Technical Appendix 14

Recreation

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Acronyms and Abbreviations

Acronym or Abbreviation	Full Phrase
2007 Final EIS	Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead Final EIS
2024 LTEMP Final SEIS	Glen Canyon Dam Long-Term Experimental and Management Plan Final Supplemental Environmental Impact Statement
°C	degrees Celsius
°F	degrees Fahrenheit
CCS	Continued Current Strategies
cfs	cubic feet per second
DMDU	Decision Making under Deep Uncertainty
EIS	environmental impact statement
FWS	United States Fish and Wildlife Service
GCNP	Grand Canyon National Park
LB Priority	Lower Basin Priority
LB Pro Rata	Lower Basin Pro Rata
LTEMP	Long-Term Experimental and Management Plan
NIB	Northerly International Boundary
NPS	National Park Service
NRA	National Recreation Area
NWR	National Wildlife Refuge
Reclamation	Bureau of Reclamation
RM	river mile
SEIS	supplemental environmental impact statement
SIB	Southerly International Boundary
UDOT	Utah Department of Transportation

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TA 14. Recreation

TA 14.1 Affected Environment

This Final Environmental Impact Statement (EIS) identifies and describes in detail the following key recreation resources or issues:

- Shoreline public use
- Reservoir boating
- River and whitewater boating
- Sportfishing

TA 14.1.1 Shoreline Public Use

The following sections describe shoreline public use associated with boating facilities (marinas, boat docks, and boat launch ramps), access to points of interest, and other opportunities within each Colorado River reach. Recreational boating in the study area depends on these major shoreline access points. While fluctuations in pool elevations are a normal aspect of dam operations, increased frequency or severity of these variations could result in changes in recreational facility operational costs and temporary closures. Below critical pool elevations and river flows, certain facilities may be rendered inoperable or require relocation to maintain operation.

Lake Powell and Glen Canyon Dam

Lake Powell is entirely within the Glen Canyon National Recreation Area (NRA), which receives approximately three to five million visitors each year (NPS 2025a). **Table TA 14-1** summarizes visitation to Glen Canyon NRA from 2019 through 2024.

Table TA 14-1
Glen Canyon NRA Recreational Visitors

Year	Recreational Visitors
2019	4,330,563
2020	2,553,392
2021	3,144,318
2022	2,842,776
2023	5,206,934
2024	4,725,610

Source: NPS 2025a

Table TA 14-2 summarizes the total number of recreational visits to Glen Canyon NRA by district for 2024, which is the most recent year for which data are available.

Table TA 14-2
Glen Canyon NRA Visits by District for 2024

District	Recreational Visitors
Wahweap District	1,612,518
Antelope Point District	532,202
Bullfrog District	101,627
Halls Crossing District	139,234
Hite District	261,725
Lees Ferry District	2,065,278
Horseshoe Bend District	831,631
Escalante District	13,029

Source: NPS 2025b

Lake Powell, with its many side canyons and related natural, cultural, and geological resources, is Glen Canyon NRA's primary recreational feature. Recreation that occurs at Lake Powell includes swimming and sunbathing, power boating, waterskiing, fishing, off-beach activities associated with boat trips (such as hiking and exploring archaeological sites), house boating, personal watercraft use, canoeing, kayaking, sailing, wildlife viewing, photography, sightseeing, and other activities. Visitors can enjoy a wide range of camping options, from remote and undeveloped campsites to fully developed campgrounds. Visitors can also see archaeologically and culturally important sites throughout Glen Canyon NRA.

Boating Facilities

Recreational boating is the most important recreational activity on Lake Powell, with nearly two million visitors accessing the reservoir by either private boat or rental (NPS 2025c). **Table TA 14-3** lists critical lake elevations for Lake Powell, identified by the National Park Service (NPS), below which certain marinas, boat docks, or boat launch ramps become inoperable. Water-based recreational facilities at Lake Powell include the marinas at Wahweap, Halls Crossing, Bullfrog, and Antelope Point. Declining water levels have rendered the Dangling Rope Marina inoperable since 2021; prior to its closure, it was the busiest gas station in Utah, despite lacking road access, because it served as the only refueling location in the middle of the lake. The Hite Launch Ramp has also been closed since 2012 due to the ramp being out of the water as a result of low reservoir levels (NPS 2025d).

Changes to the shoreline affect the usability of boat launch ramps throughout the year, especially in warmer months. Launch ramp closures due to declining water levels have resulted in longer lines, limited parking, and congestion at boat ramps and docks (NPS 2025d).

Table TA 14-3
Critical Elevations for Lake Powell by Boating Facility

Lake Elevation (feet)	Impact and Facility
3,700	Full pool
3,650	Hite Public Launch Ramp closed
3,588	Antelope Point Public Launch Ramp closed
3,583	Castle Rock Cut closed
3,578	Bullfrog Main Launch Ramp and Spur closed
3,565	Utah Department of Transportation (UDOT) Ferry and Launch Ramp closed
3,564	Wahweap Stateline Launch Ramp closed
3,556	Hall's Crossing Main Launch Ramp closed
3,550	Wahweap Main Launch Ramp closed; Rainbow Bridge National Monument closed
	Bullfrog Main Launch Ramp Spur closed
3,540	Antelope Point Business Ramp closed
3,529	Bullfrog North Launch Ramp closed
3,520	Wahweap Stateline Auxiliary Launch Ramp closed
3,515	Antelope Marina closed; Bullfrog Marina closed; Hall's Crossing Marina closed
3,430	Wahweap Boat Rental closed; Wahweap Boat Tour Dock closed

Source: Nicole Gibney, Assistant Colorado River Coordinator, NPS, personal communications, May 15, 2024

In 2022, the NPS received $26 million in Disaster Supplemental Funding to provide additional boating access at Lake Powell. Design work is underway for a north Lake Powell ramp that provides access down to an elevation of 3,450 feet in the Stanton Creek area near Bullfrog. The NPS is also working to develop schematic designs for the Antelope Point Public Ramp, Halls Crossing Public Ramp, and a primitive ramp and take-out area at the Hite Marina. The NPS continues to seek funding necessary for potential reconstruction. The NPS is also continuing to seek funds to replace the services previously offered at Dangling Rope Marina and for a navigable waterway congestion study in south Lake Powell (NPS 2023a).

State Route 276 runs through Glen Canyon NRA and crosses Lake Powell via the Charles Hall Ferry, which the UDOT operates. The ferry's southern port is at Hall's Crossing, and the northern port is at Bullfrog. The ferry does not operate if Lake Powell elevation levels drop below 3,565 feet (UDOT 2025).

Access to Points of Interest

Since 2021, the courtesy dock access to the Rainbow Bridge National Monument trail has been intermittently unavailable due to changes in the water level. When water levels fall below 3,544 feet, visitors have to leave boats and small vessels at the shoreline and traverse through mud, debris, sand, and water before reaching the established trail. While no longer connected to the shoreline, the Rainbow Bridge dock system is accessible with restroom facilities. The concessionaire-operated

tours to the monument are no longer able to access the area, thus removing access for most Glen Canyon NRA visitors. Visitors can also access Rainbow Bridge National Monument by obtaining a permit from the Navajo Nation Parks and Recreation Department to backpack for multiple days on Navajo Tribal lands from Navajo Mountain; however, this is not possible for many visitors (NPS 2021).

Harmful Algal Blooms

Warming water temperatures and increased inputs of nutrients from monsoonal storms create conditions that are more conducive to harmful algal bloom growth in freshwater bodies, also known as cyanobacterial blooms. Harmful algal blooms produce toxins that pose serious health risks to humans and animals (NPS 2019). Harmful algal blooms may necessitate temporary closures of water-based recreation to protect public health (Deemer et al. 2023). Water quality concerns are described in detail in **TA 6**, Water Quality.

Quagga Mussel Shells on Shorelines

Quagga mussels were first detected at Lake Powell in 2012. Quagga mussels have colonized practically all areas of the lake, as indicated by water sampling for veligers (NPS 2023b). Seasonally low water levels are now exposing mussel-encrusted shoreline. Sharp quagga mussel shells eventually wash up on beaches and can cut through skin, clothing, and pet paws (NPS 2016).

Hiking and Sightseeing in Glen Canyon

Declining water levels have exposed approximately 100,000 acres of Glen Canyon that were previously inundated by Lake Powell, creating new opportunities to view landscapes that have been underwater since the late 1960s (Baker 2022; Kolbert 2021). These include arches, side canyons, other rock formations, and lush desert ecosystems. This has created new hiking and sightseeing opportunities for Glen Canyon NRA visitors over the last several years. At the same time, these landscapes and archaeological sites are fragile, and exposure could result in their degradation and vandalism.

TA 14.1.2 Glen Canyon Dam to Lake Mead

The 15.5-mile river reach downstream of Glen Canyon Dam to Lees Ferry is within Glen Canyon NRA; it is used by anglers, campers, commercial float trip operators, kayakers, and other boaters. Fishing opportunities for rainbow and brown trout also occur downstream of this reach. In the last 5 years, warming water temperatures have made this reach more attractive for day and overnight use by paddleboarders, kayakers, and canoeists, resulting in increased visitation.

The NPS manages most of the reach, except where it is bordered on the east by the Navajo Indian Reservation and on the south by the Hualapai Indian Reservation. Grand Canyon National Park (GCNP) staff regulates visitor use of the Colorado River downstream of Lees Ferry in accordance with the Colorado River Management Plan (NPS 2006a, 2006b).

GCNP begins downstream of the Lees Ferry boat ramp at the confluence of the Colorado and Paria Rivers. Designated as a United Nations Educational, Scientific and Cultural Organization World Heritage Site in 1979, GCNP is valued for its superlative natural and cultural resources as well as its varied recreational experiences. Approximately 94 percent of GCNP (1,143,918 acres) qualifies as

wilderness, as described in the 1964 Wilderness Act (Public Law 88-577) and NPS Management Policies 2006 (NPS 2006b). This includes 10,919 acres of potential wilderness along the Colorado River corridor.

The Colorado River corridor borders tribal lands for nearly half the distance from the put-in at Lees Ferry to the last takeout at Pearce Ferry. The Navajo Indian Reservation borders GCNP along the eastern bank of the Colorado River from near Lees Ferry to the confluence with the Little Colorado River at river mile (RM) 61.8. The Hualapai Indian Reservation borders the river corridor for approximately 108 miles from upstream of National Canyon (RM 167) to approximately RM 274. The Hualapai Indian Reservation offers camping, fishing, hiking, and big game hunting. Tribal enterprises offer rafting trips on the Colorado River between Diamond Creek and Pearce Ferry. The NPS coordinates with tribal neighbors to address resource management and visitor use concerns along shared boundaries. Access permits from the Navajo Nation, Havasupai Tribe, or Hualapai Tribe are required by each respective tribe to access and recreate on tribal lands.

GCNP receives four to six million visitors each year (NPS 2025e). **Table TA 14-4** summarizes visitation to GCNP from 2019 to 2024.

Table TA 14-4
GCNP Recreational Visitors

Year	Recreational Visitors
2019	5,974,411
2020	2,897,098*
2021	4,532,677
2022	4,732,101
2023	4,733,705
2024	4,919,163

Source: NPS 2025e
*Park closure April–May due to the COVID-19 pandemic

The Lees Ferry to Diamond Creek reach has relatively low-use densities (attributed to the competitive lottery system) and low levels of development, providing opportunities for solitude on the Colorado River; this reach also offers many camps and attraction sites. This section of the Colorado River is where the majority of whitewater boating occurs. Takeouts are at Diamond Creek and Pearce Ferry. The reach downstream of Diamond Creek offers different recreational opportunities than the upstream reach, as it transitions to a more populated, developed setting. Whitewater boating trips become intermingled with very high levels of general boating and recreational use in the Quartermaster area (RM 260). **TA 16**, Socioeconomics, describes the social and economic importance of whitewater boating in the Grand Canyon.

Helicopter operations authorized by the Hualapai Tribe transport people into the Grand Canyon and connect them with motorized pontoon boats that give 20-minute tours of the Quartermaster area. These helicopters also fly out boaters who complete commercial motor day trips from Diamond Creek.

Boating Facilities

No boating facilities are within GCNP. Development along the Colorado River within the park is limited to the development at Phantom Ranch (RM 88) and Pipe Creek (RM 89.5). Other focal points include the launch ramp at Lees Ferry (within Glen Canyon NRA), the helipad near Whitmore Wash (RM 187) on the Hualapai Reservation, road access and minor structures operated by the Hualapai Tribe at Diamond Creek (RM 226), and the tourist area near Quartermaster Canyon (RM 260).

Camping between the Lees Ferry boat ramp and Lake Mead occurs in GCNP on undeveloped sandbars along the Colorado River. The number and usability of campsites diminish between depositional high-flow experiments, due to vegetation encroachment, sandbar erosion from hydropeaking operations, erosion from tributary flooding, aeolian sand remobilization, and recreational use.

Ongoing Glen Canyon Dam operations have resulted in encroachment of vegetation onto sandy beaches. One species that poses particular problems related to campsite encroachment is arrowweed (*Pluchea sericea*), a native shrub that can readily colonize open sandbars used as campsites. Further information on arrowweed and vegetation encroachment can be found in **TA 9**, Vegetation Including Special Status Species.

