# Technical Appendix 17

## Population and Land Use

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# Contents



# Tables

# Maps



# Figures

# Acronyms and Abbreviations

| Acronym or Abbreviation | Full Phrase |
|---|---|
| ADM | Alternative Distribution Model |
| ADWR | Arizona Department of Water Resources |
| AMA | Active Management Area |
| Basin | Colorado River Basin |
| CAP | Central Arizona Project |
| CCS | Continued Current Strategies |
| DMDU | Decision Making under Deep Uncertainty |
| EIS | environmental impact statement |
| ICS | intentionally created surplus |
| LB Priority | Lower Basin Priority |
| LB Pro Rata | Lower Basin Pro Rata |
| Lower Basin | Lower Colorado River Basin |
| maf | million acre-feet |
| M&I | municipal and industrial |
| Mexico | United Mexican States |
| MWD | Metropolitan Water District of Southern California |
| NIA | non-Indian agriculture |
| NPS | National Park Service |
| PPR | present perfected right |
| SAM | Shortage Allocation Model |
| SNWA | Southern Nevada Water Authority |
| U.S. | United States |
| USDA | United States Department of Agriculture |
| USGS | United States Geological Survey |

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# TA 17. Population and Land Use

This section explores the baseline conditions and potential impacts from different Colorado River operational strategies on analysis area population dynamics and land-use changes, with a focus on potential changes in developed lands and lands used for irrigated agriculture.

Baseline information is provided to characterize the existing setting and trends related to population, general landownership and management, and developed land patterns. Information is also provided for municipal water, which supports developed land use. Data are provided related to historical agricultural land use to support the discussion of irrigated agriculture.

Due to the influence of municipal water availability on developed lands, the impacts analysis examines changes to water availability for municipal supply and the related impacts on population and land-use changes. Due to the influence of irrigation water availability on agricultural land use, the impacts analysis examines changes to irrigation water availability and related impacts on acres of lands in agriculture.

## TA 17.1 Affected Environment

The analysis area for the population and land-use section is separated by state and is the same for both population and land-use issues. The impact analysis area is defined by those counties that may be affected by management direction that could result in water shortages to domestic and irrigation users. Because both issue statements rely on the Shortage Allocation Models (SAMs), the analysis area is informed by the SAMs and includes the counties represented in the SAMs. For more detailed information on the SAMs, see **Appendix C**, Shortage Allocation Model and Alternative Distribution Model Documentation. For more information on water deliveries, including those for irrigation, refer to **TA 4**, Water Deliveries.

The Arizona analysis area consists of Apache, Coconino, Gila, La Paz, Maricopa, Mohave, Navajo, Pima, Pinal, and Yuma Counties. These include counties that are directly adjacent to Lake Powell, Lake Mead, or the Colorado River and counties in which shortages would likely occur.

The California analysis area consists of Imperial, Los Angeles, Orange, Riverside, San Bernardino, and San Diego Counties. These counties were selected because they are either directly adjacent to the Lower Colorado River, or they are within the Metropolitan Water District of Southern California (MWD) service area. Although Ventura County is also in the MWD service area, it does not receive any water from the Colorado River; therefore, it is not included in the analysis area.

The Nevada analysis area consists of Clark County. The analysis area was limited to Clark County because Clark County is adjacent to Lake Mead and encompasses the Southern Nevada Water

Authority's (SNWA) service area and other individual water providers. Shortages in Nevada would be limited to the SNWA's service area.

The Utah analysis area consists of Kane, Garfield, and San Juan Counties. Although these counties are not in the Lower Colorado River Basin (Lower Basin) and thus would not experience shortages, baseline information on population and land use is included to provide content for analysis of social and economic impacts from recreation associated with the Colorado River, Lake Powell, and Lake Mead (see **TA 16**, Socioeconomics).

Across the states, these counties were selected for inclusion in the analysis area because they represent the counties in which there is potential for direct impacts from shortages, based on modeled domestic (municipal) delivery outcomes and the service areas of major municipal providers. Secondary impacts could also occur in adjacent counties, across states as a whole, in adjacent states, and/or on the national scale (for example, through economic linkages and supply chains). However, due to analytical constraints and the focus of this technical appendix on an assessment of modeled domestic shortage outcomes for selected municipal providers informed by Decision Making under Deep Uncertainty (DMDU), the population and land-use analysis focuses on direct impacts within the counties that correspond to municipal service areas and areas where delivery reductions could most directly influence land-use-related conditions.

This approach is consistent with the socioeconomic framing (**TA 16**, Socioeconomics), which defines the analysis areas using counties adjacent to reservoirs and the Colorado River and counties containing major municipal service areas that receive water from the Colorado River (for example, in California, counties within the MWD service area that receive Colorado River water).

### TA 17.1.1 Population

Population trends provide important context for understanding water supply (domestic and irrigation), demand, and use within the analysis area. Although population growth can influence municipal water demand, population is not a direct proxy for consumptive water use because conservation, reuse, demand-management measures, water-use efficiency, local policy, and land-use patterns can affect per-capita demand. As a result, population and water demand may not increase at the same rate. Communities throughout much of the western United States (U.S.) have followed trends of increasing population over the past decade. In the analysis areas, the population growth rate has generally been positive or stable. County- and state-level population changes are discussed below (see **Table TA 17-1** through **Table TA 17-4**).

#### *Arizona*

Except La Paz and Apache Counties, which saw a decrease in population (of 18.8 percent and 6.1 percent, respectively), and Navajo County, which maintained its population, all counties in the analysis area followed the trend of increasing population from 2010 to 2022; the biggest increase was in Pinal County (31.6 percent). **Table TA 17-1** provides an overview of populations by county in the Arizona analysis area. Arizona's population is anticipated to continue to increase over the analysis period, with similar county-level trends continuing. Drivers of population increase in Pinal County included low housing costs and workforce increases from new manufacturing, logistical, and distribution facilities (Arizona Office of Economic Opportunity 2024).

**Table TA 17-1**
**Arizona Population 2010–2040**

| Geographic Area | Population 2010[1] | Population 2022[2] | Percent Change 2010–2022 | Estimated Population 2040[3] | Estimated Percent Change 2022–2040 |
|---|---|---|---|---|---|
| Apache County | 70,312 | 66,054 | -6.1 | 64,449 | -2.4 |
| Coconino County | 131,824 | 144,705 | 9.8 | 159,557 | 10.3 |
| Gila County | 53,272 | 53,419 | 0.3 | 55,866 | 4.6 |
| Graham County | 36,030 | 38,453 | 6.7 | 44,028 | 14.5 |
| La Paz County | 20,549 | 16,681 | -18.8 | 16,897 | 1.3 |
| Maricopa County | 3,751,410 | 4,430,871 | 18.1 | 5,762,655 | 30.1 |
| Mohave County | 199,177 | 214,229 | 7.6 | 270,598 | 26.3 |
| Navajo County | 107,060 | 107,110 | 0.0 | 104,100 | -2.8 |
| Pima County | 964,462 | 1,042,393 | 8.1 | 1,195,070 | 14.6 |
| Pinal County | 329,297 | 433,338 | 31.6 | 778,909 | 79.7 |
| Yuma County | 190,526 | 204,374 | 7.3 | 259,032 | 26.7 |
| Yavapai County | 209,260 | 237,830 | 13.7 | 301,937 | 27.0 |
| Arizona | 6,246,816 | 7,172,282 | 14.8 | 9,206,879 | 28.4 |

Sources: U.S. Census Bureau 2012,[1] 2023;[2] Arizona Office of Economic Opportunity 2023[3]

### *California*

In California, the population increased by 7.4 percent from 2010 to 2022. With the exception of Los Angeles, Imperial, and Orange Counties, the analysis area counties' growth all surpassed that of the state. The largest increase in population was in Riverside County (15.2 percent; see **Table TA 17-2**). Historical trends are expected to continue over the next 20 years, with the largest increases forecasted for Imperial and Riverside Counties; notably, a decrease in population of 2.1 percent is anticipated for Los Angeles County. Factors influencing population loss likely include the cost of housing leading to out-migration, as well as other demographic factors such as population aging and low birth rate (Johnson et al. 2023).

**Table TA 17-2**
**California Population 2010–2040**

| Geographic Area | Population 2010[1] | Population 2022[2] | Percent Change 2010–2022 | Estimated Population 2040[3] | Estimated Percent Change 2022–2040 |
|---|---|---|---|---|---|
| Imperial County | 168,052 | 179,578 | 6.9 | 203,470 | 13.3 |
| Los Angeles County | 9,758,256 | 9,936,690 | 1.8 | 9,732,175 | -2.1 |
| Orange County | 2,965,525 | 3,175,227 | 7.1 | 3,243,240 | 2.1 |
| Riverside County | 2,109,464 | 2,429,487 | 15.2 | 2,703,895 | 11.3 |
| San Bernardino County | 2,005,287 | 2,180,563 | 8.7 | 2,333,216 | 7.0 |
| San Diego County | 3,022,468 | 3,289,701 | 8.8 | 3,424,184 | 4.1 |
| California | 36,637,290 | 39,356,104 | 7.4 | 40,968,090 | 4.1 |

Sources: U.S. Census Bureau 2012,[1] 2023;[2] California Department of Finance 2023[3]

### *Nevada*

In terms of population increases, Nevada represented some of the largest in the analysis areas. Nevada's population grew by 17.9 percent from 2010 through 2022. Clark County's population changed 19.5 percent, which was higher than that of the state overall. Trends are expected to continue with a change of 28.7 percent anticipated in Clark County by 2040 (see **Table TA 17-3**).

