Technical Appendix 19

Visual Resources

This page intentionally left blank.

Contents

Figures

Acronyms and Abbreviations

Acronym or Abbreviation	Full Phrase
2007 Final EIS	2007 Interim Guidelines Final Environmental Impact Statement
2007 Interim Guidelines	Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead
2007 ROD	2007 Interim Guidelines Record of Decision
2024 Final SEIS	Near-term Colorado River Operations Final Supplemental Environmental Impact Statement
CCS	Continued Current Strategies
Draft EIS	Draft Environmental Impact Statement
DMDU	decision making under deep uncertainty
GCNP	Grand Canyon National Park
HFE	High-Flow Experiment
maf	million acre-feet
NRA	National Recreation Area
U.S.	United States

This page intentionally left blank.

TA 19. Visual Resources

TA 19.1 Affected Environment

Visual resources are the physical features that make up the visible landscape, including land, water, vegetation, topography, and human-made features such as buildings, roads, utilities, and structures. They also include the response of viewers to those features.

Visual resources are important both to visitors to Grand Canyon National Park (GCNP), Glen Canyon National Recreation Area (NRA), Lake Mead NRA, as well as the Basin Tribes who use these lands for subsistence or ceremonial uses. The Grand Canyon Protection Act of 1992 specifically calls for the conservation of visual resources, which are also a key component of federal management of these areas. GCNP, Glen Canyon NRA, and Lake Mead NRA identify management directions for visual resources as part of their general management plan, which are described below.

The portion of the Colorado River adjacent to Lake Powell, as well as a portion of the river upstream and downstream of Lake Powell, is managed under the Glen Canyon NRA General Management Plan. Large areas of the Glen Canyon NRA, including those adjacent to the Colorado River, are managed as a Natural Zone, which includes "…the recreation area's outstanding scenic resources, relatively undisturbed areas isolated and remote from the activities of man…" (NPS 1979:5).

Further downstream, the landscapes adjacent to the Colorado River are managed under the GCNP General Management Plan which also identified the lands adjacent to the river as a Natural Zone which is managed to "…conserve natural resources and ecological processes and to provide for their use and enjoyment by the public in ways that do not adversely affect these resources and processes" (NPS 1995:19).

Past GCNP, the portion of the Colorado River adjacent to Lake Mead and downstream to Bullhead City is managed under the Lake Mead NRA General Management Plan. An amended plan from 2018, to address low-water levels, does not specifically address visual resources but does acknowledge that "Lowering lake levels exposes new shoreline, which is susceptible to the spread of weeds and invasive nonnative plants" and "The appearance of mineral deposits, mudflats, denuded shorelines, and abandoned high-grounded facilities detract from the scenery of the lake" (NPS 2018:5).

TA 19.1.1 Lake Powell and Glen Canyon Dam

Landscape Character

The landscapes of the Lake Powell and Glen Canyon area are characterized by sweeping vistas of red rock towers, buttes, and mesas typical of the Colorado Plateau (Fenneman 1931). Navajo

Sandstone and desert varnish dominate the existing landscape character, with the introduction of water, associated with Lake Powell, framing these natural features.

Lake Powell has deposits of calcium carbonate, which become visible as reservoir levels decrease. At lower lake elevations, the colorful sandstone canyon walls show a white band of calcium carbonate deposits between the full reservoir elevation and the lower reservoir elevation, which contrasts with the natural, red-colored sandstone (see **Figure TA 19-1**). At lower lake elevations, motorists view the calcium carbonate ring from Utah State Route 95 (near Hite, Utah), boaters view it on Lake Powell, recreationists see it at developed and undeveloped recreation areas (for example, Hite, Bullfrog, Halls Crossing, Antelope Point, and Wahweap), and hikers see it on trails adjacent to Lake Powell.

Figure TA 19-1
Photo of Existing Calcium Carbonate Rings at Lake Powell

Source: USGS 2022

Additionally, sediment deltas have formed near the inflow areas of Lake Powell as a result of sediments carried by the Colorado River and the San Juan, Dirty Devil, and Escalante Rivers, resulting in downstream-progressing deltas. These appear as expansive, deep, and eroding mud flats cut by river channels. Similarly, lower reservoir levels also expose a band of exposed sediment along the shoreline, which in some areas may expose garbage and other waste adjacent to Lake Powell. Sediment exposed for more than a few months is soon colonized by tamarisk, an invasive shrub. These sediment deltas and exposed shoreline areas are considered a visual distraction, particularly as

the reservoir elevation decreases and these features become more visible. The sediment deltas and exposed shoreline areas can be seen from viewing locations, including Utah State Route 95 (Utah Bicentennial Scenic Byway) and scenic overlooks adjacent to these inflow areas; water-based recreationists can also see the deltas and exposed shoreline from Lake Powell.

Attraction Features

The analysis will focus on the following specific attraction features:

- **Rainbow Bridge:** Contained within Rainbow Bridge National Monument, established in 1910, it was originally only accessible via the rugged Wetherill Trail from Navajo Mountain. Today, no facilities support visitation to Rainbow Bridge National Monument from Lake Powell. All infrastructure (docks and restrooms) was relocated to the main channel in 2021, due to the narrowing of the canyon and a delta that has formed at the back of the canyon. Some small, motorized vessels may be able to access the monument; however, they must beach their boat, and the walk may be through very soft sediment to reach the trail. Based on lower lake elevations, visitors do not see water under or near the Rainbow Bridge. Therefore, while Rainbow Bridge is an important visual resource, the potential impacts on access would be the primary effect on visitors, which are described in **TA 14**, Recreation.
- **Cathedral in the Desert:** This feature was inundated by the waters of Lake Powell as the reservoir filled. This feature is only exposed at lower Lake Powell elevations, and it is completely visible and accessible when reservoir elevations are below 3,550 feet. However, boats may not be able to reach it at reservoir elevations below 3,525 feet. Note, other attraction (geological) features, including Gregory Bridge, La Gorce Arch, and other features inundated by Lake Powell, could also become visible at lower lake elevations.
- **Glen Canyon Dam:** The American Society of Civil Engineers considers this dam one of the finest examples of concrete, thin-arch dams in the United States. The dam is visible from the adjacent visitor center as well as from a designated overlook location approximately 0.5 mile south of the dam. While visibility of the dam as an attraction feature is part of the current visual landscape in this area, as reservoir levels decrease, exposing more of the dam's concrete structure, its effect on the area's landscape character would increase and further dominate the area's natural landscape character.

TA 19.1.2 Glen Canyon Dam to Lake Mead

Landscape Character

The landscape character along the Colorado River within GCNP and Glen Canyon NRA, as well as within the Hualapai and Navajo Indian Reservations, is defined by towering cliff faces with banded rock strata containing a variety of colors, including reds, oranges, grays, browns, and white. The Colorado River Management Plan builds on this for the portion of the Colorado River in Grand Canyon as providing "a unique combination of thrilling whitewater adventure and magnificent vistas of a remarkable geologic landscape including remote and intimate side canyons" (NPS 2006:2).

Vegetation along the river mostly consists of riparian species, such as native willows; nonnative and invasive tamarisk (salt cedar); and isolated areas of cottonwoods and cattails, bulrushes, and reeds in return-current channels (backwaters), channel margins, and mouths of tributary streams from Glen

Canyon Dam downstream to Lake Mead. These tributary streams form numerous side canyons leading away from the Colorado River, with many of these side canyons only accessible from the river. Vegetation farther upslope along rock terraces includes saltbush, arrowweed, rabbitbrush, and other arid-adapted plant species. Previously planned and implemented High-Flow Experiment (HFEs) from Glen Canyon Dam, to re-create natural floods common before Glen Canyon Dam's construction, have allowed for the transportation and deposition of sand, resulting in the formation of sandbars along the river. In some areas, these HFEs can strip vegetation along the existing sandbars, including tamarisk (salt cedar), which allows the landscape to appear more similar to its natural character.

