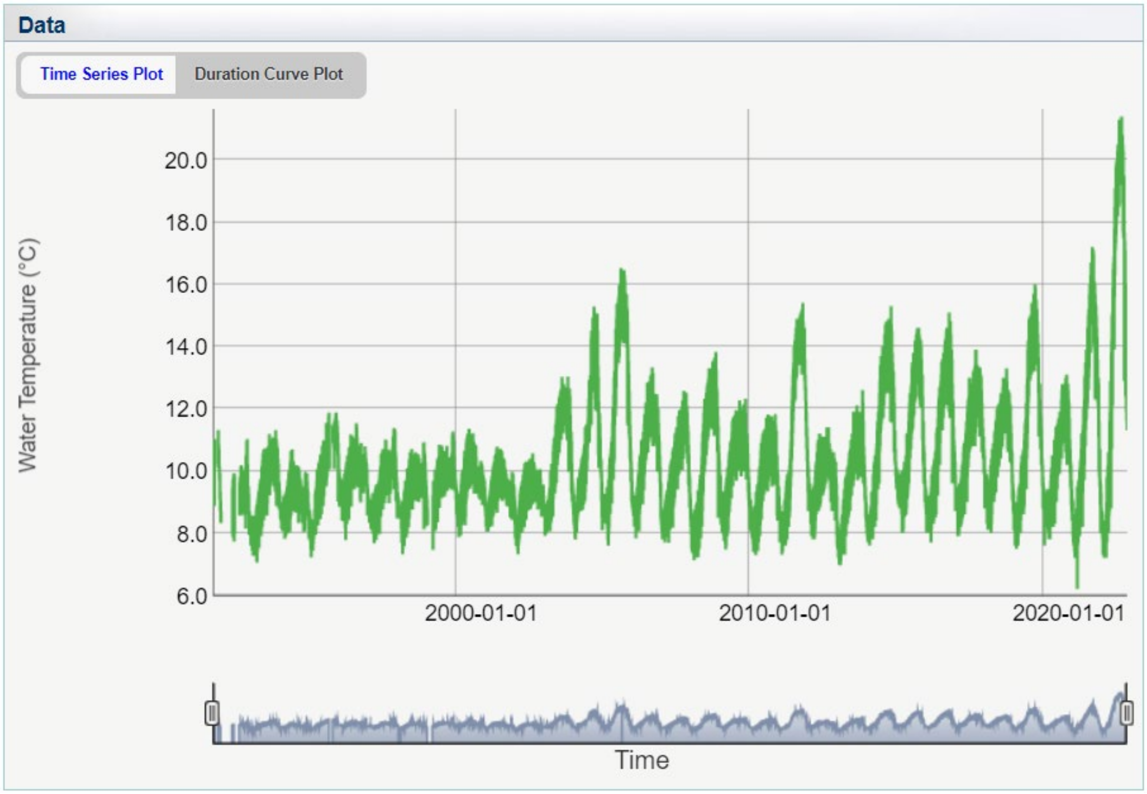
When HFEs have been conducted, a large, temporary change in water quality below GCD has been observed. The excess discharge is typically derived from the bypass tubes, meaning the water is cooler and higher in salinity. The increased discharge from the bypass tubes creates aeration at the outlet and increased dissolved oxygen. 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 3.5** for additional information on sediment resources.

Temperature

Following the completion of GCD, the Colorado River temperatures just below the dam stabilized and ranged from 7.2˚C to 12.2˚C annually. Since the early 2000s, drought conditions and lower water levels in Lake Powell have led to a general warming of water temperatures in the Colorado River below the dam (DOI 2016a). Summer water temperatures in 2022 rose above 21˚C at Lees Ferry (GCMRC 2022). **Figure 3-5** shows the recent warming trend of the Colorado River below GCD.

Temperatures in the Colorado River increase as the water moves downstream of GCD (Dibble et al. 2021). This warming is due to ambient input from solar radiation, air temperature, and input from warm tributaries. The warming is greatest from June through August. The water in the Colorado River generally warms 1˚C for every 30 miles traveled downstream. Some variation in lateral warming also occurs, with warmer temperatures along the shoreline and cooler water in the deep, fast-moving areas (DOI 2016a).

Figure 3-5: Water Temperature at Lees Ferry, 1991–2022



Source: GCMRC 2022
Note: The green line represents water temperatures at Lees Ferry. The annual undulation shows peaks during the summer and troughs during the winter. The annual peak summer temperatures have risen from around 11˚C to above 21˚C over the last 30 years.

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. The construction of GCD has moderated and stabilized salinity levels in the Colorado River below the dam by controlling discharges from Lake Powell. Salinity below the dam typically ranges from 300 milligrams per liter to 600 milligrams per liter for total dissolved solids.[17] 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 (DOI 2016a).

Turbidity

Prior to the GCD construction, the Colorado River was a highly turbid system with a suspended load (suspended sediment)[18] averaging between 1,450 milligrams per liter and 6,140 milligrams per liter at Lees Ferry. Following the dam's construction, the sediment supply decreased sharply, with a suspended load ranging from 1 milligram per liter to 150 milligrams per liter at Lees Ferry. Suspended sediment can

[17] Total dissolved solids is a quantitative measure of the residual mineral dissolved in water that remains after the evaporation of a solution. Usually expressed in milligrams per liter or parts per million. Total amount of dissolved material, organic and inorganic, contained in water.
[18] Suspended sediment is sediment that is supported by the upward components of turbulence in a stream and that stays in suspension for an appreciable length of time.

temporarily increase during HFEs due to scouring near the dam. Turbidity increases downstream of the dam as tributaries with high suspended loads join the Colorado River.

Dissolved Oxygen

Current dissolved oxygen levels in Lake Powell and the Colorado River are lower than historical levels. Dissolved oxygen levels below the dam vary throughout the year, starting as low as 3.5 milligrams per liter in the fall and rising as high as 9–10 milligrams per liter in the spring (GCMRC 2022). This seasonal variation is due to changes in dissolved oxygen at the penstock level of Lake Powell during the year. In recent years, periods of low dissolved oxygen (that is, less than 5 milligrams per liter) have become more common.

The exact cause of these low dissolved oxygen events remains uncertain (Deemer 2020). 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 dissolved oxygen in the downstream reach. Notably, when water is discharged through the bypass tubes, such as during HFEs or the flow options evaluated here, it becomes well-aerated and increases the dissolved oxygen level. This aeration also occurs farther downstream of the dam in stretches of rapids (DOI 2016a).

3.4.2 Environmental Consequences

No Action Alternative

Under the no action alternative, GCD's operations would not be changed. Therefore, water would continue to be discharged primarily through the penstocks, as described in the LTEMP Final EIS. 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 produce a negligible increase in salinity and a decrease in dissolved oxygen. The exact impacts on water quantity and quality would continue to be highly dependent on water availability for releases.

Proposed Action with Options

The amount of water discharged would determine the impact on hydrology. The main components of water quality that would be influenced by the proposed action are water temperature, salinity/conductivity, turbidity, and dissolved oxygen. As such, this analysis focuses on these parameters. All impacts would be temporary, as these flow options would only occur for limited duration. Winter inflows would act as a replenishing period for the reservoir levels and temperature. The proposed action would not influence the inflows, so inflows are not discussed further.

The range of flow volumes of potential discharges under the proposed action would be within the range of existing flows outlined in the LTEMP Final EIS; therefore, hydrological conditions downstream of the dam would remain within the range described in the LTEMP Final EIS (DOI 2016a). Flow Options A and C would continue to operate discharges at typical levels and would only change the release point from the dam, whether from the penstocks or bypass tubes. These options would, therefore, have minimal impacts on the hydrology of the system.

Flow Options B and D would include flow spikes that would create a temporary, large discharge of water through the bypass tubes. The volume of water released during flow spikes would be higher than during typical operations; however, it still would be within the range analyzed in the LTEMP Final EIS with lower magnitudes than previously conducted HFEs. The flow spikes would release additional water below GCD, which could impact sandbars that are critical for recreation. More information on sandbar creation and recreation is included in **Section 3.5**, Sediment Resources, and **Section 3.3**, Recreation, respectively. The flow spike would temporarily pull additional water from Lake Powell, which could result in lower water elevations immediately after the flow spike, with levels restoring at varying rates, depending on inflows. These spike flows would not impact the monthly volume released, and this change in water elevation would be temporary.

The effects on the other water quality parameters from all four flow options would mainly consist of negligible changes to salinity, conductivity, and dissolved oxygen below the dam. All four flow options would result in more cold water released below GCD. The colder water would be slightly higher in salinity and conductivity. Discharges from the bypass tubes would result in marginally elevated levels of salinity and conductivity in the Colorado River below the dam. These elevated levels would not be enough to have any major impacts on the system. During releases from the bypass tubes, the discharged water would become aerated, which would increase dissolved oxygen levels. The resulting elevated dissolved oxygen levels would positively impact the system below the dam. Many fish and aquatic species rely on higher dissolved oxygen levels; more information is available in **Section 3.2**, Aquatic Ecology.

Cumulative Impacts

Impacts on water resources from the proposed action with options would be temporary and would not have major 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 LTEMP Final EIS. There would be no cumulative impacts on water resources beyond those included in the LTEMP Final EIS. The cumulative impacts in the LTEMP Final EIS include, but are not limited to, water elevations of Lake Powell, Colorado River flows downstream of the dam, and changes to the water temperature of the Colorado River below the dam.

3.5 Sediment Resources

3.5.1 Affected Environment

Historically, the Colorado River conveyed high suspended sediment concentrations throughout most seasons with larger flood flows and lower base flows (USGS 2011b). The placement of GCD 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 9,000 cfs occurred frequently enough to allow for seasonal sand accumulation and storage downstream of RM 16. Current dam operations do not allow for sustained discharges lower than 5,000 cfs at night and 8,000 cfs during the day (Topping et al. 2003). 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 2011b).

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 results 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.[19] As described above, the Paria and Little Colorado Rivers are the dominant sources. In general, the lesser tributaries in the upper Marble Canyon upstream of RM 30 together contribute roughly 10 percent of the sand annually supplied by the Paria River. Downstream from RM 30, the 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 sand supply (which is highly variable), the pattern 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 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

[19] A wash that flows part of the time, usually after rainstorm, during wet weather, or for only part of the year.

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[20] 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 channel margins on the Colorado River, is the result of coupled flow, sediment transport, and storage within fan-eddy complexes[21] that result in deposition of sediments. Fan-eddy complexes are areas along the river where a tributary debris fan partially blocks the river flow (Schmidt and Rubin 1995). 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 from 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).

Sediment-enriched conditions are anticipated to exist in Marble Canyon through summer 2023, resulting from high sediment inputs from the Paria River during the fall HFE accounting period in 2022 (Salter and Grams 2022, based on the Wright et al. 2010 model).

Geomorphic Features

The longitudinal profile of the 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 are sloping deposits of poorly sorted sediment ranging in size from clays and silts to larger boulders. 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 throughout the area. 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).

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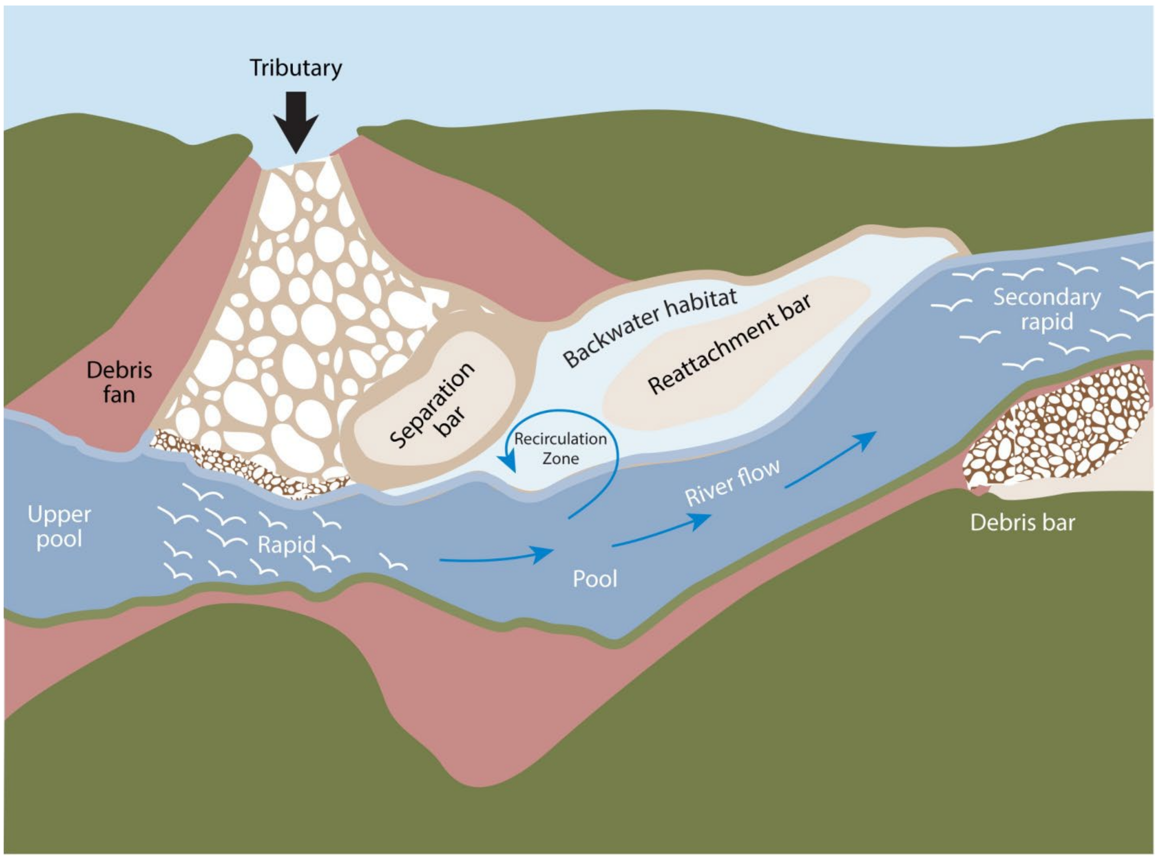
[20] Small grooves, furrows, or channels in soil made by water flowing down over its surface. A small stream.

[21] The controlling geomorphic feature in the Colorado River for sediment deposition; debris fans partially block tributaries that cause the formation of rapids and eddies.

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

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 the downstream-directed current becomes separated from the riverbank (Webb and Griffiths 2001; see **Figure 3-6**). Downstream from 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 the lower velocities enhance the potential for sediment deposition (Schmidt and Rubin 1995).

Figure 3-6: Diagram of the Fan-Eddy Complex on the Colorado River

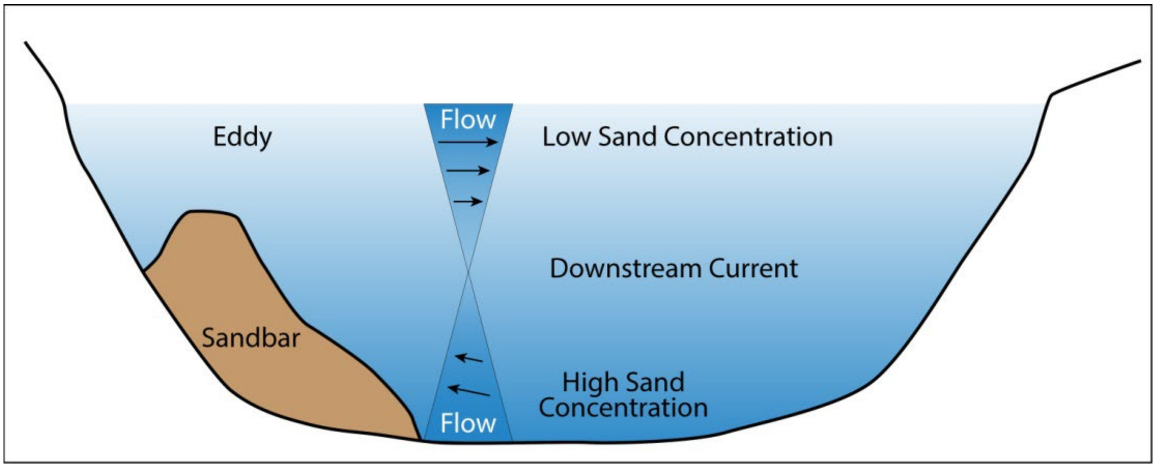


Source: Webb and Griffiths 2001

The deep pools that form upstream from rapids (**Figure 3-6**) 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, controls 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 3-7 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 3-7: 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 2011b). They continuously exchange sand with the river. Thus, the sandbars commonly found along the banks of the Colorado River are generally dynamic and unstable. HFEs 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 the geomorphic conditions and vegetation 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). For example, they form the substrate for limited riparian vegetation in the arid environment. Low-elevation sandbars create zones of low-velocity aquatic habitat (that is, backwaters) that may be utilized by juvenile native fish. 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.

3.5.2 Environmental Consequences

No Action Alternative

Under the no action alternative, operations of GCD would not change. HFEs would occur when triggered, as described in the LTEMP Final EIS. When conducted, the HFEs would continue to contribute to sandbar building and sediment export in the Colorado River downstream of the dam. The exact impacts on sediment resources would continue to be highly dependent on water availability for HFEs, the operational releases, and sediment input from tributaries.

Proposed Action with Options

Flow Options A and C would continue to discharge water, as analyzed in the LTEMP Final EIS. The only change would be where it is released from the dam. Flow Options A and C would have a minor effect on the sand-mass balance and minimal impact on sandbar building.

Flow Options B and D include flow spikes, which would export a significant amount of sand from Marble Canyon (approximately 200,000 metric tons per flow spike; Salter and Grams 2022, based on the Wright et al. 2010 model). If a flow spike from Option B or D occurred during the fall HFE accounting window (July 1–November 30, 2023), it would decrease the amount of available sand to perform an HFE. This means if a flow spike occurs after July 1, there may not be enough sand accumulation during the accounting period to perform a fall HFE.

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 2011b; Topping et al. 2019). Sand deposition for sandbar formation can only occur when there is available sand in the system (Topping et al. 2021). The sandbar model (Mueller et al. 2021) predicts an approximate 14 percent increase in sandbar volume (approximately 200,000 metric tons) for a single flow spike, and a cumulative 30 percent increase in sandbar volume following three flow spikes. The 30 percent increase in sandbar volume following three flow spikes is likely an overestimate. This is because much of this growth would occur below the maximum flow stage of typical operations, and the model is not calibrated to low-magnitude (such as 32,000 cfs) events. In addition, the model is not calibrated for multiple flow spikes in succession, and there is lower confidence in the predicted effects of the second and third flow spikes.

Sediment-enriched conditions are anticipated to exist in Marble Canyon through summer 2023 resulting from high sediment inputs from the Paria River during the fall HFE accounting period in 2022 (Salter and Grams 2022, based on the Wright et al. 2010 model). If sediment-enriched conditions persist into 2024 and beyond, it is possible that the additional flow pulses would result in additional sandbar building. Previous studies have shown that repeated flow cycles (fluctuations of any magnitude) cause sandbar erosion (Alvarez and Schmeeckle 2012). Sandbars erode between HFEs, and 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). It is also possible that subsequent flow pulses would cause more erosion than deposition, because of low modeling certainty at low magnitudes and short durations between flow spikes. Therefore, while multiple flow pulses could achieve the need to disrupt smallmouth bass spawning, a single flow pulse would likely be more beneficial for sediment resources. Additional monitoring during a period that includes multiple flow pulses would be needed to fully evaluate the quantitative impacts on sandbars.

If the maximum magnitude is higher (approximately 40,000 cfs) and the duration is longer (72 hours), there is higher confidence of sediment benefits from a flow spike. If a flow spike occurs in May or June, it would not affect the potential for a fall HFE due to the sand budget accounting window constraints. The sandbar model predicts a greater than 50 percent increase in sandbar volume for a 40,000 cfs and 72-hour flow spike, compared with approximately 14 percent for a single 32,000 cfs flow spike. There is greater confidence in sandbar building with 40,000 cfs compared with 32,000 cfs because releases of 34,000 to 37,000 cfs or greater are required to cause significant deposition at most long-term sandbar monitoring sites (Hazel et al. 2022). Furthermore, due to the higher stage, a greater proportion of this sandbar growth would occur at elevations above the maximum flow stage, under typical operations. This includes daily flows that occur below 7.5 million acre-feet per year, per the Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead Final EIS and ROD (Reclamation 2007b).

Cumulative Impacts

Cumulative impacts on sediment resources would not occur beyond those included in the LTEMP Final EIS.

Flow Options A and C would have minimal cumulative impacts on sediment resources. Flow Options B and D would increase the sandbar volume; however, based on the sand mass balance, this impact would likely not be beneficial to sediment resources for 32,000 cfs releases (at 72 hours), compared with 40,000 cfs releases. This is because the potential for sandbar building at 32,000 cfs is uncertain and likely minor, and the benefit would likely be outweighed by the amount of sediment export caused by the flow spikes. In addition, multiple flow spikes under Flow Options B and D could increase erosion. If sediment-enriched conditions continue after 2023, the flow spikes under Flow Options B and D could increase the sandbar volume, assuming releases of 40,000 cfs or more. If a flow spike occurs during the fall accounting period, it would reduce the amount of sand available to perform a fall HFE. This would cause a reduction in sandbar size, because HFEs are the only mechanism for providing substantial deposition of high-elevation sand bars (Hazel et al. 2022). Overall, a single flow spike released at 40,000 cfs would be the most beneficial for sediment resources.

3.6 HYDROELECTRIC POWER GENERATION

3.6.1 Affected Environment

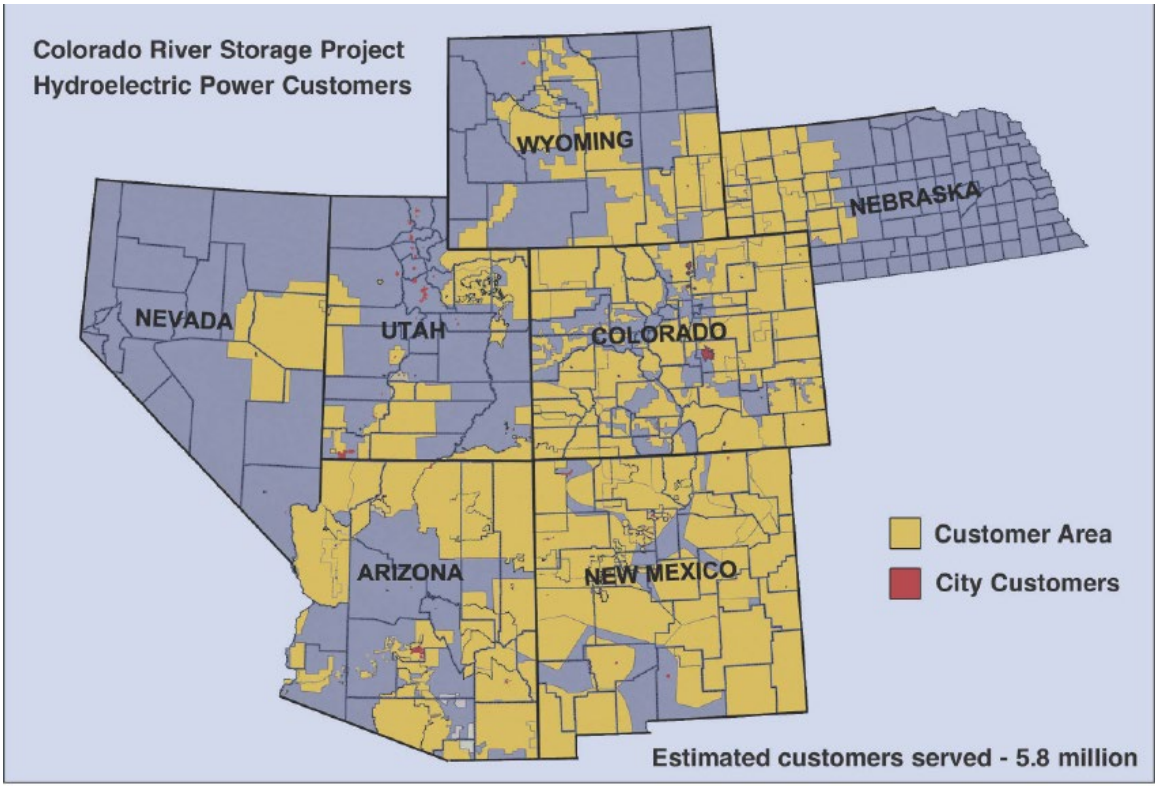
This section describes GCD and the Glen Canyon Powerplant's power operations and power marketing. Additional information on the socioeconomic environment relating to hydropower and additional resources can be found in **Section 3.7**, Socioeconomics and Environmental Justice.