**Table TA 17-3**
**Nevada Population 2010–2040**

| Geographic Area | Population 2010[1] | Population 2022[2] | Percent Change 2010–2022 | Estimated Population 2040[3] | Estimated Percent Change 2022–2040 |
|---|---|---|---|---|---|
| Clark County | 1,895,521 | 2,265,926 | 19.5 | 2,916,000 | 28.7 |
| Nevada | 2,633,331 | 3,104,817 | 17.9 | 3,889,575 | 25.3 |

Sources: U.S. Census Bureau 2012,[1] 2023;[2] Center for Business and Economic Research 2025; Wright 2025[3]

### *Utah*

Population changes in Utah are moderate compared with other states' analysis area counties. While Kane County had a 9.7 percent increase from 2010 to 2022, the population decreased in Garfield County (1.0 percent) and San Juan County (1.5 percent) over the same time period. Over the next 20 years, the population change is anticipated to accelerate, with a 25.0 percent increase in population predicted for Kane County, 11.4 percent for San Juan County, and 3.4 percent for Garfield County (see **Table TA 17-4**).

For Kane County, the main driver of population growth was net migration to the region of people 65 years and older, with quality-of-life indicators such as outdoor recreation being cited as main factors drawing people to the area (Utah Population Committee 2022).

**Table TA 17-4**
**Utah Population 2010–2040**

| Geographic Area | Population 2010 | Population 2022 | Percent Change 2010–2022 | Population 2040 | Percent Change 2022–2040 |
|---|---|---|---|---|---|
| Garfield County | 5,172 | 5,121 | -1.0 | 5,294 | 3.4 |
| Kane County | 7,125 | 7,814 | 9.7 | 9,769 | 25.0 |
| San Juan County | 14,746 | 14,524 | -1.5 | 16,186 | 11.4 |
| Utah | 2,763,885 | 3,283,809 | 18.8 | 4,440,560 | 35.2 |

Sources: U.S. Census Bureau 2023; Kem C. Gardner Policy Institute 2023

## TA 17.1.2 Industrial and Municipal (Domestic) Water Uses

This section provides a brief overview of municipal water supply, demand, and use trends within the U.S. and the Lower Basin. This section also provides information on the municipalities within

Arizona, California, and Nevada with the potential to be affected by changes in domestic water availability.

Domestic water use includes the use of water for "household, stock, municipal, mining, milling, industrial, and other like purposes," 1922 Colorado River Compact, section II(h). More granularly, this includes indoor and outdoor uses at residences, and uses such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, watering lawns and gardens, and maintaining pools. Domestic water use includes potable and non-potable water provided to households by a public water supplier (domestic deliveries) and self-supplied water use.

#### *Domestic Water Supply, Demand, and Use Trends*

Urbanization has increased the percentage of the U.S. population served by municipal water supplies from 70 percent in 1960 to 83 percent in 2021 (Liu et al. 2025). Per capita domestic water use in southwestern states varies regionally: residents in Arizona and Nevada use approximately 126–150 gallons per day, while California residents use 76–100 gallons per day (Chinnasamy et al. 2021; EPA 2025).

Although existing and ongoing municipal water management strategies do not change domestic water entitlement amounts, they illustrate how municipal systems have adapted—and may continue to adapt—to evolving water supply and demand conditions. This context is important for understanding how communities in the region respond to variability in water availability under different future conditions. Municipal water systems in these regions face growing pressures from population growth, climate trends, and uncertainties in future water availability, demand, and technological or policy adoption (Liu et al. 2025). Communities throughout the region have long implemented a range of water management strategies—including conservation programs, demand-side measures, operational changes, and infrastructure investments—to maintain municipal reliability under these evolving conditions.

Structural approaches such as dams, diversions, reservoirs, wastewater treatment facilities, and hydropower systems have historically played a critical role in supporting municipal water supply, while some more recent approaches involve building on existing infrastructure while emphasizing demand-side management through institutional, technological, and behavioral changes (Larson et al. 2016). Strategies can range from implementation of water-use efficiencies, changes to system operations, and demand reduction through water conservation programs. Implementation of water conservation programs has significantly decreased per capita water use (Chinnasamy et al. 2021; DeOreo et al. 2016; Finley and Basu 2020; Price et al. 2014). Water conservation programs in urban areas of the southwestern U.S., including Arizona, California, and New Mexico, have reduced per capita residential water use through targeted demand-side measures (Gleick 2010; Kennedy et al. 2012; Olmstead and Stavins 2009). Programs implementing high-efficiency appliances, leak detection, landscape irrigation restrictions, and tiered pricing reduced per capita demand by roughly 10–15 percent in some cities (Chinnasamy et al. 2021; DeOreo et al. 2016; Finley and Basu 2020; Price et al. 2014).

Across the analysis areas, municipal providers employ a range of adaptation measures to manage supply variability and shortages. In Arizona, measures commonly include demand management and conservation; increased reliance on groundwater and stored supplies, including recharge and banking, where available; reclaimed water for non-potable demands; and system interconnections or operational changes. In California, measures commonly include conservation; recycled water expansion; stormwater capture and local recharge; groundwater management; interties and transfers, where available; and targeted supply or treatment improvements. In Nevada (Clark County), measures commonly include incentives to reduce outdoor water use, extensive reuse and return-flow management, and storage and exchange arrangements coupled with operational and infrastructure modifications to improve drought resilience. Many measures involve substantial capital costs and multiyear implementation timelines and may be constrained by legal or contractual availability, physical system capacity, water quality and treatment requirements, permitting, energy demands, and environmental considerations, which can limit feasibility or timing for some communities.

The availability of and access to domestic water can influence both population dynamics and land use and development. Population growth can increase the demand for water for domestic, agricultural, and industrial use and increase pressure on existing water sources. Studies have shown that population growth can be a dominant driver of long-term municipal water demand (Liu et al. 2025). Insufficient water supply can constrain population growth and development by limiting an area's capacity to support residents.

Peer-reviewed studies have documented the relationships between population growth, land-use patterns, and domestic water delivery. Urban sprawl, characterized by low-density development and increased impervious surfaces, has been shown to elevate per capita water demand through higher outdoor water use (Heidari et al. 2021). In contrast, high-density development often reduces water use per capita and can lessen the frequency and severity of water shortages. Rapid urbanization and population growth can also increase pressure on existing water infrastructure, creating challenges in maintaining consistent domestic water delivery.

Municipal water demand within the analysis areas is not solely a function of population or economic growth; it can reflect long-term trends in conservation, efficiency, reuse, land-use patterns, the climate, and provider policies. Many municipal providers in the Lower Basin have implemented demand management programs and operational practices that have reduced per capita use over time, such that total municipal demand may remain stable or grow more slowly than the population in some communities. Conversely, the magnitude of realized conservation and the remaining potential for additional cost-effective savings vary by provider due to differences in the existing program maturity, customer mix, climate, built environment, system losses, regulatory constraints, and local supply portfolios.

Municipal planning and development within the Lower Basin counties in the analysis areas rely on assumptions about the reliability, timing, and quality of water supplies used to serve existing and future demands. Within the analysis areas' counties, local governments and water providers typically integrate water supply expectations into general plans, zoning and subdivision decisions, capital improvement programs, and long-range utility master planning. These assumptions inform the sizing and sequencing of major infrastructure (for example, treatment, conveyance, storage, and pressure zones), operational and drought contingency planning, and the ability to maintain service standards under variable hydrologic conditions. Because many providers in these counties manage portfolio supplies that may include Colorado River–derived deliveries alongside local surface water, groundwater, conservation, reuse, and interconnections, reliability expectations are often expressed not only as an annual volume but also in terms of operational availability during peak demand, drought response triggers, and constraints associated with treatment and regulatory compliance. Accordingly, changes in the reliability of Colorado River supplies can be relevant to municipal planning baselines and the context for evaluating potential effects related to domestic water shortages discussed in **Section TA 17.2.2**.

Water supply has influenced land use and development within the analysis areas. The Arizona Department of Water Resources' (ADWR) Assured and Adequate Water Supply Programs provide a concrete example of how water availability can constrain development. While not directly related to Colorado River water, these programs require developers within active management areas (AMAs) to demonstrate assured or adequate water supplies before recording plats or selling parcels. The Assured Water Supply Program requires that the following seven criteria be met: physical, continuous, and legal availability of water; water quality; financial capability; consistency with AMA management plans, and consistency with AMA management goals. The Adequate Water Supply Program requires demonstration of all criteria, excluding consistency with AMA management plan(s) and goal(s).

The Arizona Department of Real Estate will not issue the public report needed to market lots without such determinations (ADWR 2025). The ADWR's programs illustrate the role of water supply in constraining development, requiring developers to demonstrate reliable water before proceeding (ADWR 2025). This context provides one example of how planning assumptions for water supply relate to residential and commercial development and helps frame how communities might respond to changes in water availability under future conditions.