This portion of the Colorado River does not include visible calcium carbonate rings, sediment deltas or exposed shoreline, as it is not contained within an area of fluctuating reservoir levels associated with Lake Powell and Lake Mead.

Attraction Features

This portion of the river, including GCNP, is heavily visited and has been determined to be an eligible (but not yet designated) wild river segment by the NPS associated with the Wild and Scenic Rivers Act (Barnes 2005). It includes world-renowned whitewater rafting and other recreational opportunities along the Colorado River, including boating, kayaking, swimming, and fishing, in addition to viewing this varied, high-quality landscape from both locations along the river and from scenic overlooks above the river. The river is also viewed from proposed wilderness areas adjacent to the river, including superior views from high points in these areas. See **TA 14**, Recreation, and **TA 17**, Population and Land Use, for more information regarding recreational opportunities and special management areas along the Colorado River.

TA 19.1.3 Lake Mead to Hoover Dam

Landscape Character

The landscapes of the Lake Mead and Hoover Dam area are similar to those described for the Lake Powell area, except the adjacent landscapes are more typical of the Basin and Range physiographic province, characterized by parallel, north–south-oriented mountain ranges surrounded by nearly level, typically undrained basins (Fenneman 1931).

Similar to Lake Powell, Lake Mead also has deposits of calcium carbonate, which become visible as reservoir levels decrease. At lower lake elevations, the steep rock slopes, canyon walls, and islands show a white band of calcium carbonate deposit between the full reservoir elevation and the lower reservoir elevation, which contrasts with the natural rock colors. At lower lake elevations, motorists view the calcium carbonate ring on United States (U.S.) Highway 93 (between Boulder City, Nevada, and Hoover Dam), boaters view it on Lake Mead, and hikers see it on trails adjacent to Lake Mead. Sediment deltas have been built up at the confluence of the Virgin River and Muddy River at the upper Overton Arm and at upper Lake Mead (Iceberg Canyon, Pearce Basin, and lower Granite Gorge). Similarly, lower reservoir levels also expose a band of exposed sediment along the shoreline, which in some areas may expose garbage and other waste adjacent to Lake Mead. Sediment exposed for more than a few months is soon colonized by tamarisk, an invasive shrub. Sediment deltas and

the exposed shoreline are visible primarily to water-based recreationists. Visitors to Lake Mead NRA at Overton Beach and Pearce Ferry can also view them.

Attraction Features

The analysis will focus on the following specific attraction feature:

- **Hoover Dam:** Hoover Dam is a major destination and national landmark with high levels of visitation. In 1955, the American Society of Civil Engineers selected it as one of the seven engineering wonders in the United States. Since the Hoover Dam is in the narrow, steep-walled Black Canyon, only a small portion of Lake Mead is visible from Hoover Dam and adjacent visitor facilities. While visibility of the dam as an attraction feature is part of the current visual landscape in this area, as reservoir levels decrease, exposing more of the dam's concrete structure, its effect on the area's landscape character would increase and further dominate the area's natural landscape character.

TA 19.1.4 Hoover Dam to Southerly International Boundary

The landscapes from the Hoover Dam area to the Southerly International Boundary are characterized by arid mountain ranges and intervening desert plains associated with the Basin and Range physiographic province (Fenneman 1931). Availability of Colorado River water has resulted in large areas of irrigated landscapes, including agricultural lands in Nevada, Arizona, and California (Lower Division States), which have altered the natural landscapes. This increased water availability has introduced vivid greens into these landscapes, associated with crops and ornamental plantings, which expand the influence of the Colorado River into adjacent arid lands beyond the narrow, natural riparian corridor.

TA 19.2 Environmental Consequences

TA 19.2.1 Methodology

The Bureau of Reclamation (Reclamation) used similar methods to those in the 2007 Interim Guidelines Final Environmental Impact Statement (2007 Final EIS) and Near-term Colorado River Operations Final Supplemental Environmental Impact Statement (2024 Final SEIS) to analyze potential impacts on visual resources. This analysis assesses the potential effects on attraction features, the extent of the visible calcium carbonate ring, and exposure of sediment deltas at reservoir inflow areas while incorporating the decision making under deep uncertainty (DMDU) framework for this Draft Environmental Impact Statement (Draft EIS). Additionally, this analysis considers the effects of expanded shoreline exposure on the area's landscape character. The assessment of effects on landscape character adjacent to Lake Powell and Lake Mead used similar methods identified in the 2007 Final EIS and 2024 Final SEIS. However, using modeling and DMDU concepts, the analysis first focuses on the percent of time during the planning window that Lake Powell would decrease below elevation 3,550 feet. At that elevation, Cathedral in the Desert (and other attractions [geological] features, including Gregory Bridge, La Gorce Arch, and other features inundated by Lake Powell) would become visible and accessible. Based on historical averages, Lake Powell was below 3,550 feet approximately 9.9 percent of months between October 2007 and May 2025. The alternative comparison focuses on maintaining this lake elevation for at

least 10 percent of the months during the planning window. Conversely, this analysis also identifies the percentage of preferred minimum performance of futures in which Lake Powell would be above 3,550 feet, resulting in less of the upstream side of Glen Canyon Dam being visible.

The potential height of the calcium carbonate ring was calculated by comparing differing reservoir elevations with the full pool elevations of Lake Powell (3,700 feet) and Lake Mead (1,221 feet) under DMDU concepts. The assessment of effects from sediment deltas and shoreline exposure considers these differing reservoir elevations and references the analysis conducted in the 2007 Final EIS.

Reclamation added two new analysis items, similar to the 2024 Final SEIS, to assess impacts on the Colorado River's landscape character and broader landscape character in the Lower Division States. This assessment is based on changes in modeled hydrologic conditions under the No Action Alternative and Continued Current Strategy (CCS) Comparative Baseline, as well as management direction associated with the action alternatives. To assess potential changes to the landscape character along the Colorado River (between Glen Canyon Dam and Lake Mead), this analysis includes a qualitative assessment of effects associated with lower flow rates and the potential inability to conduct HFEs from Glen Canyon Dam. This analysis considers and references the analyses contained in **TA 5**, Geomorphology and Sediment, **TA 9**, Vegetation Including Special Status Species, and **TA 14**, Recreation, which assess the effects of the different flow rates resulting from the alternatives on the prevalence of riparian vegetation, sand bars, and the visibility of river features. Historically, from 1906 to 2007, the average annual natural flow at the Lees Ferry Gaging Station was 14.9 million acre-feet (maf), ranging from 5.4 maf to 24.4 maf. Since the implementation of the Record of Decision for Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead (2007 ROD; 2008 to 2022), the annual natural flow at the Lees Ferry Gaging Station has averaged 12.7 maf, ranging from a low of 6.7 maf (2021) to a high of 20.3 maf (2011). For more information on historic flow rates along the Colorado River, refer to **TA 3**, Hydrological Resources.

The assessment of potential impacts on the broader landscape character in the Lower Division States considered changes in annual Colorado River water supplies available to these states. This identifies the extent of large-scale changes in visual character in irrigated landscapes, including changes associated with agricultural production. This analysis considers and references assessment items contained in **TA 16**, Socioeconomics, including the effect of each alternative's proposed distribution of water on agricultural operations, as well as the potential for Lake Mead to reach dead pool–related shortages as described in **TA 4**, Water Deliveries. The analysis of impacts on the broader landscape character also considers the effect of increased dust generation from aridification of exposed lands, as described in **TA 7**, Air Quality, potentially impacting visibility and views within GCNP and other visually sensitive landscapes.