The power plant is connected to the Western Power Grid via a regional transmission system. Power generated at GCD provides electricity for the US Department of Energy's Western Area Power Authority (WAPA) customers. WAPA is responsible for providing electricity to a 15-state region of the western US. GCD is a major contributor to the transmission system and typically provides electricity to Wyoming, Utah, Colorado, New Mexico, Arizona, Nevada, and Nebraska (DOI 2016a, p. 3.221). GCD also provided emergency power supplies to California in 2020 (Stone 2020). **Figure 3-8** shows a map of the CRSP hydroelectric power customers.

Operations at GCD affect the Basin Fund,[23] consumers, and government agencies. Revenues from power generation are deposited into the Basin Fund, which directs revenues toward other programs, as dictated by the CRSP Act of 1956 and the Grand Canyon Protection Act of 1992.

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

Figure 3-8: CRSP Hydroelectric Power Customers Map



Source: Reclamation 2008

Power Operations

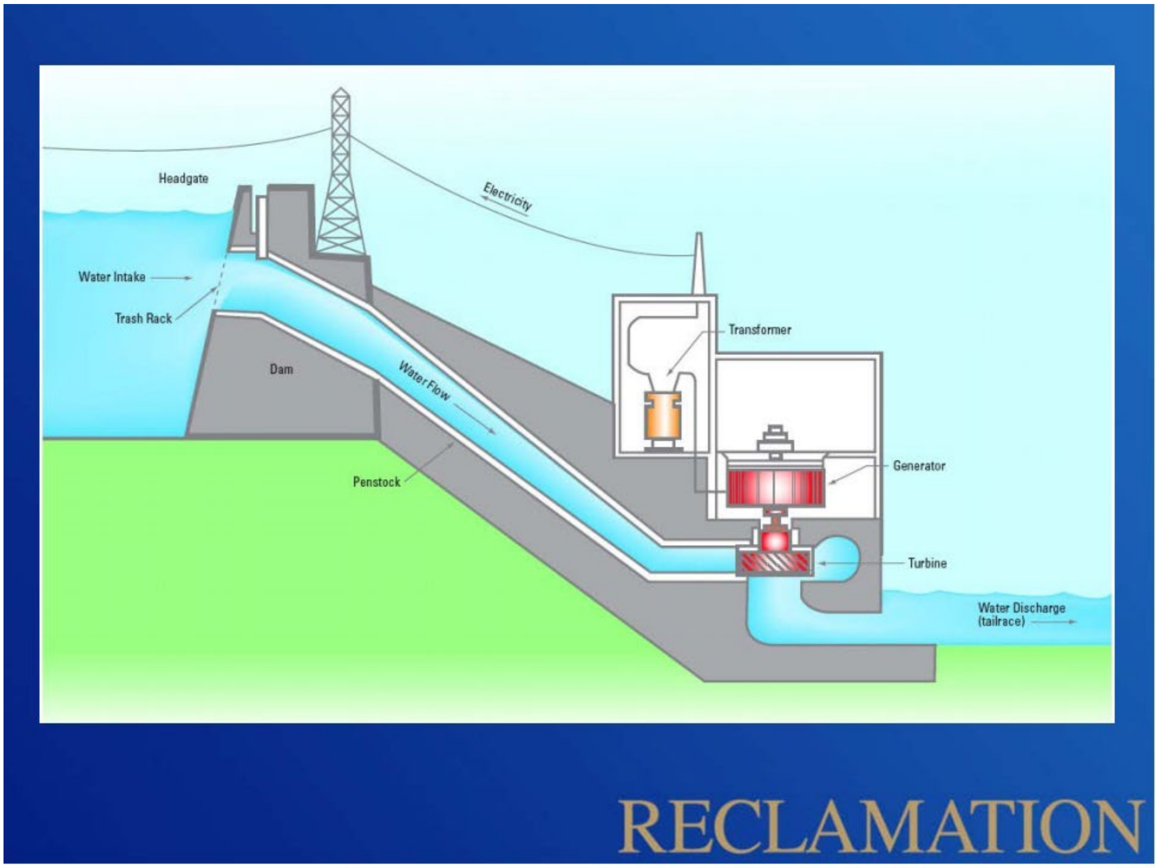
Power operations are the physical operations of an electrical power system, including hydropower generation and control, operational flexibility, scheduling, power generation load following, regulation, reserves, transmission, and emergency operations. These are discussed in the sections below.

GCD 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 GCD result in power generation at the power plant, with electricity moving from the plant, along the transmission system, to the customers. A simplified diagram of the power plant's operations is provided in **Figure 3-9**.

Hydropower Generation

GCD has eight generators, with a maximum combined capacity of 1,320 MW when the reservoir elevation is 3,700 feet (DOI 2016a). The power plant requires a minimum Lake Powell elevation of 3,490 feet to operate. Reclamation reported a net generation of 3,345 gigawatt-hours in fiscal year 2021 and 2,583 gigawatt-hours in fiscal year 2022 (Reclamation 2022c). The LTEMP Final EIS 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 due to contract obligations, water release schedules, power needs, reservoir levels, and other operational requirements. Releases through the bypass tubes do not generate power and, therefore, have no power system economic value (DOI 2016a).

Figure 3-9: Glen Canyon Powerplant Operations Diagram



Source: GCDAMP 2022

Basin Fund

The Basin Fund was established under Section 5 of CRSPA. CRSPA "authorized a separate fund in the Treasury of the United States to be known as the Upper Colorado River Basin Fund [...] for carrying out provisions of this Act other than Section 8." Money appropriated for construction of CRSP facilities, except recreation and fish and wildlife facilities constructed under Section 8, is transferred to the Basin Fund from the General Fund of the Treasury. Revenues derived from operation of the CRSP and participating projects are deposited in the Basin Fund. Most of the revenues come from sales of hydroelectric power and transmission services. The Basin Fund also receives revenues from municipal and industrial water service sales, rents, salinity funds from the Lower Colorado Basin (as a passthrough for the Colorado River Basin Salinity Control Program), and miscellaneous revenues collected in connection with the operation of the CRSP and participating projects. Revenues and appropriated funds are accounted for separately in the Basin Fund (DOI 2016a, p. 3.201).

Scheduling

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

Load/Generation Following and Regulation

Hydropower generation can change instantaneously in response to changes in the load or unanticipated changes in the power generation resources within the operating region. This ability to respond to rapidly changing load conditions is called load- and/or generation-following (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 Friday, but the load drops considerably on Saturday and Sunday. The 1996 ROD (Reclamation 1996) reduced the ability of power generation at GCD to respond to customer load. This type of operation creates large fluctuations in water releases, which has negative impacts on environmental resources (DOI 2016a, p. 3.204).

Changes in WAPA's scheduling guidelines typically occur slowly 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 LTEMP also further reduced the load-following capability despite increasing down-regulation rates, and it followed more natural flows (DOI 2016b), reducing operational flexibility. Operational flexibility has been affected by persistent drought, electricity market disruptions in 2000 and 2001, and extended experimental releases that have large 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/Emergencies and Outage Assistance

WAPA, as the balancing authority[24] for the operating region, 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 power plants. This is particularly important for emergency situations (DOI 2016a).

In the event of a large loss of generation capacity, the North American Electric Reliability Corporation's reserve standards require that available generation capacity be used to return the electric generation to normal operating conditions within 10 minutes following the disturbance. Typically, these reserves are only needed for an hour or less. WAPA's ability to supply emergency assistance is limited by available transmission capacity and available generation capability. The ability to deliver emergency assistance varies on an hourly basis, depending on the firm load obligations and available generation from project resources (DOI 2016a, p. 3.205). WAPA will continue to operate under the emergency exception criteria, as stipulated under the 1996 ROD, which allows GCD to be operated outside of minimum and maximum flow limits, daily change constraints, and both maximum hourly up-and-down ramp rates in the event of a power system emergency (Reclamation 1996).

[24] The control agency responsible for ensuring a balance between energy demand and supply.

Transmission System

GCD is connected to a transmission system that allows for power to serve users such as municipal, residential, tribal, irrigation district, and commercial consumers. GCD's generation can be affected by transmission limitations when 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).

Power Marketing

WAPA markets wholesale CRSP Act power to preference entities (WAPA, n.d.) serving approximately 5.8 million retail customers in the operating region (DOI 2016a, p. 3.206). Sales of electric power in fiscal year 2021 were $87.8 million (WAPA 2020). Additional information on power marketing, including wholesale and retail rates, is included in the LTEMP Final EIS. The information is incorporated by reference (DOI 2016a, pp. 3.206–3.209).

WAPA modified firm power rates for fiscal year 2022[25] in response to continued drought conditions, Lake Powell's reservoir level, associated reductions in power production caused by lower GCD water releases, and increasing market prices for firming power. Under this new rate, WAPA delivers just the power and energy produced from CRSP resources, and deliveries are directly affected by GCD operations and water releases.

3.6.2 Environmental Consequences

No Action Alternative

Under the no action alternative, no changes would be made to GCD operations. Therefore, water would continue to be released primarily through the penstocks, as described by the LTEMP. Power generation would continue, similar to historical levels, with slight variations, depending on water availability and constraints outlined in the LTEMP Final EIS. Revenue from generation would also continue to be generated, similar to historical levels, with slight variations, depending on consumer demands, generation levels, and constraints outlined in the LTEMP Final EIS.

Proposed Action with Options

WAPA is working in conjunction with Reclamation, the National Renewable Energy Laboratory, and Argonne National Laboratory to produce power generation and financial impact models. These models have been used to quantitatively analyze the impacts from each flow option.

Modeling efforts included the PLEXOS model, a high-resolution power systems model that determines the least cost unit commitment schedule and dispatch of generating resources, along with the GTMAX-SL model, which optimizes electrical production based on water availability and operating constraints. Modeling was conducted for the operating window in 2023. Model results produced the replacement power needed for each flow option, along with the financial cost of purchasing the replacement power.

[25] Internet website: https://www.wapa.gov/regions/CRSP/rates/Pages/rate-order-199.aspx

The proposed action options would not be implemented during the winter months, so there would be no effect on power generation during this timeframe. The following analysis focuses on warm-weather months, when the flows could be implemented under the proposed action with options.

Compared with current conditions, all four flow options would include passing more water through the bypass tubes where power is not generated. Power generation effects would vary, depending on the flow option implemented. Each flow would impact hydropower by reducing the power generation and increasing the amount of replacement power WAPA or its customers would be required to purchase. The flow options would impact consumers and the Basin Fund due to the amount of replacement power purchased. The flow options would have minor impacts to the transmission system if the flow of electricity is reversed during the use of replacement power. There would be no impacts on reserve or emergency power supplies.

Flow Option B would result in the most impacts to power generation, with a loss of approximately 600.7 GWh during summer 2023. This loss is because water would be consistently released through the bypass tubes, with large amounts released during the flow spikes. Flow Option A would result in the second-most impacts on power generation, with a loss of approximately 563.7 GWh because water would be consistently released from the bypass tubes but without the flow spikes. Flow Option C would have the least impacts on power generation, with a loss of approximately 322.3 GHw; water would only be released through the bypass tubes during cold-shock events. Flow Option D would have the second-fewest impacts, with a loss of approximately 380.2 GHw. It would mirror Flow Option C but would include flow spikes, which would result in large releases of water through the bypass tubes during those events. **Table 3-2** outlines the total loss of generation from each flow option.

Table 3-2: Potential 5-Month Flow Impacts to Power Generation and Firming Expenses, as Estimated by WAPA

	Total Lost Generation (GWh)	Total Firming Expense ($ millions)
Flow Option A	563.7	78.4 (if implemented for 5 months)
Flow Option B	600.7	81.2 (if implemented for 5 months)
Flow Option C	322.3	41.0 (if implemented for 5 months, however Reclamation only proposes a maximum of 12 weeks)
Flow Option D	380.2	48.6 (if implemented for 5 months, however Reclamation only proposes a maximum of 12 weeks)

Source: WAPA 2023

WAPA's model results for the operating period from June to October 2023. Totals were calculated using the PLEXOS model and GTMAX-SL model. This table presents WAPA's higher-limit estimates of total lost power generation and total costs of replacement power for each flow option.

In addition, the timing of these releases would impact the efficiency of power generation. For Flow Options A and B, water would constantly be released through the bypass tubes, regardless of demand. These options would result in less power generation, even during peak demand hours. Flow Options C and D would mostly impact generation during weekends, when demand is lower.

The proposed action with options would have financial impacts. Less power generated would mean a reduction in the revenue generated from power proceeds that would be transferred into the Basin Fund. Replacement energy sources would need to cover the decrease in power generation. WAPA would purchase replacement power using funds from the Basin Fund. Much of this replacement power would be generated from other sources, which may be wind, solar ,or other less environmentally friendly sources.

The decrease in funds available in the Basin Fund could result in an increased costs to customers, triggering a cost-recovery charge.

Financial impacts would be directly correlated to impacts from power generation. Therefore, Flow Option B would have the most financial impacts, with an estimate firming expense of $81.2 million; Flow Option A would have the second-most financial impacts, with an estimated firming expense of $78.4 million; Flow Option C would have the least financial impacts, with an estimated firming expense of $41.0 million; and Flow Option D would have the second-least financial impacts, with an estimated firming expense of $48.6 million. If there is insufficient funding available in the Basin Fund, WAPA would not be able to secure replacement power, which could result in reduced power deliveries to customers.

These initial estimates assumed certain hydrologic conditions from a broader range of hydrologies, which is important because the relationship between hydrology and the amount of bypass required is nonlinear and depends on the starting elevation for the year. Given the starting elevation in Water Year 2022, hydrology near the 30-year average is predicted to lead to the highest required bypass and highest costs.

An additional analysis for Flow Option A estimated the cost associated with average (median) predicted bypass over the 30 traces (as opposed to the average inflow hydrology). Using this method, an estimated firming expense for Flow Option A was reduced from $78.4 million to $51.5 million and may better represent a more likely cost estimate, given the recent projections. Assuming the costs are roughly proportional to the expenses in **Table 3-2**, then Flow Option B would be increased by 4 percent, Flow Option C would be decreased by 48 percent, and Flow Option D would be decreased by 38 percent when compared to Flow Option A.

The amount of bypass needed will vary based on the elevation of Lake Powell, the inflows that can affect release temperature and the monthly outflow volumes, and whether the flows are conducted during months when alternate power is more expensive. The costs in **Table 3-2** were calculated based on a single trace from the August 24-month projections and are likely an overestimate of the actual cost of implementing any of the flow actions.

If replacement power is required, it could put pressure on parts of the transmission system. Any replacement power must travel along the transmission system in the reverse direction of historical operations. This reversal of power along the transmission system could result in congestion and additional maintenance costs on the transmission system. The extent of impacts would correlate with the amount of replacement power purchased. WAPA's modeling shows the potential transmission congestion would increase 2 percent under Flow Option B compared to existing conditions, and 1 percent under Flow Options A, C, and D.

None of the four options would result in a decrease of reserve and emergency power available. Operations would follow LTEMP requirements for emergency situations. As outlined in the LTEMP Final EIS, emergency reserves are typically only needed for a short period of time, and any operational changes included in the proposed action would be adjusted to meet the emergency exception criteria.

Overall, the effects described above may be most likely for power consumers in the surrounding counties and states. However, effects could be felt across the Western Power Grid because GCD can supply power to this area. The effect's intensity would diminish farther from the dam. This is because while GCD is a major power supplier for the immediate surrounding counties and states, other power suppliers would have increased influence in more distant portions of the Western Power Grid.

Cumulative Impacts

Cumulative impacts on hydropower from the proposed action with options would only occur during months when the flow options were implemented. All proposed flow options would operate within the range of operations, as described in the LTEMP Final EIS and under the assumptions of the existing cumulative effects analysis for hydropower conducted in the LTEMP Final EIS, described in Section 4.17.3.12 of that document (DOI 2016a, p. 4.471).

The proposed action with options would result in impacts on power generation at GCD during the peak summer power months. Changes in operations at GCD would reduce available generating capacity at GCD under all four flow options. This reduction in capacity would need to be replaced by purchases and generation from replacement sources. The financial impacts from the flow options would vary, depending on the amount of power generated and the cost to purchase power from replacement sources. Power consumers would experience these impacts to varying degrees, depending on the location, with more severe impacts in the immediate areas around GCD and less severe impacts farther away from the dam.

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 Flow Option B. Flow Option A would result in the second-most impacts on the system, Flow Option D would have the second-fewest impacts, and Flow Option C would have the fewest impacts.

If less hydropower generation occurs at GCD, replacement power would most likely be provided from natural gas power plants, with a smaller portion supplied by coal-fired power plants. Non-renewable replacement power sources would be associated with increased greenhouse gas emissions as compared to hydropower generation.

3.7 SOCIOECONOMICS AND ENVIRONMENTAL JUSTICE

3.7.1 Affected Environment

This section provides a brief socioeconomic background for two regions of influence: Coconino County, Arizona, where the recreation analysis area (the Colorado River corridor from just below GCD downstream to the confluence of the Little Colorado River at RM 61) is located, and a seven-state region where power from the Glen Canyon Powerplant is marketed (Arizona, Colorado, Nebraska, Nevada, New Mexico, Utah, and Wyoming). The affected environment related to environmental justice issues is Coconino County, Arizona, which corresponds to the area where most impacts on recreation would likely occur from changes in dam operations. A brief description is also included of the numbers and locations of tribal populations that are part of the GCDAMP.

No effects were identified for population growth and housing, public health, traffic, and transportation. These are not considered further in this assessment. It is also acknowledged that if significant impacts occurred to hydropower, this could affect the 15-state region of the western US that the WAPA serves. In addition to the states described above in the seven-state region, this 15-state region includes California, Iowa, Kansas, Minnesota, Montana, North Dakota, South Dakota, and Texas. However, this larger region is not analyzed in this EA.

More detailed socioeconomic baseline conditions are described in **Appendix B**, Socioeconomic Baseline Conditions.

Recreational Expenditures Analysis Area

The analysis area for recreational expenditures consists of Coconino County, Arizona. This includes the GCNRA and GCNP, as well as various surrounding cities. Expenditures were assumed to occur only in the county included in the analysis.

Regional Economic Activity Related to Recreation

Recreational resources of concern in the socioeconomics recreation analysis area include rainbow trout fishing and boating (such as kayaking, rafting, and canoeing) from GCD to Lees Ferry, and boating through the Grand Canyon. Recreation is discussed in **Section 3.3**, Recreation. 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. These expenditures impact the regional economy through direct, indirect, 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 inter-industry 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 2011).

The annual regional economic activity generated from nonresident anglers, boaters, and rafters who visited GCNRA and GCNP in 1995 was estimated at approximately $50.1 million in 2023 dollars (Reclamation 1995). A 2007 study found that recreational use in the region supported approximately 394 jobs in Coconino County (Hjerpe and Kim 2007).

Environmental Justice

Environmental justice refers to those issues resulting from a proposed action that would disproportionately affect minority or low-income populations. 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), the Council on Environmental Quality (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 disproportionately high 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 high and adverse; and 3) if impacts are high and adverse, a determination as to whether these impacts disproportionately affect minority and low-income populations.

The affected environment related to environment justice issues is Coconino County, Arizona, which corresponds to the area where most impacts would likely occur on recreation from changes to dam operations.

The data in **Table 3-3** and **Table 3-4** show the minority and low-income composition of the total population in Coconino County and Arizona based on the 2020 census and 2021 American Community Survey data and Council on Environmental Quality guidelines. Within Coconino County, 45.8 percent of

Table 3-3: 2022 Populations for Environmental Justice Consideration (Minority)

Location	Total Population[1]	White	Black or African American	American Indian and Alaska Native	Asian	Native Hawaiian and Other Pacific Islander	Some Other Race	Two or More Races	Hispanic or Latino of any Race	Total Minority Population[1]	Meets "Meaningfully Greater" Environmental Justice Threshold[2]
Arizona	7,276,316	4,241,669	326,638	294,658	245,285	12,432	693,486	1,462,148	2,351,124	3,034,647	N/A
	—	58.3%	4.5%	4.0%	3.4%	0.2%	9.5%	20.1%	32.3%	41.7%	
Coconino County, Arizona	145,052	78,570	2,009	37,699	2,717	288	10,824	12,945	21,666	66,482	No
	—	54.2%	1.4%	26.0%	1.9%	0.2%	7.5%	8.9%	14.9%	45.8%	

Source: US Census Bureau 2022a

[1] Total minority population is calculated based on the total population minus those identifying as White, of non-Hispanic descent.

[2] Calculated based on comparison with the State of Arizona.

Table 3-4: Populations for Environmental Justice Consideration (Low Income)

Location	Environmental Justice Indicators (Poverty Status) as a Percentage of Total Population		
	Median Household Income (2020 dollars)	Poverty Status (%)	Meets "Meaningfully Greater" Environmental Justice Threshold[1]
Arizona	$61,529	12.8	N/A
Coconino County, Arizona	$59,000	17.2	No

Source: US Census Bureau 2022a
[1] Calculated based on comparison with the State of Arizona

the population is classified as minority, while 17.2 percent is classified as low income. Because the number of minority and low-income individuals does not exceed the state average by more than 10 percentage points, there are no environmental justice communities, based on county-level data in Coconino County.

With respect to identifying tribal areas, federally recognized Native American tribes in the region continue to have ancestral and cultural ties to the lands in the analysis area. For the purposes of this analysis, and in conjunction with ongoing cultural and tribal activities associated with Glen Canyon, the following tribes were contacted:

- Hopi Tribe
- Hualapai Tribe
- Navajo Nation
- Pueblo of Zuni
- Southern Paiute Consortium (Kaibab Band of Paiute Indians and Paiute Indian Tribe of Utah)

Reclamation initiated government-to-government consultation with the above federally recognized tribes on October 25, 2022. See **Section 3.8**, Cultural Resources, and **Section 3.9**, Tribal Resources, for more detailed information on tribes and tribal interests.

Electricity generated by GCD is marketed to a variety of customers, including small and medium-sized towns that operate publicly owned electrical systems; irrigation cooperatives and water conservation districts; rural electrical associations or generation and transmission cooperatives that are wholesalers to these associations; federal facilities such as Air Force bases; universities and other state agencies; and Native American tribes.