Domestic water supply reliability also supports baseline employment and community functions across the socioeconomic analysis area. **Section TA 16.1.2** in **TA 16**, Socioeconomics, provides baseline employment by sector for the Arizona, California, Nevada, and Utah counties included in the socioeconomic analysis area for 2010 and 2022 (see **Tables TA 16-1, 16-2, 16-6, 16-7, 16-11**, and **16-14**). These tables provide context for the composition of employment in the analysis areas, including sectors that typically rely on continuous municipal water service to support day-to-day operations and public services. Examples of these sectors include, but are not limited to, information; healthcare and social assistance; retail trade; real estate; arts, entertainment, and recreation; construction; finance and insurance; manufacturing; professional, scientific, and technical services; state and local government; and accommodation and food services. While county-level employment data do not distinguish among the water sources supporting certain sectors and the associated economic activity and public services, the sector employment helps frame domestic water supply, demand, and use trends in the counties included in the socioeconomic analysis area. In models of projected water yield and demand in the western U.S. to 2070, data indicate that demands for municipal water are increasing across the socioeconomic analysis area, while projected water availability is decreasing (see, for example, Warziniack and Brown 2019). While this trend is seen throughout the western U.S., the Colorado River region has the largest percentage increases in projected domestic water use and the greatest percentage decreases in projected water yield from all sources, including Colorado River water (Warziniack and Brown 2019).

### TA 17.1.3 Study Area Municipalities

The analysis area is informed by the SAMs and includes the counties represented in the SAMs. Further, the municipalities described below include those represented in the SAMs.

#### *Arizona*

Municipalities potentially affected by the alternatives include Arizona municipalities along the Colorado River that have Colorado River water delivery contracts, such as Lake Havasu City, Yuma, and Bullhead City, as well as Phoenix, Tucson, Scottsdale, and other Arizona municipalities and tribal communities within the Central Arizona Project (CAP) service area, which includes more than 80 percent of the state's population (Central Arizona Project 2024). In Arizona, land uses on the Colorado River include the major power facilities of Glen Canyon Dam in Coconino County, Hoover and Davis Dams on the Arizona-Nevada border in Mohave County (and Clark County, Nevada), and Parker Dam in La Paz County (and San Bernardino County, California).

#### *California*

Municipalities potentially affected by the alternatives include 7 cities in Imperial County, 88 cities in Los Angeles County, 34 cities in Orange County, 28 cities in Riverside County, 24 cities in San Bernardino County, and 18 cities in San Diego County, as well as many more rural communities around the analysis area that are served by entities that use the Colorado River for water supply (California State Association of Counties 2024). These entities in California that use the Colorado River for water supply include the MWD, Imperial Irrigation District, Desert Water Agency, Coachella Valley Water District, Palo Verde Irrigation District, and tribal reservations (Metropolitan Water District of Southern California 2024).

#### *Nevada*

Municipalities potentially affected by the alternatives include Boulder City, Henderson, Las Vegas, Laughlin, and North Las Vegas due to their reliance on Colorado River water supplied by SNWA, which serves more than two million people in Clark County (Southern Nevada Water Authority 2024).

### TA 17.1.4 Land Use

#### *Introduction and Scope*

This section describes existing land-use conditions along the mainstream Colorado River from Glen Canyon Dam to the U.S.-United Mexican States (Mexico) border. Land use includes recreation, agriculture, tribal land use, conservation and habitat management, residential and urban development, and utility and infrastructure corridors. **Map TA 17-1** shows the landownership.

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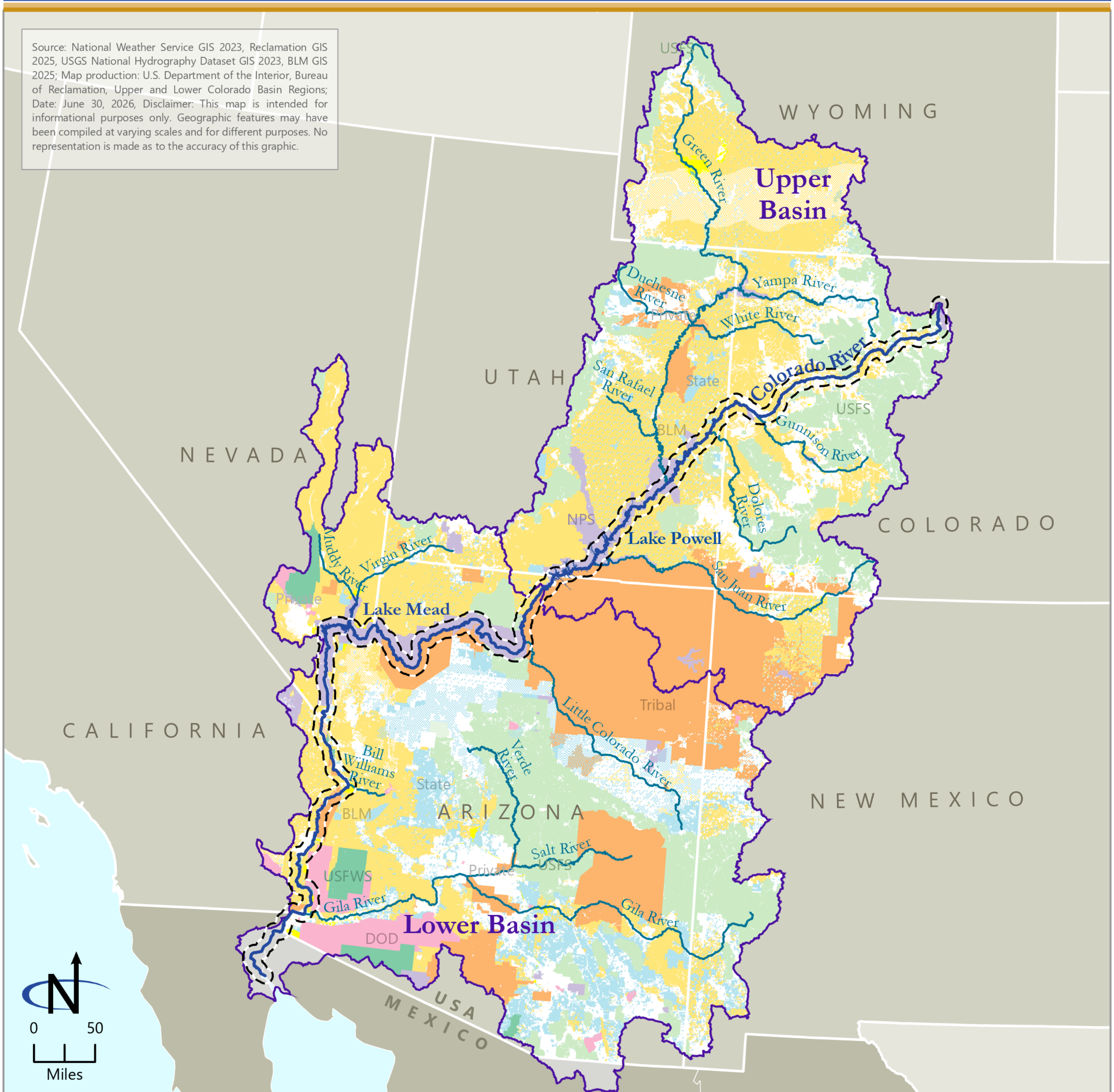
## Map TA 17-1
## Land Ownership of the Colorado River Basin




| | |
|---|---|
| Bureau of Land Management | Private or other |
| Bureau of Reclamation | Other federal |
| US Forest Service | Colorado River |
| US Fish and Wildlife | Major Colorado River tributary |
| National Park Service | Colorado River, 5-mile buffer |
| Department of Defense | Colorado River Basin, Upper and Lower Basins |
| Tribal land | States in the Colorado River Basin (Wyoming, Colorado, Utah, and New Mexico are Upper Division states, and Arizona, California, and Nevada are Lower Division states) |
| State or local government | |

### *Landownership and Management*

Landownership along the Colorado River is highly variable and includes federal (National Park Service [NPS], Bureau of Land Management, U.S. Fish and Wildlife Service, and Reclamation), tribal, state, and private lands. Federal agencies manage much of the land in the upper and middle portions of the river corridor, particularly in areas surrounding Glen Canyon National Recreation Area, Grand Canyon National Park, Lake Mead National Recreation Area, and multiple national wildlife refuges. Tribal lands are prominent in both Arizona and California. State and private lands are more common in the Lower Basin, especially in urban areas like Bullhead City and Yuma, and along agricultural corridors in California and Arizona.

### *Developed Land Use*

Land development has continued across the analysis areas over the past two decades. **Table TA 17-5** to **Table TA 17-8** summarize the number of acres classified as developed in 2001 and 2023 for each county in the analysis area, along with the percentage change during this period. The data are based on U.S. Geological Service (USGS) land cover classifications and provide a snapshot of how developed land has expanded over time. The table shows that most counties experienced growth in developed acreage, though the magnitude of change varies. State- and local-level details are provided in the state sub-sections below. This information establishes a baseline for understanding patterns of land use change within the socioeconomic analysis area and provides context for evaluating potential interactions between land development and Colorado River operations.