Impact Analysis Area

The visual resources impact analysis area was defined as the area within 5 miles of the Colorado River, from Lake Powell to the Southerly International Boundary, and full pool elevations of Lake Powell and Lake Mead. While the 2007 Final EIS did not specifically identify an analysis area for visual resources, the 2024 Final SEIS identified the same 5-mile-wide analysis area, based on the typical threshold between the Bureau of Land Management's foreground/middle ground distance

zone and background distance zone, where views of the change in management could attract attention in the landscape. Visual effects beyond this geographic area were considered, where appropriate, including the potential effects on the broader landscape character associated with potential decreased water availability for the Lower Division States.

Assumptions

- The analysis methods are consistent with the 2007 Final EIS and 2024 Final SEIS. Attraction features analyzed include Cathedral in the Desert, Glen Canyon Dam, and Hoover Dam. Other attraction features, such as Gregory Bridge, La Gorce Arch, and other features currently inundated by Lake Powell, will be mentioned but not analyzed.
- Decreasing flow rates along the Colorado River and the potential inability to conduct HFEs from Glen Canyon Dam would modify the river corridor's natural, visual character by limiting natural flooding processes.
- This Draft EIS references the analysis from the 2007 Final EIS and 2024 Final SEIS regarding impacts associated with expanding sediment deltas.
- Decreasing water availability for the Lower Division States would result in large-scale changes to the visual character of irrigated landscapes, including those associated with agricultural production.

Impact Indicators

- Attraction Features: Qualitative assessment describing the effects from visibility and access to Cathedral in the Desert, as well as more of Glen Canyon Dam and Hoover Dam becoming visible on their upstream side, informed by the Colorado River Simulation System and DMDU analysis. Quantitative analysis identifying the percent of preferable futures in which Lake Powell would be below 3,550 feet (Cathedral in the Desert would be visible and accessible) for at least 10 percent of the months under each alternative. Conversely, this analysis also identifies the percentage of preferred minimum performance of futures in which Lake Powell would be above 3,550 feet, resulting in less of the upstream side of Glen Canyon Dam being visible.
- Calcium Carbonate Rings: Comparison of modeled heights (in feet) of the calcium carbonate ring at Lake Powell and Lake Mead under each alternative, considering the Colorado River Simulation System and DMDU analyses.
- Exposed Shoreline and Sediment Deltas: Qualitative assessment references the 2007 Final EIS and 2024 Final SEIS, considering differing reservoir elevations under each alternative, to assess receding shorelines and formation of sediment deltas resulting from lower reservoir elevations.
- Colorado River Landscape Character: Qualitative description of the effect associated with proposed flow rates and the potential to conduct HFEs from Glen Canyon Dam under each alternative, considering the modeling presented in **TA 9**, Vegetation Including Special Status Species, **TA 5**, Geomorphology and Sediment, **TA 14**, Recreation, and **TA 7**, Air Quality.
- Broader Landscape Character: Qualitative description of the effects associated with potential decreases in water availability for the Lower Division States on the broader landscape character. This includes considering modeling associated with potential changes to crop

production resulting from proposed distribution of water, as described in **TA 16**, Socioeconomics, as well as the potential for Lake Mead to reach dead pool–related shortages as described in **TA 4**, Water Deliveries.

TA 19.2.2 Issue 1: How would management of reservoir elevations affect visibility of attraction features?

The assessment of impacts on landscape character associated with the elevations of Lake Powell considers two concepts. The first part of the assessment considers the positive impact on landscape character that occurs when Lake Powell is below 3,550 feet and Cathedral in the Desert (and other attraction features inundated by Lake Powell) is visible and accessible. For some recreationists and other users of this landscape, visibility and access to this feature are important and perceived as an improvement to the area's landscape character. Whereas other recreationists and users may prefer a landscape where water levels are higher, minimizing the impacts on landscape character associated with calcium carbonate rings, exposed shoreline, and sediment deltas (see Issue 2). Historically, Lake Powell has been at or below this elevation approximately 10 percent of the months. As shown in **Figure TA 19-2**, the CCS Comparative Baseline and the No Action, Basic Coordination, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives would result in the largest percentage of preferable futures where Cathedral in the Desert is visible and accessible at least 10 percent of the months during the planning period (similar to historic frequency). The Enhanced Coordination and Maximum Operational Flexibility Alternatives would have fewer preferable futures where Cathedral in the Desert is visible and accessible at least 10 percent of the months during the planning period. The positive influence on landscape character associated with the visibility of Cathedral in the Desert would occur in the most futures under the CCS Comparative Baseline and the No Action, Basic Coordination, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives.

The second part of the analysis focuses on keeping the Lake Powell water levels high, which reduces visibility of Glen Canyon Dam, specifically when above 3,550 feet. Therefore, as reservoir levels decrease, exposing more of the dam's concrete structure, its effect on the area's landscape character would increase and further dominate the landscape character. As shown in **Figure TA 19-3**, the Enhanced Coordination and Maximum Operational Flexibility Alternatives would result in more preferable futures where less of the upstream side of Glen Canyon Dam would be visible, resulting in this feature being "blocked" by water. Lower flows could keep Lake Powell at higher elevations under the Enhanced Coordination and Maximum Operational Flexibility Alternatives compared to the CCS Comparative Baseline and the No Action, Basic Coordination, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives. This would result in more preferable outcomes under the Enhanced Coordination and Maximum Operational Flexibility Alternatives, with less of the upstream side of Glen Canyon Dam being visible. As shown in **Figure TA 19-4**, comparing DMDU modeling with the driest historic 10-year average flows, the CCS Comparative Baseline and the No Action, Basic Coordination, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives would require higher flows to maintain similar elevations, which increases the vulnerability of meeting a preferred minimum performance of futures under those alternatives. Specifically, those alternatives would be more vulnerable than the Enhanced Coordination and Maximum Operational Flexibility Alternatives, with over 75 percent of the historic hydrological conditions resulting in conditions where Lake Powell could decrease below 3,550 feet for 10 percent

or more of months during the planning period. Under the Enhanced Coordination Alternative, approximately 25 percent of the historic hydrological conditions, and approximately 50 percent under the Maximum Operational Flexibility Alternative, would result in conditions where Lake Powell could decrease below 3,550 feet for 10 percent or more of the planning period.

Based on modeling scenarios that show lake levels within Lake Powell and Lake Mead, impacts associated with the visibility of Hoover Dam would be similar to Glen Canyon Dam under the CCS Comparative Baseline and the No Action, Enhanced Coordination, and Maximum Operational Flexibility Alternatives. Under the Basic Coordination and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives, based on managing higher reservoir levels in Lake Mead compared to Lake Powell, less of the upstream side of Hoover Dam would be visible under these alternatives, with comparatively more of the upstream side of Glen Canyon Dam being visible as described above. Therefore, as reservoir levels decrease, exposing more of the dam's concrete structure, its effect on the area's landscape character would increase and further dominate the landscape character.