The Seven-State Region of Influence

The WAPA markets wholesale CRSP Act power to preference entities serving approximately 5.8 million retail customers in Arizona, Colorado, Nebraska, Nevada, New Mexico, Utah, and Wyoming. Sales of electric power in fiscal year 2021 were approximately $87.8 million (WAPA 2020). Additional information on power marketing, including wholesale and retail rates, is included in the LTEMP Final EIS and incorporated by reference (DOI 2016a). The current socioeconomic conditions within the seven-state region (the area where electricity from GCD is marketed) are described in **Appendix B**, Socioeconomic Baseline Conditions.

3.7.2 Environmental Consequences

No Action Alternative

Under the no action alternative, operations of the GCD would not change. Therefore, water would continue to be discharged primarily through the penstocks, as described in the LTEMP ROD. Similar to historical levels, power generation would continue, with slight variations, depending on water availability and constraints outlined in the LTEMP Final EIS. Similar to historical levels, revenue from generation would also continue, with slight variations, depending on consumer demands, generation levels, and constraints outlined in the LTEMP Final EIS.

Impacts on Regional Economic Activity Related to Recreation

The no action alternative would not likely change regional recreation-related economic activity. There would be no change in direct and indirect employment and income in Coconino County.

Impacts on Environmental Justice Populations

Because there are no environmental justice populations identified in the affected environment, under the no action alternative there would be no disproportionately high and adverse impacts to minority or low-income populations.

Impacts on the Seven-State Region

In the seven-state region, under the no action alternative there would be no change in direct or indirect employment or income resulting from dam operations. There would be no change to WAPA customer utility electricity rates.

Proposed Action with Options

There would be no impact from the proposed action with options on operations and power generation during the winter months. Therefore, operations and power generation during this time are not discussed further. The following analysis focuses on the spring and summer months (approximately May to October), when operations would potentially be altered under the proposed action with options to disrupt smallmouth bass spawning below the GCD.

Impacts on Regional Economic Activity Related to Recreation

All flow options would result in temporary disruptions to fishing in the Glen Canyon reach. There would be no change in fishing visitation under Flow Options A and C, as compared to the no action alternative. Flow Options B and D include flow spikes that overlap with one of the peak fishing months (May) and would disrupt fishing during the 36-hour period of release. This could result in negative impacts on the recreational economy from lost fishing days, but not beyond what was analyzed in the LTEMP Final EIS.

Compared with the no action alternative, all four flow options would reduce the water temperatures of the Colorado River below the dam during and after releases. This would benefit the rainbow trout fishery because water temperatures would be reduced to a range more suitable for the cold-water species. This, in turn, would improve the recreational angling experience in the Glen Canyon reach.

Flow Options A and C would be unlikely to impact boating. Flow Options B and D would temporarily disrupt boating within the Glen Canyon reach during the flow spike, which could result in lost revenue to Coconino County. See **Section 3.3**, Recreation, for more detailed information on visitor use in the Glen Canyon reach.

All flow options under the proposed action would not be anticipated to affect the regional economy resulting from boating in the Grand Canyon.

Impacts on Environmental Justice Populations

Impacts on environmental justice populations would be the same as those described under the no action alternative. See **Section 3.9**, Tribal Resources, for the impacts on tribes and tribal interests.

Impacts in the Seven-State Region

Compared with current conditions, all four proposed flow options would result in additional water passing through the bypass tubes where power cannot be generated. This would affect the power-generation system to a varying degree, depending on the flow option implemented. This would result in reduced energy generation at GCD and an increase in consumer costs to purchase replacement energy. See **Section 3.6**, Hydroelectric Power Generation, for more detailed impacts on hydropower.

Forecasted increases in population in the seven-state region would result in similar forecasted increases in the demand for electricity. All four proposed flow options would reduce the generating capacity at GCD, which would mean that alternative generating capacity would be required by WAPA customer utilities to replace lost hydropower capacity. This would result in economic impacts related to the operation of additional capacity of WAPA's largest customer utilities.

Costs associated with reductions in electricity generation no longer provided by GCD would mean changes in retail rates charged by WAPA customer utilities, and, consequently, changes in the electric bills of residential customers. Although there is considerable variation in the amount of power sold by WAPA to customer utilities, only a small portion of power sales for all eight of the largest customer utilities comes from WAPA. This means that the cost of additional capacity required under the proposed action with options to replace capacity lost at GCD would have only negligible impacts on electric bills paid by residential customers of the eight largest WAPA customer utilities (DOI 2016a).

Changes in retail electricity rates and the corresponding impacts on residential customer bills would depend on the timing and magnitude of capacity expansion; however, these changes would likely be small (DOI 2016a). Impacts on economic activity from changes to residential electricity bills could result in small losses of jobs and income in the seven-state region.

Cumulative Impacts

Cumulative impacts on socioeconomics from the proposed action would mainly occur during months when the flow options would be implemented. These would only occur during the years when the flows were conducted. However, population growth is expected to continue within the seven-state region, which will likely increase the demand for recreation along the river corridor and electricity demand from GCD. All proposed flow options would operate within the spatial and temporal bounds and under the assumptions of the existing cumulative effects analysis for socioeconomics and environmental justice conducted in the LTEMP Final EIS.

The impacts of the proposed action with options on socioeconomics would be relatively small and variable. Changes to operations at GCD during the flows would reduce energy generated and available capacity at GCD under all four flow options and would result in reduced boating and angling access during flow spikes. These impacts would be temporary and could occur up to three times per year for up to 36 hours per occurrence. Energy generation that would be foregone at GCD would need to be replaced with presumably more expensive generation sources. Additionally, the lost generation capacity would need to be replaced by other sources. The financial impacts from the flows would vary, depending on the energy generation and purchases from replacement power sources. These impacts would be experienced by power consumers to varying degrees, depending on the reliance on energy and capacity from GCD.

3.8 Cultural Resources

The following discussion relies on and is condensed from Section 3.8, Cultural Resources, and Section 4.8, Cultural Resources in the LTEMP Final EIS (DOI 2016a).

As defined in the LTEMP Final EIS, 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, p. 3.144)

Of the many laws, regulations, executive orders, and policies concerning cultural resources, the most pertinent to this project is the 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 historical properties. Historical 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 NRHP. As such, they are a subset of cultural resources.

The regulations establish a process for consultation with the SHPO and/or Tribal Historic Preservation Officer, interested tribes, the Advisory Council on Historic Preservation, and other interested parties regarding an undertaking's effect on historical properties. If a project has the potential to affect historical properties, the federal agency must, in consultation with the SHPO or Tribal Historic Preservation Officer and other interested parties, establish the area of potential effects (APE); identify historical properties within the undertaking's APE; assess what, if any, effects the undertaking may have on historical properties in the APE; and attempt to resolve adverse effects through avoidance, minimization, or mitigation of the adverse effects.

The LTEMP PA was executed in September 2017 (Reclamation 2017). Reclamation is preparing a draft proposed amendment to the LTEMP PA that includes the proposed action discussed in this EA. In addition, Reclamation is developing a memorandum of agreement under the LTEMP PA regarding nonnative fish control and flow actions under GCD's operations.

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 GCD to the western boundary of Grand Canyon National Park, including direct or indirect effects that may be caused to historic properties by the Undertaking from rim-to-rim of the Canyons." The geographic scope/analysis area for the 2016 LTEMP Final EIS consisted of a larger area than the APE; it encompassed Lake Powell, GCD, and the Colorado River to Lake Mead (DOI 2016a, p. 3.147).

The analysis area for direct and indirect impacts for this EA includes the Colorado River below GCD to its confluence with the Little Colorado River, as described in the LTEMP Final EIS.

Resources important to tribes, such as traditional cultural places (TCPs) and ecological resources, will be discussed in greater detail in **Section 3.9**, Tribal Resources.

3.8.1 Affected Environment

The history and importance of Glen and Marble Canyons to humans spans thousands of years and continues into the present day. The following is a brief summary of human history and the associated cultural resources from a Western viewpoint, as condensed from the LTEMP Final EIS Section 3.8.2, Description of Cultural Resources and Site Types (DOI 2016a, pp. 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.

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 continues today. Archaeological sites can be attributed from 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 10,000–6,000 BC. 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).

The Archaic period (6,000–500 BC) 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 GCNRA, there is also a distinctive petroglyph style called the Glen Canyon Linear Style.

The beginning of the Formative period (500 BC–AD 700) 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.

In the later Formative period (AD 700–1300), 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 are Puebloan; modern Puebloans are 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 canyon during the Late Prehistoric period (AD 1250–1540). 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 (AD 1540–1776), 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 Pai and Southern Paiute were the main groups in the area.

Historic Resources

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. Other Spanish and then American expeditions visited the Colorado River area in the 18th and 19th centuries. As more European and American settlers moved into the Colorado River corridor, Indigenous groups moved into smaller territories and more remote areas. The Havasupai, Hualapai, and Southern Paiute stayed to the west of Glen Canyon in and around the Grand Canyon; the Navajo lived along the east rim of the canyons. Eventually, all the tribes were forced or coerced onto reservations and out of their much larger traditional territories. Native American archaeological sites from this period contain a mix of Indigenous and non-Native artifacts.

European or 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, p. 3.156). All 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. Tribal perspectives on cultural landscapes are summarized in **Section 3.9**, Tribal Resources.

Lees Ferry is a cultural landscape representing 130 years of 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 historical buildings and the district, a cemetery, an orchard and other trees, fields, trails, and dugways. Today, river runners' access, camping, and USGS gauging stations demonstrate the continued use of the Lees Ferry landscape (DOI 2016a, p. 3.155).

Traditional Cultural Place 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, p. 10).

Native American 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 3.9**, Tribal Resources.

3.8.2 Environmental Consequences

Changes in flow could have direct, indirect, and cumulative impacts on cultural resources. Specifically, impacts could occur on historical 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 LTEMP Final EIS consisted of direct impacts from changes to terraces from flow effects and on the stability of the Spencer Steamboat, indirect effects from visitors' time off the river, and cumulative effects.

GCD flow effects can be seen most prominently in the reach below the dam. This is 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, p. 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 3.3**, Recreation).

No Action Alternative

Under the no action alternative, Reclamation would not change GCD's current operations. No new impacts on terraces in Glen Canyon, where archaeological sites are located, would occur beyond those expected from current dam operations. 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 historical properties. Impacts on the Spencer Steamboat would be the same as those analyzed in the LTEMP Final EIS for the dam's current operations (DOI 2016a, p. 4.248).

Proposed Action with Options

Impacts from the proposed action with flow options would be the same, as described for the no action alternative. The proposed action consists of four possible flow options (A through D); all of these are within the range of permitted flows under the LTEMP Final EIS. Therefore, Reclamation would not anticipate additional impacts on historical properties beyond those analyzed for the LTEMP Final EIS. It is probable that the flow spikes (Options B & D) could contribute to sand bar building, which may positively impact archaeological sites within those elevations by replacing sediment lost to erosion.

Cumulative Impacts

The proposed action would not contribute to cumulative impacts on historical properties. No additional impacts, other than those analyzed in the LTEMP Final EIS, would be anticipated under the proposed action. Cumulative impacts under the LTEMP Final EIS, which include erosion of terraces and effects from visitor traffic, are considered negligible (DOI 2016a, Table 4-17.2).

3.9 TRIBAL RESOURCES

The following discussion relies on Section 3.9, Tribal Resources, and Section 4.9, Tribal Resources in the LTEMP Final EIS (DOI 2016a). For the current project, Reclamation is consulting with the tribal signatories to the PA, which include the Hopi Tribe, Hualapai Tribe, Navajo Nation, Pueblo of Zuni, and the Southern Paiute Consortium. Although the focus of this EA is on the Colorado River below GCD to the confluence of the Little Colorado River, because Glen and Marble Canyons are connected to the Grand Canyon and cannot be separated in some cases for tribes, the Grand Canyon is included, as applicable (together, the three canyons are referred to as the Canyons in this section).

3.9.1 Affected Environment

From time immemorial, the Canyons, including Glen and Marble Canyons, and the Colorado and Little Colorado Rivers have been sacred places for Native communities. The Colorado River features prominently in the cosmology and culture of Indigenous peoples of the Southwest (DOI 2016a, pp. 3.156–3.157). The 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)), which is often abbreviated as 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 (Coulam 2011; Dongoske 2011; Hopi CPO 2001; 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 2016, pp. 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, pp. 3.159–3.162).

For the Navajo Nation (Diné), the Colorado and Little Colorado Rivers are deities, and their confluence is associated with Changing Woman (DOI 2016a, pp. 3.162–3.164). Glen and Marble Canyons are home to many other deities who gave ceremonial and resource knowledge to the Diné. Traditional narratives of the Southern Paiute Consortium, which include 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, pp. 3.167–3.168). The Colorado River corridor, and its resources, is one of their most powerful natural resources.

The Colorado River is also sacred to the Zuni people (DOI 2016a, pp. 3.164–3.167). After their emergence to 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.

No effects were identified on Indian Trust Assets, therefore, these are not considered further in this assessment.

3.9.2 Environmental Consequences

During consultation for the LTEMP Final EIS, seven themes were identified of concern to tribes and analyzed in the Final EIS (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

Because the proposed action is within GCD's range of operations, as described in the LTEMP Final EIS, no new impacts, beyond those analyzed under these themes, are expected.

The most pertinent theme for this EA—preserve and enhance respect for life in the Canyons—is derived from Section 4.9.3 of the LTEMP Final EIS:

> "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, p. 4.256).

No Action Alternative

Under the no action alternative, Reclamation would not change GCD's current operations. Tribal concerns would not be different from those described in the LTEMP Final EIS.

Proposed Action with Options

Flow Options A and B are meant to stop spawning before it occurs, which means there would be no taking of life, but in backwater or margin habitats some mortality could occur under Option B if fish are moved off of nests. Since Flow Options C and D include a cold shock, this could result in mortality of eggs or larval fish.

The tribes hold the Canyons sacred. Rather than interventions, they prefer nature to take its course regarding fish management (DOI 2016a, p. 4.257). In particular, the Pueblo of Zuni has expressed that the taking of life is an adverse impact on the TCP and is culturally offensive. Such actions have corresponding highly negative effects within the Pueblo of Zuni and, thus, have far-reaching consequences beyond the Colorado River itself.

Flow Options C and D of the proposed action could result in fish mortality; Flow Option B would only result in fish mortality if fish in backwater or margin habitats were moved off of nests; and Flow Option A would deter spawning, meaning that no smallmouth bass mortality would occur as related to the flow. Any adverse effects on the contributing elements of TCPs would be mitigated through the Nonnative Fish Management Memorandum of Agreement that Reclamation is preparing.

Cumulative Impacts

If Flow Options C or D were implemented, there would be an adverse impact on tribal values because it would result in fish mortality. Flow Option B would only result in fish mortality if fish were spawning in margin habitats and pushed off of nests. Flow Option A is meant to deter spawning, which means no fish mortality would be expected. Cumulative impacts to tribal values would occur if flow options with expected mortality are chosen. 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 will have negative cumulative impacts on Zuni. Because the proposed action options could result in the taking of life within the Canyons, it would have an adverse impact on Zuni culture and TCPs, if Reclamation implements Flow Options B–D. The memorandum of agreement under development regarding nonnative fish management and flow actions will put forth procedures for consultation to resolve any adverse effects on the TCPs; however, because Flow Options B–D would result in additional taking of life within the Canyons in excess of the present conditions under the LTEMP dam operations, they could contribute to negative cumulative impacts on Zuni culture and TCPs.

3.10 RIPARIAN VEGETATION

3.10.1 Affected Environment

Healthy riparian landscapes are biodiverse communities that provide valuable habitat and foraging opportunities for both aquatic and terrestrial species, particularly in arid regions (DOI 2016a). In western North American rivers, such as the Colorado River, the establishment of riparian vegetation is primarily affected by interactions between river-flow patterns and sediment transport and deposition. This includes the timing, magnitude, and duration of elevated and low flows and the characteristics of the sediment, such as particle size, water-holding capacity, aeration, and nutrient levels (Merritt et al. 2010). Many plant species in southwestern riparian communities rely on periodic flooding events to restructure the riparian area, transport seeds for germination, support seedling germination, and redistribute sediment and nutrients. Elevated flows create an opportunity to scour, or remove, riparian vegetation, reducing the density of plant species and allowing new individuals to establish.

Since the operation of GCD 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).

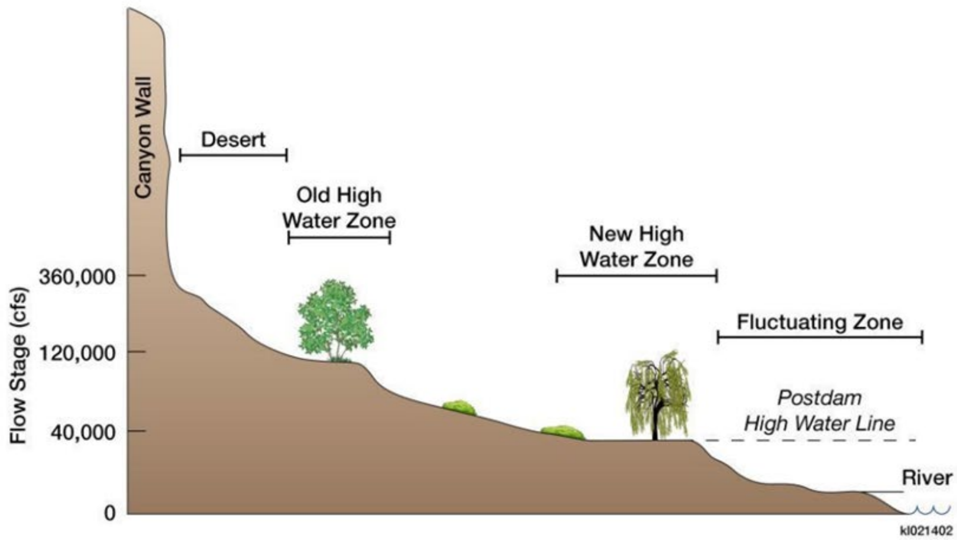
For the purpose of this EA, the definition of the riparian zone is consistent with the definition provided in the LTEMP Final EIS (DOI 2016a). Riparian vegetation includes all plant species found within the fluctuating zone,[26] new high-water zone[27] (NHWZ), and old high-water zone[28] (OHWZ) of the main stem Colorado River downstream from GCD, as first described by Carothers and Brown (1991) and shown in **Figure 3-10**.

[26] Fluctuating zone (varial zone): The lowest riparian zone adjacent to the river, which is inundated and exposed on a daily basis

[27] New high-water zone (line): The riparian zone that is impacted by dam operations but lies above daily fluctuation levels

[28] Old high-water zone: The riparian zone outside the dam operations above pre-dam scour levels

Figure 3-10: Riparian Vegetation Zones along the Colorado River below Glen Canyon Dam



Source: adapted from Carothers and Brown 1991; Reclamation 1996; DOI 2016a

Historical and Remnant Riparian Communities

Prior to GCD'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).

These 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; DOI 2016a). 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 operation of GCD 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 a 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 (DOI 2016a; 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 (DOI 2016a; Durning et al. 2021; Palmquist et al. 2018). Prior to the dam's construction, fluvial[29] 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, 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 (DOI 2016a; 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).

Special Status Plant Species

Several special status species occurring within the Colorado River corridor are outside the zone of the dam's operational effects (DOI 2016a); therefore, they were dismissed from further consideration.[30]

3.10.2 Environmental Consequences

No Action Alternative

Under the no action alternative, no changes would be made to GCD's operations. The flow regime and sediment transport conditions would remain consistent with the management actions described in the LTEMP Final EIS (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 would likely transition to desert ecosystems.

Proposed Action with Flow Options

Under Flow Option A, flow patterns would be similar to current patterns; therefore, Flow Option A is expected to have similar impacts as current flows on riparian vegetation.

Flow Options B and D include flow spikes that would consist of brief periods of elevated flows between May and July. These flow spikes correspond with the timing of pre-dam seasonal flooding conditions and

[29] Fluvial: Of, or relating to, a river or stream

[30] Zoom call between Emily Palmquist, USGS, and Stephen Zipper and Katelyn Cary, SWCA Environmental Consultants, on December 1, 2022.

could provide benefits to riparian species that germinate in the late spring and early summer by aiding in seed dispersal and germination (Mahoney and Rood 1998; Rood et al. 2005).

The flow spikes could also provide critical water resources to facultative[31] and obligate riparian species at higher elevations during the hottest months (Butterfield et al. 2022). Because these flow spikes would be up to similar magnitude (up to 45,000 cfs) as HFEs previously conducted in the program, these flow spikes are not expected to noticeably remove vegetation. For riparian species that seed during and shortly after the spike flow, there is the possibility of enhanced germination. However, the rapid down-regulation, daily fluctuating flows (load-following flows), and additional spike flows would likely desiccate and erode many seedlings (Bejarano et al. 2020; Mahoney and Rood 1998; Porter and Kearsley 2001), preventing their establishment and maturation. Therefore, Flow Options B and D would more likely result in higher rates of germination success and establishment when compared with the other options; however, widespread, dense establishment and maturation of seedlings would be unlikely.

Flow Options B, C, and D would have periods of steady flows that are consistent or higher than the minimum daily flow (8,000 cfs) under LTEMP. Higher discharge rates during these consistent flow periods could provide additional benefits to obligate wetland species that favor wet environments (Gorla et al. 2015). Daily load-following flows can have negative impacts on willows and other riparian plant species in the form of erosion and desiccation (Bejarano et al. 2017; Gorla et al. 2015). Periodic releases from daily fluctuating flows could then stimulate plant growth. The lack of periodic disturbance events, however, would not simulate spring flood events and is not expected to stimulate riparian plant seed germination differently from current flow patterns.

Cumulative Impacts

Under all four flow options, the range of potential discharge volumes would remain within the existing range of flows outlined in the LTEMP Final EIS. Therefore, the proposed flow regimes would likely have few long-term impacts on riparian vegetation communities. Some plant species could experience temporary, positive impacts from high-flow disturbance events and access to higher water tables during summer months. However, steady flow conditions are necessary for germination success rates; therefore, higher germination rates would be possible but unlikely to result in widespread establishment under Flow Options B and D due to the frequency between disturbances.

3.11 Anticipated Effects on LTEMP Resource Goals

The following table includes a summary of anticipated effects on resource goals below GCD, as described in the LTEMP ROD (DOI 2016b, Attachment A).