Sites can also be closed to protect sensitive resources (NPS 2006a). Further information on sedimentation and beach building can be found in **TA 5**, Geomorphology and Sediment. Of the 276 campsites referenced in Section 3.12.1.1 of the Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead Final EIS (2007 Final EIS), 195 sites (71 percent) are still classified as "camps";[1] 68 sites (25 percent) have been classified as "noncamps" due to sand erosion, vegetation overgrowth, or both; 2 sites could not be ascertained based on the float-by methodology used during the November 2022 NPS Colorado River Management Plan monitoring trip; and 10 campsites were not evaluated (Kearsley 2023).

TA 14.1.3 Lake Mead and Hoover Dam

Lake Mead NRA encompasses 1.5 million acres. It encompasses the 110-mile-long Lake Mead, the 67-mile-long Lake Mohave, the surrounding desert, and the isolated Shivwits Plateau in Arizona. Recreation such as camping, boating, fishing, and hiking occurs on upper Lake Mead. The Overton Wildlife Management Area provides opportunities for wildlife viewing and photography, waterfowl and upland game-bird hunting, hiking, and fishing. The Overton Wildlife Management Area averages 4,226 annual visitor use days.[2]

Lake Mead NRA extends along the lower Colorado River from GCNP's western border to Davis Dam. The primary recreational activities on Lake Mead include cruising/sailing, personal watercraft usage, waterskiing, fishing, and swimming. A number of campgrounds and picnic areas, including Boulder Beach, Calville Bay, Echo Beach, Las Vegas Bay, and Temple Bar, provide additional

[1] Campsite area is defined as any region of smooth substrate (most commonly sand) with no more than an 8-degree slope and little or no vegetation (Kaplinski et al. 2014).
[2] Nevada Department of Wildlife, personal communication, 2023

recreational opportunities. Lake Mead NRA had approximately 6.4 million visitors in 2024 (NPS 2025f).

Table TA 14-5 summarizes recreational visits to Lake Mead NRA for 2019 to 2024.

Table TA 14-5
Lake Mead NRA Recreational Visitors

Year	Recreational Visitors
2019	7,499,049
2020	8,016,510
2021	7,603,474
2022	5,578,226
2023	5,798,541
2024	6,412,854

Source: NPS 2025f

Water quality concerns are increasing and are described in detail in **TA 6**, Water Quality. In the spring and summer of 2015, Lake Mead experienced notable concentrations of harmful blue-green algae, which triggered harmful algal bloom advisories for various locations across the lake (NPS 2023b). In 2022, a swimmer was fatally infected with a brain-eating amoeba (*Naegleria fowleri*) at Lake Mead. Brain-eating amoebas are commonly found in bodies of warm, fresh water, such as lakes, rivers, and geothermal water (NPS 2022). These trends may continue to increase as water temperatures warm.

Declining reservoir elevations at Lake Mead in recent years have exposed mudflats along several areas of the shoreline. These have created dangerous conditions where recreationists have periodically become stuck in wet, muddy deposits. Some of these areas have access roads that previously enabled visitors to drive close to the shoreline when reservoir elevations were higher. As reservoir elevations have declined over recent years, visitors have often attempted to chase the shoreline both in their vehicles and on foot to gain access to the changing shoreline for such purposes as fishing, hiking, and other recreational activities. In doing so, they and their vehicles have created unauthorized vehicle routes toward the lowering water levels, and they have become stuck in these muddy conditions, requiring assistance from NPS personnel and others to extract themselves and/or their vehicles.

Boating Facilities

Lake Mead NRA is considered one of the nation's premier water-based recreation areas. Most visitors participate in water-based recreational activities, primarily between May and September. These recreational activities are supported by marina and launch ramp facilities developed along the Lake Mead shoreline. On average, the majority of boats are personal watercraft. Water-based recreational facilities at Lake Mead are located at Callville Bay, Hemenway Harbor, Temple Bar, Echo Bay, South Cove, and Pearce Ferry boat ramps. Pearce Ferry is used as a takeout by Colorado River boaters.

Table TA 14-6 shows critical elevations identified by the NPS for Lake Mead, below which marinas, boat docks, or boat launch ramps become inoperable. The Pearce Bay launch ramp, a take-out point for rafts and whitewater boats, is closed at 1,175 feet. This results in rafts and other whitewater boats having to continue downstream to South Cove, which is an additional 16 miles.

Table TA 14-6
Critical Elevations for Lake Mead by Boating Facility

Lake Elevation (feet)	Impact and Facility
1,221	Full pool
1,075	Boulder Harbor closed
1,035	South Cove Ramp closed
1,000	Echo Bay public launch ramp closed
950	Hemenway Harbor public launch ramp closed; Callville Bay public launch ramp closed; Temple Bar public launch ramp closed

Source: Nicole Gibney, Assistant Colorado River Coordinator, NPS, personal communications, May 15, 2024; December 3, 2024; and December 10, 2025

Since the publication of the 2007 Final EIS, the Echo Bay, Boulder Harbor, and South Cove boat ramps have closed due to low water levels. The NPS facilities at the Temple Bar Marina are also inoperable; however, the concessionaire's launch operations remain operable. The Pearce Bay launch ramp, a take-out point for rafts and whitewater boats, previously closed at elevation 1,175 feet. Access to Lake Mead was closed at Pearce Ferry in 2001 when the water elevation dropped to 1,175 feet. In 2010, the NPS extended Pearce Ferry Road 2 miles to the Colorado River to provide for river take-out operations for private and commercial river runners (NPS 2010).

Changes to water levels affect the usability of the remaining boat launch ramps throughout the year, especially in warmer months. Launch ramp closures due to declining water levels have resulted in longer lines, limited parking, and congestion at boat ramps and docks. In addition, ongoing maintenance and construction at ramps have resulted in temporary closures.

TA 14.1.4 Hoover Dam to Davis Dam

Visitation and recreational use at Lake Mohave have increased in response to more variable Lake Mead levels and the closure of associated boating infrastructure. Recreational opportunities at Lake Mohave include boating, canoeing on the northern parts of the lake, camping, exploring, fishing, photography, picnicking, swimming, parasailing, and waterskiing. There are also hundreds of beaches accessible only by boat. As with Lake Mead, harmful blue-green algal blooms occurred at Lake Mohave in 2015, leading to advisories for multiple locations across the lake (NPS 2023b).

The main shoreline access points for Lake Mohave are Katherine Landing, Cottonwood Cove, and Willow Beach. Facilities for public use and boat launching are located at Katherine's Landing in Arizona near Davis Dam and at Cottonwood Cove, which is east of Searchlight, Nevada. Boats and jet skis can be rented at both locations. Public campgrounds are available at both locations, where concessionaires provide trailer parks, restaurants, lodging, docking facilities, boat and fishing tackle

equipment, and fishing licenses. Facilities for public use and boat launching are also at Willow Beach, 31 miles upstream on the Arizona shore.

TA 14.1.5 Davis Dam to Parker Dam

The Davis Dam to Parker Dam reach includes several recreational areas along the Colorado River, including Laughlin, Bullhead City, Davis Camp, Needles, Havasu National Wildlife Refuge (NWR), Lake Havasu State Park, and Bill Williams River NWR. Relevant recreational areas are briefly described in the following sections.

Davis Camp. Davis Camp contains a campground and day use area. It has boat launching facilities, picnic areas, numerous campsites, and recreational vehicle hookups. Davis Camp offers many river-oriented recreational opportunities, including fishing and water sports.

Havasu NWR. The Havasu NWR, managed by the United States Fish and Wildlife Service (FWS), covers 30 RMs (300 miles of shoreline) from Lake Havasu City, Arizona, to Needles, California. Typical activities include canoeing, fishing, boating through the scenic Topock Gorge, and hiking in the Havasu Wilderness Area. The 4,000-acre Topock Marsh offers excellent canoeing, fishing, and bird-watching. Other activities offered at the Havasu NWR include camping and hunting.

Lake Havasu State Park. Formed by Parker Dam, Lake Havasu contains several coves and inlets and is a popular spot for fishing. Lake Havasu's waters are also used for canoeing, houseboating, riding watercrafts, kayaking, sailing, speedboating, swimming, and waterskiing. Camping and hiking also occur along the more than 400 miles of the lake's shoreline. Additional visitor opportunities include viewing the London Bridge. Lake Havasu is a popular destination for spring break and family vacations.

Lake Havasu is the premier attraction area within the Davis Dam to Parker Dam reach. **Table TA 14-7** lists the visitation from 2019 to 2024 at Arizona's Lake Havasu and Cattail Cove State Parks.

Table TA 14-7
Visitation at Arizona's Lake Havasu and Cattail Cove State Parks

Year	Lake Havasu State Park Visitation	Cattail Cove State Park Visitation
2019	488,597	111,262
2020	598,403	116,822
2021	492,074	95,179
2022	494,318	86,385
2023	484,716	79,978
2024	468,535	83,992

Source: Arizona Hospitality Research and Resource Center 2025

Bill Williams River NWR. Managed by the FWS, the Bill Williams River NWR is along the Bill Williams River near its confluence outlet into Lake Havasu. The refuge offers a variety of recreational opportunities, including hiking, bird-watching, and other wildlife viewing. Hunting is

permitted for dove, cottontail, quail, and desert bighorn sheep. Other activities include boating and fishing.

Boating Facilities. The Davis Dam to Parker Dam reach includes shoreline public use facilities at Laughlin, Bullhead City, Davis Camp, Needles, Havasu NWR, Lake Havasu State Park, and Bill Williams NWR. Recreational activities within this reach include canoeing, fishing, houseboating, riding watercrafts, kayaking, sailing, speedboating, swimming, and waterskiing.

TA 14.1.6 Parker Dam to Cibola Gage

The Parker Dam to Cibola Gage reach includes several recreational areas, including Parker Strip Recreation Area, Palo Verde Diversion Dam, Blythe, and the Cibola NWR. The following are brief descriptions of the relevant recreational areas on this reach.

Parker Strip Recreation Area. The Parker Strip Recreation Area includes an 11-mile road along the Colorado River. Recreation includes boating, camping, fishing, hiking, rock hounding, swimming, and wildlife viewing.

Palo Verde Diversion Dam. There are approximately 95 miles of navigable waters between Imperial Dam downstream of Yuma and Palo Verde Diversion Dam upstream of Blythe. Activities include canoeing, fishing, hunting, power boating, and other water sports.

Cibola NWR. The Cibola NWR, including Cibola Lake, is managed by the FWS and located about 15 miles south of Blythe. Visitors to the refuge engage in canoeing, fishing, hiking, hunting, photography, and wildlife viewing.

Boating Facilities. The Parker Dam to Cibola Gage reach includes shoreline public use facilities at Parker Strip Recreation Area, Palo Verde Diversion Dam, Blythe, and the Cibola NWR. Typical water activities within this reach include canoeing, power boating, fishing, swimming, and other water sports.

TA 14.1.7 Cibola Gage to Imperial Dam

The Cibola Gage to Imperial Dam reach includes the following few recreational areas: Picacho State Recreation Area, Imperial NWR, and Martinez Lake. Brief descriptions of these recreational areas follow.

Picacho State Recreation Area. This area is popular for camping, desert exploring, river running, and sportfishing. It received approximately 10,763 visitors in 2022 (including day and overnight use),[3] and it has a group boat-in area, three individual boat-in camp areas, and large group camping areas. Bird-watching and small-game hunting for doves, ducks, and quail are among the other recreational opportunities.

Imperial NWR. Recreational opportunities at the Imperial NWR include canoeing, fishing, and hunting. Boaters value the refuge for its remote scenery.

[3] T. Unzicker, personal communication, December 5, 2024.

Martinez Lake. Martinez Lake, which adjoins the Imperial NWR, offers opportunities for fishing, bird-watching, boating, hunting, rock hounding, sightseeing, and waterskiing.

Boating Facilities. The Cibola Gage to Imperial Dam reach includes shoreline public use facilities at Picacho State Recreation Area, Imperial NWR, and Martinez Lake. Typical water activities within this reach include river running, boating, canoeing, waterskiing, and sportfishing.

TA 14.1.8 Imperial Dam to the Northerly International Boundary (NIB)

The Imperial Dam to the NIB reach includes a few recreational areas along the Colorado River, including Betty's Kitchen and Mittry Lake Wildlife Area. The following are brief descriptions of these recreational areas.

Betty's Kitchen. This 10-acre wildlife interpretative area provides bird-watching and fishing opportunities.

Mittry Lake Wildlife Area. Mittry Lake, within the Mittry Lake Wildlife Area, covers approximately 600 acres and provides small-game hunting and sportfishing opportunities. There is a three-lane boat launch ramp for motorized boating on the lake. The area is also popular for bird-watching and nature study.

Boating Facilities. The Imperial Dam to the NIB reach includes shoreline public use facilities, including a public fishing pier at Betty's Kitchen and a boat launch ramp for motorized boating and fishing jetties at Mittry Lake Wildlife Area. Typical water activities within this reach include boating, swimming, and sportfishing.

NIB to the Southerly International Boundary (SIB)

The NIB to the SIB reach includes shoreline public use facilities in the city of Yuma, Arizona. Typical water activities within this reach, which is on the edge of the historical floodplain to the east of the Colorado River, include boating, swimming, and sportfishing.

TA 14.1.9 Reservoir Boating

Reservoir boating is affected by fluctuating reservoir elevations; these fluctuations specifically alter exposure to boating navigational hazards and safer boating capacities. Hazards such as exposed rocks may become more evident, and changes in navigational patterns may be necessary as reservoir elevations decline. At low-pool elevations, special buoys or markers may be placed within reservoirs to warn boaters of navigational hazards. In addition, signs may be posted in areas deemed unsuitable for navigation.