Figure TA 19-2
Visibility and Access to Cathedral in the Desert (and other attraction features inundated by Lake Powell): Robustness.
Percent of futures in which the elevation of Lake Powell is less than 3,550 feet in the percent of months specified by each row

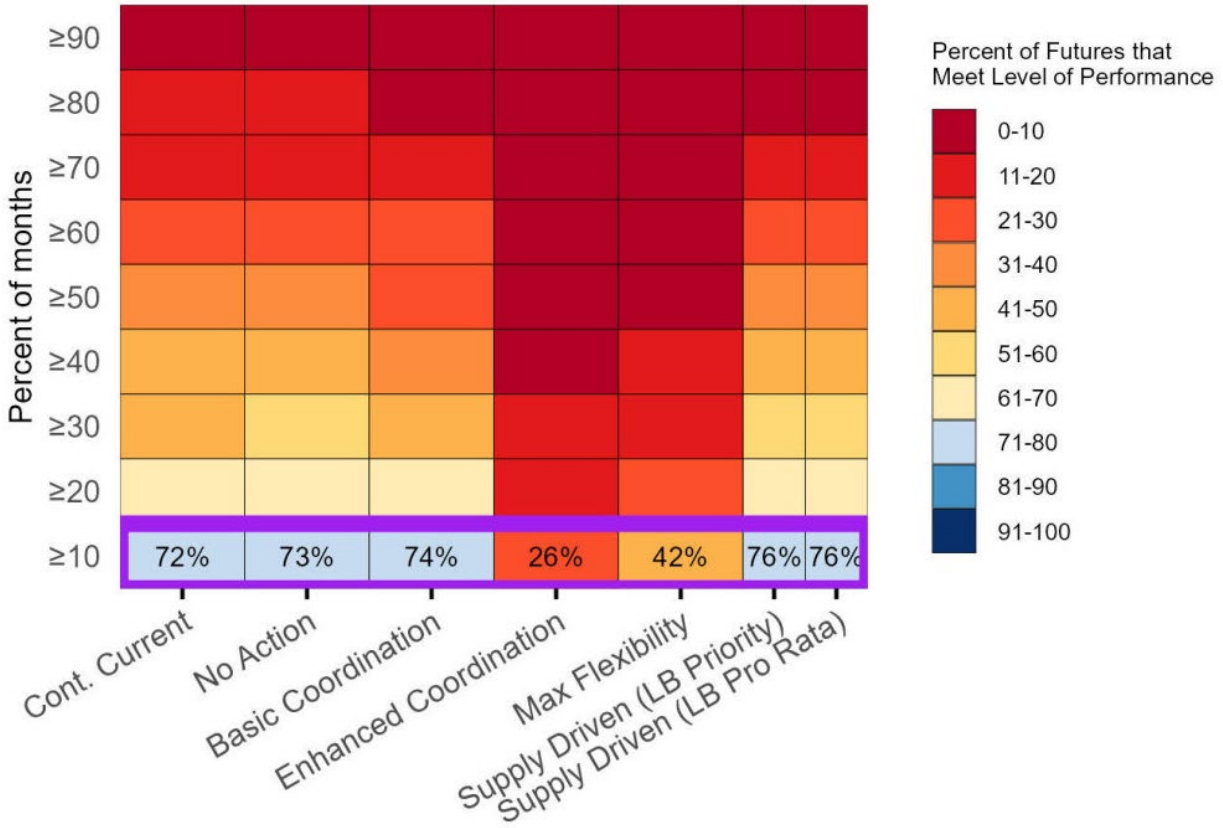


Figure TA 19-3
Limiting the Visibility of Glen Canyon Dam: Robustness.
Percent of futures in which the elevation of Lake Powell is above 3,550 feet in the percent of months specified by each row

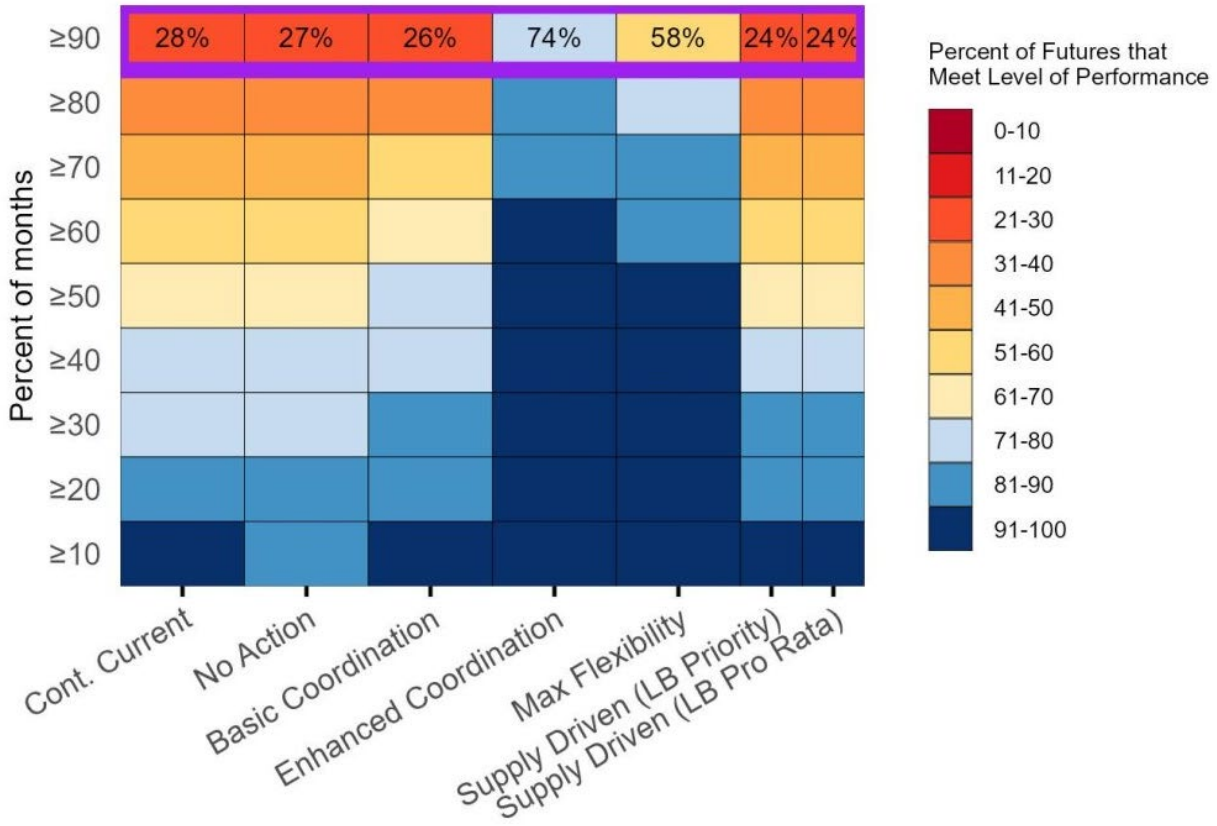
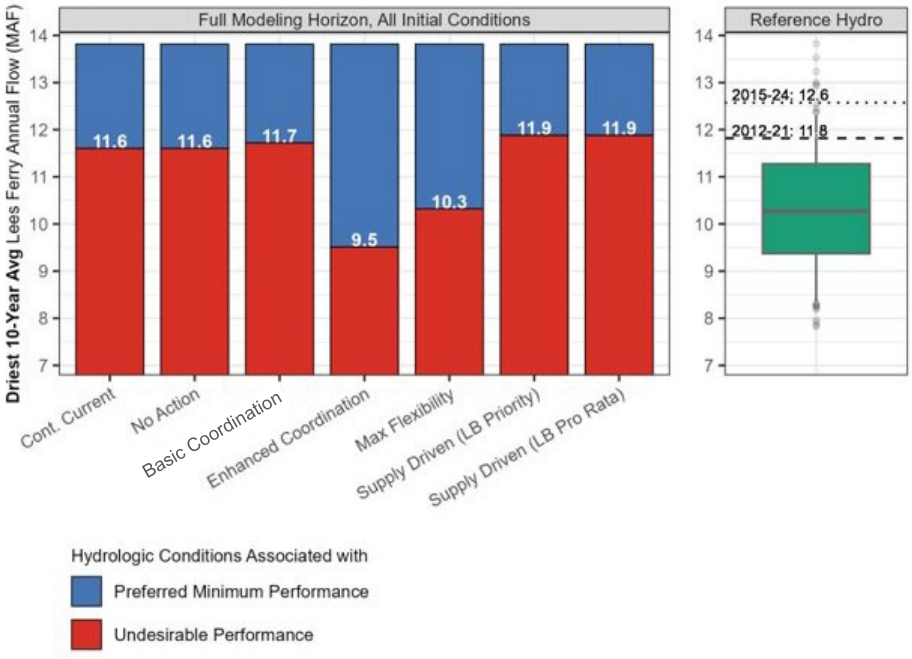