[31] Facultative (botany): Plants equally likely to be found in wetlands and uplands

Table 3-5: Summary of Anticipated Effects on LTEMP Resource Goals

LTEMP Resource Goal	No Action Alternative	Proposed Action, Flow Option A	Proposed Action, Flow Option B	Proposed Action, Flow Option C	Proposed Action, Flow Option D
Archaeological and Cultural Resources	No change	Negative—would potentially impact the integrity of cultural resources by eroding terraces and exposing resources similar to current flows	Positive—flow spikes would contribute sand input to protect cultural resources in Glen Canyon	Negative—would potentially impact the integrity of cultural resources by eroding terraces and exposing resources similar to current flows	Positive—flow spikes would contribute sand input to protect cultural resources in Glen Canyon
Natural Processes	No change	Positive—colder water temperatures in the Colorado River during the flow operation could temporarily move ecological processes toward pre-drought conditions	Positive—colder water temperatures in the Colorado River during the flow operation could temporarily move ecological processes toward pre-drought conditions; flow spikes could mimic pre-dam flood events	Positive—colder water temperatures in the Colorado River during the flow operation could temporarily move ecological processes toward pre-drought conditions	Positive—colder water temperatures in the Colorado River during the flow operation could temporarily move ecological processes toward pre-drought conditions; flow spikes could mimic pre-dam flood events
Humpback Chub	Negative—Could lead to smallmouth bass establishment below GCD, which would likely prey on humpback chub and negatively affect humpback chub recovery goals	Positive—Would indirectly help meet humpback chub recovery goals by preventing smallmouth bass establishment below GCD	Positive—Would indirectly help meet humpback chub recovery goals by preventing smallmouth bass establishment below GCD	Positive—Would indirectly help meet humpback chub recovery goals by preventing smallmouth bass establishment below GCD	Positive—Would indirectly help meet humpback chub recovery goals by preventing smallmouth bass establishment below GCD
Hydropower and Energy	No change	Negative—Would reduce hydropower generation and load following capacity, and would likely increase the need for replacement power purchases	Negative—Would reduce hydropower generation and load following capacity, and would likely increase the need for replacement power purchases	Negative—Would reduce hydropower generation and load following capacity, and would likely increase the need for replacement power purchases	Negative—Would reduce hydropower generation and load following capacity, and would likely increase the need for replacement power purchases

LTEMP Resource Goal	No Action Alternative	Proposed Action, Flow Option A	Proposed Action, Flow Option B	Proposed Action, Flow Option C	Proposed Action, Flow Option D
Other Native Fish	Negative—Could lead to smallmouth bass establishment below GCD, which may reduce native fish populations due to smallmouth bass predation and competition	Positive—Could prevent smallmouth bass establishment below GCD indirectly and protecting native fish populations due to smallmouth bass predation and competition	Positive—Could prevent smallmouth bass establishment below GCD indirectly and protecting native fish populations due to smallmouth bass predation and competition	Positive—Could prevent smallmouth bass establishment below GCD indirectly and protecting native fish populations due to smallmouth bass predation and competition	Positive—Could prevent smallmouth bass establishment below GCD indirectly and protecting native fish populations due to smallmouth bass predation and competition
Recreational Experience	Negative—Could lead to smallmouth bass establishment below GCD, which may result in smallmouth predation on rainbow trout, thus degrading the quality of recreational angling; no change to boater or camper recreational experiences	Positive—Colder water below GCD during and after releases would benefit rainbow trout populations; no change to boater or camper recreational experiences	Negative—Colder water below GCD during and after releases would benefit rainbow trout populations, but flow spikes may preclude angling access temporarily; flow spikes may also preclude some boat types and prevent access to certain campsites, and may cause erosion at some campsites	Positive—Colder water below GCD during and after releases would benefit rainbow trout populations; no change to boater or camper recreational experiences	Negative—Colder water below GCD during and after releases would benefit rainbow trout populations, but flow spikes may preclude angling access temporarily; flow spikes may also preclude some boat types and prevent access to certain campsites, and may cause erosion at some campsites
Sediment	No change	No change	Negative and Positive—Flow spikes would export sediment from Marble Canyon, which could reduce the amount available for HFEs, but would contribute to beach building in Glen Canyon	No change	Negative and Positive—Flow spikes would export sediment from Marble Canyon, which could reduce the amount available for HFEs, but would contribute to beach building in Glen Canyon
Tribal Resources	No change	No change—could deter smallmouth bass spawning but would not result in mortality	Negative—Could result in smallmouth bass mortality	Negative—Could result in smallmouth bass mortality	Negative—Could result in smallmouth bass mortality

LTEMP Resource Goal	No Action Alternative	Proposed Action, Flow Option A	Proposed Action, Flow Option B	Proposed Action, Flow Option C	Proposed Action, Flow Option D
Rainbow Trout Fishery	Negative—Could lead to warmwater temperatures and smallmouth bass establishment below GCD, which may reduce the quality of the recreational rainbow trout fishery	Positive—Could prevent smallmouth bass establishment below GCD and reduce water temperatures, which are positive for rainbow trout, increasing the quality of the recreational rainbow trout fishery	Positive—Could prevent smallmouth bass establishment below GCD and reduce water temperatures, which are positive for rainbow trout, increasing the quality of the recreational rainbow trout fishery	Positive and Negative—Could prevent smallmouth bass establishment below GCD, increasing the quality of the recreational rainbow trout fishery; cold shocks could temporarily reduce catchability for anglers	Positive and Negative—Could prevent smallmouth bass establishment below GCD, increasing the quality of the recreational rainbow trout fishery; cold shocks could temporarily reduce catchability for anglers
Nonnative Invasive Species	Negative—Could lead to warmwater temperatures below GCD, which would increase the potential for smallmouth bass and other aquatic invasive nonnative species establishment	Positive—Could reduce water temperatures below GCD, decreasing the potential for smallmouth bass and other aquatic invasive nonnative species establishment	Positive—Could reduce water temperatures below GCD, decreasing the potential for smallmouth bass and other aquatic invasive nonnative species establishment	Positive—Could reduce water temperatures below GCD, decreasing the potential for smallmouth bass and other aquatic invasive nonnative species establishment	Positive—Could reduce water temperatures below GCD, decreasing the potential for smallmouth bass and other aquatic invasive nonnative species establishment
Riparian Vegetation	No change	No change	Positive—Flow spikes could provide a higher water table for plants during summer months and better conditions for germination, but spike flows may desiccate or erode seedlings	Positive—Periods of elevated steady flows may benefit riparian species that grow in wet environments	Positive—Flow spikes could provide a higher water table for plants during summer months and better conditions for germination, but spike flows may desiccate or erode seedlings

Source: DOI 2016b

Chapter 4. Preparers and Contributors

4.1 Preparers and Contributors

The table below lists those who prepared and contributed to this EA.

Table 4-1: Preparers and Contributors

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Chapter 6. Glossary

Acre-foot—A unit of volume equal to the volume of a sheet of water 1 acre in area and 1 acre in depth; 43,560 cubic feet.

American Indian—The Indigenous peoples in North America within the boundaries of the present-day continental United States, Alaska, and the island State of Hawaii.

Backwaters—A part of a river not reached by the current, typically defined by stagnant or minimal flows.

Balancing authority—The control agency responsible for ensuring a balance between energy demand and supply.

Benthic—Bottom of rivers, lakes, or oceans; organisms that live on the bottom of water bodies. Bottom- or depth-inhabiting.

Blue Ribbon fishery—Designation given to trout fisheries that are extremely high quality for anglers and wildlife enthusiast.

Bypass tubes—Dam structures that conduct water from the reservoir to the river without passing through a power plant. These are also referred to as jet tubes, river outlets, or outlet works.

Capacity—In power terminology, the load for which a generator, transmission line, or system is rated; expressed in kilowatts. In this document, capacity also refers to power plant generation capability under specific operating conditions and the number of marketable resources under such conditions.

Conductivity—A measure of water's ability to pass an electrical current.

Confluence—The junction of two rivers.

Debris fan—Accumulations of deposits formed by debris flows that emanate from steep tributary canyons.

Debris flow—A large deposit of sediment into a tributary caused by slope failures on tributary canyons.

Dissolved oxygen—The measure of how much oxygen is dissolved in water. Low dissolved oxygen levels adversely affect fish and other aquatic life. The ideal dissolved oxygen for fish life is between 7 and 9 milligrams per liter; most fish cannot survive when the dissolved oxygen level falls below 3 milligrams per liter.

Eddy—A zone of low-velocity recirculating water.

Environmental justice—Fair treatment of people of all races, cultures, incomes, and educational levels with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

Ephemeral (botany)—Plant with a short life span.

Ephemeral wash—A wash that flows part of the time, usually after rainstorm, during wet weather, or for only part of the year. Wash on or in contact with the groundwater table that flows only at certain times of the year when the groundwater table is high.

Epilimnion—The upper stratum of the water column of a reservoir. This layer is generally warm, circulating, and turbulent.

Executive order—A directive or declaration by the president of the United States or state governor that implements or interprets a federal statute, a constitutional provision, or a treaty. It has the force of law and is usually based on existing statutory powers; requires no action by Congress or a state legislature.

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 eddies.

Fluvial—Of, or relating to, a river or stream.

Gigawatt hour—A unit of energy representing one-billion-watt hours, equivalent to one-million-kilowatt hours; often used as a measure of the output of large electricity power stations.

Hydropower—The use of water to produce electricity.

Hypolimnion—The lower stratum of the water column of a reservoir. This layer is generally undisturbed, and respiration and decomposition predominate.

Inflows—An amount of water that moves into a river or lake.

Load—Amount of electrical power or energy delivered or required at a given point.

Load-following—A pattern of hydropower generation that reacts instantaneously to change in demand for power.

Mesolimnion—The thermally-stratified layer of a reservoir characterized by a rapid change in temperature with depth, that effectively isolates the waters of the epilimnion from those of the hypolimnion during the period of stratification.

Penstocks—Dam structures that conduct water from the reservoir through the dam to the turbines of a power plant.

Preference entity—A power customer given preference by WAPA in purchasing federal power; may include state and federal agencies, water and irrigation districts, municipalities, public utility districts, Native American tribes, and rural electrical cooperatives (WAPA n.d.).

Ramping—The rate at which a power plant can increase (up) or decrease (down) power generation.

Rapid—A zone of high-velocity water.

Rills—Small grooves, furrows, or channels in soil made by water flowing down over its surface. A small stream.

Salinity—The amount of salt dissolved in a body of water.

Sandbar—A long, narrow deposition of sediment within a river.

Socioeconomic—Refers to the social and economic conditions in the analysis area.

Suspended load (suspended sediment)—Sediment that is supported by the upward components of turbulence in a stream and that stays in suspension for an appreciable length of time.

Total dissolved solids—A quantitative measure of the residual mineral dissolved in water that remains after the evaporation of a solution. Usually expressed in milligrams per liter or parts per million. Total amount of dissolved material, organic and inorganic, contained in water.

Transmission system—A system of generators, transmission lines, substations, and transformers capable of transmitting electricity from generators to consumers.

Tribe—A term used to designate a federally recognized group of American Indians and their governing body. Tribes may be comprised of more than one band.

Tributary—A river or stream flowing into a larger river or lake.

Western Power Grid—The entire power generation and transmission system for the western United States, including 14 states.

Willingness to pay—A method of estimating the value of activities, services, or other goods where value is defined as the maximum amount a consumer would be willing to pay for the opportunity rather than do without. The total willingness to pay, minus the user's costs of participating in the opportunity, defines the consumer surplus and benefits.

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Appendix A

Stakeholder Input Letters

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American Rivers
RIVERS CONNECT US®

December 12, 2022

Ms. Sarah Bucklin
Project Coordinator, Bureau of Reclamation

Re: Response to the Bureau of Reclamation's "Request for Input on the Glen Canyon Dam/Smallmouth Bass Environmental Assessment"

Dear Ms. Bucklin:

On behalf of American Rivers, thank you for allowing us to provide input on the Bureau of Reclamation's "*Glen Canyon Dam/Smallmouth Bass Environmental Assessment*" as described in a webinar you hosted on Thursday, December 1, 2022.

We appreciate the opportunity to help inform and shape the process for evaluating new Colorado River management strategies and operations to disadvantage smallmouth bass reproduction and vitality after passing through Glen Canyon Dam into Grand Canyon through this environmental assessment under the National Environmental Policy Act.

The risk of smallmouth bass penetrating Glen Canyon Dam poses significant risks to the downstream Colorado River ecosystem. AR appreciates the focus and effort around how to best manage this condition going forward. Unfortunately, this is not the only issue of immediate concern within the Colorado Basin. The 20+ year drought accelerated by climate change is posing problems and creating emergencies in multiple parts of the Basin. As such, it is important for this EA to not be done in isolation. To be meaningful, it should consider how the actions considered will fit within actions being considered under the Drought Response Operations Agreement of 2019 and the most recent investigation under the Supplemental EIS to the Interim Guidelines for Lower Basin Shortages and Coordinated Operation of Lakes Powell and Mead. Only by including and considering the operational activities that will influence the conditions at and releases from Glen Canyon Dam can the EA process fully address the risk of smallmouth bass in a meaningful way.

We also would like to encourage Reclamation to remember that any of the actions contemplated within this EA process should consider and comply with both the Long-Term Experimental Management Plan (LTEMP) under the Record of Decision, as well as compliance with the Grand Canyon Protection Act of 1992.

In addition to the alterations and adjustments of flows being contemplated to disadvantage smallmouth bass in the Canyon, we are also concerned about the impacts to other elements of the ecology and ecosystem within the Grand Canyon itself due to the changes in the flow regime that these systems have adapted to over the past 50 years. As such, we would encourage Reclamation to work with and allow involvement on the evaluation of various alternatives from the Grand Canyon Research and Monitoring Center (GCMRC) and the Adaptive Management Work Group/Technical Work Group under the Glen Canyon Dam Adaptive Management Program (GCDAMP.) GCMRC has some of the best, world renowned scientists and modeling experts who could create and model various scenarios pertaining to how elements of environmental resources within the Canyon may be impacted or react to the different proposed alternatives. We are most interested in expertise from a few different categories within GCMRC's current Project Elements, including Project A (Streamflow, Water Quality, and Sediment Transport), Project B (Sandbar and Sediment Storage), Project C (Riparian Vegetation), and Project G (Humpback Chub Population Dynamics.) Additionally, we encourage study of the impacts to water quality in Lake Powell from the potential alternatives, likely through Bridgett Deemer's work via the ad-hoc committee studying water quality in Powell. We feel that GCMRC and AMWG/TWG are best positioned to inform Reclamation of the key resources, impacts to those resources, and possible mitigation strategies related to modifying flow-related operations at Glen Canyon Dam, and that Reclamation should provide ample opportunity for both GCMRC and AMWG/TWG to inform the impact analysis and develop effective mitigation strategies for each alternative presented in the Environmental Assessment.

In contemplating the actual flow alternatives presented by Reclamation, we would like to state our support most notably for Option B: Cool Mix with Flow Spikes, followed closely by Option D: Cold Shock with Flow Spikes. With the body of evidence around how positively impactful High Flow Experiments are to the health of the overall ecosystem within Grand Canyon, especially around sediment transport and sandbar building and maintenance, as well as inhibiting unfettered encroachment of vegetation on sandbars and beaches, we feel strongly that flow spikes must be part of the equation when it comes to determining the most advantages alternative to the ecosystem. Ideally under either alternative, the Flow Spike would be the maximum length possible, as the volume of sand in the system from the past two monsoon seasons would be beneficial to move as far downstream as possible.

We value the opportunity to inform the processes for developing the NEPA analyses for the Glen Canyon Dam/Smallmouth Bass Environmental Assessment. We look forward to working together to inform the actions being considered to confront this challenge in a manner that considers all who are concerned with the future of the Grand Canyon and the fragile ecosystem that thrives within it.

Sincerely,

Sinjin Eberle

Sinjin Eberle
American Rivers Southwest Communications Director &
GCDAMP-TWG Environmental Representative

Arizona Department of Water Resources
1110 W. Washington, #310
Phoenix, AZ 85007

Southern Nevada Water Authority
100 N. City Pkwy # 700
Las Vegas, NV 89106

Colorado River Commission of Nevada
555 E Washington Ave, #3100
Las Vegas, NV 89101

Colorado River Board of California
770 Fairmont Ave., #100
Glendale, CA 91203

December 15, 2022

via e-mail to sbucklin@usbr.gov only

Sarah Bucklin
Regional Environmental Coordinator
Bureau of Reclamation
125 South State Street, Room 8100
Salt Lake City, Utah 84138-1147

Re: Stakeholder Input to the National Environmental Policy Act (NEPA) Compliance for Glen Canyon Dam Operational Flexibilities in Response to Warmwater Invasive Fish

Dear Ms. Bucklin:

The Bureau of Reclamation (Reclamation) has announced plans to prepare an Environmental Assessment (EA) to consider a proposed action to provide a comprehensive framework for implementing operational alternatives at Glen Canyon Dam consistent with the Glen Canyon Dam Long-Term Experimental and Management Plan (LTEMP), Grand Canyon Protection Act and other provisions of applicable Federal laws to reduce the threat of warmwater invasive fish below Glen Canyon Dam. During a Virtual Information Webinar Session (Webinar) held on December 1, 2022, Reclamation requested stakeholder input on the EA by December 15, 2022. The following comments are submitted on behalf of the Glen Canyon Dam Adaptive Management Program (GCDAMP) Technical Work Group (TWG) representatives from the three lower Colorado River Basin states (LB States TWG Reps) as part of the stakeholder input process.

The LB States TWG Reps appreciate this opportunity to provide comments during the EA process and are in support of preventing smallmouth bass establishment. The LB States TWG Reps acknowledge the immediate need to address smallmouth bass through flow-related actions but want to emphasize that operational alternatives alone will not provide prevention. Additional actions, including implementation of a fish exclusion device(s) and fishery actions, such as targeted removals, will be necessary to achieve this goal and should be developed and deployed as expeditiously as possible – ideally by 2024.

Implementation of Operational Alternatives: Reclamation indicates that operational flexibilities considered in the EA will be compatible with the LTEMP. As such, we recommend that implementation of operational alternatives follow the communication and consultation processes that have been developed according to Section 1.4 of the LTEMP Record of Decision.

Moreover, the flow options analyzed in the EA may each be important to have available to implement given certain conditions. We recommend that, to the extent multiple alternatives meet the Finding of No Significant Impact threshold, more than a single operational alternative be available for implementation in the spring and summer of 2023. We also recommend that offramps be identified for emergency exception criteria or if conditions indicate that implementation will not appreciably prevent the establishment of smallmouth bass.

Purpose and Need Statements: The LB States TWG Reps recommend the Purpose and Need statements be revised as follows (major revisions are shown in **bold red** text format):

> … an Environmental Assessment is necessary to pursue implementation of **operational alternatives (**flow options**)** at Glen Canyon Dam **as a temporary means to help prevent establishment of** smallmouth bass.

The Need statement should be revised as follows:

> Need: As water levels in Lake Powell continue to decline to historical lows, warmer epilimnetic water released through Glen Canyon Dam (GCD) is causing record high water release temperatures. Below the dam, these warm water releases are creating ideal spawning conditions for smallmouth bass (SMB), a predatory warmwater invasive fish species. If SMB successfully spawn and establish below GCD and expand downstream into the Grand Canyon, they will likely pose a threat to the federally protected humpback chub and other native fishes. To respond to the threat of SMB establishment, this EA identifies various GCD flow options designed to disadvantage and disrupt SMB from spawning in the Colorado River between Glen Canyon Dam and the confluence with the Little Colorado River. A mix of water releases would be needed to cool the river below 16 degrees C, which is **a generally acknowledged** temperature **threshold** for SMB to spawn. **A r**educed **GCD** water **release** temperature ***target of 13 degrees C or below***, combined with changes in velocity would be used to prevent SMB from successfully spawning and establishing downstream of GCD.

The LB States TWG Reps recommend inclusion of the temperature target in order to further identify the alternatives available for analysis and for selection by the agency decision-maker. Ensuring any available alternative meets the indicated temperature target provides greater certainty that limited operational actions taken at GCD are anticipated to be highly effective.

In addition, the LB States TWG Reps also recommend ample notice of the trigger be provided by forecasting water release temperatures at least three months in advance to allow hydropower managers as much time as possible to plan for, and replace, lost generation resources.

Range of Alternatives: Reclamation should consider the inclusion of the non-bypass flow alternative originally prepared by GCMRC through the Smallmouth Bass Ad Hoc Group and presented at the August Adaptive Management Work Group meeting. Consideration of inclusion of this alternative should focus on whether the flow parameters will meet the stated Purpose and Need.

Hydropower: The analysis of impacts needs to thoroughly address the quantitative impacts of flow options in 2023 (and only if necessary and upon further review in 2024) to hydropower generation, grid stability, the Basin Fund, and recipients of hydropower, including Native American Tribes and disadvantaged communities. Specifically, the analysis should quantify the lost generation due to bypass and the financial impact of that loss on Western Area Power Administration (WAPA) customers, as well as assess the risk of that loss on market power prices and to the electric grid during peak energy times.

Biological Impacts: The potential for fish displacement and potential downstream establishment, including smallmouth bass, green sunfish, striped bass, and other species of concern identified in the National Park Service Non-Native Aquatic Species Management Plan EA should be evaluated for each alternative. Influencing factors such as cold-water avoidance and behaviors with rapidly increased/decreased velocities should be considered for each species. During the consideration of a 2022 Fall High Flow Experiment (HFE), smallmouth bass dispersal was cited as a concern due to the higher chance of dispersal in young-of-year smallmouth bass. Age classes should also be assessed to determine the potential risks for dispersal for warmwater species of concern. The impacts of the alternatives should also be assessed on the humpback chub population, as well as other native species.

The LB States TWG Reps recommend monitoring be included to assess behaviors and distribution of both high-risk nonnatives and native fish for the duration that flow options would be implemented.

Available Flow Rate: Analysis should consider if the desired flow rate for each alternative would be available from both the penstocks and the river outlet works given the current 24-month study elevations for the months of May-November. A detailed analysis of those months would assess the feasibility of the alternatives during the potential trigger windows of all four alternatives. For example, during the consideration of a Fall HFE in 2022, the river outlet works were only capable of discharging 14,000 cubic feet per second (cfs) during the November elevation range.

Monthly Release Pattern: Each alternative should be assessed to determine the minimum monthly release volume that is necessary for it to be effective to prevent SMB establishment. Moreover, the analysis should consider the reductions described by Reclamation in the November 29 and December 2, 2022 public scoping webinars for the Supplemental Environmental Impact Statement, including an annual release as low as 5,200,000 af, and how implementation would occur in order to meet the minimum required monthly volume to implement the flow options effectively. Analysis should consider how these reallocated monthly volumes may impact the remainder of monthly water deliveries during the water year, and their impact to Lake Powell's elevation. Additionally, impacts to resources such as hydropower and downstream resources should be considered under the circumstances described above, with the potential of significantly reduced monthly allocations for the remaining months of the water year.

Infrastructure: Three of the four proposed alternatives include frequent and variable adjustments to the river outlet works (also referred to as "bypass tubes"), including a ramping from zero bypass to approximately 11,000 cfs bypass.
Furthermore, slides presented during the Webinar indicated alternatives designed with bypass tube operations potentially at half increments. Impacts to the abrupt changes in use and volume from the river outlet works should assess the capabilities of the infrastructure to operate in this pattern and consider infrastructure reliability and potential impacts to water delivery if the bypass tubes were to malfunction during this process.

Triggers: The Webinar slides outlining Options A and B state implementation would occur whenever temperature at the LCR is at 16°C, while Options C and D state implementation would occur when daily water temperatures near the LCR approach 16°C. The triggers identified need to be clarified to the exact location and parameters a trigger would have been met. Parameters for the triggers should identify how long the gage reads 16 °C and account for daily fluctuations in temperature that may exist until temperature stabilizes and consider that inflow from the LCR is significantly warmer than the Colorado main stem. The gage location should also be identified, to ensure effective and appropriate indicators of temperature. Lastly, temperature should be modeled for each of the hydrographs.