Near Hite, a delta has formed that can affect river boaters coming into Lake Powell at low-pool elevations. River boaters from the Colorado River row or motor through Lake Powell to a location where a boat transports them 20 to 25 miles to the Hite Marina. At low elevations, the river boaters must travel farther downstream to reach a location accessible to the transport company's boat. Although this results in more miles to the takeout, there is usually enough current in the river to carry the boats. At lower elevations, additional rapids are exposed in Cataract Canyon. Lower Lake Powell elevations may create additional navigational hazards due to restricted channel widths and subsurface conditions.

Lake Powell

Safe boating navigation. The navigation system on Lake Powell uses regulatory buoys and other marking devices to warn boat operators of hazardous conditions associated with subsurface obstructions or changes in subsurface conditions that could be hazardous for safer passage. Placement of many of these marking devices depends on the lake's elevation.

Lake Mead

Safe boating navigation. Regulatory buoys and other marking devices are used on Lake Mead to warn boat operators of dangers, obstructions, and changes in subsurface conditions in the main channel or side channels. Excursions from Lake Mead into the Grand Canyon are a popular activity. Boats entering the Grand Canyon usually launch at Pearce Ferry, South Cove, or Temple Bar. Many boaters include overnight camping on these excursions.

The upper arms and inflow areas of Lake Mead may be difficult to navigate due to shifting subsurface sediments. Over the years, sediment has built up in the section of the reservoir between Grand Wash and Pearce Ferry. When Lake Mead elevations drop below 1,170 feet, the sediment is exposed as mud flats, and there is no well-defined river channel. As a result, the area is too shallow for motorboats to navigate upstream and into the lower reaches of the Grand Canyon. With fluctuating flows, even smaller crafts may have difficulty accessing the area due to the shifting channel. Based on this information, an elevation of 1,170 feet is considered a threshold elevation for safer boating navigation for Lake Mead's upper end.

Since the publication of the 2007 Final EIS, the NPS has extended the Pearce Ferry launch ramp to provide river take-out operations for private and commercial river runners. However, due to the proximity of the developing Pearce Ferry Rapid, the public launch of boats is prohibited (NPS 2010).

Lake Mohave and Lake Havasu

Because Lake Mohave and Lake Havasu will continue to be operated to meet monthly target elevations, the alternatives will not affect reservoir boating and navigation in these reaches beyond the trends previously described.

TA 14.1.10 River and Whitewater Boating

Whitewater boating is the key recreational activity in the Grand Canyon from Lees Ferry to the Diamond Creek or Pearce Ferry takeouts. Other reaches are not predominantly whitewater localities; therefore, they will not be discussed in this section.

Glen Canyon Dam to Lake Mead

Grand Canyon whitewater boating trips launch at Lees Ferry in Glen Canyon NRA and take out at Diamond Creek on the Hualapai Indian Reservation or at Pearce Ferry in Lake Mead NRA. River trips are conducted using a variety of boats and rafts; group sizes can range up to 32 people (including guides). Trip lengths range up to 25 days and can be run by commercial companies or by private individuals. There are various ways to join trips, including launching from Lees Ferry, hiking into or out of the canyon to join and leave a trip, and gaining limited access by vehicle and helicopter (commercial use only) to join trips in the western portion of the Grand Canyon.

GCNP staff regulates recreational boating in accordance with the Colorado River Management Plan (NPS 2006a). The Colorado River Management Plan prescribes management of recreational use by establishing limits on the number of daily launches, group size, trip length, and periods of motorized and nonmotorized use. Motorized use is permitted between April 1 and September 15. In general, whitewater navigability can be affected by river flows and by large amounts of side canyon debris washed into the river channel. Due to reduced water levels in Lake Mead, rapids like Separation Rapid have returned, and new rapids have formed from the Colorado River scouring a new path in the deltaic sediments, making it more challenging to navigate. While most of the river still follows the old river channel, a new channel has developed near Pearce Ferry, creating a new impassible class VI rapid known as the Pearce Ferry Rapid (Joel 2016). A new waterfall or rapid is expected to form downstream from the North Wash boat ramp that serves as the take-out point for Cataract Canyon rafters (Returning Rapids Project 2023). Intermittent, larger-volume, and higher-magnitude flows could improve navigability at some of these rapids.

River flow levels and fluctuations are important for whitewater boaters (Bishop et al. 1987; Shelby et al. 1992; Hall and Shelby 2000; Stewart et al. 2000; Neher et al. 2017). Past studies have polled commercial and private whitewater trip leaders for their preferences on the minimum levels for running the river safely with passengers. Preferences may vary by experience level and equipment types for different boaters, but a majority have reported that flows below 10,000 cubic feet per second (cfs) and above about 45,000 cfs are considered less than optimal; flows between 20,000 and 26,000 cfs are considered optimum (Shelby et al. 1992; Bishop et al. 1987; Neher et al. 2017). Flows above 8,000 cfs have been identified by commercial guides as the minimum level necessary to safely run the river with passengers (Shelby et al. 1992; Stewart et al. 2000). At low flows (5,000 cfs or less), it often becomes necessary to either walk passengers around some rapids or wait for higher water. The risk of accidents varies by the type of boat employed. At extremely low flows (less than 5,000 cfs), motor rigs have the highest incidence of accidents, followed by small (typically private group) rafts (Jalbert 1992). At flows higher than power plant capacity, smaller craft, such as small rafts, dories, kayaks, and canoes and inflatables, experience more accidents (Brown and Hahn-O'Neill 1987).

Hoover Dam to SIB

The alternatives are not expected to adversely affect river and whitewater boating between Hoover Dam and the SIB.

TA 14.1.11 Sportfishing

No specific reservoir elevation thresholds or river stages related to sportfishing were identified in the literature reviewed. Catch rates for reservoir fishing are assumed to be directly related to reservoir habitat, including water quality. Please refer to **TA 8**, Biological Resources – Fish and Other Aquatic Resources, for more information regarding impacts on fish habitat, and **TA 6**, Water Quality, for impacts on water quality. Fishing satisfaction is assumed to be directly related to (1) the general recreational issues of boating access to water via shoreline facilities, and (2) the potential for boating navigational hazards or reservoir detours due to low reservoir elevations.

Lake Powell and Glen Canyon Dam

Lake Powell supports a popular warmwater sportfishery composed mainly of striped and smallmouth bass. The striped bass depends on threadfin shad for a significant portion of their diet. The threadfin shads in Lake Powell are at the northernmost portion of their range, and they are sensitive to fluctuations in water temperature. Gizzard shads may become an important forage fish for striped bass. In addition to striped and smallmouth bass, Lake Powell supports other nonnative fish species, including largemouth bass, walleye, channel catfish, bluegill, and black crappie. Angler use in 2018 was at a 40-year low, mainly attributed to a decline in the percentage of boat days that were spent angling (Blommer and Gustaveson 2021).

Glen Canyon Dam to Lake Mead

The 15.5-mile Glen Canyon reach of the Colorado River supports a Blue Ribbon recreational rainbow trout fishery that attracts local, national, and international anglers. The NPS, in coordination with the Arizona Game and Fish Department and the FWS, manages fish in all waters within Glen Canyon NRA and GCNP. The intention of Blue Ribbon management is to provide a quality fishing opportunity where anglers can catch larger-than-average trout at a relatively high catch rate in a unique recreational setting. Most angling is from boats or is facilitated by boat access, often provided by guide services. Some anglers also wade or fish from shore.

Fishing in the Glen Canyon reach occurs year-round. Peak usage is in April and May; however, substantial fishing has occurred from March through October in most years (Rogowski and Boyer 2023). An estimated 5,095 anglers used the rainbow trout fishery in 2022; of these, 3,594 were boat anglers, and 1,501 were walk-in anglers (Rogowski and Boyer 2023). Boat and walk-in angler use decreased in 2022 relative to 2021 (Rogowski and Boyer 2023).

The quality of the rainbow trout fishery at Lees Ferry is highly dependent on water quality within the reach, which is a proxy for catch (Bishop et al. 1987). Prior to 2022, fish species from Lake Powell were periodically entrained and survived passage through the dam; however, water temperatures within the Glen Canyon reach were generally cold enough to impede growth and cease reproduction. In 2022, water temperatures within the Glen Canyon reach were the highest on record, which led to higher survival of entrained warmwater and cool-water fish through the dam (Rogowski and Boyer 2023). There is concern that as Lake Powell continues to decline and warm water is subsequently discharged, coupled with low dissolved oxygen, there will be an increase in warmwater fish, successful recruitment of the highly invasive smallmouth bass, and a decrease in rainbow trout (Rogowski and Boyer 2023).

The Glen Canyon Dam Long-Term Experimental and Management Plan Final Supplemental Environmental Impact Statement (2024 LTEMP Final SEIS) was developed to implement water management actions to temporarily control smallmouth bass populations downstream of Glen Canyon Dam from 2024 to 2027 (Reclamation 2024). The Bureau of Reclamation (Reclamation) is planning to continue coordination with stakeholders for future control of smallmouth bass populations. **TA 8**, Biological Resources – Fish and Other Aquatic Resources, provides further information on rainbow trout dynamics in the Glen Canyon reach.

Lake Mead and Hoover Dam

Lake Mead has an excellent warmwater sportfishery composed of largemouth bass, striped bass, channel catfish, rainbow trout, bullhead catfish, sunfish, crappie, and bluegill. Fishing is generally better in September, October, and November. Larger fish are caught by deepwater trolling in spring from March through May.

The Lake Mead Fish Hatchery, operated by the Nevada Department of Wildlife, historically raised rainbow trout, endangered razorback suckers, and bonytail chub. The Lake Mead Fish Hatchery ceased operations in 2022 in response to Lake Mead declining below 1,060 feet, the point at which the hatchery drew its water (Peterson 2022). The Nevada Department of Wildlife and the Southern Nevada Water Authority are currently developing a project to replace the hatchery's water supply line to draw deeper in the water column.

Hoover Dam to Davis Dam

Lake Mohave's fishery is similar to Lake Mead's fishery. In Lake Mohave, there are largemouth bass, striped bass, channel catfish, rainbow trout, bullhead catfish, sunfish, crappie, and bluegill. Largemouth and striped bass are in deep water in the winter and move into shallow water to spawn in the spring. Fishing is open year-round, but the best fishing generally occurs in September, October, and November. For deepwater trolling, March through May tends to provide the best conditions.

Davis Dam to Parker Dam

Striped bass is the dominant sportfish in Lake Havasu. It can be caught throughout the year, but the best fishing locations change with the seasons and water temperature. The largemouth bass population supports tournaments nearly every weekend from September through May. The smallmouth bass population has increased in number over the past couple of years. Channel catfish are abundant and average 2 to 4 pounds in size. Flathead catfish grow to large sizes in Lake Havasu. Only a limited number of anglers fish specifically for catfish. Black crappie numbers are limited due to overharvesting and a lack of habitat.

Parker Dam to SIB

Fishing in Cibola NWR is available in Pretty Water, Cibola Lake, the Colorado River, and the old river channel. Cibola NWR is managed to protect wintering waterfowl that use Cibola Lake. Fishing is permitted March 15–October 1, unless otherwise stated. Sportfishing in Cibola Lake includes largemouth, smallmouth, and striped bass; channel and flathead catfish; crappie; sunfish; tilapia; and common carp.

Imperial NWR is managed as a refuge and breeding area for migratory birds and other wildlife. Hunting and fishing are permitted in some areas, according to state regulations, and fishing by boat is allowed on the mainstream Colorado River at any time of the year.

TA 14.2 Environmental Consequences

TA 14.2.1 Methodology

Reclamation used similar methods for the analysis of potential impacts on recreation as were used in the 2007 Final EIS and 2024 LTEMP Final SEIS to assess the effects on shoreline public use facilities, reservoir boating and navigational hazards, whitewater boating, and sportfishing. This analysis also incorporates additional Decision Making under Deep Uncertainty (DMDU) concepts, specifically robustness heat maps and vulnerability bar plots, developed to provide an indicator of an alternative's performance across many possible hydrologic futures. Refer to **TA 3**, Hydrologic Resources, and **Section 3.2**, Analysis Methods, for additional information on DMDU. Also, see **Appendix E**, DMDU Overview and Approach, for an overview of interpreting the DMDU robustness heat maps and vulnerability bar plots.

Method Used to Assess Shoreline Public Use Facilities

This section analyzes the impacts that reservoir elevations decreasing below critical thresholds would have on selected marinas, boat docks, and launch ramps, as well as whether these elevations could impact access to or use of attraction features. The NPS provided threshold reservoir elevations included in this analysis. The DMDU analysis uses the subset of reservoir elevations used in the regional economic modeling (see **TA 16**, Socioeconomics). The DMDU analysis for shoreline public use facilities analyzes the percentage of selected marinas, boat docks, and launch ramps. Threshold elevations were used as indicators of recreational facilities that might be rendered inoperable or require relocation or modification to remain operational. The narrative of the alternatives' effects is provided below for selected facilities at both Lake Powell and Lake Mead. These facilities are representative of the alternatives' potential effects on shoreline recreational opportunities at each reservoir.

Method Used to Assess Reservoir Boating and Navigational Hazards

This analysis assesses the effects of reservoir elevations falling below critical thresholds, which would result in boating navigational hazards and changing navigable areas and passageways. This methodology is consistent with the 2007 Final EIS and 2024 LTEMP Final SEIS, but with the addition of new modeling and DMDU concepts, it assesses the percentage of futures in which reservoir elevations never drop below identified thresholds. Threshold pool elevations were determined using the methodology identified in the 2007 Final EIS.