**Table TA 17-5**
**Acres of Development from 2001 to 2023 in the Arizona Analysis Area**

| County in Arizona | Acres Developed[1] in 2001 | Acres Developed in 2023 | Percent Change |
|---|---:|---:|---:|
| Apache County | 45,500 | 67,400 | 48 |
| Coconino County | 81,000 | 104,300 | 29 |
| Gila County | 25,100 | 33,300 | 33 |
| Maricopa County | 544,800 | 727,400 | 34 |
| Mohave County | 106,100 | 137,600 | 30 |
| Navajo County | 47,300 | 65,700 | 39 |
| Pima County | 168,500 | 227,500 | 35 |
| Pinal County | 129,300 | 147,800 | 14 |
| Yuma County | 55,100 | 67,100 | 22 |
| La Paz County | 32,200 | 35,100 | 9 |

Source: USGS 2023

[1] Acreages classified as “developed” include low-, medium-, and high-intensity development or roads. Low-intensity development can include mixed forest, herbaceous, and shrubland cover.

### *Arizona*

Counties in the Arizona analysis area all had an increase in developed land use in the last 20 years. The largest increase was in Apache (48 percent) and Navajo (39 percent) Counties, while Maricopa, Pima, Gila, and Mohave Counties also had 30 percent or more of growth. The smallest increase was in Pinal County (14 percent) and La Paz County (9 percent; **Table TA 17-5**).

### *California*

A few counties in the California analysis area, including Los Angeles, San Diego, and Orange Counties, showed slight declines in developed acreage between 2001 and 2023. These decreases may reflect land reclassification or changes in land-use patterns rather than large-scale removal of development. San Bernardino County had the largest increase in the California analysis area, with 14 percent growth from 2001 to 2023 (see **Table TA 17-6**).

**Table TA 17-6**
**Acres of Development from 2001 to 2023 in the California Analysis Area**

| County in California | Acres Developed[1] in 2001 | Acres Developed in 2023 | Percent Change |
|---|---:|---:|---:|
| Imperial County | 83,100 | 86,100 | 4 |
| Los Angeles County | 861,800 | 833,100 | -3 |
| Orange County | 305,800 | 293,400 | -4 |
| Riverside County | 407,700 | 425,600 | 4 |
| San Bernardino County | 424,200 | 483,000 | 14 |
| San Diego County | 479,400 | 469,600 | -2 |

Source: USGS 2023
[1] Acreages classified as "developed" include low-, medium-, and high-intensity development or roads. Low-intensity development can include mixed forest, herbaceous, and shrubland cover.

### *Nevada*

Compared with other counties in the region, Clark County, Nevada, had robust growth in the past 20 years. At 37 percent, this increase was met or exceeded by only one county in Utah and one in Arizona (see **Table TA 17-7**).

**Table TA 17-7**
**Acres of Development in the Nevada Analysis Area from 2001 to 2023**

| County in Nevada | Acres Developed[1] in 2001 | Acres Developed in 2023 | Percent Change |
|---|---:|---:|---:|
| Clark County | 214,800 | 294,000 | 37 |

Source: USGS 2023
[1] Acreages classified as "developed" include low-, medium-, and high-intensity development or roads. Low-intensity development can include mixed forest, herbaceous, and shrubland cover.

### *Utah*

Development in some portions of the Utah analysis area, notably Garfield County (37 percent) and Kane County (18 percent), were higher than regional averages from 2001 to 2023. San Juan County, in contrast, saw only a 10 percent increase in developed acres (**Table TA 17-8**).

**Table TA 17-8**
**Acres of Development in the Utah Analysis Area from 2001 to 2023**

| County in Utah | Acres Developed[1] in 2001 | Acres Developed in 2023 | Percent Change |
|---|---|---|---|
| Garfield County | 28,900 | 39,700 | 37 |
| Kane County | 17,300 | 20,400 | 18 |
| San Juan County | 31,000 | 34,200 | 10 |

Source: USGS 2023
[1] Acreages classified as "developed" include low-, medium-, and high-intensity development or roads. Low-intensity development can include mixed forest, herbaceous, and shrubland cover.

## TA 17.1.5 Agricultural Land Use

### *Arizona*

In the western U.S., agriculture represents a relatively small share of overall land use, but it requires large amounts of irrigation water. The most water-intensive crops include crops for food, feed, and fiber production. In Arizona, in 2015, irrigated agriculture accounted for about 74 percent of the state's water use; more than 50 percent of this is from surface waters (Dieter et al. 2018). Implementation of certain recent strategies and techniques in the western U.S. has reduced agriculture's share of water consumption. These methods include improvements in irrigation technology, voluntary fallowing programs that compensate farmers who reduce water consumption, and utilization of more effective irrigation strategies, such as changes to irrigation timing and using cover crops to protect the soil (Presson and Eden 2023). However, conservation methods do not reduce the legal water entitlement held by agricultural users.

Pinal, Maricopa, and Pima Counties account for approximately 50 percent of statewide irrigated, harvested cropland (USDA NASS 2024). Colorado River water in these counites is associated primarily with tribal agricultural users receiving CAP water. Agricultural resources in western Arizona are primarily along the Colorado River in Mohave, La Paz, and Yuma Counties and along the Gila River Valley in Yuma County. These western counties account for approximately 32 percent of irrigated agricultural land in Arizona. **Table TA 17-9** provides a summary of county-wide irrigated agricultural lands within the Arizona analysis area.

Production of winter vegetables and leafy greens in the U.S. is seasonally concentrated in the irrigated desert production regions of the Southwest. The U.S. Department of Agriculture's (USDA) Economic Research Service notes that from mid-November through early April, most lettuce sold in the U.S. is sourced from Southern California's Imperial County and the Yuma area of Arizona, and that shipments from Florida help fill in regional market gaps during winter and spring months (Weber 2023).

## Table TA 17-9
## Irrigated Acres of Harvested Cropland in the Arizona Analysis Area (2022)

| Area | Irrigated Harvested Cropland (Acres) | Total Harvested Cropland (Acres) | Percent Irrigated Harvested Cropland to Total Harvested Cropland | Percentage of Statewide Irrigated Harvested Cropland |
|---|---|---|---|---|
| Maricopa County | 202,086 | 202,092 | 100 | 23 |
| Pima County | 27,512 | 27,516 | 100 | 3 |
| Pinal County | 202,429 | 202,430 | 100 | 23 |
| **Total within CAP counties** | **432,027** | **432,038** | **100** | **50** |
| Apache County | 5,339 | 5,369 | 99 | 1 |
| Coconino County | 511 | 520 | 98 | 0 |
| Gila County | 615 | 618 | 100 | 0 |
| La Paz County | 80,176 | 80,176 | 100 | 9 |
| Mohave County | (D) | (D) | (D) | (D) |
| Navajo County | 2,876 | 2,911 | 99 | 0 |
| Yuma County | 178,842 | 178,843 | 100 | 21 |
| **Total Arizona analysis area[1]** | **700,386** | **700,475** | **100** | **80** |
| **Total Arizona[1]** | **871,746** | **871,863** | **100** | **—** |

Source: USDA NASS 2024

(D) = The USDA determined the data are too sensitive to disclose.

— = not applicable

[1] The totals for the Arizona analysis area do not include data for Mohave County because the USDA determined the data were too sensitive to disclose; however, the totals for Arizona include data for Mohave County.

**Table TA 17-10** shows changes between 2017 and 2022 in acres of irrigated harvested cropland and in acres of total harvested cropland in each county in the Arizona analysis area. In all counties where data were disclosed, except Maricopa County, there was a decrease in acreage of harvested cropland. In Pima, Pinal, and Gila Counties, this decrease in acreage of harvested cropland corresponded with a similar percent decrease in irrigated harvested cropland. In Navajo and Yuma Counties, the reduction in harvested cropland was largely made up of non-irrigated cropland. In Apache County, the reduction in harvested cropland was fully made up of non-irrigated cropland, and irrigated harvested cropland saw an increase from 2017 to 2022. In Maricopa County, where there was an increase in total harvested cropland, the increase corresponded to an increase in irrigated cropland (USDA NASS 2024).

**Table TA 17-10**
**Irrigation Trend for Harvested Cropland in the Arizona Analysis Area (2017–2022)**

| Area | Percent Change in Irrigated Harvested Cropland | Percent Change in Total Harvested Cropland |
|---|---|---|
| Maricopa County | 13.5 | 7.8 |
| Pima County | -5.6 | -5.7 |
| Pinal County | -12.4 | -13.9 |
| **Total within CAP counties** | **-1.4** | **-4.4** |
| Apache County | 23.9 | -7.4 |
| Coconino County | (D) | (D) |
| Gila County | -36.6 | -36.5 |
| La Paz County | (D) | (D) |
| Mohave County | (D) | (D) |
| Navajo County | -30.2 | -50.0 |
| Yuma County | -1.3 | -7.7 |
| **Total Arizona analysis area[1]** | **-1.5** | **-5.8** |
| **Total Arizona[1]** | **-0.5** | **-4.8** |

Source: USDA NASS 2024
(D) = The USDA determined the data are too sensitive to disclose.
[1] The totals for the Arizona analysis area do not include data for Coconino, Mohave, and La Paz Counties because the USDA determined the data were too sensitive to disclose; however, the totals for Arizona include data for all counties in the state.

**Table TA 17-11** shows the proportion of irrigation water that came from all surface water resources in each county in the analysis area in 2015. In Apache County and Maricopa County, where there were increases in irrigated harvested cropland from 2017 to 2022, approximately 94 percent and 21 percent of the irrigated water comes from surface waters, respectively. In Gila County and Navajo County, which had the largest percentage decrease in irrigated harvested cropland from 2017 to 2022, approximately 30 percent and 54 percent of the irrigation water comes from surface waters, respectively (see **Table TA 17-10** and **Table TA 17-11**).