Analysis should examine the impacts of the potential "three 36-hour flow spikes" for Options B and D, in varying time intervals to limit potential impacts to other resources. Triggers and timing for the flow spikes were not clear to stakeholders during the Webinar. The LB States TWG Reps look forward to a detailed explanation of these triggers in the Draft EA. The analysis should also examine scenarios where quickly repeated flow spikes may have tradeoffs, including decreased reservoir elevation.

Conclusion
The LB States TWG Reps appreciate the aggressive timeline presented by Reclamation in order to address the immediate concern of smallmouth bass, and recommend Reclamation pursue other potential actions that are needed to complement smallmouth bass targeted flows in order to succeed in the goals identified by this EA. While there are several environmental compliance endeavors currently being undertaken by Reclamation, it is important to recognize that while this EA has a targeted purpose, other potential actions will inevitably impact the effectiveness of smallmouth bass targeted flows. Cumulative impact analyses should consider these other parallel proposals that would impact the implementation of smallmouth bass flows.

Should there be any questions or concerns regarding this letter or any other aspect of the LB States TWG Reps interest regarding the EA process, please contact us at your earliest convenience.

Sincerely,

Kristen Johnson
Manager, Colorado River Programs
Arizona Department of Water Resources

Laura Dye
Natural Resource Specialist
Colorado River Commission of Nevada

Seth Shanahan
Colorado River Programs Manager
Southern Nevada Water Authority

Jessica Neuwerth
Deputy Director
Colorado River Board of California

cc:
Wayne Pullan, Regional Director, Upper Colorado Basin, Bureau of Reclamation
Kathleen Callister, Resources Management Div., Upper Colorado Basin, Bureau of Reclamation

December 15, 2022

Via E-Mail to sbucklin@usbr.gov

Sarah Bucklin
Regional Environmental Coordinator
Bureau of Reclamation
125 South State Street, Room 8100
Salt Lake City, Utah 84138-1147

Re: Stakeholder Input to the National Environmental Policy Act (NEPA) Compliance for Glen Canyon Dam Operational Flexibilities in Response to Warmwater Invasive Fish.

Dear Ms. Bucklin,

The Bureau of Reclamation (Reclamation) has announced plans to prepare an Environmental Assessment (EA) to consider a proposed action to provide a comprehensive framework for implementing operational alternatives at Glen Canyon Dam consistent with the Glen Canyon Dam Long-Term Experimental and Management Plan (LTEMP), the Grand Canyon Protection Act and other provisions of applicable Federal laws to reduce the threat of warmwater invasive fish below Glen Canyon Dam. During a Virtual Information Session held on December 1, 2022, Reclamation requested stakeholder input on the EA by December 15, 2022. The following comments are submitted on behalf of the Glen Canyon Dam Adaptive Management Program (GCDAMP) Technical Work Group (TWG) representatives from the four Upper Division (UD) Colorado River Basin states (Colorado, New Mexico, Utah, and Wyoming) and the Upper Colorado River Commission (UCRC) (collectively referred to herein as the UD Basin States TWG Reps) as part of the stakeholder input process.

Interests of the UD Basin States TWG Reps

The UD Basin States TWG Reps are active and vocal participants in the GCDAMP, including the TWG and its subcommittees. Members are selected who believe in the importance of these processes for providing technical advice and recommendations to the Secretary of the Interior relative to the operation of Glen Canyon Dam. For many years, we have closely monitored the status and trends of nonnative warmwater fish species and other potentially problematic fish species below Glen Canyon Dam. This is because of their potential for threatening the progress that has been made toward recovering the Endangered Species Act protected humpback chub (*Gila cypha*) and impacting other native species. As threats to native fish populations have grown, the UD Basin States TWG reps have consistently considered potential consequences to native fish populations in their recommendations regarding potential LTEMP experiments.

When large numbers of green sunfish (*Lepomis cyanellus*) were detected in Glen Canyon in 2015, the UD Basin States TWG Reps recommended not to implement a Fall High Flow Experiment for fear of dispersing this species downstream and promoting establishment. When brown trout detections increased during the period 2014-2016, the UD Basin States TWG Reps were among those who advised that immediate removal efforts should be implemented. Recently, projections showed that Lake Powell elevations will decline and water quality conditions would become more suitable for smallmouth bass (*Micropterus dolomieu*) establishment in 2021-2022. Once evidence of smallmouth bass recruitment was observed in 2022, the UD Basin States TWG Reps recommended the rapid deployment of response actions and recommended against implementing a Fall High Flow Experiment for fear of dispersing this species downstream and promoting establishment. These are just a few examples of how the UD Basin States TWG Reps have demonstrated their interest in diminishing threats to humpback chub in Marble and Grand canyons.

General Comments

A) **Operational Alternatives are Not a Panacea:** The Smallmouth Bass Ad Hoc Group was charged by the TWG with developing a draft strategic plan to prevent, detect, and respond to cool- and warmwater invasive fish establishment below Glen Canyon Dam. This task originated from the Secretary's Designee during the May 2022 AMWG meeting. The Smallmouth Bass Ad Hoc Group, with input from the Basin States TWG Reps, Grand Canyon Monitoring and Research Center, and other stakeholders, has been developing a comprehensive strategic plan. The strategic plan includes several important types of actions, including early detection, rapid response, fish exclusion, and possible short-term operations that could help prevent invasive fish establishment, while minimizing potential adverse effects to other resources. What is undeniably clear from these efforts is that Glen Canyon Dam operations alone are insufficient to prevent invasive fish establishment. Other actions are needed to meet these goals, including early detection and rapid response, and fish exclusion. Any use of operational alternatives to discourage or reduce establishment should be implemented in conjunction with non-operational alternatives.

B) **Fish Exclusion:** Reclamation has indicated its intent to initiate environmental compliance for the installation of a fish exclusion device in the Glen Canyon Dam forebay and/or below the dam, or consider other existing authorizations that would allow rapid deployment of a fish exclusion device (or multiple types of devices). We recommend that, at a minimum, a temporary fish exclusion device (or multiple types of devices) be installed no later than the summer of 2023, while a more permanent solution is devised.

C) **Early Detection and Rapid Response:** Reclamation should increase their financial support for expanded early detection and rapid response actions such as the actions that have occurred in the 12-mile slough and recent electrofishing actions in Glen Canyon.

D) Implementation of Operational Alternatives: Reclamation indicates that operational flexibilities considered in the EA will be consistent with the LTEMP. As such, we recommend that implementation of operational alternatives follow the communication and consultation processes that have been developed according to Section 1.4 of the LTEMP Record of Decision. Moreover, the flow options analyzed in the EA may each be important to have available to implement depending on conditions. We recommend that more than a single operational alternative be available for implementation in the spring and summer of 2023. We also recommend that offramps for emergency exception criteria and futility of the operational alternative be identified in the EA.

E) **Powell Pool Elevations:** The UD Basin States TWG Reps recognize that if dry hydrologic conditions similar to recent years occur in 2023, resulting water release temperatures are almost certain to support the establishment of smallmouth bass below Glen Canyon Dam. The UD Basin States TWG Reps further recognize that any increase to Lake Powell pool elevations from current elevations will likely lead to cooler water releases and a lower likelihood of smallmouth bass establishment.

Environmental Assessment-Specific Comments

A. **Scope:** The EA should clearly state that the proposed operational alternatives are for implementation in WY 2023, and, if necessary and upon further consultation, WY 2024, consistent with the LTEMP Record of Decision.

B. **Purpose and Need Statements:** The language in these sections needs to be tightened up for clarity. The Purpose statement should be revised to say, "… an Environmental Assessment is necessary to pursue implementation of ***operational alternatives*** **(flow options)** at Glen Canyon Dam as a ***temporary*** means ***to help prevent establishment of smallmouth bass through 2023, and, if necessary and upon further consultation, in 2024.***" Likewise, the final sentence of the Need statement should be revised to say, "Reduced water temperature, changes in velocity, ***or a combination could*** be used to ***help*** prevent SMB from successfully spawning and establishing downstream of GCD." See A) under General Comments. Reclamation should further consider whether the confluence with the LCR is too far downstream to be the appropriate terminus.

C. **Range of Alternatives:** We believe that the range of alternatives presented is insufficient because there is no alternative proposed that does not use the bypass tubes (reservoir outlet works). Reclamation could have included, for example Alternative #2 from the August 2022 Adaptive Management Working Group Meeting, "Once a week, lower flows to 2,000 cfs and increase to 25,000 cfs – the maximum range without any bypass". A design without the use of the bypass tubes could be developed to help prevent the establishment of SMB before installation of an exclusion device (see (B) under General Comments). Such a design would at the same time minimize the impacts to hydropower generation, grid-stability disadvantaged communities that are recipients of hydropower, and the Basin Fund. Creation of a non-bypass alternative would focus on flow fluctuations to impact SMB in contrast to bypass alternatives, which focus more on reducing temperature to negatively impact SMB. Inclusion of a non-bypass alternative would also strengthen the environmental compliance analysis by increasing the range of the alternatives analyzed.

D. Analysis of Impacts: The analysis of impacts needs to thoroughly address the quantitative impacts of flow options in 2023 (and, only if necessary, and upon further consultation, in 2024) to hydropower generation, grid stability, the Basin Fund, and recipients of hydropower, especially Native American Tribes and disadvantaged communities. We encourage Reclamation to work with WAPA to evaluate impacts of the proposed action under the minimum, maximum, and most probable hydrologic scenarios. We also encourage Reclamation to include a SMB specialist on the EA team.

The analysis of impacts should also include an evaluation of the potential for dispersing invasive fish downstream. High Flow and Bug Flow experiments have generated concern regarding their potential for promoting invasive species establishment by relocating invasive species further down river. The Basin States TWG Reps recommend the EA evaluate this potential risk and clarify how risks from the operational flows under consideration differ from those risks presented by experimental flows. For these reasons, any proposed action warrants a similar process that follows the communication and consultation processes that have been developed according to Section 1.4 of the LTEMP Record of Decision.

E. Drought Response Operations and Protection of Infrastructure: During calendar year 2021, Reclamation released a total of 161,000 acre-feet of water from Flaming Gorge and Blue Mesa Reservoirs under the emergency provision of the Drought Response Operations Agreement (DROA) in an effort to help protect critical elevations at Lake Powell. Pursuant to a 2022 Drought Response Operations Plan approved by the DROA Parties in May 2022, Reclamation is in the process of making additional DROA releases from Flaming Gorge to Lake Powell in the amount of 500,000 acre-feet. This release began in May 2022 and will continue through April 2023. Actions contemplated under this EA should not interfere with past, current, or future DROA releases and recovery operations intended to protect critical elevations in Lake Powell.

F. Schedule: In October 2022, Reclamation provided the Dual Charter and Project Management Plan to GCDAMP stakeholders. The Plan outlined a schedule of tasks for completing the EA by March 29, 2023. Although this is an aggressive schedule for completing the EA, the UD Basin States TWG Reps recognize Reclamation's interest in proceeding quickly with this schedule to ensure that there is the opportunity to implement operational flexibilities in 2023.

Reservation of Rights

The UD Basin States TWG Reps' comments are intended to highlight overarching issues that will require acknowledgment, specification, or clarification as the EA process continues to progress. The UD Basin States TWG Reps' failure to provide specific comments regarding details of the EA is not, and shall not be construed as, an admission with respect to any factual or legal issue or the waiver of rights for the purposes of any future legal, administrative, or other proceeding. Furthermore, the UD Basin States TWG Reps reserve the right to comment further on EA documentation as Reclamation proceeds with subsequent phases of the EA process.

Conclusion

The UD Basin States TWG Reps thank you for the opportunity to provide these scoping comments for the EA. If you have any questions or concerns regarding this letter, or any other aspect of the UD Basin States TWG Reps interest regarding the EA process, please contact us at your earliest convenience.

Sincerely,

[*Signatures on next page*]

Signatures:

Michelle Garrison

Michelle Garrison, Colorado TWG Representative

Christina Noftsker

Christina Noftsker, New Mexico TWG Representative

Scott McGettigan, Utah TWG Representative

Mel Fegler, Wyoming TWG Representative

Sara Larsen

Sara Larsen, UCRC TWG Representative

Cc:

Wayne Pullan, Regional Director, Upper Colorado Regional Office, Reclamation
Kathleen Callister, Manager, Upper Colorado Regional Office, Reclamation
Bill Stewart, Upper Colorado Regional Office
Seth Shanahan, Nevada TWG Rep and TWG Chair

CREDA
Colorado River Energy Distributors Association

December 13, 2022

ARIZONA
Arizona Municipal Power Users Association

Arizona Power Authority

Arizona Power Pooling Association

Irrigation and Electrical Districts Association

Navajo Tribal Utility Authority (also New Mexico, Utah)

Salt River Project

COLORADO
Colorado Springs Utilities

CORE Electric Cooperative

Holy Cross Energy

Platte River Power Authority

Tri-State Generation & Transmission Association, Inc. (also Nebraska, Wyoming, New Mexico)

Yampa Valley Electric Association, Inc.

NEBRASKA
Municipal Energy Agency of Nebraska (also Colorado)

NEVADA
Colorado River Commission of Nevada

Silver State Energy Association

NEW MEXICO
Farmington Electric Utility System

Los Alamos County

UTAH
City of Provo

City of St. George

Heber Light & Power

South Utah Valley Electric Service District

Utah Associated Municipal Power Systems

Utah Municipal Power Agency

WYOMING
Wyoming Municipal Power Agency

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Bureau of Reclamation
Smallmouth Bass EA
Project Manager – Sarah Bucklin
Via Email only – sbucklin@usbr.gov

The Colorado River Energy Distributors Association (CREDA) appreciates the opportunity to provide informal comments by December 15, 2022, following Reclamation's stakeholder meeting held December 1, 2022, addressing Reclamation's preparation of an environmental assessment (EA) regarding smallmouth bass (SMB) at Glen Canyon Dam (GCD). As a member of the GCD Adaptive Management Work Group (AMWG) and Adaptive Management Program (AMP), CREDA is one of the representatives of contractors who purchase federal hydropower and resources from the GCD, a primary feature of the Colorado River Storage Project (CRSP). CREDA members serve over 4.1 million consumers in the Colorado River basin states of Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming, and represent the majority of the firm electric service customers of the CRSP. As such, CREDA and its members have a unique interest and role in issues associated with Colorado River operations, specifically GCD operations. CREDA and CREDA members Tri-State G&T, UMPA (identified as Known Stakeholders in the SMB EA Project Management Plan p. 9) and UAMPS and SRP (as LTEMP cooperating agency subject matter experts) are prepared to collaborate closely with you as SMB EA project manager and WAPA and Reclamation as federal interdisciplinary agencies, through this EA process.

In response to your request for input on the December 1 materials, as well as information that is important to CREDA and its members and to this EA process, CREDA offers the following and looks forward to working with Reclamation on this important issue and associated processes.

<u>PURPOSE AND NEED</u>

1) The draft Purpose Statement as presented is extremely broad. It is not clear what "respond to smallmouth bass" means. Please consider narrowing the statement to be consistent with the Directive from the Secretary's Designee that begins with "to *help prevent*……..".
2) The Need Statement includes "various" alternatives. The four proposed alternatives may not be diverse enough to be considered "various" if the alternatives are not capable of providing disruption from Glen Canyon Dam down to the confluence of the Little Colorado River, as stated in the Need Statement.

<u>SCOPE OF THE EA AND PROPOSED ALTERNATIVES</u>

3) It is unclear whether this "Targeted/Focused" EA is intended to address threats *only* to Humpback Chub (HBC) or will cover impacts to other native fishes. It is important to understand whether, and to what extent, the

measures being considered by Reclamation, will also impact other native fishes even if that means expanding the scope of the EA.

4) A quantitative analysis of the impacts to hydropower is needed to determine whether they are significant. As indicated on the webinar, CREDA agrees that WAPA should perform the hydropower impacts assessment, which would include hydropower customer impacts assessment, such as they did for the High Flow Experiment EA (as well as multiple EIS processes in the Colorado River Storage Project). As indicated at the beginning of this letter, CREDA and its members who have subject matter expertise in this area are prepared to provide assistance in this specific and unique area.
5) The May 2022 Secretary's Designee directive included a requirement to minimize impacts to other resources. None of the presented alternatives include an attempt to minimize impacts to the hydropower resource, as did an alternative presented to the SMB Ad Hoc Group. Yet, on the webinar, it was stated that direction was given to "include flows to benefit sediment." This direction appears to conflict with the purpose and need statement, as sediment is not a resource targeted for improvement or mitigation. Considering the impact on sediment and not other resources seems inconsistent with a "single purpose," or "Targeted/Focused EA, if addressing the impact of SMB on the threatened HBC is the target/focus.
6) CREDA would like to understand what screening tools/metrics were used to eliminate a non-bypass alternative? To be consistent with the Directive, and in an attempt to meet the objective of being able to issue a Finding of No Significant Impact (FONSI), at least one alternative that does not include bypass operations should be considered and analyzed. See for example, Alternatives 4 and 5 as described in the November 18, 2022, WAPA correspondence. Finally, the Project Management Plan (p.5) presented to AMP stakeholders on 10/14/2022, directs that a "minimum of four" operational alternatives should be anticipated.

<u>COMMENTS ON THE SLIDE "CONSIDERATIONS FOR DEVELOPING FLOW OPTIONS"</u>

7) The "Regulatory/1500 cfs" is related to grid operations. Impacts to grid operations must be considered in analyzing each alternative, and off-ramp/mitigation measures established (see item 12)C. below).
8) "Maintenance schedule" and "bypass coating" relate to some of the structural elements of Glen Canyon Dam. The impacts assessment must take into consideration the volume and duration of proposed bypass flows, to assess physical capabilities and impacts to the tubes. The SMB Ad Hoc Group and the Technical Work Group (TWG) have heard presentations regarding scheduling and timing of a specific project to recoat the bypass tubes, and how the original GCD design and current operations do not contemplate frequent or continued use of those facilities. Timing of that maintenance project is just one aspect that must be considered in this EA. Timing, duration, and frequency of flows utilizing those facilities must be analyzed to assess feasibility without undermining the structural integrity of the tubes, and any physical impacts must be mitigated.
9) The Secretary's Designee Directive considered the potential of alternatives "outside ROD" operations; but the "Considerations" slide limits alternatives to *within* existing ROD operations. CREDA would like to understand how the determination was made to deviate from the Directive and limit the scope. Disturbance/fluctuations are related to this issue.

From the initial filling of Lake Powell to the early 1990's, pre-ROD flow fluctuations limited rainbow trout (RBT) reproduction to the point that the fishery had to be sustained through stocking. The scientific literature suggests that SMB are more sensitive to flow fluctuations than RBT. This would suggest that daily flow fluctuations like those used during the pre-ROD period could help prevent establishment of SMB in the tailwater and since daily fluctuation waves travel all the way through the Grand Canyon to Lake Mead, they may be more effective at preventing establishment of SMB in the Grand Canyon than trying to reduce release temperatures with bypass. Fluctuating flows (including "outside ROD" levels) should not be discounted or dismissed as being effective to help prevent SMB establishment.

10) See comment 1) above – a Goal of the Flow options should be to *help* prevent establishment of SMB. There is no certainty and no actual experience that *any* flow option alone will achieve prevention of establishment of SMB. Hence the need to rapid response actions, as well as long-term strategies and physical treatments (in addition to potential flow treatments). In other words, the EA cannot assume that flows are the panacea.

<u>GENERAL QUESTIONS/RESPONSE TO INPUT SOUGHT:</u>

11) CREDA would like to understand the term/duration of the EA. At one point in the webinar, a comment was made that it may need to go into summer 2024. If that is the case, the impacts assessment will likely prevent issuance of a FONSI, based on very preliminary assessment of the GCMRC-developed alternatives presented to the TWG.
12) The webinar asked for "things that you think are most important, either positive or negative." The following listing is an initial list of information CREDA has identified at this point, given the brief comment period.
    A. The CRSP hydropower community is significantly disadvantaged by not knowing how much hydropower generation is going to be impacted BEFORE we have to offer comment. WAPA has provided some analysis but only of the "original" four alternatives presented to the SMG Ad Hoc Workgroup. Since those alternatives have been modified, CREDA's ability to offer quantitative input is inhibited. However, we predict that including a range of alternatives that *all* include bypass operations will result in significant impacts to the hydropower resource and its community of customers. Quantitative impacts analysis is required to confirm (or not) that prediction.

    B. Alternatives as presented that are tied solely to a temperature trigger of 16 degrees are unworkable. Utilities cannot just have generation removed on short notice when the temperature hits 16 degrees Celsius. A reasonable amount of notice is needed so that utilities can plan for the loss of the generation, particular in resource limited, high demand summer months. Having a defined window and knowing what that window is earlier rather than later is necessary for planning and required to meet customer electrical loads. A significant loss of generation from GCD is likely to have a measurable financial impacts on WAPA and WAPA's customers. WAPA's analysis of the alternatives should be broad enough to quantify the impact of customers having to replace GCD generation with other resources. 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 GCD/CRP has implications and impacts to both direct contracts of that/those resources as well as exchange agreements that rely on the output of that/those resources. Consideration of resource adequacy requirements, replacement resource availability, and contractual impacts impacting utilities' obligation to serve customers are essential elements that must be addressed in the EA's effects analysis. On September 29, 2022, CREDA submitted comments to Reclamation regarding potential fall experiments under LTEMP. These comments apply to every experiment or changed operation that may be considered for CRSP generating units. This EA, as well as any other proposed operation or experiment considered during the pendency of the LTEMP ROD, must evaluate and consider *hydropower production*, as well as WAPA's assessment of the Basin Fund. (ROD section 1.3).

C. Section 1.2 of the LTEMP ROD calls out the need for flexibility to address and consider "… 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." The Western grid faces increasing shortages and reliability risks, particularly during the summer months. The reduction of available hydropower in the Colorado River system during those months further exacerbates those risks and adds related challenges. WAPA's analysis should consider the impact of losing GCD generation on WAPA's ability to transmit power and respond to regional emergencies. In addition, WAPA's analysis should include an assessment on the reliability of the electric grid, including the adequacy of purchased power resources and the potential impact on regional market power prices.

D. Societal and environmental justice analysis must include the impacts of increased cost and rate increases to CRSP firm electric service customers as they replace bypassed generation on the open market. Impacts to the 53 CRSP tribal customers are unique: Many tribal customers receive the benefit of the federal hydropower through benefit or bill crediting. These customers can use that benefit in a manner determined by the tribe to best suit the community. When that power is not available or reduced, that credit is diminished. This means that tribes may be impacted not only from a financial standpoint, but from a quality-of-life standpoint as well. Operations and experiments that include water bypassing generators exacerbate these impacts.

CREDA appreciates the opportunity to provide comments on the approach for the EA. As our concerns above indicate, the scope of impacts may be significant, thereby triggering the fuller analysis required by an Environmental Impact Statement (EIS). In considering the issues noted above, we encourage Reclamation to consider carefully whether the impacts of the action are significant and an EIS is required.