Method Used to Assess Whitewater Boating

The assessment of effects on whitewater boating used a similar methodology identified in the 2007 Final EIS and 2024 LTEMP Final SEIS by using river flow data from **TA 3**, Hydrologic Resources, to analyze whether there would be increased exposures to boating navigational hazards, changes in access or use of rest areas and takeouts, or changes in trip durations resulting from the alternatives. The analysis additionally incorporates DMDU concepts and analyzes the percentage of futures in which daytime flows of the Colorado River would not drop below an identified minimum threshold, previously identified as the minimum preferred flow (Shelby et al. 1992; Stewart et al. 2000).

Methods Used to Assess Sportfishing

This analysis assesses the effects on fishing opportunities by river reach under the alternatives, using similar methods identified in the 2007 Final EIS and 2024 LTEMP Final SEIS. There are no specific reservoir elevation thresholds related to sportfishing; therefore, DMDU concepts are not used in the reservoir sportfishing analysis. A general discussion of changes in flow and salinity, and the possible effects on sportfish is also provided.

A more detailed analysis of effects on rainbow trout based on changes in water temperature is used for the Lees Ferry reach of the Colorado River, which incorporates DMDU concepts. Rainbow trout were chosen for the analysis based on the importance of their recreational fishery in the Colorado River reach below Glen Canyon Dam.

TA 14.2.2 Impact Analysis Area

The impact analysis area for recreation aligns with the general analysis area, which encompasses the Colorado River corridor from the full pool elevation of Lake Powell to the SIB. Flows below Hoover Dam are consistently low due to upstream diversions and delivery obligations. As a result, the range of operational changes evaluated across the alternatives would not meaningfully alter flow conditions in a manner that would measurably affect recreational opportunities in this reach. Given the limited variability in flows and the constrained nature of water-based recreation downstream of Parker Dam, a detailed analysis was determined to be unwarranted. Potential effects in this area would be negligible and would not differ substantially among the alternatives.

Assumptions

- The analysis assumes that the demand for recreational opportunities will either remain constant or increase over time, forming the basis for evaluating impacts on activities such as reservoir recreation, fishing, and whitewater boating.
- The analysis considers 5,000 cfs and 8,000 cfs as two levels at which commercial and private boaters may experience navigability challenges (Bishop et al. 1987; Shelby et al. 1992; Stewart et al. 2000).
- While high-flow experiments are not directly incorporated into the recreation modeling, actual high-flow experiment frequency may differ from that assumed or predicted in other modeling efforts.
- Additional assumptions related to modeling are considered in the analysis, contributing to the accuracy and reliability of the hydrologic models used to anticipate impacts resulting from various actions.

Impact Indicators

- Threshold reservoir elevations
- Threshold river flows
- Water temperatures

TA 14.2.3 Issue 1: How would the management of reservoir elevations affect recreation?

This issue examines how different reservoir elevations (Lake Powell and Lake Mead) resulting from different operational strategies would impact shoreline recreational facilities, reservoir boating activities, sportfishing opportunities, and the ferry and taxi boat services at Lake Powell. This analysis first presents and analyzes DMDU figures, and then assesses qualitative impacts on selected recreation activities resulting from changes in reservoir elevations.

Lake Powell

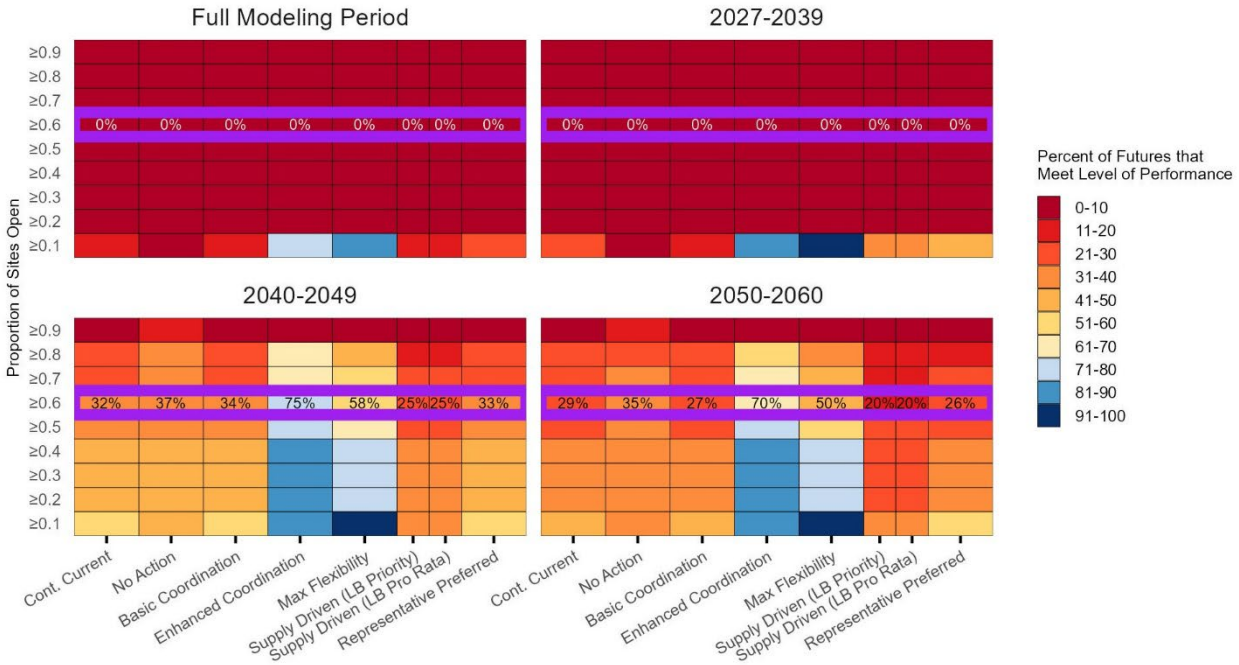
Table TA 14-3 identifies the threshold elevations, or preferred minimum performance levels, below which shoreline recreational facilities at Lake Powell could be affected. Below these elevations, facility adjustments or capital improvements would be required, creating potential impacts on recreation at Lake Powell. The analysis first examines the proportion of Lake Powell recreation sites that would remain open every summer month, then analyzes the performance of alternatives in maintaining Lake Powell elevations above 3,620 feet, which corresponds to the elevation required for safely navigating the Castle Rock Cut; 3,590 feet, the critical threshold for most boat launch facilities; 3,525 feet, below which nearly all current boat ramps would become inaccessible; and 3,500 feet, the critical threshold for planned boat ramp extensions to date.

Figure TA 14-1 below depicts the performance of each alternative with regard to keeping a specified proportion of Lake Powell recreational sites open over every summer month, which corresponds to peak visitation (May 31 – August 31). The figure is divided into four robustness heat maps, each showing a different time period across the analysis. The highlighted row represents the percentage of futures that an alternative achieves maintaining a 0.6 proportion of Lake Powell recreational sites open between May 31 and August 31. The 0.6 proportion row was chosen to be highlighted because it corresponds to approximately the 10th percentile from the historical analysis that informed the thresholds.

Across the full modeling period and the 2027–2039 subperiod, none of the alternatives would maintain keeping at least 60 percent of Lake Powell recreational sites open during the summer months. This indicates that reservoir elevations sufficient to sustain broad recreational site accessibility are unlikely under near-term conditions. Given the planned length of this decision, it is notable that the Representative Preferred Alternative does not meet the preferred minimum performance across the full modeling period or 2027–2039 subperiod, achieving it in only 30 percent of modeled futures in the 2040–2049 subperiod, and 22 percent of modeled futures in the 2050–2060 subperiod.

These results translate to widespread closures of Lake Powell recreation sites and boat launch ramps over the next decade. As access becomes increasingly constrained, use would be concentrated at the remaining operable locations, resulting in longer wait times, limited parking available, and increased congestion at boat ramps and associated facilities. These conditions would reduce the reliability and overall quality of recreation opportunities and may displace some users entirely.

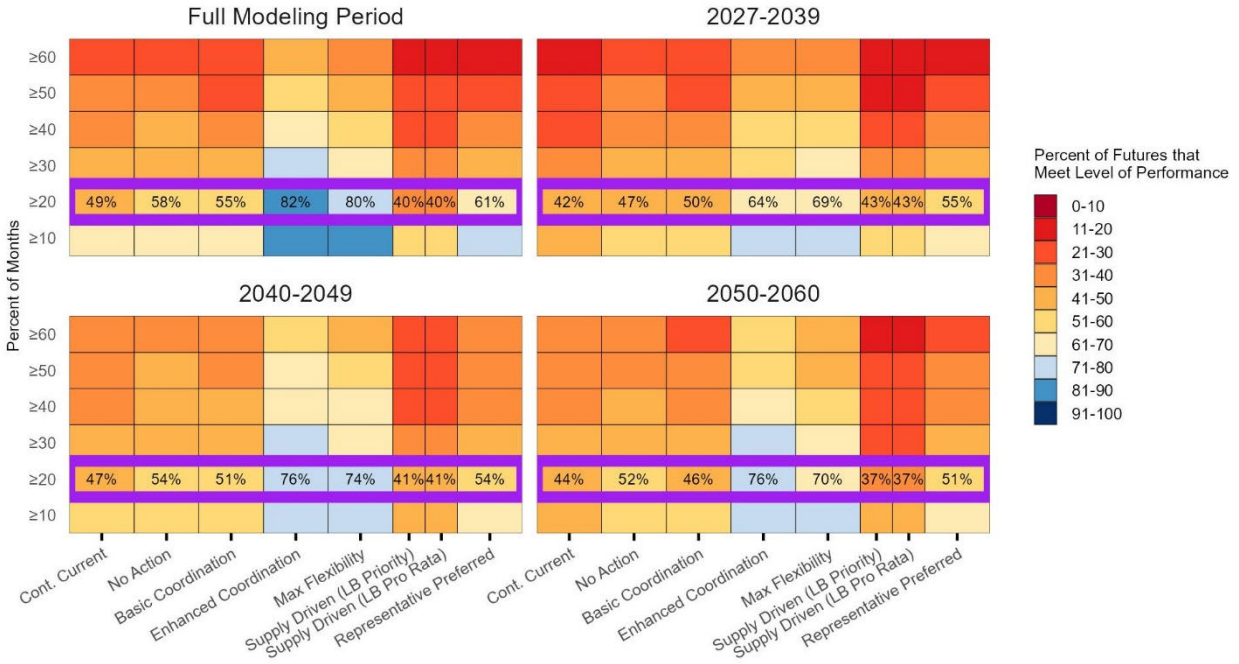
Figure TA 14-1
Lake Powell Recreation Sites: Robustness.
Percent of futures in which the proportion of open Lake Powell sites stays above the value specified by each row in every summer month (May 31 – August 31)



In the later subperiods (2040-2049 and 2050-2060), all alternatives show improved performance in maintaining the 60 percent threshold. This is likely attributed to the preferred standard being easier to meet over shorter timespans than over the full 34 years, and also because these subperiods are further removed from the present dry initial conditions. The Enhanced Coordination and Maximum Operational Flexibility Alternatives are the most robust at meeting the preferred minimum performance, doing so in 75 percent and 58 percent of futures, respectively, in 2040-2049, and 70 percent and 50 percent of futures, respectively, in 2050-2060. This is considerably more robust than the other alternatives. While these alternatives demonstrate comparatively greater robustness, even their improved performance does not eliminate the risk of access limitations and associated declines in reservoir boating experience under lower reservoir elevations.

Figure TA 14-2 below depicts the performance of each alternative with regard to maintaining Lake Powell above an elevation of 3,620 feet, which corresponds to the elevation required for safely navigating the Castle Rock Cut. The figure is divided into four heat maps, each showing a different time period across the analysis. Rows of the heat map show different frequency ranges (percent of months) for keeping Lake Powell above an elevation of 3,620 feet. The highlighted row shows the percentage of futures that an alternative achieves in maintaining Lake Powell above this elevation in 20 percent or more of months. This row was chosen to be highlighted because, from October 2007 through May 2025, Lake Powell was at or above 3,620 feet in 24.5 percent of months.