**Table TA 17-11**
**Percentage of Irrigated Water from Surface Water Sources (2015)[1]**

| Area | Percentage of Irrigated Water Withdrawal for Crops from Surface Waters |
|---|---|
| Maricopa County | 21 |
| Pima County | 38 |
| Pinal County | 62 |
| **Total within CAP counties[2]** | **39** |
| Apache County | 94 |
| Coconino County | 0 |
| Gila County | 30 |
| La Paz County | 87 |
| Mohave County | 56 |
| Navajo County | 54 |
| Yuma County | 90 |
| **Total within the Arizona analysis area** | **61** |
| **Total Arizona** | **57** |

Source: Dieter et al. 2018
[1] The 2015 USGS water use (for specific purposes, such as irrigation) data by source (surface water or groundwater, etc.) are the most recent available county-level data.
[2] CAP values are the aggregated values of Maricopa, Pima, and Pinal Counties. Surface water sources include all sources; they are not exclusive to the Colorado River.

### *California*

About 96 percent of harvested cropland in the California analysis area is irrigated, which is the same as the percentage of irrigated harvested cropland for California. However, the percentage varies across the counties in the analysis area, ranging from a low of 68 percent in Los Angeles County to a high of 99 percent in San Bernardino County. The proportion of irrigated croplands within the California analysis area represents approximately 11 percent of total irrigated croplands in the state. **Table TA 17-12** shows the acres of irrigated harvested and total harvested cropland within the California analysis area.

**Table TA 17-13** shows changes between 2017 and 2022 in acres of irrigated harvested cropland and in acres of total harvested cropland in each county in the analysis area. In Imperial, Los Angeles, and Riverside Counties, there was an increase in the number of acres of harvested cropland and in irrigated harvested cropland. However, in Orange, San Bernardino, and San Diego Counties, there was a decrease in the number of acres of harvested cropland that corresponded to a similar decrease in the number of irrigated harvested cropland acres (USDA NASS 2024).

## Table TA 17-12
## Irrigated Acres of Harvested Cropland in the California Analysis Area (2022)

| Area | Irrigated Harvested Cropland (Acres) | Total Harvested Cropland (Acres) | Percent Irrigated Harvested Cropland to Total Harvested Cropland | Percentage of Statewide Irrigated Harvested Cropland |
|---|---|---|---|---|
| Imperial County | 623,098 | 634,602 | 98 | 8 |
| Los Angeles County | 13,876 | 20,422 | 68 | 0 |
| Orange County[1] | 3,241 | 3,299 | 98 | 0 |
| Riverside County | 166,297 | 183,926 | 90 | 2 |
| San Bernardino County | 15,039 | 15,210 | 99 | 0 |
| San Diego County | 35,535 | 37,953 | 94 | 0 |
| **Total California analysis aarea** | **857,086** | **895,412** | **96** | **11** |
| **California** | **7,739,236** | **8,081,181** | **96** | **—** |

Source: USDA NASS 2024
— = not applicable
[1] The number of irrigated harvested cropland acres was not disclosed for Orange County to avoid publishing confidential information; therefore, the total number of irrigated acres, including harvested cropland, was used as a proxy.

## Table TA 17-13
## Irrigation Trend for Harvested Cropland in the California Analysis Area (2017–2022)

| Area | Percent Change in Irrigated Harvested Cropland | Percent Change in Total Harvested Cropland |
|---|---|---|
| Imperial County | 36.7 | 35.8 |
| Los Angeles County | 1.7 | 59.5 |
| Orange County[1] | -23.1 | -43.2 |
| Riverside County | 32.7 | 28.1 |
| San Bernardino County | -30.0 | -31.3 |
| San Diego County | -14.6 | -22.7 |
| **Total California analysis area** | **29.5** | **27.8** |
| **Total California** | **5.3** | **2.8** |

Source: USDA NASS 2024
[1] The number of irrigated harvested cropland acres was not disclosed for Orange County to avoid publishing confidential information; therefore, the total number of irrigated acres, including harvested cropland, was used as a proxy.

In California, in 2015, irrigated agriculture accounted for about 74 percent of the state's water use; approximately 27 percent of this was from surface waters (Dieter et al. 2018). **Table TA 17-14** shows the proportion of irrigation water that came from all surface water resources in each analysis area county in 2015. In all counties in the analysis area, approximately 30 percent of the irrigated water comes from surface waters, which is consistent with the state's amount.

**Table TA 17-14**
**Percentage of Irrigated Water from Surface Water Sources (2015 Data)[1]**

| Area | Percentage of Irrigated Water Withdrawal for Crops from Surface Waters |
|---|---|
| Imperial County | 30 |
| Los Angeles County | 30 |
| Orange County | 30 |
| Riverside County | 30 |
| San Bernardino County | 30 |
| San Diego County | 30 |
| **Total within California analysis area** | **30** |
| **Total California** | **27** |

Source: Dieter et al. 2018
Note: Surface water sources include all sources; they are not exclusive to the Colorado River.
[1] The 2015 USGS water use (for specific purposes, such as irrigation) data by source (surface water or groundwater, etc.) are the most recent available county-level data.

### ***Nevada***

Agriculture in the Nevada analysis area—Clark County—is small, with only 2,322 total acres for harvested cropland (USDA NASS 2024). Of the total harvested agricultural lands in Clark County, 100 percent were irrigated cropland, which is similar to the percentage of irrigated cropland in Nevada (99.8 percent; see **Table TA 17-15**). In Nevada, in 2015, irrigated agriculture accounted for about 71 percent of the state's water use; approximately 53 percent of this was from surface waters (Dieter et al. 2018). Approximately 35 percent of the irrigated water in Clark County comes from surface waters (see **Table TA 17-16**).

**Table TA 17-15**
**Irrigated Acres of Harvested Agriculture in the Nevada Analysis Area (2022)**

| Area | Irrigated Harvested Cropland (Acres) | Total Harvested Cropland (Acres) | Percent Irrigated Harvested Cropland to Total Harvested Cropland |
|---|---|---|---|
| Clark County | 2,322 | 2,322 | 100.0 |
| **Total Nevada** | **486,100** | **486,935** | **99.8** |

Source: USDA NASS 2024

**Table TA 17-16**
**Percentage of Irrigated Water from Surface Water Sources (2015)[1]**

| Area | Percentage of Irrigated Water Withdrawal for Crops from Surface Waters |
|---|---|
| Clark County | 35 |
| **Total Nevada** | **53** |

Source: Dieter et al. 2018
Note: Surface water sources include all sources; they are not exclusive to the Colorado River.
[1] The 2015 USGS water use (for specific purposes, such as irrigation) data by source (surface water or groundwater, etc.) are the most recent available county-level data.

## TA 17.1.6 Land Use and Management by Reach

### *Upper Reach (Glen Canyon Dam to Lees Ferry)*

This reach is dominated by federal lands managed by the NPS as part of Glen Canyon National Recreation Area. Land use is primarily recreational, with boating, fishing, and sightseeing as the dominant uses. Infrastructure in this reach includes the Glen Canyon Dam and associated access roads. These facilities are sensitive to reservoir elevation changes, and declining water levels may in reduced functionality, relocation needs, or closure.

### *Grand Canyon Reach (Lees Ferry to Lake Mead)*

The NPS manages most land in this reach as part of Grand Canyon National Park. Land use is regulated to preserve natural and cultural resources and to provide for controlled public recreation. Access is limited, and development is minimal. This reach includes tribal lands, which are used for tourism and cultural purposes.

### *Lower Basin Reach (Hoover Dam to U.S.–Mexico Border)*

Land use in this reach is more varied. It includes the following:

- Urban development near Las Vegas, Bullhead City, Lake Havasu City, and Yuma
- Extensive irrigated agriculture in areas such as the Palo Verde and Imperial Valleys
- Recreation and habitat management within national wildlife refuges (Cibola, Havasu, and Imperial)
- Transportation and utility corridors, including transmission lines and canals

Landownership in this reach includes a greater proportion of state and private land, and land use is more intensive compared with upstream reaches. Also, fluctuating water levels can affect the usability of the reach's recreation facilities and require adaptive management, such as ramp extensions, marina relocations, or temporary closures. These infrastructure elements are vital to supporting recreation and tourism in the region and may be affected under the alternatives that result in lower Lake Mead elevations.

Water delivery constraints may influence future land-use decisions in this reach. Some counties could experience changes in agricultural viability and development patterns due to reduced water reliability (see **TA 4**, Water Deliveries).

# TA 17.2 Environmental Consequences

## TA 17.2.1 Methodology

The analysis of population and land-use impacts evaluates (1) how operational changes and changes to domestic water delivery could affect the overall population and land-use patterns, including developed lands for residential and commercial uses, and (2) how operational changes and changes to irrigation water delivery could affect lands used for irrigated agriculture.