Figure TA 19-4
Limiting the Visibility of Glen Canyon Dam: Vulnerability.
Conditions that could cause Lake Powell to fall below 3,550 feet in more than 10% of months



TA 19.2.3 Issue 2: How would management of reservoir elevations affect landscape character including visibility of calcium carbonate rings, exposed shoreline, and sediment deltas?

The assessment of impacts on landscape character along Lake Powell and Lake Mead was based on determining the percentage of futures at different reservoir levels, compared to the full pool elevation. This difference in reservoir elevations creates white-colored calcium carbonate rings, as well as generating larger sediment deltas and exposing more shoreline. The lower the lake levels become, impacts on landscape character associated with calcium carbonate rings, exposed shoreline including garbage and refuse, and sediment deltas would increase accordingly. To compare alternatives, the assessment focused on whether calcium carbonate rings, during the planning period, would exceed historic maximums at any time.

For Lake Powell, the tallest calcium carbonate ring was 179 feet tall, which occurred in February 2023. As shown in **Figure TA 19-5**, the CCS Comparative Baseline and the No Action, Basic Coordination, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives would result in more futures where the calcium carbonate rings would exceed the historical maximum during the modeling period with only 18 percent, 16 percent, 16 percent, and 13 percent of futures under these Alternatives resulting in calcium carbonate rings being less than 175 feet tall for all the months of modeling. The Enhanced Coordination and Maximum Operational Flexibility Alternatives increase these values to 51 percent and 38 percent. Expanding the threshold to 200-foot

calcium carbonate rings, as shown in **Figure TA 19-6**, the CCS Comparative Baseline and the No Action, Basic Coordination, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives would maintain the calcium carbonate rings below this height for all months in only 23 percent, 20 percent, 25 percent, and 24 percent of the futures, respectively. Comparatively, the Enhanced Coordination and Maximum Operational Flexibility Alternatives would result in 82 percent and 87 percent of the futures resulting in calcium carbonate rings being under 200 feet for all months.

For Lake Mead, the tallest calcium carbonate ring was 180 feet, which occurred in July 2022. As shown in **Figure TA 19-7**, the CCS Comparative Baseline and the No Action Alternative would result in more futures where calcium carbonate rings would exceed the historical maximum during the modeling period, with only 13 percent and 6 percent of futures under these alternatives resulting in calcium carbonate rings being less than 175 feet tall for all the months of modeling. The Basic Coordination, Enhanced Coordination, Maximum Operational Flexibility, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives increase these percentages to 30 percent, 29 percent, 32 percent, and 40 percent. Expanding the threshold to 200 feet tall calcium carbonate rings, as shown in **Figure TA 19-8**, the CCS Comparative Baseline and the No Action Alternative would keep the calcium carbonate rings below this height for all months in only 22 percent and 12 percent of the futures. Comparatively, the Basic Coordination, Enhanced Coordination, Maximum Operational Flexibility, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives would result in 41 percent, 44 percent, 50 percent, and 52 percent of the futures resulting in calcium carbonate rings under 200 feet for all months.

As described in the 2007 Final EIS, sediment deltas would continue to build up over time and would be visible as the reservoir elevations decrease, including under the No Action Alternative. The expanding sediment deltas would become populated by vegetation, including tamarisk, which would introduce bright greens into the landscape that contrast with the arid landscapes adjacent to Lake Powell and Lake Mead. Additionally, the receding shorelines would expose garbage and refuse, which would diminish the area's landscape character. The lower the lake levels become, impacts on landscape character associated with calcium carbonate rings, exposed shoreline including garbage and refuse, and sediment deltas would increase accordingly.

Both the calcium carbonate ring, exposed shoreline including garbage and refuse, and sediment deltas would modify the landscape character along the edge of Lake Powell. These modifications would be visible for motorists on Utah State Route 95, boaters on Lake Powell, recreationists at developed and undeveloped recreation areas, and hikers on trails adjacent to Lake Powell. Similarly, the calcium carbonate ring, exposed shoreline including garbage and refuse, and sediment deltas would modify the landscape character along the edge of Lake Mead; these modifications would be visible for motorists on U.S. Highway 93 (between Boulder City, Nevada, and the Hoover Dam), boaters on Lake Mead (including visitors to Overton Beach and Pearce Ferry), and hikers on trails adjacent to Lake Mead.

Figure TA 19-5
Maximum Height of Lake Powell Calcium Carbonate Ring: Robustness.
Percent of futures in which the monthly calcium carbonate ring at Lake Powell is always less than the height specified by each row