Figure TA 14-2
Lake Powell Boating Hazards: Robustness.
Percent of futures in which the elevation of Lake Powell is at least 3,620 feet in the percent of months specified by each row



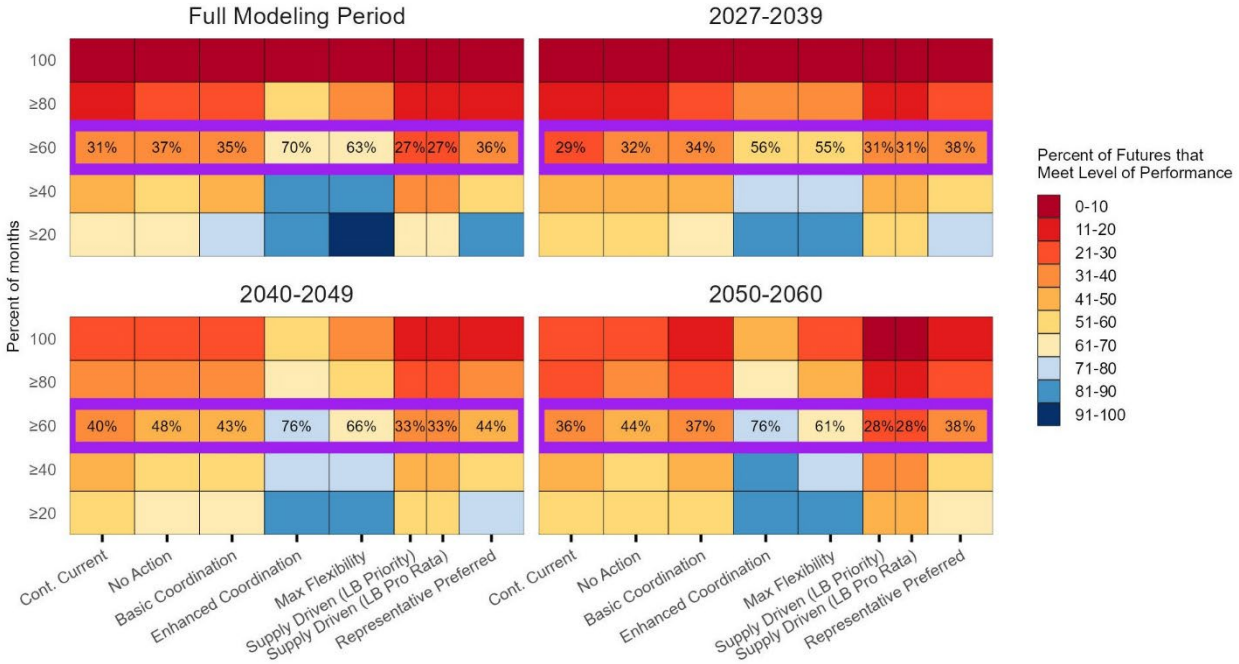
The Enhanced Coordination and Maximum Operational Flexibility Alternatives are the most robust at maintaining or exceeding a Lake Powell elevation of 3,620 feet in 20 percent or more of months over the full modeling period, as shown in the upper-left heat map. These alternatives perform similarly to one another, doing so in 82 percent and 80 percent of futures, respectively. Over the full modeling period, the Basic Coordination, No Action, and Representative Preferred Alternatives perform similarly, succeeding in 55 percent, 58 percent, and 61 percent of futures, respectively. These alternatives are slightly more robust than the Continued Current Strategies (CCS) Comparative Baseline and the Supply Driven Alternative (both Lower Basin Priority [LB Priority] and Lower Basin Pro Rata [LB Pro Rata] approaches), which only meet the preferred minimum performance in 49 percent and 40 percent of futures across the full modeling period, respectively.

Across the full modeling period, all alternatives exhibit poor performance for the upper rows. Under all alternatives, projected Lake Powell elevations for much of the analysis period would be below the critical threshold for safely navigating the Castle Rock Cut. This would result in a reduction in the quality of or the loss of reservoir boating opportunities on Lake Powell. Under all alternatives, dock access would continue to be unavailable from the Rainbow Bridge National Monument shoreline, which would continue until a long-term access solution is developed. Similarly, under all alternatives, projected Lake Powell elevations for much of the analysis period would be below the critical threshold for the Charles Hall Ferry, which would therefore be unable to operate.

Based on the planned length of this decision, it is important to compare robustness in the 2027–2039 modeling period. The Enhanced Coordination and Maximum Operational Flexibility Alternatives are the most robust, meeting the preferred minimum performance level in 82 and 80 percent of futures, respectively. The No Action, Basic Coordination, and Representative Preferred Alternatives perform similarly, meeting the preferred minimum performance level in 55 to 61 percent of futures. The CCS Comparative Baseline and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives are less robust, meeting the preferred minimum performance level in 49 and 40 percent of futures, respectively.

Figure TA 14-3 below depicts the performance of each alternative with regard to maintaining Lake Powell above an elevation of 3,590 feet, which corresponds to the critical threshold for most boat launch facilities. The figure is divided into four heat maps, each showing a different time period across the analysis. Rows of the heat map show different frequency ranges (percent of months) for keeping Lake Powell above an elevation of 3,590 feet. The highlighted row shows the percentage of futures that an alternative achieves in maintaining Lake Powell above this elevation in 60 percent or more of months. This row was chosen to be highlighted because it corresponds to approximately the 10th percentile from the historical analysis.

Figure TA 14-3
Lake Powell Boat Ramps 3,590 Feet: Robustness.
Percent of futures in which Lake Powell elevation is 3,590 feet or greater in the specified percent of months



The Enhanced Coordination and Maximum Operational Flexibility Alternatives are the most robust at maintaining or exceeding a Lake Powell elevation of 3,590 feet in 60 percent or more of months over the full modeling period, as shown in the upper-left heat map. These alternatives perform

similarly to one another, succeeding in 70 percent and 63 percent of futures, respectively. Over the full modeling period, the CCS Comparative Baseline, No Action, Basic Coordination, and Representative Preferred Alternatives perform similarly, succeeding in 31 percent, 37 percent, 35 percent, and 36 percent, respectively. These alternatives are slightly more robust than the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches), which only meet the preferred minimum performance in 27 percent of futures.

Across the full modeling period, all alternatives exhibit poor performance for the upper rows. This suggests that challenges related to accessing existing Lake Powell boat ramps and associated impacts described above will continue under all alternatives.

Based on the planned length of this decision, it is important to compare robustness in the 2027–2039 modeling period. The Enhanced Coordination and Maximum Operational Flexibility Alternatives are the most robust, meeting the preferred minimum performance level in 56 and 55 percent of futures, respectively, followed by the Representative Preferred Alternative at 38 percent. The No Action, Basic Coordination, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives perform similarly, meeting the preferred minimum performance level between 31 and 34 percent of futures. The CCS Comparative Baseline is least robust, meeting the preferred minimum performance level in 29 percent of futures.

Figure TA 3-9 in **TA 3,** Hydrologic Resources, compares alternatives with respect to maintaining Lake Powell above an elevation of 3,525 feet. This elevation is important to recreation because it corresponds to the threshold that nearly all existing boat ramps become inaccessible. The purple highlighted row shows the percentage of futures that an alternative maintains Lake Powell above 3,525 feet in at least 90 percent of months. Please refer to this figure in **TA 3**, Hydrologic Resources.

In the Full Modeling Period, the Enhanced Coordination and Maximum Operational Flexibility Alternatives can meet the preferred minimum level of performance in 80 percent and 72 percent of the modeled futures, respectively, which is considerably more robust than the other alternatives. The CCS Comparative Baseline and No Action Alternative are only able to meet the preferred minimum performance in 29 percent and 24 percent of futures, respectively. The Representative Preferred Alternative meets the preferred level of performance in 50 percent of modeled futures in the Full Modeling Period. For the more stringent performance standard of keeping Lake Powell above 3,525 feet in 100 percent of months, all alternatives and the CCS Comparative Baseline show poor levels of performance and can only meet the more stringent standard in 0-10 percent of futures.

Based on the planned length of this decision it is important to note that in the first subperiod (2027–2039) the Enhanced Coordination and Maximum Operational Flexibility Alternatives meet the preferred minimum performance in 72 percent and 64 percent of futures respectively. The CCS Comparative Baseline and Basic Coordination and Supply Driven (both LB Priority and Pro Rata approaches) Alternatives are similarly less robust meeting the preferred minimum performance in 34 percent, 38 percent, and 36 percent of futures respectively. The No Action Alternative is least robust meeting the preferred minimum performance in only 25 percent of futures in the first subperiod.

The Representative Preferred Alternative meets the preferred minimum performance level in 52 percent of futures in the first modeling period (2027–2039).

The alternatives meet the preferred minimum level of performance in greater percentages of futures in subperiods than the Full Modeling Period because the preferred standard is easier to meet over shorter timespans than over the full 34 years. Additionally, the observed data prior to modeling and the initial system state (2027 begins with relatively low reservoir elevations) cause worse performance in the first decade than the following two decades. The robustness ranking across the three alternatives in each subperiod is consistent with the ranking in the Full Modeling Period.

With respect to lower rows in the heatmap, which reflect lower percentages of years where Lake Powell elevation is above 3,525 feet, all alternatives improve.

Figure TA 3-7 in **TA 3,** Hydrologic Resources, compares alternatives with respect to maintaining Lake Powell above an elevation of 3,500 feet. This elevation is important to recreation because it corresponds to the threshold that nearly all planned extensions to boat ramps would become inaccessible. The purple highlighted row shows the percentage of futures that an alternative maintains Lake Powell above 3,500 feet in 100 percent of months. This was chosen as the preferred minimum performance level due to the importance of avoiding critical impacts on water deliveries and hydropower, which, although not directly related to recreation, also aligns with a key recreational infrastructure threshold. Please refer to this figure in **TA 3**, Hydrologic Resources.

In the Full Modeling Period, the Enhanced Coordination and Maximum Operational Flexibility Alternatives can meet the preferred level of performance in 74 percent and 86 percent of the modeled futures, respectively, which is considerably more robust than the other alternatives. The CCS Comparative Baseline and the No Action, Basic Coordination, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives are the least robust and are only able to meet the preferred minimum performance in 18 percent, 4 percent, 13 percent, and 18 percent of futures, respectively.

Based on the planned length of this decision, it is important to note that in the first modeling period (2027–2039) the Enhanced Coordination and Maximum Operational Flexibility Alternatives are most robust, achieving the preferred minimum level of performance in 81 percent and 94 percent of futures respectively. The Supply Driven (both LB Priority and LB Pro Rata approaches) Alternative and the CCS Comparative Baseline are less robust meeting the preferred minimum performance in 35 percent and 30 percent of futures respectively. The No Action and Basic Coordination Alternatives are least robust in the first modeling period meeting the preferred minimum performance in only 4 percent and 19 percent of futures respectively.

In the three subperiods, the alternatives meet the preferred minimum level of performance in greater percentages of futures because the preferred standard is easier to meet over shorter timespans than over the full 34 years. Additionally, the observed data prior to modeling and the initial system state (2027 begins with relatively low reservoir elevations) cause worse performance in the first decade.

In the lower rows of the heat maps, which reflect lower percentages of months where Lake Powell elevation stays above 3,500 feet, all alternatives improve.

The Representative Preferred Alternative meets preferred level of performance in 40 percent of modeled futures in the Full Modeling Period. Based on the planned length of this decision, it is

important to note that the Representative Preferred Alternative meets the preferred minimum performance level in 58 percent of futures in the first modeling period (2027–2039).

These results indicate a substantial risk that reservoir elevations would drop below the thresholds required for the planned boat ramp extensions to function, particularly over the next decade. This suggests that even with planned infrastructure improvements, access could remain constrained or, in some cases, unavailable without additional modifications to support operations at elevations below 3,500 feet. As a result, Lake Powell reservoir boating access may be intermittent and concentrated at a limited number of locations.

Sportfishing

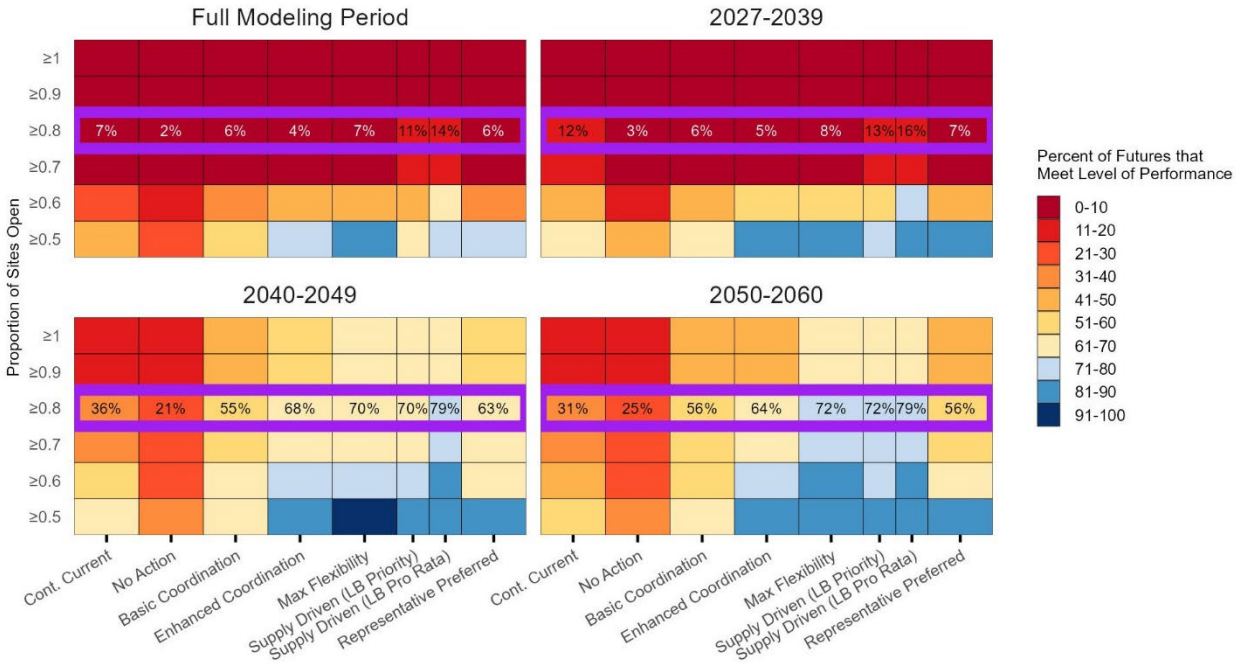
There are no specific reservoir elevation thresholds or river stages related to sportfishing identified from the literature reviewed. Catch rates for reservoir fishing are assumed to be directly related to reservoir habitat. Generally, lower reservoir elevation also reduces lake habitat for sportfish, which may have a negative impact on recreational sportfishing. Higher lake levels tend to favor popular sportfish, like largemouth bass, bluegill, and crappie, whereas lower levels favor smallmouth bass (Gustaveson 2018). The general trend for the alternatives indicates that the Maximum Operational Flexibility and Enhanced Coordination Alternatives have higher, less variable results centered around 3,600 feet, while the Supply Driven (both LB Priority and LB Pro Rata approaches), Basic Coordination, No Action, and Representative Preferred Alternatives, and the CCS Comparative Baseline, have median elevations around 3,560 feet. Therefore, the Maximum Operational Flexibility and Enhanced Coordination Alternatives would likely be more beneficial for reservoir sportfishing.