To analyze how operational changes may affect population and land-use patterns (Issue 1), DMDU was applied to the modeled shortage to domestic users provided by the SAMs and Alternative Distribution Models (ADMs). There are three unique SAMs and five Alternative Distribution Models to capture the nuances of the alternatives and sensitivity analyses; these are further explained in **Appendix C**, Shortage Allocation Model and Alternative Distribution Model Documentation. **Table C-1** in **Appendix C** provides a crosswalk between the alternatives and SAMs and ADMs. The application of DMDU to analyze domestic water impacts involved multiple steps. First, to capture variation in modeled shortage by priority across the SAMs, the following priority groupings were established: Arizona CAP non-Indian agriculture (NIA)-A and NIA-B (Group 1), Arizona CAP municipal and industrial (M&I) and Priority 4(i) (Group 2), Arizona Priorities 2 and 3 (Group 4), Arizona present perfected right (PPR) (Group 5), California Priority 4 (Group 6), California PPR (Group 7), Nevada Priority 8 (Group 8), Nevada Priorities 1–7 (Group 9). Second, the modeled domestic shortage was analyzed for each of these priority groups, to identify at which shortage level, the average percentage shortage across a given priority group equals approximately 20, 40, 60, 70, 80, or 100 percent of the priority group's total entitlement.

DMDU was then applied to generate **Figure TA 17-1** through **Figure TA 17-8**. These figures are the result of applying SAM-based, volumetric thresholds of the Lower Basin shortage to annual shortage volumes computed from the Colorado River Simulation System. The figures display the percentage of modeled futures in which annual domestic water delivery to a given priority group are always the specified percentage of "normal delivery," across the alternatives. For purpose of this analysis, "normal delivery" is defined as a full Colorado River or CAP entitlement supply. The figures provide a comparison of impacts on domestic water by priority group across the action alternatives. While this appendix focuses on domestic shortage impacts to priority groups, domestic shortage impacts for each entitlement can be found in **Appendix C**. Refer to **Table C-1** and the following tables in **Appendix C** for entitlement-level impacts:

- **Table C-19**, Priority Shortage Allocation Model Domestic Summary
- **Table C-24**, Continuing Current Strategies Shortage Allocation Model Domestic Summary
- **Table C-29**, Lower Basin Priority Shortage Allocation Model Domestic Summary
- **Table C-41**, Pro Rata Alternative Distribution Model Domestic Summary
- **Table C-46**, Lower Basin Pro Rata Alternative Distribution Model Domestic Summary

To analyze how operational changes may affect agricultural land use (Issue 2), the analysis relied on modeled shortages to irrigation users at the state level, produced by the SAMs. For more detailed information on the SAMs and consumptive impacts on irrigation users, see **Appendix C**, Shortage Allocation Model and Alternative Distribution Model Documentation**.** For more information on water deliveries and shortage impacts, including those for irrigation, refer to **TA 4**, Water Deliveries.

For analysis of how operational changes may impact socioeconomic conditions related to agriculture, recreation, and nonmarket values and associated county-level socioeconomic data, refer to **TA 16**, Socioeconomics. Because baseline county-level socioeconomic data do not distinguish among water sources supporting economic activity (including non-Colorado River sources or blended supplies), and comparable utility-specific financial and economic modeling inputs are not uniformly available across all municipal providers and service areas in the analysis areas, the analysis in this technical appendix provides a qualitative discussion of municipal impact pathways using the modeled delivery-reliability and shortage outputs from **TA 4**, Water Deliveries. With respect to hydropower and reservoir elevation thresholds, **TA 15**, Dams and Electrical Power Resources, evaluates how the alternatives affect the frequency of operations that would fail to meet customary or desirable firm capacity, energy generation, facility operability, and electricity rate and market value outcomes.

### *Impact Analysis Areas*

The analysis area for the population and land-use section is separated by state and is the same for both population and land-use issues. The impact analysis area is defined by those counties that may be affected by management direction that could result in water shortages to domestic and irrigation users. As described above, both issue statements rely on the SAMs. As a result, the analysis area is informed by the SAMs and includes the counties represented in the SAMs. The Arizona analysis area consists of Apache, Coconino, Gila, La Paz, Maricopa, Mohave, Navajo, Pima, Pinal, and Yuma Counties. These are counties that are directly adjacent to Lake Powell, Lake Mead, or the Colorado River and counties in which shortages would likely occur. The California analysis area consists of Imperial, Los Angeles, Orange, Riverside, San Bernardino, and San Diego Counties. The Nevada analysis area consists of Clark County. The Nevada analysis area was limited to Clark County because Clark County is adjacent to Lake Mead and encompasses SNWA's service area and other individual water providers. Shortages in Nevada would be limited to SNWA's service area.

### *Assumptions*

- Colorado River operations do not directly control population change, but they may indirectly influence migration patterns.
- Local socioeconomic conditions and demographic trends may also be influenced by factors outside river operations, such as housing costs, infrastructure investment, local attitudes toward water conservation, and regional employment patterns.
- In most cases, the contractor, subcontractor, or entitlement holder of an allocation is shown as the entity bearing shortage. In some cases, water allocated to an entitlement holder (for example, a tribal CAP contractor) may lease its allocation to other users (for example, to a non-Indian municipality). The SAMs and ADMs do not attempt to replicate those arrangements, and they only provide approximate estimates at the level of the entitlement

holder, contractor, or subcontractor. The entitlement holder, contractor, or subcontractor to the leasing arrangements would have specific decisions to make during Shortage Conditions to administer those arrangements; Reclamation cannot predict those decisions with sufficient certainty to analyze them in this Final Environmental Impact Statement (EIS).

#### *Impact Indicators*

- Shortage to domestic water users
- Acres of developed land within the analysis areas and the potential for changes based on municipal water availability
- Acres of irrigated agricultural land within the analysis areas and the potential for changes based on agricultural water availability

### TA 17.2.2 Issue 1: How would operational changes affect population and developed land-use patterns?

This issue examines how different operational strategies may influence population dynamics and developed land-use patterns in communities that rely on Colorado River water for municipal water uses. While Colorado River operations do not directly determine population movement or developed land-use patterns, long-term changes in water availability and recreational access may influence migration patterns and developed land patterns. This issue statement is analyzed by first presenting the DMDU figures and a detailed analysis for domestic water delivery and then by assessing how domestic water delivery changes would impact population and developed land-use patterns.

The analysis for this issue statement evaluates how modeled changes in domestic (municipal) delivery reliability may influence population- and land-use-related outcomes, including constraints on residential and commercial development and potential qualitative effects on existing communities reliant on municipal water supplies. The analysis uses modeled changes in domestic water delivery reliability to understand how communities and land-use-related conditions may be constrained. DMDU results are interpreted as indicators of exposure to domestic shortage and associated impacts; they are not direct forecasts of economic output or sector-specific impacts. Additionally, population is not treated as a direct proxy for consumptive use because conservation, reuse, and local policy can substantially mediate demand. Modeled domestic shortage outcomes are derived from the water deliveries analysis in **TA 4**, Water Deliveries and the shortage allocation frameworks documented in **Appendix C**; because allocations are modeled based on entitlement structures and assumptions, results may not capture all potential place-of-use transfers or future programmatic adjustment that could occur through separate agreements or actions. Quantitative economic impact estimates at the municipality level were not developed across the full analysis area due to inconsistent availability of comparable economic, utility finance, and sector-specific data across all municipal providers; therefore, this appendix describes pathways qualitatively and references related analyses in other sections and appendixes, where applicable.

**TA 16,** Socioeconomics, provides baseline socioeconomic context for the analysis area, including employment by sector for 2010 and 2022 (**Tables TA 16-1, 16-2, 16-6, 16-7, 16-11**, and **16-14** in **Section TA 16.1.2**). These baseline data describe economic conditions and the composition of employment in the counties included in the socioeconomic analysis area; however, baseline county-level socioeconomic data do not distinguish among water sources supporting economic activity (including non-Colorado River sources or blended municipal portfolios), and comparable utility-specific financial and economic modeling inputs are not uniformly available across municipal providers and service areas. Accordingly, this appendix does not forecast sector-specific production or employment impacts. Instead, this appendix uses the modeled domestic delivery outcomes and delivery-reliability results reported in **TA 4**, Water Deliveries, together with the modeling frameworks documented in **Appendix C**, Shortage Allocation Model and Alternative Distribution Model Documentation, discuss qualitative pathways by which reduced municipal delivery reliability may affect community conditions and land-use-related outcomes.

Domestic water delivery impacts are discussed in the context of a DMDU analysis framework. Additional information on the DMDU robustness and vulnerability concepts used to interpret these results is provided in **Appendix E**, DMDU Overview and Approach. Modeling assumptions and shortage allocation frameworks that inform domestic delivery outcomes are documented in **TA 4**, Water Deliveries, and the Final EIS discussion recognizes that adaptation feasibility and constraints vary by location and provider.

In addition to potential constraints on future development, reductions in municipal delivery reliability could affect existing residents and essential services. Severe or abrupt delivery reductions can create operational challenges for conveyance and treatment systems and may affect service reliability depending on local infrastructure and operational constraints. For instance, damage to CAP infrastructure or other diversion facilities can occur under low- or no-flow conditions. In addition, depending on local system configuration and available alternative supplies, severe or abrupt delivery reductions may require additional conservation measures or development of replacement supplies over time. The degree to which these effects would occur, and the time required to adapt, varies by community and is influenced by existing conservation achievements, infrastructure, regulatory requirements, and local hydrologic conditions.