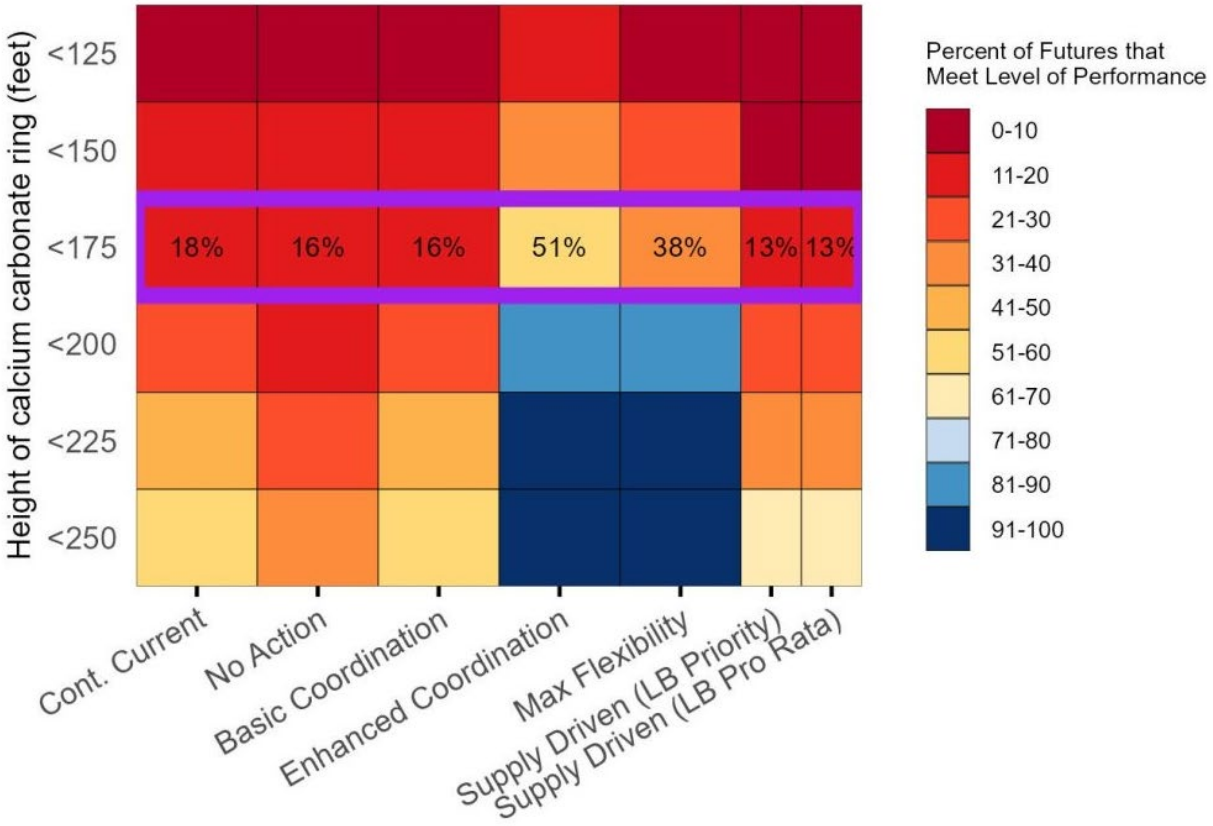


Figure TA 19-6
Monthly Height of Lake Powell Calcium Carbonate Ring: Robustness.
Percent of futures in which the height of the calcium carbonate ring at Lake Powell is less than the reference height in the percent of months specified by each row

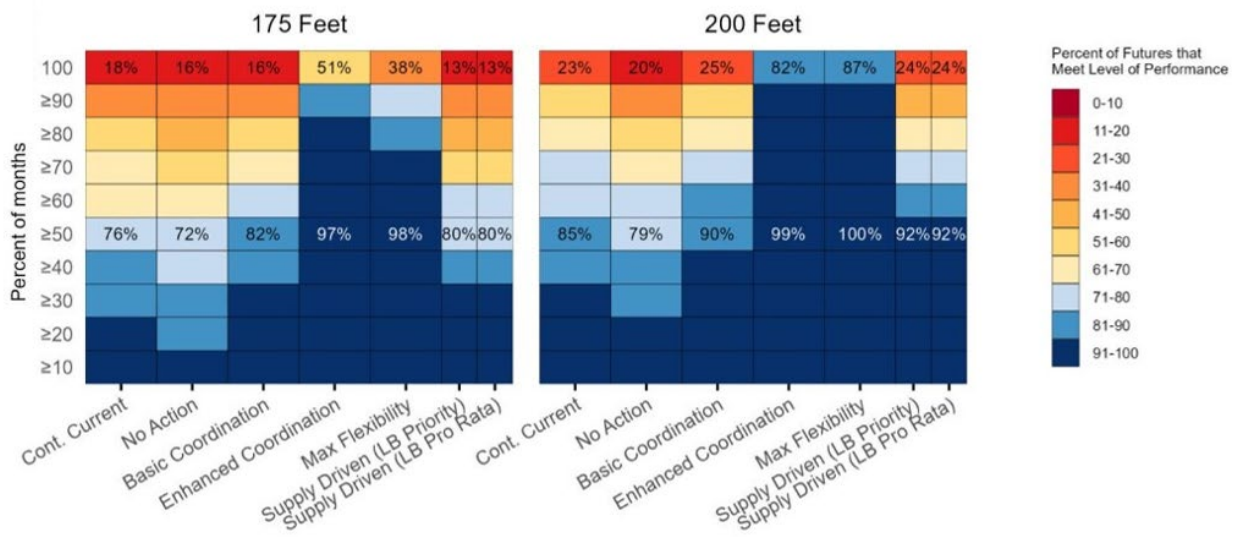


Figure TA 19-7
Maximum Height of Lake Mead Calcium Carbonate Ring: Robustness.
Percent of futures in which the monthly calcium carbonate ring at Lake Mead is always less than the height specified by each row

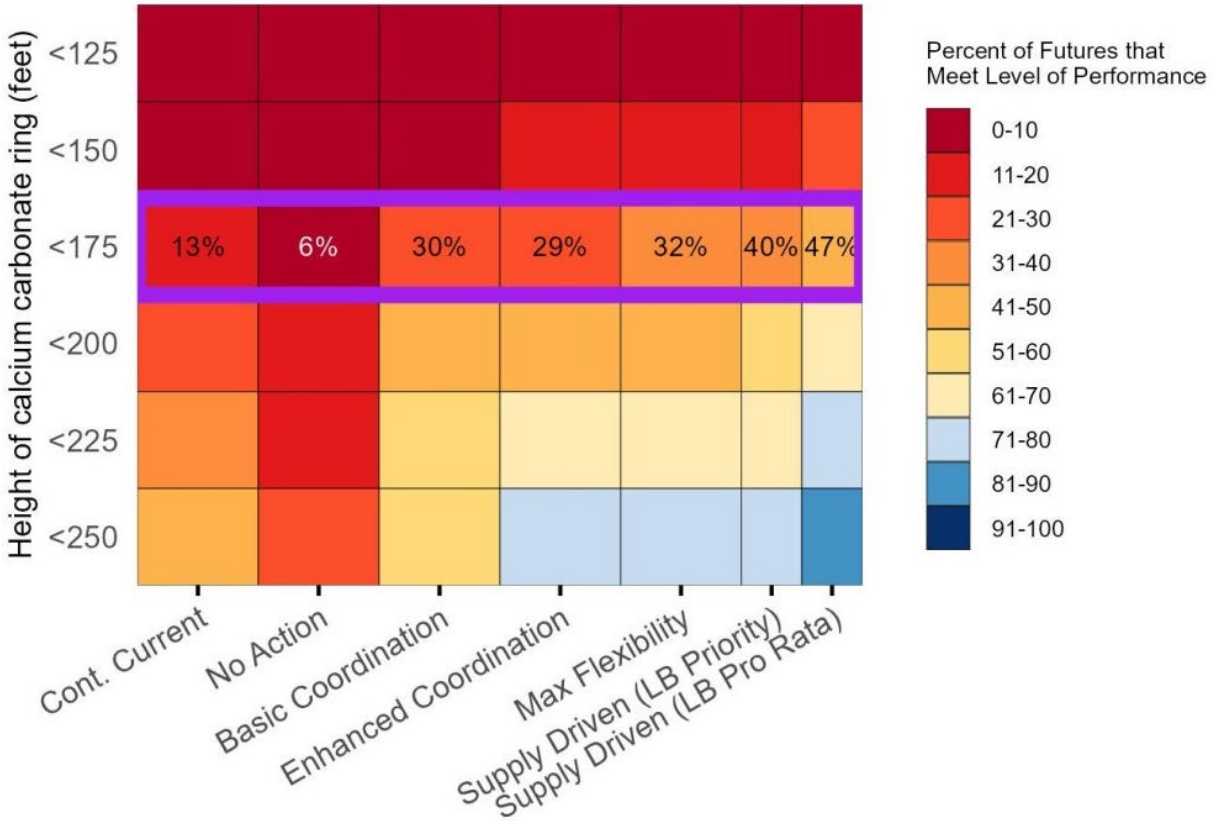
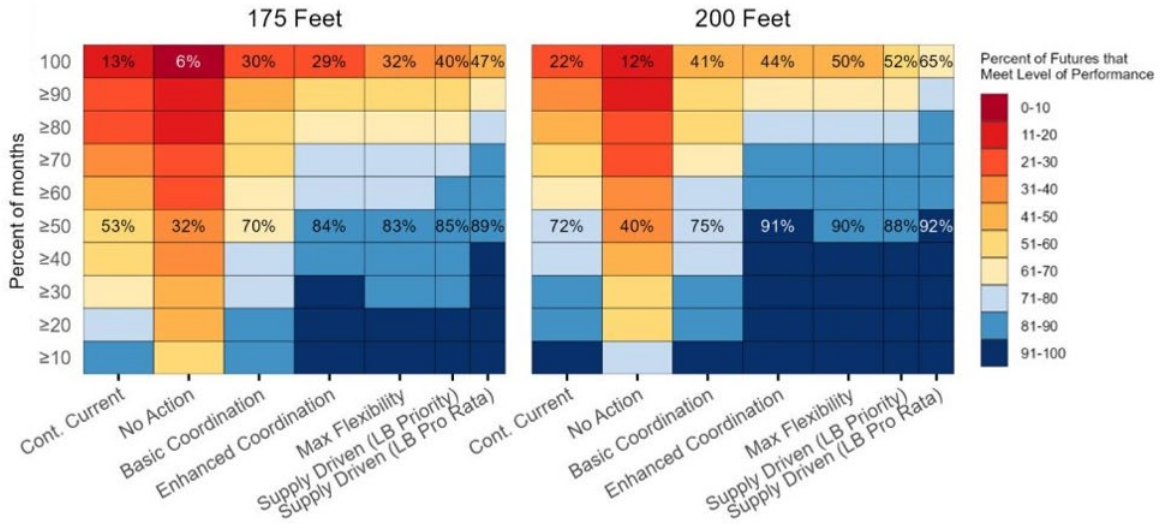