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Cc: CREDA Board
Wayne Pullan – Reclamation UC Region
Rodney Bailey – WAPA CRSP Management Center

United States Department of the Interior

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IN REPLY REFER TO:
IMRO-RSS-COR (1241)

VIA ELECTRONIC MAIL: NO HARD COPY TO FOLLOW

Memorandum

To: Wayne Pullan, Regional Director, Upper Colorado Basin, Reclamation
Sarah Bucklin, Project Manager, Bureau of Reclamation

From: Edward Keable, Superintendent, Grand Canyon National Park (NP) Edward T. Keable Digitally signed by Edward T. Keable Date: 2022.12.14 16:16:05 -07'00'
Michelle Kerns, Superintendent, Glen Canyon National Recreation Area (NRA) MICHELLE KERNS Digitally signed by MICHELLE KERNS Date: 2022.12.14 22:04:28 -07'00'

Subject: NPS Comments in response to the "Glen Canyon Dam Smallmouth Bass Flow Options Environmental Assessment" to be prepared by the Bureau of Reclamation

The National Park Service (NPS) appreciates the opportunity to provide input on the Bureau of Reclamation's (Reclamation) "Glen Canyon Dam/Smallmouth Bass (SMB) Flow Options Environmental Assessment (EA)" announced in the webinar facilitated by Sarah Bucklin on December 1, 2022. The following statements represent the views of the NPS.

We believe this is an important and urgent process that must address the impacts of dam operations on the native fish communities and the federally listed fish below the Glen Canyon Dam (GCD). There is a clear and present danger to the federally threatened humpback chub and other native fish in Glen and Grand Canyon downstream of the dam from the passthrough of warmwater non-native fish and the warmer river temperatures that occur in the lower operating range of Lake Powell (falling below the 3540' level). If smallmouth bass or other highly predatory non-native fish breed and establish below the dam then there is a strong possibility of their establishment in both the mainstem and tributaries and the likelihood of negative impacts to many of these fish populations, including the federally listed fish populations, over the coming years.

Cooperation and Coordination

The alternatives to be considered in this planning process may affect resources the NPS is legislatively mandated to protect, including threatened and endangered fish and wildlife, water quality, vegetation, wildlife habitat, geological features, geomorphic processes, cultural, paleontological, and ethnographic resources, among others.

We note the impacts of climate change generally, and the smallmouth bass invasion into the Grand Canyon specifically, have extremely important implications for Indigenous people who have called the Grand Canyon home since time immemorial. In addition to the significance to Indigenous people, these issues are also important for Department of the Interior (DOI) agencies, as we have a trust responsibility to these Tribes, and we must consider this responsibility in our planning processes.

We understand that Reclamation will not have cooperating agencies involved in this process given the urgency to stay ahead of smallmouth bass breeding and the expedited process. We do, however, request a close working relationship with Reclamation on this initiative. NPS is one of the DOI bureaus with responsibility for these resources and, as stated in the 2016 Long Term Experimental and Management Plan (LTEMP) Record of Decision (ROD), has a role in the Adaptative Management Program as one of the bureaus that contributes to the decision making for the Secretary. Close NPS involvement in the form of weekly meetings and pre-review of information to be distributed to stakeholders would ensure that all DOI mandates are considered in these materials.

Potential Impacts to NPS Resources

As mandated by the Organic Act of 1916 ("NPS Organic Act"), the NPS manages and protects resources including recreation in Glen Canyon National Recreation Area (NRA) and Grand Canyon National Park (NP). Approximately 292 miles of river corridor in these park units may be impacted by this project's alternatives. The 1992 Grand Canyon Protection Act (GCPA) also mandates that the GCD be operated in a manner to protect, mitigate adverse effects to, and improve the natural and cultural resources and recreation below the GCD in Grand Canyon NP and Glen Canyon NRA.

<u>Impacts to native and federally listed fish</u>

The most serious resource issue for the GCD related to this process is in the past year, we have been documenting an increase of invasive warmwater non-native fish passing through GCD. The Post 2026 alternatives will affect this situation with important differences between alternatives. Currently, dramatically increasing release temperatures have created suitable habitats for reproduction of these warmwater non-natives in the Colorado River below GCD. As of July 2022, there have been monitoring observations supporting the occurrence of breeding smallmouth bass below the GCD. Additional numbers of smallmouth bass have been documented and removed in the past two months during mechanical and chemical removal efforts in the Glen Canyon reach.

Resource protection and hydropower have often been competing concerns in decision processes in the past. As important as hydropower is to the region, we cannot afford to prioritize short term hydropower production concerns over the protection of federally listed fish in this alternatives analysis. We are now in a time of major changes in river temperatures and flow regimes when it is vital to prioritize federally listed fish in alternatives analysis. Failure to prioritize fish now could lead to legal challenges with water management in the Colorado River, as well as probable risk to fish populations and our agency's legal obligations to these populations under the

Endangered Species Act (ESA), the Grand Canyon Protection Act (GCPA), and the 2007 Interim Guidelines ROD and the 2016 LTEMP ROD.

Smallmouth bass are a particularly voracious predator species that has impacted native and federally listed fish in the upper basin. If smallmouth bass and other high-risk, warmwater, non-native predators establish below the dam, this would significantly impact native fish communities, based on experience in the upper basin, presenting great risk to the status of the federally listed humpback chub in the near future. This is a high priority for protection under the Grand Canyon Protection Act, the Endangered Species Act, and the 2007 Interim Guidelines ROD and the 2016 LTEMP ROD. Millions of state and federal dollars have been invested in the protection of this species throughout the Colorado River basin over the past decades. We believe the investment of a relatively small amount of state and federal resources now would avoid having to spend additional millions of dollars in the future, by engaging in prudent planning that seeks to best minimize smallmouth bass invasion.

The NPS has identified ahigh priority need to specifically model the risk to humpback chub populations (including minimums and maximums), by habitat modeling that considers the potential establishment of these non-natives over time and the potential variations in water quality and water quantity in the Grand Canyon with lower Lake Powell elevations. The modeling would allow for a comparison between alternatives and demonstrate different trajectories between the alternatives that are important to decision-makers to assess the risk to humpback chub populations over time.

Given the expedited timeline for this EA and the intersection with the concurrent Reclamation Interim Guidelines Supplemental Environmental Impact Statement (SEIS), we strongly urge Reclamation to immediately provide U.S. Geological Survey (USGS) Grand Canyon Monitoring and Research Center (GCMRC) modelers with direction to conduct this modeling and the funding and any other resources needed, including additional staff, to conduct modeling according to the timeline. Additionally, this information will be useful and should be incorporated in the environmental documents for post-2026 operations.

Modeling should consider annual and multiyear impacts to fish and consider prioritizing those over impacts to hydropower. Again, Federal agencies have certain legal obligations to protect the environmental and other resource interests on the Colorado River in the Grand Canyon pursuant to the GCPA, the ESA and the NPS Organic Act.

<u>Sandbars, Beaches, Cultural Resources and River Recreation</u>

The alternatives in this process will influence the second major resource issue, sandbars and beaches in the Grand Canyon. Recent lower levels of Lake Powell have prevented the High Flow Experiments (HFE) from being carried out in the Grand Canyon since 2018. HFE's represent the only river-wide tool to rebuild sandbars and beaches in the canyon, critical for the protection of irreplaceable cultural resources in this park, also a UNESCO World Heritage site. There are approximately 362 recorded archeological sites in this part of the river corridor that could potentially be impacted by flows that impact sediment and wind-based processes. The sediment from these HFEs also provides the camping areas required for recreational access for river rafters through the canyon. These resources are mandated for protection under the GCPA.

This EA would need to consider compliance with the GCPA, the National Historic Preservation Act (NHPA) and the NPS Organic Act. Through consultation with the NPS and in the Glen Canyon Dam Adaptive Management Program, the Hualapai Tribe expressed concern that the lack of HFE's is causing sediment deposition in western Grand Canyon, promoting a buildup of sand in the river in areas where their river operations occur. This sediment buildup is creating a safety concern to visitors and has an impact on the Tribe's commercial recreational interests. Grand Canyon NP has similar concerns.

The effects of flow spike alternatives (Options B and D), which are designed to disadvantage smallmouth bass, would vary depending on whether the river channel is sediment rich or sediment poor at the time of the flows. Flow spikes in July (which is a new sediment accounting window) could reduce the chances of an HFE in the Fall months by depleting the sediment available in the channel, using the current accounting process under the LTEMP sediment protocol. This could be resolved with changes to the LTEMP protocols for low water conditions (see below in "alternative additions"). Whether the flow spikes are beneficial or detrimental to sediment in the longer term may also depend on the effects to vegetation that could increase or decrease aeolian (wind) transport of sand from the river channel to higher elevation dune fields where the sand buries and protects archaeological sites from erosion and visitor impacts. A single flow spike at higher magnitude and longer duration might redistribute more sediment onto the beaches and sandbars and accomplish the objectives of fall sediment-triggered HFEs. However, multiple flow spikes could also erode sand in the channel during the fall sediment accounting window. The magnitude of the flow spikes may affect how much scour of undesirable beach vegetation exists, and the timing of the flow spikes might determine if that spike is beneficial or detrimental to plant growth. We request that the alternatives be evaluated for these concerns using the modeling capabilities of GCMRC to estimate sandbar and beach erosion and rebuilding, the potential for vegetation to increase or decrease, the impacts to aeolian sediment supply to archaeological sites, and campable area. This would allow for the disclosure of how these alternatives impact the protection of cultural resources and river-based recreation through the Grand Canyon.

Water Quality in the Colorado River

Water quality impacts in the Colorado River through the Grand Canyon are a result of lower Powell elevations and the increases in river temperatures. Over summer 2022, water temperature in the river estimated approximately 5 degrees C warmer than the past 50 years combined, and depending on future hydrology numbers for summer of 2023, could result in an increase of 10 degrees C. The change from a baseline of 14 C to 24C (or 18-degree Fahrenheit increase) is a dramatic difference in a short duration for an aquatic ecosystem.

These major changes in temperatures would be above breeding temperatures of warm water non-native fish passing through the GCD. In addition to creating favorable temperatures for non-native fish, the warmer water would have additional negative impacts on aquatic communities. We recommend that this be analyzed in the no action alterative as well as the potential human health impacts for river recreation. It is our belief that the action alternatives that utilize bypass to lower river temperatures would address these concerns. The use of bypass is also likely to reduce dissolved oxygen problems in Lees Ferry and impacts to the rainbow trout fishery. These issues should be modeled using the modeling capabilities of GCMRC. The viability of bypass option alternatives to improve the viability of native and endangered fish and the recreational trout fishery should be disclosed in this analysis to inform recreational anglers and environmental groups about the differences between the alternatives.

Traditional Cultural Properties and Values of Importance to Tribes

Many issues are important to tribal communities, from hydropower to recreation to water rights; however, within National Park units, our long consultation history with tribal partners has documented additional areas of special traditional importance. Some areas are documented Traditional Cultural Properties (TCPs), and others represent areas of traditional importance to tribal histories. Many Tribes consider the river a living entity, preserving it and considering it a significance spiritual importance. The river is thought of as the lifeblood of the Grand Canyon and the backbone of life for many Indigenous people of the area.

The Pueblo of Zuni and other Tribes have expressed concerns over mechanical and chemical fish control actions to manage non-native fish, though all Tribes have expressed the importance of maintaining the native fish in the river. The action alternatives for this process that use more bypass and as well as flow (such as Option B) may allow reducing the spread of the non-native fish the most, provide the most protection of the native fish by lowering the river temperature to where it is less suitable for the non-natives, and therefore may require less mechanical or chemical fish control actions. This information should be disclosed in this analysis so that if the Tribes prefer a preventative approach rather than an active management approach, they can distinguish between the alternatives this issue.

Alternatives

NPS respectfully asks that the following issues be considered in the alternative development process:

- Given the history of invasive species, it is critical that an alternative that proves to be effective at reducing both passthrough of these fish at the dam and reducing the potential for these species to reproduce below the dam is chosen. Warmwater invasive fish species present a high risk of impacting native fish species in the canyon, including the federally threatened humpback chub and the federally endangered razorback sucker. In the information available, the alternatives with the most frequent bypass use through the potential SMB breeding season appear to be the most effective alternatives. The bypass use appears to be critical to achieving both goals of reducing passthrough and reducing temperatures below the range at which these warmwater non-natives can breed effectively. It is imperative that the range of alternatives chosen are those that will be likely to stop reproduction before these fish are widely established through the canyon and in the tributaries; it may be impossible to eradicate them after they fully establish.

- Based on the analysis, Option B: Cold Mix with Spike Flow is expected to have high certainty of prevention under most conditions. This appears to be the most effective at preventing the establishment of new warmwater invasive fish below the GCD. If this remains the most effective option, then NPS will prefer this as the best approach for protecting native and federally listed fish. Options without flow spikes will fail to reach fish in the backwaters. Option C appears to be less effective and more likely to result in a population level decline of federally listed fish in this system.

- We understand that bypass would have negative impacts to the hydropower production at the dam, and these flows will only be needed when Lake Powell elevations are between 3490' to between 3525'-3540'. If other Reclamation processes, such as the Supplemental EIS to the 2007 Interim Guidelines ROD, choose a 'protection elevation' for Lake Powell that is at or above 3525', the need to use these bypass flows may be reduced. A higher protection level would be beneficial for both power production and for protection of federally listed fish.

Modification to Flow Spike Alternatives (Option B and D) to Address Impacts to Sediment
NPS would like to submit a modification to the flow spike alternatives that could modify LTEMP to reconcile sediment and fish needs at 'low water conditions.' This could be addressed in this EA or in the Interim Guidelines SEIS, whichever Reclamation believes is the most appropriate of the two processes to address these adjustments to the LTEMP protocols. Wayne Pullan articulated at the August 2022 Adaptative Management Working Group (AMWG) meeting tasks for GCMRC to find a way to address both the SMB invasion issue and the lack of HFEs in the Grand Canyon under these lower water conditions. Based on dialog with GCMRC researchers, these modifications below would resolve both issues to provide benefits to resources and better compliance with the GCPA, but also modify the LTEMP protocols in a way that would be more effective in terms of staff time and planning under low water conditions:

1. Low water conditions for this concept would be defined as when Lake Powell elevation is below 3550' (or as adjusted based on the best available information from GCMRC for a trigger level at which river temperatures or fish passthrough become problematic) and the annual release from GCD in the current water year is 7.0 maf or below.
2. In these low water conditions, a fall HFE or a spring HFE in March or April would not be considered. Either SMB flow spikes would be considered in the May to mid July timeframe, or if SMB flow spikes were not to be considered, a sediment triggered HFE between 24-72 hours would be considered in the May-June time window. The only modification to the SMB flow spikes would be, if a sediment trigger was reached, an extended duration flow spike between 36 hrs. and 72 hrs. on the first of the three possible flow spikes.
3. The LTEMP sediment accounting window would be altered to start and end on July 1 every year and would continue for the entire year rather than 2 separate periods. This would allow for, and limit it to, one sediment triggered HFE-type flow considered during a year (an HFE or the SMB flow spike). The SMB flow spike from May-July 1 would 'count' as an HFE if a sediment trigger was reached by May 1.
4. If there were higher water conditions (Lake Powell elevation is above 3550' or GCD release is => 7.0 maf), the LTEMP HFE protocol would still apply (with a single year-long accounting period). This would still allow for sediment triggered fall HFEs in Oct-Nov, spring HFEs in the Mar-April window, for extended duration HFEs, and for proactive spring HFEs in May-June, but the accounting window would still be a year long starting and ending July 1 and restricting it to only one sediment triggered HFE during that time period.

5. This adjusts the LTEMP protocols to function in 'lower water conditions' as suggested by Secretary's Designee in the August AWMG meeting and would allow compliance with the GCPA in these conditions.

For Reclamation and other partners, we believe these additions would have these benefits:

1. This allows for NOT conducting fall HFE planning nor Mar-Apr spring HFE planning in low water years (less than 3550' and release < 7.0 maf). This would save the time and effort for Reclamation staff, GCMRC researchers and the States' technical staff. In addition, it would formally acknowledge that when the Lake Powell reservoir is lower (as defined above), it may be impractical to conduct HFEs in the standard LTEMP timeframe (when reservoir level is that low and lacking the volume and elevation during those time windows).
2. In low water years, it sets up a way to get sediment 'credit' for SMB flow spikes in most years (when sediment triggers are reached), meaning only one type of bypass flow rather than two, resulting in accomplishing two goals in one action.
3. For higher elevation or higher release years, it would maintain all types of HFEs allowed in the LTEMP protocol but limit it to one sediment triggered HFE on a 1-year accounting period. This could lead to decisions to forgo a fall HFE and increase the frequency of spring HFEs; however, that could offer benefits to other aquatic resources since this is the natural timing for peak flows in this system.

Intersections with other Planning Processes
The Reclamation 2007 Interim Guidelines SEIS will interact with and influence this EA because the process would determine dam releases with respect to inflows and is likely to set a protected minimum operating range for Lake Powell elevations. If the protection elevation is set lower, for example to 3500', it would greatly increase fish passthrough and increase river temperatures. It would greatly increase the chances of SMB establishment in the Grand Canyon and result in detrimental impacts to the humpback chub population from predation, unless the bypass operations contemplated in this EA were used frequently. If the protection elevation in the SEIS is set higher, for instance above 3540', the likelihood of SMB passthrough and temperature related issues is greatly reduced and may reduce the need for bypass alternatives. This intersection should not be ignored because the lower the protection elevation, the more conflict appears between power needs and environmental impacts in this part of the system. If protection elevation is set higher, such as over 3540' (if that is possible – we know it is below that now, but expect it would be above that in June and could potentially be maintained above that depending on the inflow spring of 2023 if the new SEIS adjusted outflows), there would be better protection of both hydropower for the western grid, environmental impacts and the native and federally listed fish in the Grand Canyon.

To the extent possible while meeting other water delivery mandates, protecting higher lake elevations would also allow for HFEs for continued protection of beaches, sandbars, cultural resources and river recreation in the Grand Canyon. Based on the information available at this time, operating the dam in this range would comply with the GCPA 1802a mandates and reduce conflicts in this part of the system, if it could be done while still meeting GCPA 1802b requirements.

Thank you for the opportunity to comment on this important and expedited process. We want to ensure full consideration of the impacts within the National Park units in this EA. We look forward to sharing available data and working closely with you as soon as possible on the modeling that can be performed on this timeline and ensure utilization of the best available scientific information from the GCMRC.

Please contact Rob Billerbeck, NPS Colorado River Program Coordinator, at 303-987-6789 or rob_p_billerbeck@nps.gov if you have any questions on these comments or wish to discuss them further.

Edward Keable, Superintendent, Grand Canyon NP
Michelle Kerns, Superintendent, Glen Canyon NRA
National Park Service serving Department of Interior Regions 6, 7, & 8

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To: Sarah Bucklin
sbucklin@usbr.gov
Bureau of Reclamation

Re: Grand Canyon River Guides' Stakeholder Comments re: Small Mouth Bass EA

Date: December 14, 2022

Dear Ms. Bucklin,

Grand Canyon River Guides would like to submit the following comments and suggestions regarding the upcoming Glen Canyon Dam Smallmouth Bass Environmental Assessment being prepared by the Bureau of Reclamation (BOR). We understand that the BOR needs to respond to the threat of Smallmouth Bass (SMB) establishment below Glen Canyon Dam. The BOR's purpose is to identify methods to prevent this from happening by proposing multiple release (flow) options from the dam that cool the river below 16 degrees Celsius and introduce unfavorable flow velocities for SMB spawning.

Additionally the purpose of this EA is to respond to a directive from the Secretary's designee that requests the BOR identify operational alternatives, some of which may not be within the scope of the LTEMP Record of Decision, that inhibit SMB establishment while minimizing potential adverse effects to other resources. The BOR hopes to make a decision in time for implementation in late spring/early summer 2023. The directive continues to request that *'this NEPA analysis must not become a vehicle for addressing the range of concerns about the LTEMP FEIS and ROD but should rather give us possible tools that we can implement in a timely manner to address the non-native fish challenges we are currently facing.'*

The four alternatives being analyzed are:

- Option A: Cool Mix
- Option B: Cool Mix with Flow Spikes

- Option C: Cold Shock
- Option D: Cold Shock with Flow Spikes

Grand Canyon River Guides believes that the EA should analyze the following issues:

- How will the different flow alternatives impact recreation? In particular we would like to understand how the different options would impact river trips when the flows would be implemented and what metrics will be used to assess and compare alternatives in terms of impacts to river recreation. Relevant data that should be considered are the scheduled commercial and private river trip launch dates for 2023.
- How will the flow alternatives affect the sediment balance in the river and the potential to conduct spring and fall HFEs? How are they considering the LTEMP's sediment accounting periods?
- What is more effective in preventing SMB establishment – low water temperature or flow velocity?
- Do the flow alternatives satisfy the BOR's Section 10 responsibilities to species listed under the Endangered Species Act?
- What other flow alternatives were considered that prevent the establishment of SMB and why were they dismissed?
- Given that an EA cannot result in any significant impacts, what thresholds will be used to assess the severity of impacts to sediment and recreation?

Grand Canyon River Guides is deeply concerned that Flow Options B and D (the 2 spike flow alternatives) could be extremely detrimental to sediment, resulting in substantial erosion of the sand that has accumulated in the channel from the Paria River over the last two seasons, and precluding the opportunity to conduct an HFE in 2023. The EA should consider a flow option with a larger magnitude (single) spike flow timed to disrupt SMB spawning while simultaneously being potentially beneficial for sediment. Please refer to recent HFE optimization modeling conducted by Grand Canyon Monitoring and Research Center (specifically Paul Grams' September 1, 2022 presentation, Scenario C).

Moreover, what supporting evidence suggests that multiple spike flows are necessary? A single flow above 40,000 CFS may be more beneficial than multiple flows at 30,000 CFS. Additionally, as you consider how to lessen impacts to hydropower, please consider that less water would be going through the bypass tubes with a single 40,000 cfs spike than with multiple 30,000 cfs spikes.

Finally, if reduced water temperatures are shown to be more effective than higher velocities, then the EA should consider an alternative that focuses on reducing water temperatures below 13 degrees Celsius. The EA should consider sustained flows with reduced water temperatures that may be more effective at inhibiting SMB establishment while not adversely affecting sediment resources.

Respectfully,

Lynn Hamilton, Executive Director, David Brown, AMWG Member, and Ben Reeder, TWG Member

December 15, 2022

Recreational Fishing Comments
on the Glen Canyon Dam/Smallmouth Bass Environmental Assessment

As the AMWG Recreational Fishing Representative in the Glen Canyon Dam Adaptive Management Program, I appreciate the attention given to this threat to the river system and the efforts by BOR, GCMRC and the SMBAHG to offer and consider strategies to address the problem.

While the request is to comment specifically on the flow options being considered under the EA, it is imperative that the response to warm-water invasive species is not dependent entirely on flow manipulation, but rather the plan must be multi-faceted. Given the likely conditions that we are projected to face within the river system for perhaps the foreseeable future, the plan must include a commitment to continue all of these interventions for an extended period of time, or until the efforts prove hopeless due to continuing worsening conditions.