As described in **Section TA 17.1**, water supply reliability is a key input to municipal planning and development. Municipal providers within the analysis area may have structured infrastructure investments, regulatory compliance strategies, and economic development assumptions around continued Colorado River supplies and delivery reliability. Where domestic water shortages reduce available Colorado River deliveries, potential effects may include the need to revise supply planning assumptions; changes in the timing, scale, or sequencing of infrastructure and compliance investments; and constraints or delays affecting planned development or other investments that rely on a defined level of Colorado River domestic water supply. The degree to which these effects may occur would vary by community because municipal supply portfolios, contractual arrangements, demand management capacity, and regulatory contexts differ by provider. Although utility- and project-specific decisions (for example, local growth management actions, capital programming, and rate-setting) would occur outside the scope of this EIS, reduced supplies could increase reliance on alternative sources and require adaptation measures (for example, additional supplies, treatment upgrades, system interconnections, conservation actions, and financing). Such measures can require substantial time and resources to plan, permit, fund, and implement and may not be achievable on the same schedule for all communities.

Similarly, reductions in municipal delivery may result in secondary impacts that may affect the socioeconomic setting and quality of life in affected communities. These impacts may include but are not limited to changes to public and private space landscaping, changes to the quality or availability of recreational opportunities which require water use, impacts to property value, and changes to economic contributions and employment opportunities associated with businesses which rely on domestic water. As noted above, the degree to which these effects would occur varies by community and is influenced by geography (on-river and rural areas), existing conservation achievements, infrastructure, regulatory requirements, adaptation capacity, and local hydrologic conditions.

In evaluating these outcomes, it is important to recognize that the DMDU framework highlights the potential for a wide range of plausible future conditions that cannot be predicted with confidence. Factors such as climate trends, hydrologic change, and evolving population or land-use trends may interact in complex ways that influence domestic water delivery. Therefore, while robustness provides an indicator of how well an alternative performs across many possible futures, decision makers should consider these uncertainties when interpreting results and determining which management approaches are most adaptive and resilient under changing conditions.

Incorporating DMDU principles supports a transparent and adaptive evaluation by considering a range of plausible futures rather than a single forecast. This approach helps decision makers understand the trade-offs, vulnerabilities, and adaptive capacity of each alternative, enhancing the resilience of long-term management strategies.

The alternatives with greater robustness would likely result in fewer potential indirect impacts on population growth and developed land. Greater robustness corresponds to a higher percentage of futures in which domestic water delivery remains consistent with normal conditions and shortages occur less frequently. In contrast, less robust alternatives are more susceptible to reductions in domestic water availability because modeled shortages occur more frequently or the volume of shortage is higher. These shortages could manifest as reduced water deliveries, delivery restrictions, or the need for additional conservation measures, which could in turn limit the capacity to meet domestic water demand. A more robust alternative would therefore help ensure that domestic water supplies remain reliable to support existing populations and accommodate anticipated future growth, thereby minimizing potential secondary impacts on development patterns and land use.

**Figure TA 17-1** through **Figure TA 17-8** display potential impacts on domestic water deliveries by presenting the percentage of normal domestic water deliveries that can be achieved across a range of modeled futures. Specifically, each figure shows the percentage of normal domestic water deliveries that can be achieved in 90 percent of years, over a 34-year modeling period, across different percentages of potential futures for each priority group. The metric of 90 percent of years was selected for this analysis, rather than 100 percent of years, because it better displays variation between the alternatives. For each figure, the rows represent different performance thresholds, as percentages of normal domestic water delivery. Higher rows indicate a higher volume of delivery (closer to normal conditions) and are therefore more difficult to achieve across a large percentage of potential futures, while lower rows represent lower levels of delivery that are easier to achieve because they allow for more frequent modeled shortages to domestic water delivery. For this analysis, greater than 80 percent of normal delivery in 90 percent of years was selected as the minimum level of performance. This row was highlighted because it represents the performance level closest to normal domestic water delivery of the thresholds displayed in the figures, while also representing the earliest point at which differences among alternatives begin to emerge in the DMDU results. In other words, the greater than 80 percent row reflects the least amount of modeled shortage to domestic water users displayed in the figures and is the first row where shortages begin to manifest across alternatives.

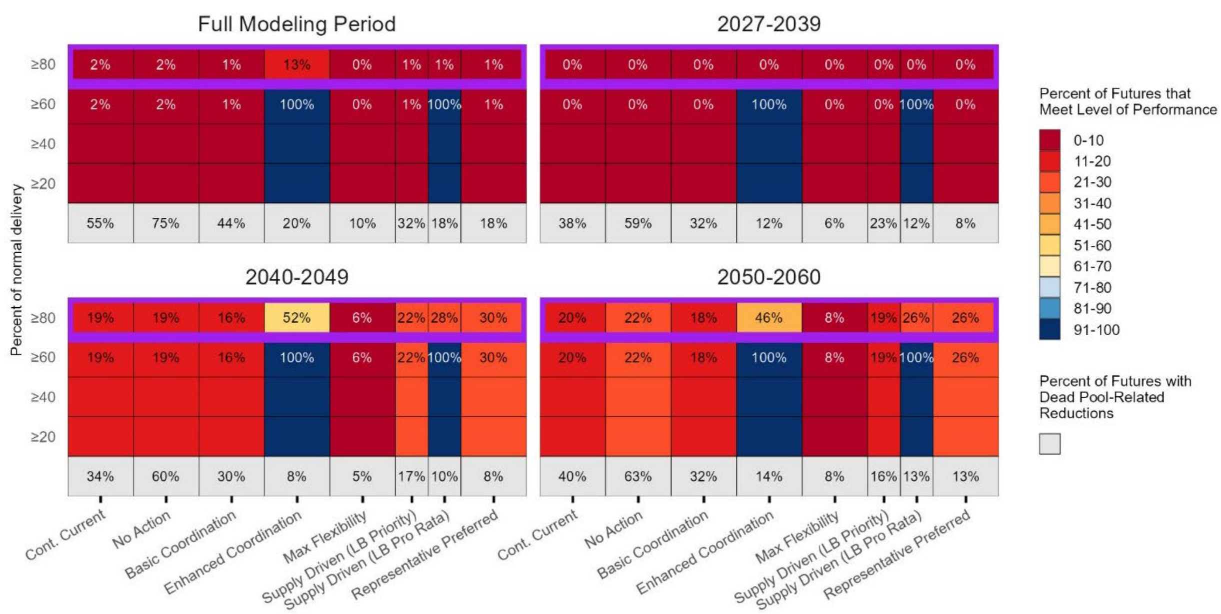
Each figure also displays a row at the bottom for percent futures with dead pool–related reductions. As described in **TA 4**, Water Deliveries, dead pool–related reductions occur when there is not enough water in Lake Mead to fully meet downstream demands and/or when Hoover Dam infrastructure constraints result in releases below the demand volume. In some cases, this occurs because Lake Mead is approaching dead pool (elevation 895 feet) and in some cases it occurs earlier (up to elevation 950 feet). The approach to distributing reductions associated with dead pool is not addressed in this analysis. By providing the information on dead pool–related reductions in the domestic water, the DMDU figures provide additional context on the robustness of the alternatives. **Figure TA 17-1** through **Figure TA 17-8** are described in further detail below.

**Figure TA 17-1** through **Figure TA 17-8** display the full modeling period and each of the decadal subperiods within the full modeling period. Across all priority groups, the DMDU modeling results displayed in **Figure TA 17-1** through **Figure TA 17-8** follow a pattern: performance across all alternatives is poorest in the first decade of the modeling period (2027 – 2039). This is because 2027 begins with relatively low reservoir elevations, which results in poorer first decade performance. This is an expected consequence of the initial system state and observed data from the years immediately prior to the modeling rather than a modeling anomaly.

**Figure TA 17-1** presents potential shortage impacts on domestic water deliveries to Arizona CAP NIA-A and NIA-B priorities.

Across the first decade of the modeling period (2027–2039), there are no potential futures in which any of the alternatives meet the preferred minimum performance (greater than 80 percent of normal domestic water is delivered in 90 percent of years) for the Arizona CAP NIA-A and NIA-B priorities. Therefore, all alternatives would result in similar impacts on shortage for domestic deliveries to Arizona CAP NIA-A and NIA-B priorities. Under these alternatives, shortages would be high for these users, and domestic deliveries would not be consistent with annual normal delivery.