Figure TA 19-8
Monthly Height of Lake Mead Calcium Carbonate Ring: Robustness.
Percent of futures in which the height of the calcium carbonate ring at Lake Mead is less than the reference height in the percent of months specified by each row



TA 19.2.4 Issue 3: How would management of releases from Glen Canyon Dam affect landscape character along the Colorado River?

The No Action Alternative and CCS Comparative Baseline would include lowering releases from Glen Canyon Dam as Lake Powell elevations decrease; this would result in releases as low as 7.0 maf when elevations drop below 3,525 feet. Since neither the No Action Alternative nor the CCS Comparative Baseline includes reducing releases from Glen Canyon Dam under 7.0 maf, including if Lake Powell drops below power pool but remains above dead pool, there would be minor, incremental impacts on the landscape character along the Colorado River, including through the Grand Canyon. The current trends of increasing bank armoring, associated with expanding riparian vegetation areas (including tamarisk), would continue under the No Action Alternative and CCS Comparative Baseline. If the elevation of Lake Powell were to drop below dead pool, flows from Glen Canyon Dam could dramatically decrease, resulting in more extensive impacts on the landscape character, including the appearance of river features previously not visible under current conditions. Additionally, the positive influence of the moving, turbulent Colorado River adds to the existing landscape character, which would be degraded if releases from Glen Canyon Dam were dramatically reduced. The No Action Alternative would result in relatively short and few HFE releases, resulting in fewer opportunities for sand bar volumes to increase compared to the CCS Comparative Baseline, which would result in longer and more frequent HFE releases with more opportunities for increased sand bar volumes as compared to the No Action Alternative.

The Basic Coordination Alternative would result in similar impacts as the No Action Alternative and CCS Comparative Baseline, since it includes a similar range of releases from Glen Canyon Dam, but would include an increased number of futures where HFEs are conducted. The Enhanced Coordination, Maximum Operational Flexibility, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives would include lower releases, as low as 4.7 maf, which is lower than

historic minimum flows. Lower releases from Glen Canyon Dam would result in less water flowing along the Colorado River (and through the Grand Canyon), which could increase existing trends of bank armoring associated with more extensive riparian vegetation, including tamarisk. Lower releases also could limit the number of times an HFE could be triggered from Glen Canyon Dam, which would only occur when the HFE furthers maintenance of target reservoir elevations. The Enhanced Coordination and Maximum Operational Flexibility Alternatives would result in the most futures where HFEs are conducted. These lower flows may also result in the appearance of river features previously not visible under current conditions and less movement of the river's natural sandbars. If yearly elevations facilitate releases of 7.0 maf or more under the Enhanced Coordination, Maximum Operational Flexibility, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives, the impact under these alternatives would be similar to those described under the No Action Alternative and CCS Comparative Baseline, as the lower releases from Glen Canyon Dam would be avoided. If the elevation of Lake Powell were to drop below dead pool, flows from Glen Canyon Dam could dramatically decrease, resulting in similar impacts as described under the No Action Alternative and CCS Comparative Baseline.

For more information on the impacts on riparian vegetation, refer to **TA 9**, Vegetation Including Special Status Species; for impacts associated with sand bars including their volume, refer to **TA 5**, Geomorphology and Sediment; and for impacts on recreation, including visibility of river features, refer to **TA 14**, Recreation.

TA 19.2.5 Issue 4: How would management of water availability for the Lower Division States affect landscape character?

Since the No Action Alternative includes minor adjustments (0.6 maf) to the distribution of water for Arizona and Nevada (no adjustments for California), based on lowering Lake Mead elevations, there would initially be a limited incremental effect on irrigated landscapes, including those in agricultural use. If elevations in Lake Mead were to drop to dead pool (895 feet), flows from Lake Mead would dramatically decrease, resulting in lower water deliveries than currently allocated, affecting all three Lower Division States. As described in **TA 4**, Water Deliveries, the No Action Alternative would result in the most futures where dead pool–related shortage may be reached during the modeling period. Depending on the duration of these decreased water deliveries, the character of irrigated and agricultural landscapes within the Lower Division States would be modified through aridification of these areas; this would diminish the vivid greens associated with crops and ornamental plantings. The influence of the Colorado River on adjacent lands would narrow as these areas would transition to their natural, arid condition. This would result in large-scale changes to the landscape character compared with the existing condition. Additionally, the aridification of these lands could also result in more exposed soil, generating fugitive dust affecting visibility within the region, including from GCNP and other highly valued viewsheds. For more details on the impacts related to fugitive dust, please see **TA 7**, Air Quality.

CCS Comparative Baseline would include a series of water supply adjustments for the Lower Division States based on lower elevations of Lake Mead. If water levels in Lake Mead drop below 1,075 feet, similar effects as described under the No Action Alternative would occur, with conservation measures tempering these effects. As lake levels continue to drop toward 1,025 feet, all three states would receive less water from the Colorado River under this alternative through

proposed shortages and conservation measures. As Lake Mead approaches dead pool, to avoid a dramatic decrease in water releases from Hoover Dam affecting all three Lower Division States, more reductions could occur (up to 1.38 maf). These include further reductions in water deliveries based on extraordinary circumstances, as described in Section 7(D) of the 2007 Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead (2007 Interim Guidelines). These reductions to avoid reaching dead pool would temper the impacts on the character of irrigated and agricultural landscapes within the Lower Division States, as described under the No Action Alternative. If Lake Mead reaches dead pool elevation during the planning period, impacts would be similar to those described under the No Action Alternative.

The Basic Coordination Alternative would have similar impacts as the No Action Alternative as there would be adjustments to the distribution of water for Arizona and Nevada, but no adjustments for California, based on lowering Lake Mead elevations. As Lake Mead elevation drops below 1,160 feet, shortages would begin with those increasing to 1.48 maf when Lake Mead is below 1,110 feet. Through increased shortages under this alternative, the number of futures where Lake Mead reaches dead pool would be reduced compared to the No Action Alternative and CCS Comparative Baseline, but there is still a risk of reaching dead pool under this alternative. As described in **TA 4**, Water Deliveries, the Basic Coordination Alternative would result in the second most futures where dead pool–related shortage may be reached during the modeling period. If Lake Mead reaches dead pool elevation during the planning period, impacts would be similar to those described under the No Action Alternative.