These other strategies should include, but not be limited to:

- Ongoing, expanded monitoring of the extent of warm-water invasive species in the entire river system.
    - This should continue to include sampling in the Lees Ferry reach and in particular, areas in that reach that are more prone to harbor these species.
    - Sampling in the LCR area specifically to gauge impact as quickly as possible.
    - Sampling in and around all other warm water tributaries farther downstream that could become refuges for these species.
    - Continue to monitor the effectiveness of the Pearce Ferry rapid as a deterrent to upstream movement of warm-water invasive species.
- Sound data collection and analysis to determine the effectiveness of mechanical removal as a deterrent in the expansion of these species in these different locations and have that inform future actions.
    - The use of mechanical removal as the primary tool is unlikely to have any significant impact on addressing the problem. It should only be employed if there is confidence in its effectiveness as a tool, and genuine commitment to employ other key strategies including the strategies being considered as part of this EA.
- Efforts to limit the movement of warm-water invasive species from Lake Powell through Glen Canyon Dam and movement of these species upstream from Lake Mead in the event that conditions change at Pearce Ferry Rapid or if flow manipulations from Glen Canyon Dam cause that barrier to become less effective.
- Actions to increase colder water flow through that area should be considered if the sloughs downstream from the Glen Canyon Dam are found to be a major contributor to the problem.
- Development of plans and the capacity to immediately implement those plans as threats farther downstream, nearer to the native species that are threatened by this invasion, become apparent.
    - What measures are being readied to be implemented in and around the LCR?
    - What measures are being implemented to keep warm-water downstream tributaries from becoming sanctuaries for these species?
- Continued education and pressure to reduce the use of water in the system so that the lakes can return to levels that allow for deeper, colder water that protect the river system from these warm-water invasive threats and allows for more effective use of the dams for power generation.

With regard to the specific flow options being considered as part of the EA, the caveat on PowerPoint slide 29 of the presentation “Success of any of these options depends on available hydrology” is crucial to any decision. The availability of cold water and sufficient lake level capacity to allow for flow spikes, and the willingness to sacrifice power generation capabilities and water delivery at times that might be different than power or downstream users would prefer, is all part of the considerations that must be agreed to if this threat is to be managed effectively.

Of the options presented in the EA, Option B seems to offer the highest probability of success in reducing the threat with Option A as the second best option.

Thank you for the opportunity to provide comment on this EA.

Jim Strogen

Jim Strogen
Glen Canyon Dam Adaptive Management Program
AMWG Recreational Fishing Representative

USFWS Comments In Response to USBR Stakeholder Meeting and Request for Stakeholder Input on Glen Canyon Dam/Smallmouth Bass Environmental Assessment

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Hello Sarah,

On behalf of the U. S. Fish and Wildlife Service (USFWS), we thank the U.S. Bureau of Reclamation (USBR) for holding a virtual information session on December 1, 2022, to describe its plans to move forward with an Environmental Assessment (EA) to develop operational alternatives that could help prevent the establishment of Smallmouth Bass (SMB) and other invasive warmwater fish. Given the recent concern regarding the presence and reproduction of SMB in the Lee's Ferry reach below Glen Canyon Dam (GCD), USBR worked with partners to identify four options for GCD release flows that could potentially disadvantage SMB establishment. The USFWS is providing feedback regarding our agency's perspectives on these potential plans to address this important issue herein. We acknowledge the changing conditions in the Colorado River below GCD. Specifically, the water being released from Lake Powell is much warmer that preceding years and that this pattern is associated with the entrainment and increased potential for establishment of warm-water species such as SMB below GCD. Below are three critical pieces of information for your consideration as you plan for this process in the coming year.

The USFWS sees this action as a necessary one given the current circumstance. The threat presented to the federally threatened Humpback Chub (HBC; *Gila cypha*) by SMB comes in the form of direct predation as documented within the Colorado River Basin upstream (USFWS 2018). Recent expansion of SMB in the Yampa River and elsewhere in the upper Colorado River basin poses a significant threat to small-bodied fishes throughout the system (Johnson et al. 2008) including HBC. Recent modeling by the Grand Canyon Monitoring and Research Center has predicted positive population growth of SMB in Glen, Marble and Grand canyons in the coming years (Yackulic and Eppehimer 2022). The USFWS thinks effects to HBC in the Grand Canyon are likely to be appreciable if SMB become established below Glen Canyon Dam. Establishment and expansion of invasive predators in the Grand Canyon represents a threat to HBC and has been established as one of the key monitoring metrics of recent compliance documents (e.g.. the Biological Opinion for the Long-term Experiment Management Plan (LTEMP) for Glen Canyon Dam [USFWS 2016]).

While the USFWS will review the EA in depth when it is released, we agree based on the information provided to this point that the proposed flow actions are likely to be effective. Stakeholders and scientists assessed and deliberated on how to respond to the increased and potential establishment of SMB for nearly a year though the forums of the Glen Canyon Dam Adaptive Management Program. The proposed flow actions represent the most likely effective options for preventing establishment of SMB below GCD and down to the Little Colorado River confluence. Therefore, these flow options are likely the best options for limiting the effects of SMB to HBC and other native fishes in Grand Canyon. These proposed actions are time sensitive and should be available to implement in late spring/early summer 2023 or their success will likely be limited.

Additionally, in the EA, the USFWS strongly suggests that USBR plan for flexibility among action alternatives. Adaptive management is the guiding principle of the LTEMP and this EA would tier to the LTEMP Environmental Impact Statement. To adequately apply adaptive management, it is necessary to understand if actions are being effectively applied. This helps establish if this or other actions may be warranted, and thus we recommend USBR monitor the success of this effort from the start. Whether this monitoring is done through agreements with USGS, NPS, or by USBR we have some specific requests regarding how it could be most effectively applied. Monitoring both biological and physical resource (water temperature, flow, etc.) responses to the operational alternatives would provide valuable information for the partners in deciding on how to continue addressing this ensuing problem. Moreover, there is a range of potential success for the proposed alternatives. As such, we recommend that the targeted EA provide for flexibility to move from one alternative to another if it is found that the action undertaken is not having the intended effect of preventing SMB establishment; assuming there is an alternative action that has increased likelihood of success based on monitoring assessments following the evaluation.

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Yackulic, C. B. and D. Eppehimer. 2022. Operational alternatives to address warmwater invasives. Presentation to the Glen Canyon Dam Adaptive Management Program.

Thank you,
Heather

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Department of Energy
Western Area Power Administration
Colorado River Storage Project
1800 South Rio Grande Avenue
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December 15, 2022

SENT ELECTRONICALLY

Sarah Bucklin
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Dear Ms. Bucklin:

Western Area Power Administration (WAPA) is providing the following input for the draft Environmental Assessment (EA) for Glen Canyon Dam as described in the December 1 stakeholder update. We applaud the Bureau of Reclamation (Reclamation) for preparing this National Environmental Policy Act (NEPA) assessment, analyzing the possible impacts, and involving various Glen Canyon Dam Adaptive Management Program (GCDAMP) stakeholders.

As stated in our pre-scoping letters dated October 26 and November 18, 2022, we offer our assistance in evaluating the hydropower impacts for the EA. WAPA has the technical expertise, data, and models to estimate electrical power impacts using the best available scientific information. Staff in WAPA's Colorado River Storage Project (CRSP) office have contributed to several of Reclamation's EAs and Environmental Impact Statements regarding the operation of CRSP dams. In addition, national laboratories have assisted WAPA in developing data and models that will be of assistance to Reclamation in preparing this EA. These projects are underway, and we appreciate the collaboration with Reclamation.

Reclamation's schedule for this EA is ambitious considering the number of resources and impacts that will need to be described. The purpose of this letter is to offer Reclamation feedback on the draft alternatives and identify areas of analysis that must be done for the hydropower section of the EA.

Electrical Hydropower Power Resources Potentially Impacted by the Federal Action

With the continued drought and low elevations at Lake Powell, we continue to be very concerned about the status of the Basin Fund and our ability to absorb impacts from experimental releases at Glen Canyon Dam. The Action Alternative being discussed may be of a scale that exceeds WAPA's ability to locate and purchase replacement electrical energy. If significant hydropower impacts are identified, we need to work together to find ways to mitigate those impacts with appropriations or from some other Reclamation funding source.

We have listed here, the hydropower resources potentially impacted by Reclamation's Proposed Action. Each needs to be evaluated to determine if impacts exist and if so, whether the impacts could be significant.

<u>Replacement power - availability</u>: The electric industry is experiencing a period of great change. The introduction of intermittent resources coupled with the closure of traditional sources of electrical generation have reduced the availability of energy throughout the west. WAPA is currently experiencing difficulty in purchasing even modest amounts of energy on the market. WAPA does not know if replacement electrical power is available for the Flow Options that require water bypass and thus reduce energy production as part of the experiment.

On August 18, 2022, Glen Canyon Dam (GCD) produced almost 500 megawatts (MW) of clean, renewable energy during the hours of the afternoon peak. Simply put, if WAPA or its customers have to replace that energy, we do not believe replacement power will be available during peak summer months in 2023 at any price. This may result in impacts to the electrical grid and may, in the most severe cases result in customers losing power. This will most likely occur during episodes of high heat. An analysis must be completed to determine if replacement energy is available and if so identify if sources are from renewable sources or from fossil-fuel generation.

<u>Replacement power - cost</u>: There is considerable uncertainty in power costs for the summer of 2023. If GCD generation is reduced and replacement power is available, it will be costly. When generation at GCD is reduced, WAPA or its customers must replace that energy from alternate resources. That replacement energy is becoming extremely difficult to find and exponentially more expensive. For example, in January of 2023, where prices are historically $30 to $50 per megawatt, those prices have increased to $250 to $300 per megawatt. Summer prices are generally much more expensive than those prices in January. We are of the belief that WAPA cannot absorb those costs for a prolonged period of time without significantly impacting its ability to fund its requirements for CRSP operations and maintenance for both WAPA and Reclamation's programs.

<u>Basin Fund</u>: As mentioned above, WAPA must purchase replacement power up to the allocated amounts determined in our customer's contracts and rate. The EA will need to assess the impact these purchases might have on the CRSP Basin Fund and how a reduction in available funds might present risks to CRSP operations and maintenance.

<u>Transmission</u>: The transmission system was designed with generation at GCD as an integral component of the grid. It is unknown if the transmission system can accommodate the potentially significant change in energy and direction if generation at GCD is reduced to accommodate the Proposed Action. Reduced generation at GCD may result in transmission congestion, exceedance of transmission capacity limits and/or load shedding (i.e., blackouts).

<u>Regulation, reserves, and emergency operations</u>: WAPA has an obligation to supply regulation services, maintain reserve generation capabilities, and assist in emergency operations. These services are required to have a reliable electrical system. Historically, CRSP has relied on

GCD to provide these services. The CRSP units also provide ancillary electrical services such as voltage control, black start services, and emergency generation for neighboring entities such as the California Independent System Operator (ISO). Evaluating the possible impact of the Proposed Action on the reliability of the electrical system, and making accommodations for them, is an essential and required component of this EA.

WAPA's Current Plan to Provide the Analyses Necessary to Identify Hydropower Impacts

WAPA has engaged the National Renewable Energy Laboratory (NREL) and Argonne National Laboratory (Argonne) to analyze the impacts the Proposed Action may have on the hydropower resources we have listed above. Using models recently configured for WAPA for a similar study, NREL, Argonne, and WAPA have begun the analyses Reclamation will need for the EA. We have simplified data requirements and methods so that the analyses will be completed by Reclamation's target date and will make time for Reclamation to understand and review the analyses. We are willing to include Reclamation technical staff in this process to increase Reclamation's involvement and understanding of the analysis.

General Comments

The Need statement for the EA is long, complex, and incomplete. The Need statement should reflect the Secretary's Designee's direction to "develop 2-4 operational alternatives that could help prevent cool- and warmwater invasive fish establishment, *while minimizing potential adverse effects to other resources*." The Secretary's Designee has also stated he envisions disturbance flows that are like the experimental SMB spike flows from Flaming Gorge which were developed in a way to minimize hydropower impacts. However, the Need statement does not describe how the Proposed Action was developed while minimizing potential adverse impacts to other resources. During the development of the Flow Options, WAPA worked with GCRMC to include at least one flow option that did not include bypass to minimize potential adverse impacts to the hydropower resource. This flow option, then called "Alternative 2", included a short weekly release of 2,000 cubic feet per second (cfs) followed by a short flow spike to maximum generator capacity to disadvantage and disrupt smallmouth bass spawning. The proposed hydrograph was much like the one used in the Upper Basin in their experimental effort to reduce smallmouth bass spawning below Flaming Gorge. This flow option was omitted from the Proposed Action and replaced with another flow option that would substantially increase impacts to hydropower. Dropping this "Alternative 2" and including only flow options with bypass leaves Reclamation and the GCDAMP in a possible scenario where we may not be able to implement an action due to the potential impacts to the hydropower resource. A within powerplant low flow/flow spike, which may have the capability of reducing the likelihood of smallmouth bass establishing below the dam, would be a beneficial option to consider in the EA as it likely would not have a substantial negative impact on hydropower.

Other considerations include:

- The geographic scope for the EA should be clearly stated in the Purpose and Need and it should include the Colorado River mainstem and its perennial tributaries in Grand

Canyon down to Pierce Ferry. The EA should clearly state that reducing release temperatures with bypass might only reduce smallmouth bass establishment in the 72 miles of river between Glen Canyon Dam and the Little Colorado River (LCR) and might do little to help prevent establishment in the over 210 miles of river between the LCR and Lake Mead. Smallmouth bass establishment in western Grand Canyon would be detrimental humpback chub and put translocation efforts in Bright Angel and Havasu Creeks and the new western Grand Canyon aggregation at risk.

- We ask Reclamation to include at least one flow option that does not include the use of bypass but utilizes a daily fluctuation between 2,000 cfs and the maximum powerplant release (~18,600 cfs) to disadvantage and disrupt smallmouth bass spawning. This flow option would meet the Secretary's Designee's direction to minimize potential adverse effects to other resources like the hydropower resource while still providing an operation that would help prevent cool- and warmwater invasive fish establishment below Glen Canyon Dam. A description of this flow option was provided in our November 18 letter to Reclamation.

- We disagree with the assessment by GCMRC that higher daily flow fluctuations would not help prevent smallmouth bass establishment below Glen Canyon Dam. From the initial filling of Lake Powell to the early 1990's, pre-Record of Decision (ROD) flow fluctuations limited rainbow trout reproduction to the point that the fishery had to be sustained through stocking. The scientific literature suggests that smallmouth bass are more sensitive to flow fluctuations than rainbow trout (please see the USFWS Smallmouth Bass Habitat Suitability Index Model at https://apps.dtic.mil/sti/pdfs/ADA323294.pdf and compare with the Rainbow Trout Habitat Suitability Index Model at https://usace.contentdm.oclc.org/digital/api/collection/p16021coll7/id/654/download).

  This would suggest that daily flow fluctuations like those used during the pre-ROD period could help prevent establishment of smallmouth bass in the tailwater and, since daily fluctuation waves travel all the way through the Grand Canyon to Lake Mead, they may be more effective at preventing establishment of smallmouth bass in the Grand Canyon than trying to reduce release temperatures with bypass. Fluctuating flows, including minimum flows outside the ROD restrictions, should not be discounted, or dismissed as being potentially effective in helping to prevent smallmouth bass establishment until they are tested.

- Considering recent increases in entrainment of smallmouth bass through the dam, the level of uncertainty as to whether flow fluctuations might help prevent the establishment of smallmouth bass is as high as the level of uncertainty of using bypass to cool release temperatures. Both hypotheses deserve testing, and consideration must be taken to reduce potential adverse effects to other resources as directed by the Secretary's Designee. We would suggest testing the flow fluctuation hypothesis first in 2023, and if that does not yield desired results, then consider testing the bypass hypothesis in 2024, which our preliminary analyses show may have substantial hydropower impacts.

- The Secretary's Designee Directive on slide 15 of the stakeholder presentation of December 1, 2022, indicates that flow options like the one outlined above could be included in this EA but the "Considerations/Regulatory Constraint Considerations in Model" on slide 20 appears to limit flow options to within existing ROD operations for ramp rates and minimum releases. Why was the determination made to deviate from the Directive and limit the scope of flow options to those within ROD ramp rates and minimum releases? Please reconsider these limitations for these experimental flow options.

- The EA should provide an assessment of whether reducing release temperatures to ~14 degrees C in order to target a water temperature no greater than 16 degrees C at the LCR will completely eliminate spawning between Glen Canyon Dam and the LCR, including in the -12-mile slough and other off channel habitats. We have found references in the published literature that indicate that smallmouth bass spawning occurs in water temperatures as low as 12 degrees C (please see the USFWS Smallmouth Bass Habitat Suitability Index Model at https://apps.dtic.mil/sti/pdfs/ADA323294.pdf). We are concerned that the temperature target developed by GCMRC for the Action Alternative is too high to completely eliminate spawning, especially in the sloughs and other off-channel habitats between the dam and the LCR. Water has been found to warm in these habitats during the timeframe when smallmouth bass are likely spawning by as much as +4 degrees C during normal operations and by as much as +12 degrees C during steady flow experiments, (see slide 4 at https://www.usbr.gov/uc/progact/amp/twg/2022-10-13-twg-meeting/20221013-UpdateNon-nativeFishGlenCanyonReachBelowGlenCanyonDam-508-UCRO.pdf). Smallmouth bass are also more likely to use these off-channel habitats for spawning than habitats in the main channel. Flow Options C and D would mimic past steady flow options and would likely result in considerable warming in habitats like the -12 mile slough even though the main channel would remain cooler. Continued entrainment through the dam combined with the availability of warm off-channel habitats like the -12 mile slough will likely be a more important driver of smallmouth bass establishment than trying to keep water temperatures below 16 degrees C at the LCR. This is because off-channel habitats like the -12-mile slough will continue to warm above this 16 degree C smallmouth bass spawning threshold even if mainstem water temperatures are kept at between ~14 degree C and 16 degree C between the dam and the LCR.

- The EA should evaluate how flow fluctuations propagate down into western Grand Canyon and whether a flow fluctuation option might better prevent smallmouth bass establishment in western Grand Canyon than a flow option trying to reduce release temperatures. Flow fluctuations tend to persist all the way through the canyon and are affected primarily by river geomorphology and not distance from the dam like water temperature. In other words, fluctuating flows are likely to be a more effective tool at disadvantaging and disrupting smallmouth bass spawning below the LCR than manipulating release temperature.

- The flow options developed for this EA should be evaluated using a widely accepted, peer-reviewed, and published model.

- Reclamation should assess whether the flow spikes in Flow Options B and D might lead to the dispersal of green sunfish or other invasive species into Marble and Grand Canyons. We have heard repeatedly from GCMRC scientists on the concern for green sunfish, their continued increase in abundance in Glen Canyon, and their propensity to disperse during spring and summer flood events.

- The Flaming Gorge smallmouth bass flow spike experiment is more focused on reducing smallmouth bass habitat suitability through increasing flow fluctuations than by reducing temperature during the spawning season. Releases from Flaming Gorge change 5.4-fold (from 890 cfs to 4,800 cfs) during this experiment. We ask that Reclamation review the objectives and protocols for the Flaming Gorge smallmouth bass flow spike experiment and determine if a 9.3-fold change in releases from Glen Canyon Dam (from 2,000 cfs to the maximum powerplant release of ~18,600 cfs) would similarly disrupt spawning and help prevent establishment below Glen Canyon Dam. We also ask that Reclamation include an assessment whether a rapid decrease in flow would be more impactful to smallmouth bass spawning than a rapid increase in flow (please see the USFWS Smallmouth Bass Habitat Suitability Index Model at https://apps.dtic.mil/sti/pdfs/ADA323294.pdf).

We continue to be concerned about the status of the Basin Fund and our ability to absorb impacts from experimental releases at Glen Canyon Dam, as well as the availability of replacement power to offset lost hydropower generation. The Basin Fund is currently being supported with appropriated dollars and we continue to defer scheduled maintenance to maintain an adequate balance, as well as modify our deliveries to customers. The additional impacts of the Action Alternative to generation and transmission, the Basin Fund, and our customers, especially those utilities supporting underserved and disadvantaged rural and tribal communities, concern us very much. Based on our initial review of the Action Alternative, each component appears to be on a scale that will substantially impact hydropower operations and may result in what we would consider a significant impact to WAPA or our customers. For example, our initial analysis of Flow Option A for summer 2023 resulted in a ~$60 million financial impact to WAPA. If significant hydropower impacts are identified, we will need to work together to find ways to mitigate those impacts with appropriations or from some other Reclamation funding source, or we may need to find some other operational release strategy that might help control smallmouth bass below the dam.

Sincerely.

BRIAN SADLER

Digitally signed by BRIAN SADLER
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Brian J. Sadler
Administrative and Technical Services Manager

GRAND CANYON WILDLANDS COUNCIL
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12/13/2022

Ms. Bucklin:

Grand Canyon Wildlands Council (GCWC) herein provides stakeholder comments on the Environmental Assessment for Glen Canyon Dam Operational Flexibilities "…to reduce the threat of warmwater invasives below Glen Canyon Dam". GCWC has participated as a GCDAMP stakeholder for the past two decades as an environmental voice, and we are intimately familiar with the environmental, cultural, and economic trade-offs of Glen Canyon Dam management on the Colorado River ecosystem (CRE) downstream. We thank Reclamation staff for recognizing the need for NEPA assessment and inviting commentary from Glen Canyon Dam Adaptive Management Program (GCDAMP) stakeholders. Recent increases in non-native smallmouth bass (SMB), Green sunfish, brown trout, and other species in the Glen Canyon Dam tailwaters, as well as non-native invasive aquatic mollusks and fish diseases constitute critical threats to the CRE and its native species.

We note that the title and stated purpose of this document does not restrict the effort to non-native fish, but to "nonnative invasives", which could include aquatic and wetland non-native plants, macroinvertebrates (e.g., quagga mussel, New Zealand mudsnail, and two or more species of crayfish), nearly 20 species of exotic warmwater fish, and one salamander. If this is not the intent of this document (which is perhaps more clearly stated in the Background), then the title and the Purpose should be changed to make it more specific.

While we recognize the need for this EA to focus on operational alternatives/actions to disadvantage specific non-native invasive species, we remain concerned that primary focus on SMB in the forebay and Glen Canyon reach tailwaters may have unintended consequences related to other natural resources, as well as to other nonnative invasive species that also pose severe threats to the downstream river (e.g., other non-native fish, several non-native invertebrate taxa, etc.). Unintended consequences can lead to exacerbating threats to native species and natural CRE processes, greater costs to remediation and monitoring, and potentially limiting future management options. Therefore, it is important to carefully evaluate potential negative effects of alternatives, and develop robust contingency plans to cope with issues that arise unexpectedly from the pursuit of the desired alternative. There may be unexpected interaction effects among the various treatment options, requiring careful consideration including assessment in this EA and in the field during implementation.

Given its stated objective, this environmental assessment (EA) includes four overarching alternatives: 1) no change in management, 2) Glen Canyon Dam discharge management ("flow-only") options; 3) non-discharge-related ("non-flow") management options; and 4) combined flow and non-flow options. *Status quo* management (Alternative 1) stands to critically threaten the native fish the Adaptive Management Program (AMP) has worked so hard to protect over the past four decades. However, each of the other alternatives are likely to involve a mixture of treatments, with magnitude, frequency, duration, and timing subject to monitoring the success of the action. All alternatives will require monitoring and feedback to improve management in perpetuity. While the emphasis in this document is on flow-related options (Alternative 2), achieving the goal of preventing establishment of non-native SMB and other fish in the CRE almost assuredly will require both flow and non-flow actions. Thus, of these four overall alternatives, we support Alternative 4 to allow the greatest flexibility in the use of all available approaches and tools.