Lake Mead

Table TA 14-6 identifies the threshold elevations below which shoreline recreational facilities at Lake Mead could be affected. Below these elevations, facility adjustments or capital improvements would be required, potentially impacting recreation at Lake Mead. The analysis first examines the proportion of Lake Mead recreation sites that would remain open every summer month, then analyzes the performance of alternatives in maintaining Lake Powell elevations above 1,170 feet, which corresponds to the elevation required for avoiding most navigational hazards; 1,040 feet, the historic low elevation; and 1,000 feet, the elevation at which all existing boat ramp access would be lost.

Figure TA 14-4 below depicts the performance of each alternative with regard to keeping a specified proportion of Lake Mead recreational sites open over every summer month, which corresponds to peak visitation (May 31 – August 31). The figure is divided into four heat maps, each showing a different time period across the analysis. The highlighted row shows the percentage of futures in which an alternative achieves maintaining a 0.8 proportion of Lake Mead recreational sites open between May 31 and August 31. The 0.8 proportion row was highlighted because it corresponds to approximately the 10th percentile from the historical analysis that informed the thresholds.

Figure TA 14-4
Lake Mead Recreation Sites: Robustness.
Percent of futures in which the proportion of open Lake Mead sites stays above the value specified by each row in every summer month (May 31 – August 31)



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

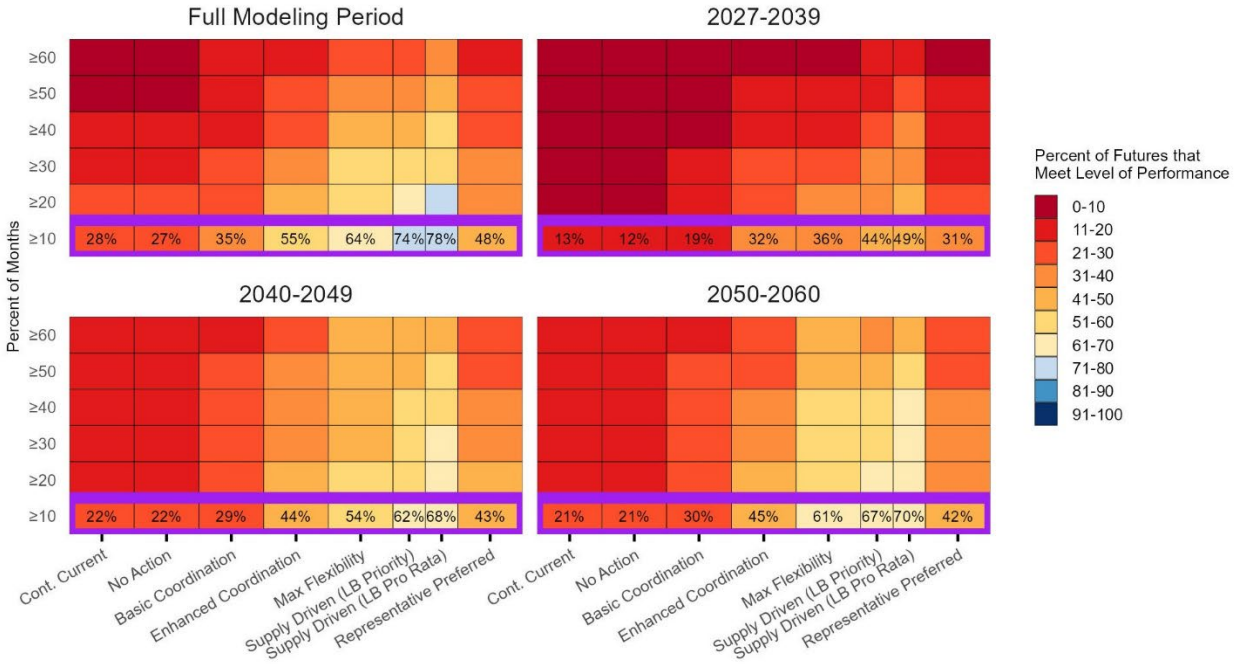
Across the full modeling period, all alternatives exhibit poor performance at maintaining at least 80 percent of Lake Mead recreational sites open during the summer months, indicating that widespread reductions in recreation site availability are likely under a broad range of future conditions. The Supply Driven Alternative (LB Pro Rata approach) is the most robust at achieving the preferred minimum level of performance over the full modeling period but still does so in only 14 percent of modeled futures. The Supply Driven (LB Priority approach) performs similarly, succeeding in 11 percent of futures. All other alternatives perform at or below these levels. The Maximum Operational Flexibility Alternative and CCS Comparative Baseline perform the same over the full modeling period, succeeding in 7 percent of modeled futures, while the Basic Coordination, Representative Preferred, Enhanced Coordination, and No Action Alternatives succeed in only 6 percent, 6 percent, 4 percent, and 2 percent of futures, respectively, over the full modeling period.

Based on the planned length of this decision, it is important to compare robustness in the 2027–2039 modeling period. The CCS Comparative Baseline and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternative are most robust, meeting the preferred minimum performance level between 12 and 16 percent of futures. The Basic Coordination, Enhanced Coordination, Maximum Operational Flexibility, and the Representative Preferred Alternatives meet the preferred

minimum performance level in 6 percent, 5 percent, 8 percent, and 7 percent of futures, respectively. The No Action Alternative is least robust, meeting the preferred minimum performance level in 3 percent of futures. These results indicate that reduced access to Lake Mead recreation sites is likely to persist over the next decade. As site availability declines, use would be concentrated at fewer locations, contributing to increased congestion, limited parking, and reduced reliability of recreation opportunities.

Figure TA 14-5 depicts the performance of each alternative with regard to the percent of futures in which the Lake Mead elevation is 1,170 feet or above in the specified minimum percent of months across the full modeling period (2027–2060) and three subperiods. Rows of the heat map show different frequency ranges for keeping Lake Mead above this elevation for a specified percentage of months throughout the full modeling period. Lake Mead has not been at or above an elevation of 1,170 feet between October 2007 and May 2025; therefore, the 10 percent row was chosen to be highlighted.

Figure TA 14-5
Lake Mead Boating Hazards: Robustness.
Percent of futures in which the elevation of Lake Mead is at least 1,170 feet in the percent of months specified by each row



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

The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) is the most robust at maintaining or exceeding a Lake Mead elevation of 1,170 feet in 10 percent or more of months over

the full modeling period, as shown in the upper-left heat map. The LB Pro Rata and LB Priority approaches perform similarly to one another, doing so in 78 percent and 74 percent of futures, respectively. Over the full modeling period, performance is followed by the Maximum Operational Flexibility Alternative, the Enhanced Coordination Alternative, and the Representative Preferred Alternative, which succeed in 64 percent, 55 percent, and 48 percent of futures, respectively. The Basic Coordination Alternative, CCS Comparative Baseline, and No Action Alternative are the least robust at achieving the minimum level of performance, succeeding in 35 percent, 28 percent, and 27 of modeled futures, respectively.

Across the full modeling period, all alternatives exhibit poor performance in the upper rows. The analysis suggests that it is difficult to achieve a Lake Mead elevation above which boating navigational hazards would not occur.

Based on the planned length of this decision, it is important to compare robustness in the 2027–2039 modeling period. The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) is most robust, meeting the preferred minimum performance level in 44 percent (LB Priority approach) to 49 percent (LB Pro Rata approach) of futures. The Maximum Operational Flexibility Alternative meets the preferred minimum performance level in 36 percent of futures, followed closely by the Enhanced Coordination Alternative (32 percent) and Representative Preferred Alternative (31 percent). The CCS Comparative Baseline and the No Action and Basic Coordination Alternatives are less robust, meeting the preferred minimum performance level in 13, 12, and 19 percent of futures, respectively.

Figure TA 14-6 below depicts the performance of each alternative with regard to the percent of futures in which the Lake Mead elevation is 1,040 feet or above in the specified minimum percent of months across the full modeling period (2027–2060) and three subperiods. This elevation corresponds to the historical low Lake Mead elevation. Rows of the heat map show different frequency ranges for keeping Lake Mead above this elevation for a specified percentage of months throughout the full modeling period. The purple highlighted row shows the percentage of futures that an alternative maintains Lake Mead at or above 1,040 feet in at least 90 percent of months. This row was chosen to be highlighted because it corresponds to approximately the 10th percentile from the historical analysis.

The Supply Driven Alternative (LB Pro Rata approach) is the most robust at maintaining or exceeding a Lake Mead elevation of 1,040 feet in 90 percent or more of months over the full modeling period, doing so in 51 percent of futures. Over the full modeling period, performance is followed by the Enhanced Coordination, Supply Driven (LB Priority approach), Maximum Operational Flexibility, and Representative Preferred Alternatives, which succeed in 42 percent, 39 percent, 33 percent, and 27 percent of modeled futures, respectively. The Basic Coordination Alternative, CCS Comparative Baseline, and No Action Alternative exhibit the worst performance, succeeding in 22 percent, 16 percent, and 8 percent of modeled futures, respectively.

Based on the planned length of this decision, it is important to compare robustness in the 2027–2039 modeling period. The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) is the most robust, meeting the preferred minimum performance level in 22 percent

(LB Priority approach) to 28 percent (LB Pro Rata approach) of futures. The Maximum Operational Flexibility and Representative Preferred Alternatives both meet the preferred minimum performance level in 18 percent of futures, followed by the CCS Comparative Baseline (17 percent), Enhanced Coordination Alternative (16 percent), and Basic Coordination Alternative (12 percent). The No Action Alternative is least robust, meeting the preferred minimum performance level in 5 percent of futures. These results indicate a high likelihood that Lake Mead levels would fall below the historic low elevation over the next decade. Such conditions would constrain access at existing boat ramps, particularly those already operating near minimum functional elevations, potentially rendering some facilities inoperable. As access becomes more limited, this would result in impacts previously described above.

Figure TA 14-6
Lake Mead Boat Ramps: Robustness.
Percent of futures in which Lake Mead elevation is 1,040 feet or greater in the specified percent of months

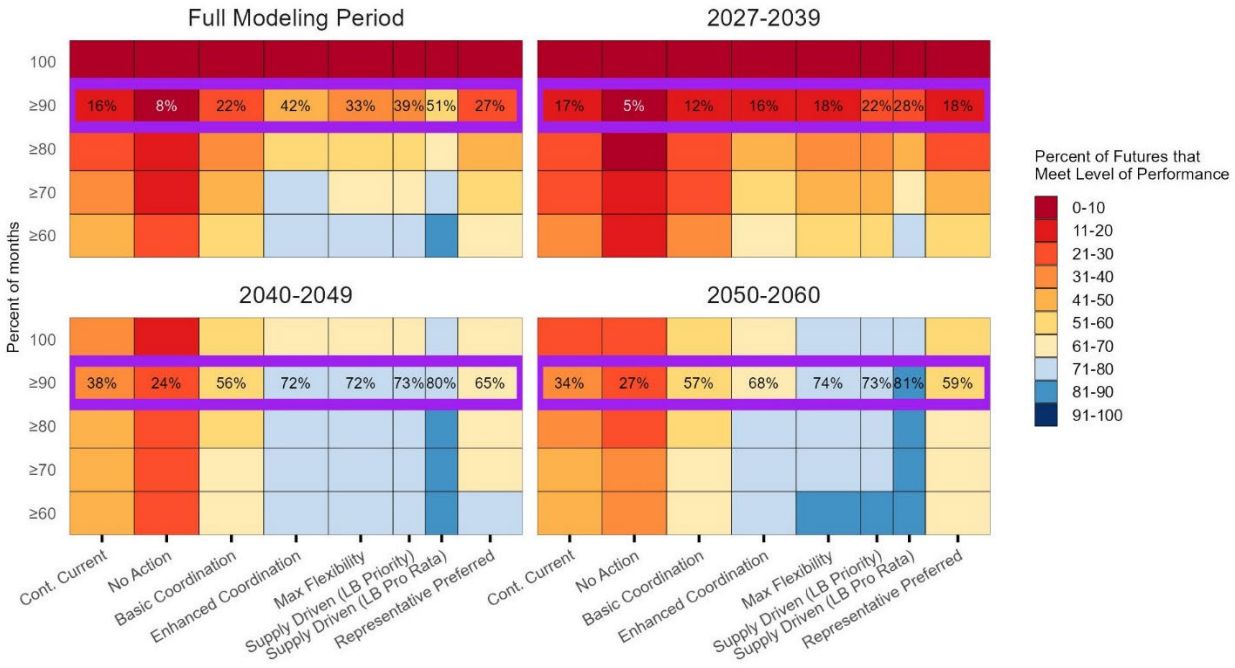


Figure TA 3-14 in **TA 3**, Hydrologic Resources, compares alternatives with respect to maintaining Lake Mead above an elevation of 1,000 feet. This elevation is important to recreation because it corresponds to the threshold that nearly all boat ramps would become inaccessible. The purple highlighted row shows the percentage of futures that an alternative maintains Lake Mead above 1,000 feet in 90 percent of months. Please refer to this figure and rationale for selection of this threshold as the preferred minimum level of performance in **TA 3**, Hydrologic Resources.