Under the Enhanced Coordination Alternative, there is a potential for larger shortages than proposed under the CCS Comparative Baseline and the No Action and Basic Coordination Alternatives, with shortages being distributed pro rata among mainstream lower Colorado River water users independent of state. Shortages would begin when Lake Powell effective storage and Lake Mead physical storage are equal to or less than 60 percent of combined capacity and greater than or equal to 30 percent combined capacity, resulting in a 1.3 maf shortage. This would increase to a 3.0 maf shortage when the sum of Lake Powell effective storage and Lake Mead physical storage is less than 30 percent of the combined capacity. These shortages would occur in all three Lower Division States and incrementally affect irrigated landscapes, including those in agricultural use, based on the extent of the shortage. These shortages are designed to avoid reaching dead pool, tempering the impacts on the character of irrigated and agricultural landscapes within the Lower Division States, and avoid more extensive impacts if Lake Mead reached dead pool. As described in **TA 4**, Water Deliveries, the Enhanced Coordination Alternative would result in the second fewest futures where dead pool–related shortage may be reached during the modeling period. If Lake Mead reaches dead pool elevation during the planning period, impacts would be similar to those described under the No Action Alternative.

Under the Maximum Operational Flexibility Alternative, there is a potential for larger shortages than under the CCS Comparative Baseline and the Enhanced Coordination, No Action, and Basic Coordination Alternatives, with shortages being based on priority. These shortages would occur based on the total system effective storage and capacity, as described in **Section 2.7.1.1**, with shortages up to 4 maf. These shortages would occur in all three Lower Division States and

incrementally affect irrigated landscapes, including those in agricultural use, based on the extent of the shortage. These shortages are designed to avoid reaching dead pool, tempering the impacts on the character of irrigated and agricultural landscapes within the Lower Division States and avoid more extensive impacts if Lake Mead reached dead pool. As described in **TA 4**, Water Deliveries, the Maximum Operational Flexibility Alternative would result in the least number of futures where dead pool–related shortage may be reached during the modeling period. If Lake Mead reaches dead pool elevation during the planning period, impacts would be similar to those described under the No Action Alternative.

Under the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches), there is a potential for larger shortages than proposed under the CCS Comparative Baseline and the No Action and Basic Coordination Alternatives, with shortages being distributed based on priority within that state or pro rata within that state as described in **Section 2.8.1.1**. If water levels in Lake Mead drop below 1,145 feet, similar effects as described under the No Action Alternative are anticipated, with conservation measures tempering these effects. As lake levels continue to drop toward 1,000 feet, all three states would receive less water from the Colorado River under this Alternative through proposed shortages, up to 2.1 maf, and conservation measures. These shortages are designed to avoid reaching dead pool, tempering the impacts on the character of irrigated and agricultural landscapes within the Lower Division States, and avoid more extensive impacts if Lake Mead reached dead pool. As described in **TA 4**, Water Deliveries, the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches), similar to the Enhanced Coordination Alternative, would result in the second fewest futures where dead pool–related shortage may be reached during the modeling period. If Lake Mead reaches dead pool elevation during the planning period, impacts would be similar to those described under the No Action Alternative.

For more information on the impacts on agricultural operations, refer to **TA 16**, Socioeconomics, and for more information on the specific, state-level water deliveries, refer to **TA 4**, Water Deliveries.

TA 19.2.6 Summary Comparison of Alternatives

In general, alternatives that facilitate higher reservoir elevations, maintain higher flows along the Colorado River, including through Grand Canyon, and support full water deliveries to the Lower Division States would result in the lowest impacts on visual resources and on landscape character. While some users may prefer lower lake levels in Lake Powell, to allow Cathedral in the Desert and other attraction features inundated by Lake Powell to be visible and accessible, in general, higher water levels would result in lower impacts on landscape character, including shorter calcium carbonate rings, less exposed shoreline, including garbage and refuse, and smaller sediment deltas.

During wet hydrologic conditions, the range of alternatives would generally produce conditions where lake levels and flows along the Colorado River would result in minimal impacts on landscape character.

As conditions become drier, the No Action Alternative and CCS Comparative Baseline would result in the most futures where landscape character is affected by lower water levels in Lake Powell and Lake Mead compared to the Enhanced Coordination and Maximum Operational Flexibility

Alternatives. The Basic Coordination and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives would result in a similar number of futures as the No Action Alternative and CCS Comparative Baseline with lower water levels in Lake Powell but would keep water levels higher in Lake Mead, similar to the Enhanced Coordination and Maximum Operational Flexibility Alternatives, resulting in more futures where water levels are higher in Lake Powell. The lower the lake levels become, impacts on landscape character associated with calcium carbonate rings, exposed shoreline including garbage and refuse, and sediment deltas would increase accordingly.

Under drier conditions, releases from Glen Canyon would be tempered under the Enhanced Coordination, Maximum Operational Flexibility, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives, which include lower releases to avoid reaching dead pool. While these lower releases would result in incremental impacts on landscape character along the Colorado River, by avoiding dead pool, more intense impacts could be avoided. Under some futures, associated with the CCS Comparative Baseline and No Action Alternative, dead pool may be reached, which would result in flows from Glen Canyon Dam dramatically decreasing, resulting in more extensive impacts on the landscape character, including the appearance of river features previously not visible under current conditions.

Water availability for the Lower Division States associated with the alternatives, under drier conditions, would vary with the No Action Alternative resulting in minimal adjustments to water deliveries from lowering Lake Mead elevations, but if dead pool were reached, flows from Lake Mead would dramatically decrease. This would result in lower water deliveries than currently allocated, affecting all three Lower Division States. Depending on the duration of these decreased water deliveries, the character of irrigated and agricultural landscapes within the Lower Division States would be modified through aridification of these areas, diminishing the influence of the Colorado River into adjacent lands through reduction of vivid greens associated with crops and ornamental plantings. Additionally, the aridification of these lands could also result in more exposed soil, generating fugitive dust affecting visibility within the region, including from GCNP and other highly valued viewsheds. CCS Comparative Baseline and the Basic Coordination, Enhanced Coordination, Maximum Operational Flexibility, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives all include more expansive decreased water deliveries which are designed to avoid reaching dead pool, tempering the impacts on the character of irrigated and agricultural landscapes within the Lower Division States and avoid more extensive impacts if Lake Mead reached dead pool. The Maximum Operational Flexibility, Enhanced Coordination, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives include the largest potential shortages to minimize the number of future conditions where dead pool could be reached based on DMDU modeling as described in **TA 4**, Water Deliveries.

TA 19.3 References

Barnes, J. 2005. Grand Canyon National Park Wild and Scenic River Narrative Catalog and Database: A Proposal for Wild and Scenic Rivers in Grand Canyon National Park. Prescott College, Prescott, Arizona.

Fenneman, N. M. 1931. Physiography of the Western United States. McGraw-Hill Book Company Inc., New York.

National Park Service (NPS). 1979. Proposed General Management Plan, Wilderness Recommendation, Road Study Alternatives, Final Environmental Statement. Glen Canyon National Recreation Area. Page, Arizona.

_____. 1995. Grand Canyon General Management Plan. Grand Canyon National Park and Denver Service Center. Grand Canyon, Arizona.

_____. 2006. Colorado River Management Plan. Grand Canyon National Park. Grand Canyon, Arizona.

_____. 2018. General Management Plan Amendment/Low-Water Plan/Environmental Assessment for Lake Mead National Recreation Area. Lake Mead National Recreation Area. Boulder City, Nevada.

This page intentionally left blank.