Attachment F of the SMB Strategic Plan provides a list of non-flow options, which deserve consideration in relation to the various flow options proposed by the Grand Canyon Monitoring and Research Center. We ranked the non-flow options based on simple numerical scoring of estimated cost, time, compliance, and implementation (low or short-term=1, medium = 2, high or long-term = 3) and simple summing of those scores (Table 1). Our analysis indicated that physical barrier screens, in-reservoir nets, floating barriers, turbine mortality, and electrofishing are all equally easy, cheap, short-term (emergency) options. If all are undertaken simultaneously, these may be the best collective strategy considered to reduce the likelihood of SMB establishment. The deeper water withdrawal and sorting facility options are intermediate management options, having higher cost or greater complexity, respectively. The lowest ranked long-term solutions are installation of an air bubble screen and/or an acoustic barrier, with greater management costs to the implementation of multi-stimulus, CO^2, and energy dissipation, and with electrical barrier as the most costly and difficult to implement option.

Table 1: Numerical scoring and summation of non-flow-related, non-native fish management options at Glen Canyon Dam.

Treatment	Cost	Time	Compli	Implem	Total Rank Score	Result
Physical Barrier Screens	1	1	1	1	4	Easy, cheap, short-term
In-Reservoir Net	1	1	1	1	4	Easy, cheap, short-term
Floating Barriers	1	1	1	1	4	Easy, cheap, short-term

Treatment	Cost	Time	Compli	Implem	Total Rank Score	Result
Turbine Mortality	1	1	1	1	4	Easy, cheap, short-term
Electrofishing	1	1	1	1	4	Easy, cheap, short-term
Deeper Water Withdrawal	3	1	1	1	6	Intermediate cost, time, medium time
Sorting Facility	2	2	1	2	7	Intermediate cost, time, medium time
Air Bubbles	2	2	2	4	10	More difficult & costly, long-term
Acoustic Barriers	3	2	1	4	10	More difficult & costly, long-term
Multi-Stimulus Barriers	3	2	2	4	11	More difficult & costly, long-term
Carbon Dioxide Barriers	3	2	2	4	11	More difficult & costly, long-term
Energy Dissipating Valve	3	2	2	4	11	More difficult & costly, long-term
Electrical Barriers	3	3	3	4	13	Difficult, expensive, long-term

Two options were not considered in the SMB Plan analysis. Rotenone treatment of the forebay and tailwaters could be accomplished at a moderate cost on a short-to-medium-term timeframe for which medium-high compliance would be needed, and would therefore have moderate implementation difficulty. This option would produce a maximum possible ranked score of “9”, placing its accomplishment difficulty between implementation of a sorting facility and construction of an air bubble net. Another unconsidered option would be propagation and release of a large number of mature, predatory Colorado River pikeminnow. This option would require low cost in a medium-to-long-term timeframe, with medium levels of compliance, and low implementation cost, leading to a maximum possible ranked score of “7”, tying it with implementation of a sorting facility. All options will require continued monitoring, likely in perpetuity. We also recommend that cost-analysis of the various flow options proposed by GCMRC should be included in this table as well.

Another category that should be added to each component of the alternatives in this EA is the level of uncertainty of its success. We encourage Reclamation to recognize and acknowledge that uncertainty is substantial in all of these management options. As such, 1) the most successful alternative is likely to be a combination of two or more options. 2) Also, contingency planning is also of paramount importance for consideration. If for some or several reasons the preferred alternative fails (whichever that is), cannot be accomplished due to unforeseen costs, complications, or resource (i.e., water supply) limitations, thoroughly considered "Plan B" and "Plan C" alternatives should also accompany this EA.

We note that threats of non-native fish invasion into the CRE in Glen and Grand canyons are multi-directional. The warmer river water temperatures also allow striped bass and other non-native fish to uprun the river from Lake Mead, and perhaps may allow other non-native species to invade through the Little Colorado River drainage. Therefore, we recommend that monitoring be conducted in the lower Colorado River and Little Colorado reaches as well.

Coupling treatments that control undesirable resource elements while benefiting desired natural resources, such as sandbar and beach habitats, is core to adaptive ecosystem management, and should play a strong role in prioritization of alternatives for this EA. It has repeatedly been shown that single-species management is ineffective as an ecosystem management approach due to the complexity of habitat X species X assemblage interactions. Therefore, we emphasize the importance of evaluating whole-system impacts of each alternative, and that the preferred alternative is designed to provide the greatest benefit to ecosystem and program integrity, such as prevention of SMB establishment along with other resource benefits, particularly those related to improvement or enhancement of habitat, such as sandbar rejuvenation.

The Scope of Work and following sections describe the duties of a contractor, without justifying how and why a contractor, rather than one or more of the participating AMP agencies is to conduct the work. With the detail included in the Project Management section, this makes the document appear to be more of a Request for Proposals that an EA. The list of tasks does not reassure us that consideration of alternatives will be integrated across the range of issues, potential consequences, and AMP priorities, not that the alternatives proposed will be sufficiently comprehensive to solve the problem. A rationale for this approach for the EA should at least be attempted in the document.

Non-native fish management has been and will continue to be an on-going challenge at Glen Canyon Dam, a challenge that requires well-trained and committed staff. We recommend that, rather than a simple "informed consent" approach to cultural compliance, Reclamation and the participating agencies develop a fisheries monitoring education program for Native American students. Such a program will build a future workforce that is technically capable, consonant with federal trust obligations, and would be a program that would directly benefit the Tribes.

We thank Reclamation for the opportunity to respond to this suite of ideas about how to prevent or reduce the threat of SMB invasion into the CRE, and we are available to answer any questions that Reclamation may have about these comments.

Appendix B

Socioeconomic Baseline Conditions

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Appendix B. Socioeconomic Baseline Conditions

This appendix provides a brief socioeconomic background for two regions of influence: Coconino County, Arizona, where the recreation analysis area (the Colorado River corridor from just below GCD downstream to the confluence of the Little Colorado River at RM 61) is located, and a seven-state region where power from the Glen Canyon Powerplant is marketed (Arizona, Colorado, Nebraska, Nevada, New Mexico, Utah, and Wyoming). Five standard measures of economic development are described in the following sections: population, income, total employment, employment by sector, and unemployment.

The affected environment related to environmental justice issues is Coconino County, Arizona, which corresponds to the area where most impacts on recreation would likely occur from changes in dam operations. A brief description is also included of the numbers and locations of tribal populations that are part of the Glen Canyon Adaptive Management Program.

COCONINO COUNTY, ARIZONA

Population

Table B-1 presents recent and projected populations in Coconino County and the state of Arizona as a whole. The 2020 population of Coconino County was 145,101. Coconino County is projected to grow 14.6 percent from 2020 to 2040, which is approximately half of the projected state growth, 29.3 percent, over the same period.

Table B-1: 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	157,773	161,771	16,670	14.6
Arizona	6,392,017	7,151,502	8,284,861	9,247,212	2,095,710	29.3

Source: US Census Bureau 2022a; Arizona Office of Economic Opportunity 2018

Income

Personal income in Coconino County was $8.3 billion in 2021 and grew at an annual average rate of 6.9 percent from 2010 to 2021 (**Table B-2**). Over the same period, personal income per capita in Coconino County rose at a rate of 5.8 percent, increasing from $34,717 to $56,914. Per capita incomes were slightly higher in Coconino County ($56,914) in 2021 than the state of Arizona average ($55,487).

Median household incomes (the income level at which half of all households earn more and half earn less) from 2016 to 2020 averaged $59,000 in Coconino County and $61,529 for Arizona (US Census Bureau 2020).

Table B-2: Income in the Recreational Expenditures Analysis Area

Location	2010	2021	Average Annual Growth Rate 2010–2021
Coconino County, Arizona			
Income (billions of 2020$)	4.7	8.3	6.9%
Per-capita income (2020$)	34,717	56,914	5.8%
Arizona			
Income (billions of 2020$)	216.9	403.7	7.8%
Per-capita income (2020$)	33,876	55,487	5.8%

Source: US Department of Commerce, Bureau of Economic Analysis 2022

Employment

In 2020, 55,308 people were employed in Coconino County, notably less than the total employment in 2012 (**Table B-3**). It should be noted that data presented in this discussion include annual averages for the most recent reporting periods. Data including the 2020 timeframe 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 which are still ongoing and not evenly distributed across industries. Growth rates between 2012 and 2020 in Coconino County (-2.2 percent) were much less than the average rate for Arizona (13.4 percent).

Table B-3: Employment in the Recreational Expenditures Analysis Area

Location	2012	2020	Average Annual Growth Rate 2012–2020
Coconino County, Arizona	67,052	55,308	-2.2%
Arizona	1,276,249	2,644,781	13.4%

Source: US Census Bureau 2022b

In 2021, the service sector provided the highest percentage of employment in Coconino County at 67.7 percent, followed by government (20.2 percent). Within the service section, accommodation and food services (16.2 percent) and health care and social assistance (11.4 percent) provided the highest percentages (**Table B-4**). Smaller employment shares were held by construction (4.8 percent) and manufacturing (4.3 percent). Coconino County had a higher percentage of employment in accommodation and food services and government than the state of Arizona as a whole (7.2 percent and 11.0 percent, respectively).

Table B-4: Employment by Industry, 2021

Industry	Coconino County		Arizona	
	Jobs	%	Jobs	%
Total Employment	84,555	—	4,055,932	—
Non-services- / government-related industries	10,220	12.1	509,941	12.6
Farm	2,117	2.5	29,309	0.7
Forestry and agriculture services	266	0.3	13,832	0.3
Mining	142	0.2	17,894	0.4
Construction	4,034	4.8	253,184	6.2
Manufacturing	3,661	4.3	195,722	4.8
Services-related industries	57,232	67.7	3,099,749	76.4
Utilities	196	0.2	12,720	0.3
Wholesale trade	1,204	1.4	115,142	2.8
Retail trade	8,669	10.3	413,565	10.2
Transportation and warehousing	2,384	2.8	224,294	5.5
Information	645	0.8	59,769	1.5
Finance and insurance	1,962	2.3	290,236	7.2
Real estate and rental and leasing	4,147	4.9	234,832	5.8
Professional and technical services	3,735	4.4	269,961	6.7
Management of companies	468	0.6	44,165	1.1
Administrative and waste services	2,626	3.1	313,831	7.7
Educational services	1,075	1.3	85,070	2.1
Health care and social assistance	9,627	11.4	459,980	11.3
Arts, entertainment, and recreation	3,083	3.7	81,541	2.0
Accommodation and food services	13,716	16.2	293,749	7.2
Other services	3,695	4.4	200,894	5.0
Government	17,103	20.2	446,242	11.0

Source: US Department of Commerce, Bureau of Economic Analysis 2022

Unemployment

Unemployment was lower in Coconino County (3.7 percent) than the rest of Arizona (3.9 percent) in 2021 (US Department of Labor, Bureau of Labor Statistics 2022a, 2022b).

The Seven-State Region of Influence

This section describes current socioeconomic conditions within the seven-state region (the area where electricity from GCD is marketed), including Arizona, Colorado, Nebraska, Nevada, New Mexico, Utah, and Wyoming.

Population

Total population in the seven-state region was 23.9 million in 2020, an increase from 21.3 million in 2010 (**Table B-5**). 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 B-5: 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
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**

Source: US Census Bureau 2022a; Arizona Office of Economic Opportunity 2018; 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 B-6**). Personal income grew at an annual average rate of 7.8 percent over the period from 2010 to 2021, with higher-than-average growth rates in Colorado (9.1 percent), Nevada (7.9 percent), and Utah (9.9 percent). Income per capita rose over the same period at a rate of 5.4 percent, increasing from $37,998 to $60,515. Per-capita incomes were higher in 2021 in Colorado ($70,706), Nebraska ($61,205), and Wyoming ($69,666) than the average for the region as a whole.

Median household incomes (the income level at which half of all households earn more and half earn less) over the period from 2016 to 2020 varied between $51,243 in New Mexico to $75,231 in Colorado (US Census Bureau 2020). Median household income in the United States was $64,994 over the same period.

Table B-6: 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%
New Mexico			
Income (billions of 2020$)	69.6	106.4	4.8%
Per-capita income (2020$)	33,710	50,311	4.5%

Location	2010	2021	Average Annual Growth Rate 2010–2021
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 (6.5 million) of all employment in the seven-state power marketing service territory (13.1 million) was concentrated in Arizona and Colorado (**Table B-7**). Employment was 401,871 in Wyoming, 1.1 million in New Mexico, 1.3 million in Nebraska, and 1.8 million in Nevada; the remaining states supported over 2 million jobs. Over the period 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 New Mexico (0.0 percent), Wyoming (0.2 percent), and Nebraska (0.5 percent) lower than the average rate of 5.0 percent.

Table B-7: 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

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) and health care and social assistance (11.2 percent) (**Table B-8**). 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 (4.0 percent) and Wyoming (3.5 percent) had a higher percentage of employment in agriculture than the region as a whole (1.3 percent), and these states have lower shares of employment in services compared with the region as whole. Service sector employment in Nevada (79.2 percent), Arizona (76.4 percent), and New Mexico (73.5 percent) is higher than in the region as a whole. Nebraska (7.8 percent), Utah (7.0 percent), and New Mexico (6.5 percent) have larger-than-average shares of manufacturing sector employment, while mining is a more significant employer in Wyoming (4.6 percent) than elsewhere in the region.

Table B-8: 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 ag 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
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

Industry	Arizona		Colorado		Nebraska		Nevada		New Mexico		Utah		Wyoming		Total	
	Jobs	%	Jobs	%	Jobs	%	Jobs	%	Jobs	%	Jobs	%	Jobs	%	Jobs	%
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

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) in 2022 (**Table B-9**).

Table B-9: 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 2022a

Appendix C

US Fish and Wildlife Service Letter

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United States Department of the Interior

Fish and Wildlife Service
Arizona Ecological Services Office
9828 North 31st Avenue, Suite C3
Phoenix, Arizona 85051
Telephone: (602) 242-0210 Fax: (602) 242-2513

In Reply Refer to:
AESO/SE/
02EAAZ00-2012-F-0059
02EAAZ00-2014-CPA-0029
02EAAZ00-2022-0063848 February 02, 2023

Memorandum

To: Regional Director, Bureau of Reclamation, Salt Lake City, Utah

From: Field Supervisor, Phoenix, AZ bbe1dac4-5e5c-4411-9d2d-4a77f49f5d22 Digitally signed by: bbe1dac4-5e5c-4411-9d2d-4a77f49f5d22 DN: CN = bbe1dac4-5e5c-4411-9d2d-4a77f49f5d22 Date: 2023.02.24 10:57:54 -07'00'

Subject: Response to Request for Agreement that Effects to Threatened and Endangered Species for Flow Options are Covered in LTEMP Biological Opinion

This letter responds to the Bureau of Reclamation's (Reclamation) December 2, 2022, memorandum requesting agreement from the U.S. Fish and Wildlife Service (Service) that Reclamation's proposed flow operational alternatives to disrupt spawning for smallmouth bass comply with the proposed actions identified in Reclamation's 2016 Long-Term Experimental and Management Plan (LTEMP) and the Service's biological opinion (BO) on LTEMP. In addition to your memorandum our offices were involved in periodic conversations and information sharing which is outlined below.

- October 4, 2022: Service and Reclamation staff held an informal meeting to discuss the four different flow options being considered and how they relate to Reclamation's current compliance. Reclamation provided an undated document named Brief Description of Alternatives (see Attachment 1). As described, the flow alternatives would use a combination of penstock and jet tube discharges and would be conducted when water temperatures approach 16˚C near the Lower Colorado River (LCR). In addition, Reclamation provided a document entitled Operational Alternatives to Address Warmwater Invasives (Attachment 2), which is a presentation from the United States Geological Survey (USGS) dated 8/18/2022.
- October 11, 2022: Reclamation provided all partners of the Glen Canyon Dam Adaptive Management Program (GCDAMP) the Project Management Plan for the Environmental Assessment (EA) of operational alternatives to disadvantage smallmouth bass. In addition, on that same day Reclamation provided the Service a Revised Description of Alternatives (Attachment 3).
- On December 1, 2022, Reclamation presented a summary of the proposed EA entitled Stakeholder Meeting, Virtual Information Session, Glen Canyon Dam/Smallmouth Bass Environmental Assessment (Attachment 4). This presentation also included a summary of the four flow options identified as Options A-D.

- December 2, 2022: Reclamation submitted a memorandum to the Service entitled "Request for Agreement that Effects to Threatened and Endangered Species for Flow Options Covered in LTEMP BiOp". Herein Reclamation stated that the effects to listed species from this flow are not different from those analyzed in the LTEMP.
- December 15, 2022: The Service submitted written comments to Reclamation in response to Reclamation's Stakeholder meeting. In that email, we stated that we see the action as necessary, the actions to be effective, and that we recommended Reclamation plan for flexibility among action alternatives.
- January 9, 2023: Reclamation shared an early version of the draft EA to the Service for review.

In your December 2, 2022, memorandum you expressed that Reclamation has been directed by the Secretary's Designee to the Adaptive Management Working Group (AMWG) to pursue flow options that will prevent establishment of smallmouth bass (SMB; *Micropterus dolomieu*) below Glen Canyon Dam. We recognize this directive as part of our mission and our representatives have been engaging with the AMWG's Technical Working Group, its subcommittee (Smallmouth Bass Ad-Hoc Group), and the National Park Services Rapid Response efforts below Glen Canyon Dam. The following letter intends to highlight a few critical pieces of information that we believe are necessary to describe in greater detail how we have come to our conclusion (see below Agreement section).

Occurrence of Smallmouth bass within the action area

On June 30, 2022, SMB young-of-year were discovered by the National Park Service (NPS) in the slough of the Glen Canyon reach of the Colorado River. The seasonal timing, size, and location of the SMB suggest spawning may have occurred upstream of Lees Ferry. As part of recurring fisheries research and monitoring efforts in this same reach, additional observations of SMB were made in the late summer and early fall 2022. In October 2022, a coordinated multiagency effort was undertaken to address the potential expansion of SMB in the Lees Ferry reach. These efforts were successful in identifying where SMB occurred at that period and 345 SMB were removed from this reach (L. Tennant *pers. comm.*). Concurrently, research trips by supported by Reclamation and conducted by Utah State University in July and October identified SMB in the forebay of Glen Canyon Dam.

The occurrence of SMB in the Glen Canyon reach of the Colorado River is of concern to the Service because SMB (and other predatory fish) pose a threat to federally listed fish species. Of particular concern is the threat of SMB populations to the federally threatened Humpback Chub ([HBC; *Gila cypha*]) and other native fish downstream of Glen Canyon Dam. Should SMB become established and spread downstream of Lees Ferry, they could pose a threat to the core populations of HBC in and around the Little Colorado River and its confluence with the mainstem. This threat has been observed in the Upper Colorado River basin and the Service and partners have gone to great lengths to protect native species through removal efforts of SMB.

Proposed action

To address the above issue, Reclamation has been directed to develop flow options at GCD to disrupt or prevent spawning of smallmouth bass and other invasive fish species that pass through the dam. Coordinated efforts were made to address this directive and the Service was grateful to be part of the planning effort. Reclamation is proposing to conduct any of four options to target SMB. Reclamation's draft EA (shared with the Service for review on January 9, 2023, [sixth timeline bullet]) stated that "...proposed flow options would be conducted within normal operations as specified within the LTEMP Final EIS". Reclamation has indicated that the proposed flow options are within the operations analyzed in the LTEMP BO (described in next section).

The proposed action (as described in the December 01, 2022, Stakeholder Meeting, Virtual Information Session, Glen Canyon Dam/Smallmouth Bass Environmental Assessment, and incorporated herein; see Attachment 4) identifies four flow options whose purpose is to: 1) disrupt or prevent smallmouth bass spawning and nest building behavior, and 2) prevent establishment of smallmouth bass until an exclusion device can be installed. The four flow options were identified as Options A-D and all options considered operational constraints of the action and determined assumptions about the flow model and the hydrograph (see Attachment 4).

Considerations for LTEMP BO

The proposed action was constructed to be implemented within the operational parameters identified in the LTEMP EIS and evaluated by the Service in the LTEMP BO, acknowledging the constraints and assumptions identified above. None of the four options lie outside of the base operating or HFE operating parameters evaluated in the LTEMP BO. The effects of this proposed action are also fully evaluated in the LTEMP BO (*pp.* 41-44, 46-47, 53-54, and 65-66). The effects of non-native fish passing through the penstocks to the river below the dam were also evaluated in the LTEMP BO (*pp.* 43). These conservation measures were developed to address the risk posed by SMB. Furthermore, the proposed action is expected to have a beneficial effect to HBC by disrupting SMB spawning and preventing the establishment of SMB populations in the river below the dam thereby minimizing predation threats to HBC.

Assumptions of the action

Reclamation's draft EA (shared with the Service for review) described a series of operations and constraints assumed for all four flow options (see Attachment 4). The constraints serve as the side boards to this activity and provide the Service with additional assurances that this action will be in the best interest of the native fish fauna of the Grand Canyon. Further Reclamation's team evaluated the effect of SMB occurrence in the forebay of Lake Powell and its relatedness to this activity with the following statement in the draft EA.

> *"Smallmouth bass are managed as a sport fish in Lake Powell, and there is a higher risk of entrainment through GCD whenever the epilimnion aligns with the dam's penstocks. Although this could happen during the flow options, smallmouth bass could also pass through GCD if no action is taken. During implementation of flow options, the velocity around the penstocks would increase, but smallmouth bass would be expected to outswim the intake velocities regardless of the flow (Webb 1998, Peake 2004). Smallmouth bass spawning typically occurs from May through July, and the forebay area does not include suitable habitat for spawning. This means that juvenile fish are unlikely to move up into the forebay area until they are larger."*

We appreciate Reclamation's consideration for this potential effect of this action. Further, we do not believe that this activity will result in further propagule pressure on the system because the intention is to bring colder water into the system, which should disrupt growth and spawning of SMB.

Consequences of not conducting this action

The Service endorses this action because the science indicates that the risk of SMB establishment is reduced through cold water discharges intended to disrupt their spawning. Under conditions where SMB or other warm water nonnative predatory species become established in the Grand Canyon the predation threats to HBC become greater. Specific conservation measures are outlined in the LTEMP BO that are intended to provide environmental conditions suitable ensure the continued existence of the HBC populations (inclusive of eradication of nonnative species). These conservation measures were designed to minimize or reduce the effects of the action or benefit or improve the status of HBC as part of the LTEMP. Thus, this action is entirely within what the LTEMP BO evaluated regarding compliance with the Endangered Species Act, Sec. 7 interagency consultation.

Agreement from the Service

We have reviewed the December 2, 2022, memorandum you submitted, considered multiple conversations between our office staff, and reviewed an early draft of the EA that Reclamation has drafted to address this need. We feel that we can conclude that Reclamation's plans are in accordance with the LTEMP BO. Further, we believe that this temperature control experiment will benefit HBC populations as opposed to taking no action.

Thank you for your continued coordination and commitment to conservation of threatened and endangered species. In all future correspondence on this project, please refer to the consultation number 2022-0063848. Should you require further assistance or if you have any questions, please contact Dan Leavitt, daniel_leavitt@fws.gov, of my office staff.

Cc: Project Leader, Arizona Fish and Wildlife Conservation Office (jess_newton@fws.gov)

Attachments:

(1) Brief Description of Alternatives (see October 4, 2022, timeline bullet)
(2) Operational alternatives to address warmwater invasives (see October 4, 2022, timeline bullet)
(3) Description of alternatives revised (see October 11, 2022, timeline bullet)
(4) Stakeholder Meeting, Virtual Information Session, Glen Canyon Dam/Smallmouth Bass Environmental Assessment (see December 01, 2022, timeline bullet)