In the Full Modeling Period, the Enhanced Coordination, Maximum Operational Flexibility, Supply Driven (LB Priority approach), and Supply Driven (LB Pro Rata approach) Alternatives are similarly robust, meeting the preferred minimum level of performance in 71 percent, 71 percent, 64 percent,

and 74 percent of futures, respectively. The CCS Comparative Baseline and No Action Alternative are the least robust, meeting the preferred minimum performance in 46 percent and 20 percent of futures, respectively.

Based on the planned length of decision, it is important to note that in the first decade (2027–2039) Enhanced Coordination, Maximum Operational Flexibility, Supply Driven (LB Priority approach), and Supply Driven (LB Pro Rata approach) Alternatives are similarly robust, meeting the preferred minimum level of performance in 70 percent, 67 percent, 64 percent, and 77 percent of futures respectively. The CCS Comparative Baseline and Basic Coordination Alternatives are somewhat less robust, meeting the preferred minimum performance in 54 percent and 55 percent of futures respectively. In the first modeling period, the No Action Alternative is the least robust, meeting the preferred minimum performance in 25 percent of modeled futures.

The Representative Preferred Alternative meets the preferred minimum level of performance in 63 percent of modeled futures in the full modeling period. Based on the planned length of this decision, it is important to note that the Representative Preferred Alternative meets the preferred minimum performance level in 62 percent of futures in the first modeling period (2027–2039).

In the three subperiods, the alternatives meet the preferred minimum level of performance in greater percentages of futures because the preferred standard is easier to meet over shorter timespans than over the full 34 years. Additionally, the observed data prior to modeling and the initial system state (2027 begins with relatively low reservoir elevations) cause worse performance in the first decade. The robustness ranking across the three alternatives in each subperiod is consistent with the ranking in the Full Modeling Period.

In the remaining modeled futures in which minimum performance is not achieved, reservoir elevations would fall below the levels required to sustain boat ramp operations, resulting in a complete loss of reservoir boating opportunities at Lake Mead. Such conditions would eliminate launching opportunities until water levels recover or additional infrastructure modifications are implemented, substantially constraining recreation access and use.

TA 14.2.4 Issue 2: How would the management of releases from Glen Canyon Dam affect recreation, including water temperature?

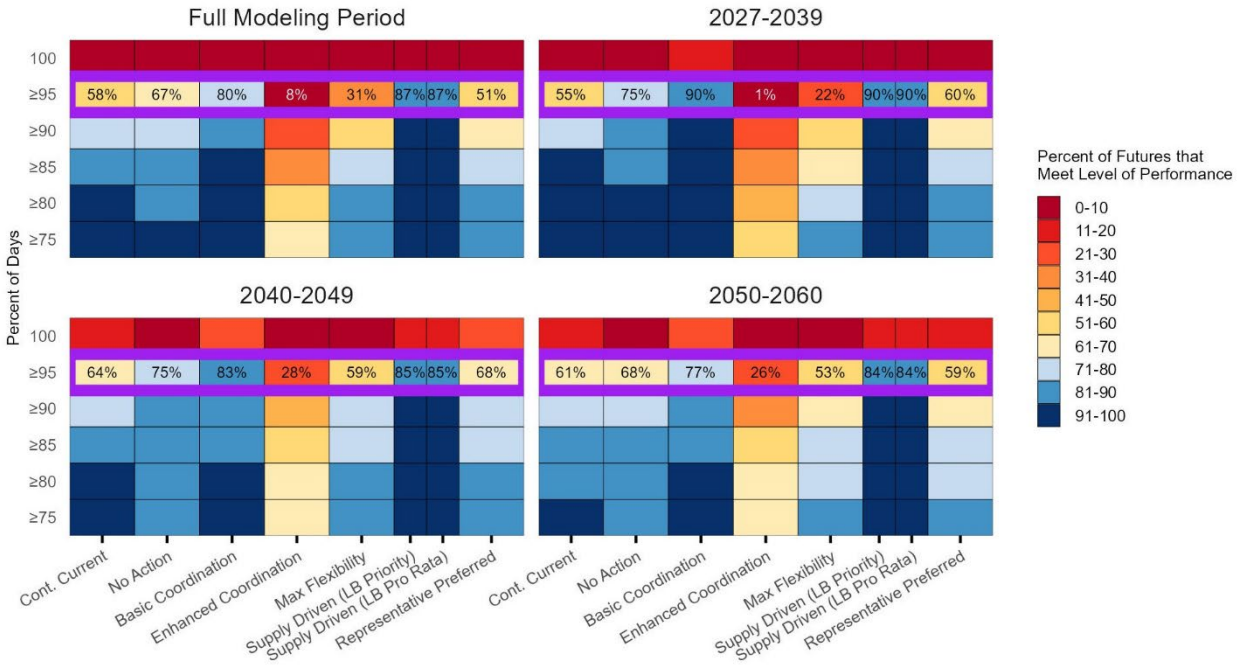
Whitewater Boating

River flow levels and fluctuations are important for whitewater boaters. The minimum daily flow levels of 8,000 cfs were set under the 2016 Glen Canyon Dam Long-Term Experimental and Management Plan Final EIS as the minimally adequate daytime levels for Grand Canyon boating. Levels lower than this may present increasing navigability challenges for the use of large (often 35 feet long) rafts equipped with motors. Extended low flows of 5,000 cfs would adversely affect navigability and trip management because of a greater risk of boating incidents. Commercial and private whitewater trip leaders have reported a preference for steady flows (flows that do not fluctuate by more than 10,000 cfs per day) in the 20,000-26,000 cfs range (Bishop et al. 1987; Neher et al. 2017); thus, there would likely be greater perceived value to rafters when flows are within this range. However, the historical and projected volume range under the alternatives may not align with

these preferences, and the exact impacts on recreation would continue to depend on water availability for releases.

Figure TA 14-7 depicts the performance of each alternative with regard to the percent of futures in which daytime flows (7 a.m. – 7 p.m.) below Glen Canyon Dam are at least 8,000 cfs in the specified percent of days over the full modeling period (2027–2060) and three subperiods. Rows of the heat map show different frequency ranges for keeping daytime flows above this threshold in the specified percentage of days throughout the full modeling period.

Figure TA 14-7
Whitewater Boating Below Glen Canyon Dam, 8,000 cfs: Robustness. Percent of futures in which daytime flows below Glen Canyon Dam are greater than or equal to 8,000 cfs in the percent of days specified by each row



The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) is the most robust at maintaining or exceeding daytime flows of 8,000 cfs below Glen Canyon Dam over the full modeling period, as shown in the upper-left heat map; succeeding in 87 percent of futures. The Basic Coordination Alternative achieves a similar robustness of 80 percent. Over the full modeling period, performance is followed by the No Action Alternative, which would succeed in 67 percent of futures, and the CCS Comparative Baseline, which would succeed in 58 percent of futures. The Representative Preferred Alternative would succeed in 51 percent of futures. The Maximum Operational Flexibility Alternative would succeed in 31 percent of futures, and the Enhanced Coordination Alternative would be the least robust, succeeding in only 8 percent of futures.

Based on the planned length of this decision, it is important to compare robustness in the 2027–2039 modeling period. The Supply Driven (both LB Priority and LB Pro Rata approaches) and Basic

Coordination Alternatives are the most robust, meeting the preferred minimum performance level in 90 percent of futures. The No Action Alternative meets the preferred minimum performance level in 75 percent of futures, and the Representative Preferred Alternative meets this performance level in 60 percent of futures. The CCS Comparative Baseline (55 percent) and Maximum Operational Flexibility Alternative (22 percent) are less robust. The Enhanced Coordination Alternative is least robust, meeting the preferred minimum performance level in 1 percent of futures.

In the remaining modeled futures in which minimum performance is not achieved, daytime flows would fall below the levels required to safely navigate the river for large rafts with motors. Such conditions would eliminate rafting opportunities for large group trips until water levels recover, substantially constraining recreation access and use.

Figure TA 14-8 depicts the performance of each alternative with regard to the percent of futures in which daytime flows (7 a.m. – 7 p.m.) below Glen Canyon Dam are at least 5,000 cfs in the specified percent of days over the full modeling period (2027–2060) and three subperiods. Rows of the heat map show different frequency ranges for keeping daytime flows above this threshold in the specified percentage of days throughout the full modeling period.

The Supply Driven (both LB Priority and LB Pro Rata approaches) and Enhanced Coordination Alternatives are the most robust at maintaining or exceeding daytime flows of 5,000 cfs below Glen Canyon Dam over the full modeling period, as shown in the upper-left heat map. These alternatives would succeed in 97 percent and 98 percent of futures, respectively. The Representative Preferred Alternative would succeed in 92 percent of futures. The CCS Comparative Baseline would succeed in 80 percent of futures across the full modeling period, followed by the Basic Coordination Alternative (79 percent), then the No Action Alternative (76 percent), and finally, the Maximum Operational Flexibility Alternative (33 percent).

Based on the planned length of this decision, it is important to compare robustness in the 2027–2039 modeling period. The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) is most robust, meeting the preferred minimum performance level in 100 percent of futures. The CCS Comparative Baseline, Enhanced Coordination Alternative, and Representative Preferred Alternative follow closely, meeting the preferred minimum performance level between 96 and 99 percent of futures. The No Action and Basic Coordination Alternatives are less robust, meeting the preferred minimum performance level in 92 and 94 percent of futures, respectively. The Maximum Operational Flexibility Alternative is least robust, meeting the preferred minimum performance level in 40 percent of futures. When flows are above 5,000 cfs, there would generally be fewer navigation challenges and boating incidents caused by a change in river levels. Minor changes in exposure to boating navigational hazards caused by a change in river velocity; changes in access or use of rest areas and take-out points; changes in trip duration caused by changes in river velocity; or the ability to use sportfishing sites caused by changes in flows, may occur under all alternatives.

Figure TA 14-8
Whitewater Boating Below Glen Canyon Dam, 5,000 cfs: Robustness.
Percent of futures in which daytime flows below Glen Canyon Dam are greater than or equal to 5,000 cfs in the percent of days specified by each row

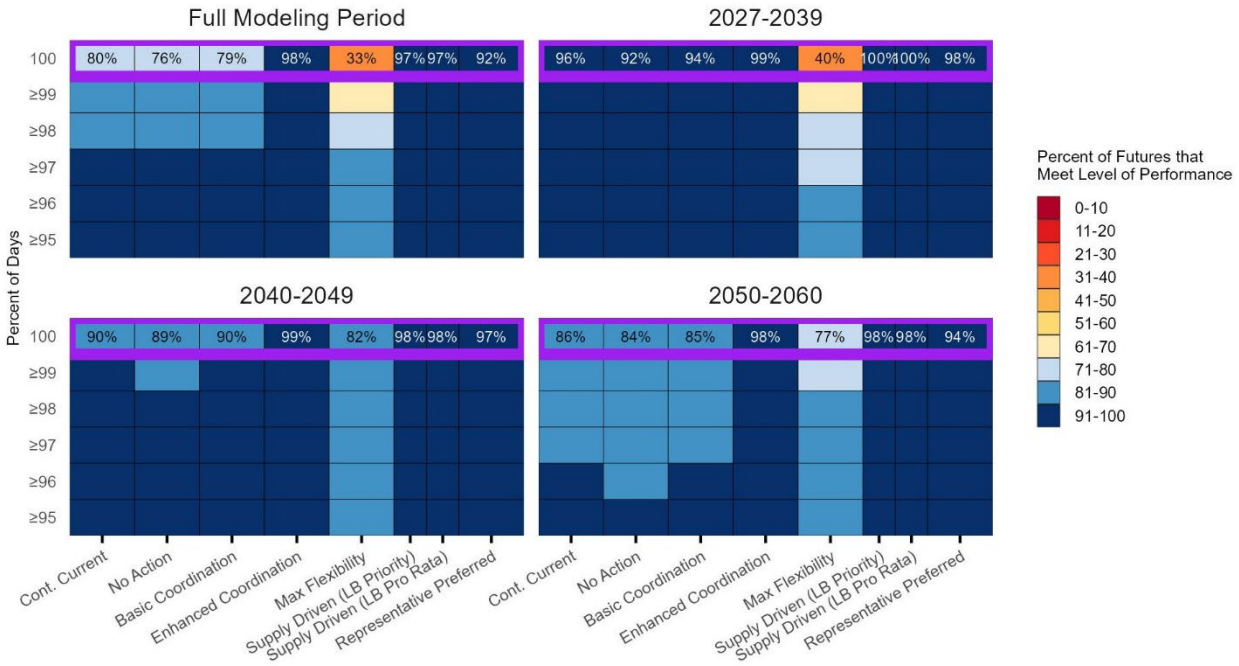


Figure TA 9-11 in **TA 9**, Vegetation Including Special Status Species, depicts arrowweed suitable habitat under each alternative by Grand Canyon sub-reach. Please refer to this figure in **TA 9**, Vegetation Including Special Status Species. Across all three reaches, all alternatives show similar trends. Under the Average Flow Category, the median for each alternative overlaps or nearly overlaps the modeled historic conditions, and the interquartile conditions are relatively small. This suggests that arrowweed suitable habitat may be similar to historic conditions under the Average Flow Category.

Across all three sub-reaches, under the Wet Flow Category and Moderately Wet Flow Category, the median and interquartile ranges are below the modeled historic conditions for all alternatives except for interquartile ranges of the No Action Alternative and Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) in the Moderately Wet Flow Category. This suggests that there would be less arrowweed suitable habitat under the Wet and Moderately Wet Flow Categories under all sub-reaches and all alternatives. Under the Dry Flow Category, the median and interquartile ranges are above historic conditions (dashed line), for all alternatives except the CCS Comparative Baseline and Enhanced Coordination Alternatives. Under the Critically Dry Flow Category the median and interquartile ranges are above the modeled historic conditions for all sub-reaches and all alternatives except for the CCS Comparative Baseline, although the median remains above historic conditions. This indicates that there may be more arrowweed suitable habitat under Critically Dry Flow Category for all alternatives across all sub-reaches.

These results indicate that in futures with drier flow category conditions, there may be more arrowweed suitable habitat, which would further encroach on available campsite areas within the Grand Canyon compared to under the average or wet flow categories.

Sportfish Populations

While different water temperature thresholds were considered for native and invasive fish species, this section focuses on impacts on the rainbow trout fishery at Lees Ferry. Water temperatures exceeding 20 °C (degrees Celsius; 68 °F [degrees Fahrenheit]) can cause thermal stress and mortality of rainbow trout while creating conditions more favorable for the growth of nonnative fish and smallmouth bass. Additionally, warmer water temperatures may increase the competitive advantage for brown trout, as this species is more tolerant of elevated temperatures. The percentage of futures for each alternative in which water temperature at Lees Ferry exceeds 20 °C (68 °F) is presented in **Figure TA 8-10** under **TA 8**, Biological Resources – Fish and Other Aquatic Resources.

Over the full modeling period, the Enhanced Coordination Alternative is the most robust, meeting the preferred minimum performance level in 56 percent of futures. The Maximum Operational Flexibility Alternative performs lower than the Enhanced Coordination Alternative at 47 percent but still performs substantially better than the remaining alternatives. The No Action Alternative and Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) perform similarly and are the least robust, meeting the preferred minimum performance level in 12 to 18 percent of futures and performing similarly to the CCS Comparative Baseline. Decadal comparisons of robustness reveal similar rankings among the alternatives. Robustness scores tend to be lowest in 2027 due to the low initial reservoir conditions in 2027. Robustness is highest after 2040, with the best-performing alternatives—the Enhanced Coordination Alternative and the Maximum Operational Flexibility Alternative—nearing or exceeding 80 percent in meeting the preferred minimum performance threshold.

The Representative Preferred Alternative meets the preferred minimum performance level robustness criteria in 20 percent of modeled futures in the full modeling period. Based on the planned length of this decision, it is important to compare robustness in the 2027-2039 modeling period. The Enhanced Coordination (62 percent) and Maximum Operational Flexibility (60 percent) Alternatives are the most robust. The remaining action alternatives (including the Representative Preferred Alternative) and the CCS Comparative Baseline are similarly less robust (27-36 percent). The No Action Alternative is the least robust (19 percent).

Alternatives that support higher Lake Powell elevations and greater river flows generally perform better at maintaining cooler water temperatures. However, under extended drought (low average flows and lower Lake Powell elevation), all alternatives become more vulnerable to undesirable temperature increases, affecting fish habitat and species composition. Please refer to **TA 8**, Biological Resources – Fish and Other Aquatic Resources, Issue 2, for more detailed information on changes in water temperature and quality from Glen Canyon Dam downstream through the Grand Canyon to Pearce Ferry and impacts on rainbow trout, native Grand Canyon fishes, and nonnative predatory fish.

TA 14.2.5 Summary Comparison of Alternatives

The alternatives vary in their potential to affect recreational resources, including shoreline public use facilities, reservoir boating, river and whitewater boating, and sportfishing. The general trend for the alternatives indicates that the Maximum Operational Flexibility and Enhanced Coordination Alternatives have higher, less variable Lake Powell reservoir elevations; therefore, these alternatives would likely be more beneficial for all Lake Powell recreational activities. The general trend for the alternatives indicates the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) has higher, less variable Lake Mead reservoir elevations, followed by the Maximum Operational Flexibility and Enhanced Coordination Alternatives; therefore, these alternatives would likely be more beneficial for all Lake Mead recreational activities. The Representative Preferred Alternative generally performs in the middle of the range of alternatives for both Lake Powell and Lake Mead elevations, showing moderate robustness but not outperforming the top-performing option.

However, across the full modeling period, all alternatives have poor levels of performance for maintaining higher elevations for a greater percentage of futures. Under all alternatives, projected Lake Powell and Lake Mead elevations for much of the analysis period would be below the critical thresholds for most boat launch facilities and safe boat navigation, which would result in a reduction in the quality of or the loss of reservoir boating opportunities.

Under the Basic Coordination Alternative, projected flows would be the highest in the Critically Dry Flow Category; however, river flows generally decrease as flow categories get drier. Higher flows would generally yield the greatest benefits to whitewater boating in the Grand Canyon. The Enhanced Coordination and the Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives are the most robust at achieving daytime flows of 5,000 cfs or greater, which is above the safe whitewater boating minimum for large, motorized watercraft. Again, the Representative Preferred Alternative generally performs in the middle of the range of alternatives, showing moderate robustness. The Enhanced Coordination Alternative is the most robust at maintaining cooler water temperatures at Lees Ferry, which would confer the greatest benefits to the rainbow trout fishery.

TA 14.3 References

Arizona Hospitality Research and Resource Center. 2025. Arizona State Parks, Revenue and Attendance Monthly Report. Northern Arizona University, W.A. Franke College of Business.

Baker, B. 2022. Glen Canyon's side canyons spring back to life: A Q&A with an ecologist on how Glen Canyon is returning as Lake Powell recedes. Salt Lake City Tribute.

Bishop, R. C., K. J. Boyle, M. O. Welsh, R. M. Baumgartner, and P. R. Rathbun. 1987. GCD Releases and Downstream Recreation: An Analysis of User Preferences and Economic Values, Glen Canyon Environmental Studies, Flagstaff, Arizona.

Blommer and Gustaveson. 2021. Lake Powell Fisheries Investigations, Completion Report, May 2015 – April 2020. Sportfish Restoration Act F-46-R. Utah Division of Wildlife Resources. Publication No. XX-XX. Salt Lake City, UT.

Brown, C.A. and Hahn-O'Neill, M.G. 1987. The effect of flows in the Colorado River on reported and observed boating accidents in Grand Canyon, Report to Glen Canyon Environmental Studies, Bureau of Reclamation.

Bureau of Reclamation (Reclamation). 2024. Glen Canyon Dam Long-term Experimental and Management Plan–Final Supplemental Environmental Impact Statement. U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado River Basins, Salt Lake City, Utah. Internet website: http://www.riversimulator.org/2025Guidelines/USBR/Bass/Final/GCDltempSEISFinal2024USBR.pdf.

Deemer et al. 2023. B. R., C. M. Andrews, K. E. Strock, N. Voichick, J. Hensleigh, J. R. Beaver, and R. Radtke. 2023. "Over half a century record of limnology data from Lake Powell, desert southwest United States: From reservoir filling to present day (1964–2021)." *Limnology and Oceanography Letters* 8(4):580–94. Internet website: https://doi.org/10.1002/lol2.10310.

Gustaveson, W. 2018. Smallmouth bass history in Lake Powell. Wayne's Words, February 21, 2018. Internet website: https://wayneswords.net/threads/smallmouth-bass-history-in-lake-powell.1340/.

Hall, T. and B. Shelby. 2000. 1998 Colorado River Boater Study, Grand Canyon National Park, prepared for Grand Canyon Association and Grand Canyon National Park, June 15.

Jalbert, L.M. 1992. The Influence of Discharge on Recreational Values, Including Crowding and Congesting and Safety in Grand Canyon National Park.

Joel, L. 2016. The drought has created new gnarly rapids in the Grand Canyon. Outside Magazine, February 10, 2016. Internet website: https://www.outsideonline.com/outdoor-adventure/water-activities/drought-has-created-new-gnarly-rapids-grand-canyon/.

Kaplinski, M., Hazel, J., Parnell, R. Hadley, D.R., and Grams, P. 2014. Colorado River campsite monitoring, Grand Canyon National Park, Arizona, 1998-2012: U.S. Geological Suvey Open-File Report 2014-1161. https://dx.doi.org/10.3133/ofr20141161.

Kearsley, M. 2023. National Park Service, Grand Canyon, Arizona. Personal communications and email.

Kolbert, E. 2021. The lost canyon under Lake Powell. New Yorker, August 9. 2023. Internet website: https://www.newyorker.com/magazine/2021/08/16/the-lost-canyon-under-lake-powell.

National Park Service (NPS) 2006a. Grand Canyon Colorado River Management Plan. Grand Canyon National Park, Grand Canyon, Arizona. October.

_____. 2006b. Record of Decision, Colorado River Management Plan. Internet website: https://www.nps.gov/grca/learn/management/upload/CRMP_ROD_2006.pdf.

_____. 2010. Pearce Ferry Road Extension Announced. Internet website: https://www.nps.gov/lake/learn/news/pearce-ferry-road-extension-announced.htm.

_____. 2016. Protect Feet and Paws from Sharp Quagga Mussel Shells on Lake Powell Shorelines. Internet website: https://www.desertusa.com/dusablog/protect-feet-and-paws-from-sharp-quagga-mussel-shells-on-lake-powell-shorelines/?srsltid=AfmBOooC08t5C4QFoQoS7a21c9gBoRtsr3z3SXDxKqgVW7T9WfYblGEw

_____. 2019. Glen Canyon National Recreation Area – Lake Powell Recreational Water Advisory. Internet website: https://www.nps.gov/glca/learn/news/lpp.htm.

_____. 2021. Immediate Access to Rainbow Bridge National Monument Impacted by Storm Debris and Low Lake Level. News release, October 20, 2021. Internet website: https://www.nps.gov/glca/learn/news/20211020.htm.

_____. 2022. "Naegleria Fowleri Fatality." News release, October 19, 2022. Internet website: https://www.nps.gov/lake/learn/news/naegleria-fowleri-fatality.htm.

_____. 2023a. Rising Lake Powell Water Level Increasing Access. Glen Canyon National Recreation Area News Release. Internet website: https://home.nps.gov/glca/learn/news/20230602a.htm.

_____. 2023b. Glen Canyon National Recreation Area – Mussel Update – History of Mussel Prevention & Containment. Internet website. Internet website: https://www.nps.gov/glca/learn/nature/history-of-mussel-prevention.htm.

_____. 2025a. History of Total Annual Visits for Glen Canyon National Recreation Area. Internet website: https://irma.nps.gov/Stats/SSRSReports/Park percent20Specific percent20Reports/Annual percent20Park percent20Recreation percent20Visitation percent20(1904 percent20- percent20Last percent20Calendar percent20Year)?Park=GLCA.

_____. 2025b. Visitation Statistics – Glen Canyon National Recreation Area. Internet website: https://www.nps.gov/glca/learn/management/statistics.htm.

_____. 2025c. Boating – Glen Canyon National Recreation Area. Internet website: https://www.nps.gov/glca/planyourvisit/boating.htm.

_____. 2025d. Changing Lake Levels – Glen Canyon National Recreation Area. Internet website: https://www.nps.gov/glca/learn/changing-lake-levels.htm.

_____. 2025e. Annual Grand Canyon National Park Recreation Visitation. Integrated Resource Management Applications (IRMA) portal. Internet website: https://irma.nps.gov/Stats/SSRSReports/Park percent20Specific percent20Reports/Annual percent20Park percent20Recreation percent20Visitation percent20(1904 percent20-percent20Last percent20Calendar percent20Year)?Park=GRCA.

_____. 2025f. Annual Lake Mead National Recreation Area Recreation Visitation. Integrated Resource Management Applications (IRMA) portal. Internet website: https://irma.nps.gov/Stats/SSRSReports/Park%20Specific%20Reports/Annual%20Park%20Recreation%20Visitation%20(1904%20-%20Last%20Calendar%20Year)?Park=GRCA.

Neher, C., J. Duffield, L. Bair, D. Patterson, and K. Neher. 2017. "Testing the limits of temporal stability: willingness to pay values among Grand Canyon whitewater boaters across decades." *Water Resources Research* 53(12):10108-10120.

Peterson, B. 2022. "On the Colorado River, Growing Concern for Trout and Chub." Associated Press, September 19, 2022. Internet website: https://www.cpr.org/2022/09/19/colorado-river-trout-chub-populations-drop/

Returning Rapids Project. 2023. The North Wash Boat Ramp. January 14, 2023. Internet website: https://drive.google.com/file/d/1oavpEfn_jP850OYoRmpWnKSlokMAtCuE/view.

Rogowski, D. L. and J. K. Boyer. 2023. Status of the Lees Ferry Rainbow Trout Fishery: 2022 Annual Report. AGFD, Colorado River Research Office. Submitted to the Grand Canyon Monitoring and Research Center, Flagstaff, Arizona.

Shelby, B., T. C. Brown, and R. Baumgartner. 1992. "Effects of Streamflows on River Trips on the Colorado River in Grand Canyon, Arizona." *Rivers* 3(3):191-201.

Stewart, W., K. Larking, B. Orland, D. Anderson, R. Manning, D. Cole, and J. Taylor et al. 2000. Preferences of Recreation User Groups of the Colorado River in Grand Canyon. Prepared for the U.S. Geological Survey, Grand Canyon Monitoring and Research Center, Flagstaff, Arizona. April.

Utah Department of Transportation (UDOT). 2025. Lake Powell Ferry Crossing. Internet website: https://connect.udot.utah.gov/current-conditions/lake-powell-ferry-crossing/.

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