**Figure TA 17-1**
**Arizona CAP, NIA-A & NIA-B: Robustness**
**Percentage of futures in which annual delivery is the percentage of normal domestic delivery specified in each row in at least 90 percent of years**



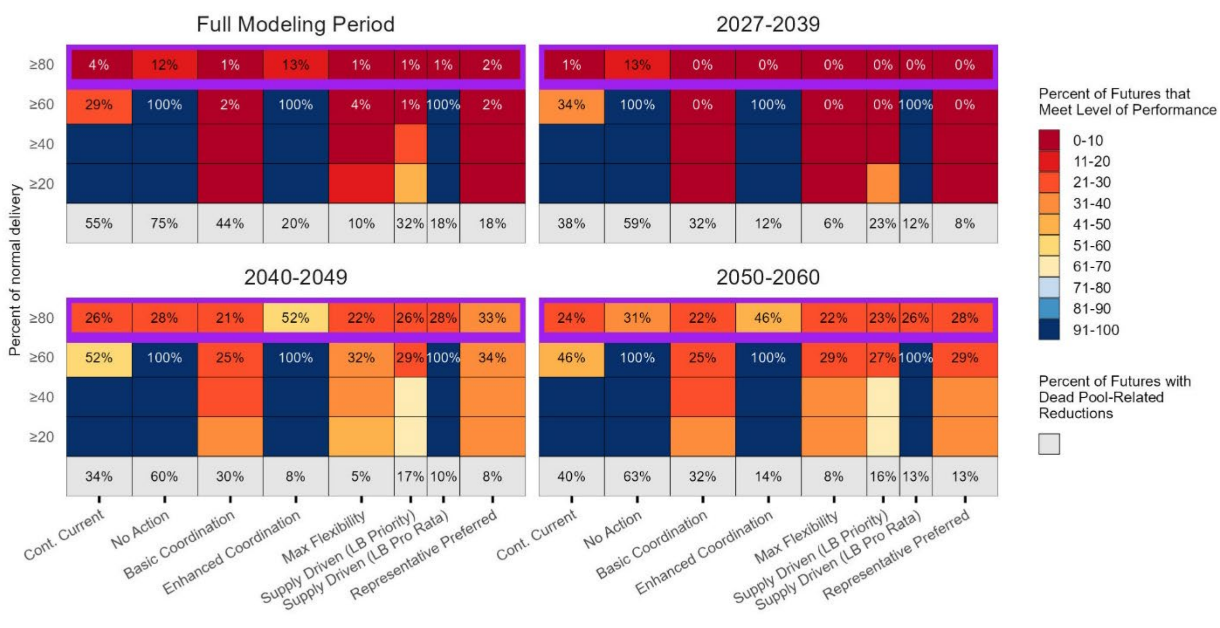

The next level below the preferred minimum performance is greater than 60 percent of normal domestic water delivery to Arizona CAP NIA-A and NIA-B priorities. When considering this next level of performance, the Enhanced Coordination and Supply Driven (Lower Basin Pro Rata [LB Pro Rata] approach) Alternatives are the most robust alternatives for CAP NIA-A and NIA-B priorities compared with all other alternatives, with greater than 60 percent of normal delivery in 90 percent of years occurring in 100 percent of potential futures across the first decade of the modeling period (2027 – 2039). The Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives perform well for CAP NIA-A and NIA-B priorities at lower volumes of delivery because they apply pro rata distribution of Lower Basin shortage (shortage is distributed evenly across entitlement holders). Note that with a priority-based distribution, water is distributed to those with more senior water entitlements first, with senior water entitlements facing less shortage. In contrast, with pro rata distribution, shortage is distributed proportionately across all entitlements, regardless of their seniority, with all users bearing some shortage. Therefore, it makes sense that these two alternatives would be the most robust alternative in terms of domestic water delivery to junior priority pools such as the Arizona CAP NIA-A and NIA-B, compared with the other alternatives. If dead pool–related reductions, which may impact these users, are considered, the Enhanced Coordination Alternative remains the most robust alternative compared with the Continued Current Strategies (CCS) Comparative Baseline and the No Action Alternative (as well as all action alternatives).

Under the Representative Preferred Alternative, there are no potential futures in which there is any percentage of normal domestic water delivery to Arizona CAP NIA-A and NIA-B priorities.

However, the modeling results in 2027-2039 for the Representative Preferred Alternative displayed in **Figure TA 17-1**, above, are not necessarily the anticipated impacts in 2027-2028 under the Preferred Alternative for Arizona CAP NIA-A and NIA-B based on the May 1 proposal by Lower Division States, which represents the best available information at the time of publication. This proposal would distribute shortage according to the Lower Basin Priority (LB Priority) approach. While the Representative Preferred Alternative does model shortages up to 1.5 maf using the LB Priority approach in 2027 and 2028, the results are heavily influenced by shortages in 2029-2039, which are distributed according to the Priority distribution. See **Chapter 2** and **Appendix C**, **Table C-1** for additional information. Refer to **Appendix C**, **Table C-28** for domestic shortage impacts for each entitlement holder under the LB Priority distribution (up to 1.5 maf shortage).

**Figure TA 17-2**, below, presents potential shortage impacts on domestic water deliveries to Arizona CAP Indian, CAP M&I, and 4(i) priorities.

**Figure TA 17-2**
**Arizona CAP Indian, CAP M&I and 4(i): Robustness**
**Percentage of futures in which annual delivery is the percentage of normal domestic delivery specified in each row in at least 90 percent of years**




Across the first decade of the full modeling period (2027–2039), there are no or minimal (less than 0-13 percent) potential futures in which any of the alternatives, meet the selected level of performance (greater than 80 percent of normal domestic water is delivered in 90 percent of years) for the Arizona CAP Indian, CAP M&I, and 4(i) priorities. As displayed in **Figure TA 17-2** above, greater than 80 percent of normal delivery occurs in 13 percent of potential futures under the No Action Alternative and 1 percent of potential futures under the CCS Comparative Baseline. There are no potential futures in which greater than 80 percent of normal delivery to Arizona CAP Indian, CAP M&I and 4(i) priority holders occurs under the Basic Coordination, Maximum Operational Flexibility, and the Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives.

Under the Enhanced Coordination Alternative, greater than 80 percent of normal delivery occurs in 12 percent and 13 percent of potential futures, respectively. Therefore, when compared with the No Action Alternative, all other alternatives are less robust. While greater than 80 percent of normal delivery occurs in the highest number of potential futures under the No Action Alternative, making it the most robust alternative, it is important to note that this is still a minimal percentage of futures (13 percent). Therefore, there would be potential shortage impacts on domestic water deliveries to Arizona CAP Indian, CAP M&I and 4(i) priority holders across all alternatives.

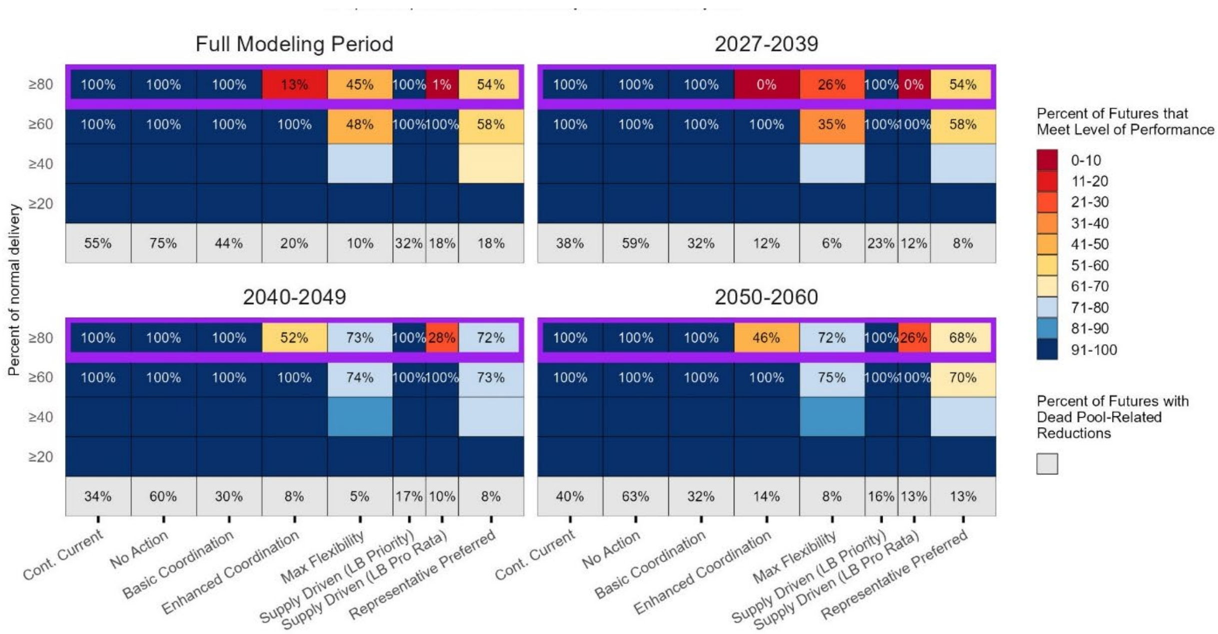
The next row below the preferred minimum performance is greater than 60 percent of normal domestic water delivery to Arizona CAP Indian, CAP M&I, and 4(i) priorities. When considering this next level of performance, the No Action, Enhanced Coordination, and Supply Driven (LB Pro Rata approach) Alternatives are the most robust for these users compared with the other alternatives, with greater than 60 percent of normal domestic water delivery occurring in 100 percent of futures across the first decade of the modeling period (2027–2039). Under the CCS Comparative Baseline, greater than 60 percent of normal delivery occurs in 34 percent of potential futures. Generally, deeper shortages do not occur for the No Action and Basic Coordination Alternatives and the CCS Comparative Baseline. For the CCS Comparative Baseline and the No Action Alternative, this is because the shortages do not extend far into the apportionments of the Lower Division States. However, it is important to note that for the No Action Alternative and the CCS Comparative Baseline, across the first decade of the modeling period the percentage of futures with dead pool–related reductions are 38 percent and 59 percent, respectively. The No Action, Enhanced Coordination, and Supply Driven (LB Pro Rata approach) Alternatives would result in similar impacts on shortage for Arizona CAP M&I and Priority 4(i). However, if dead pool–related reductions, which may impact these users, are considered, the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives are the most robust alternatives for these users compared with the CCS Comparative Baseline and the No Action Alternative (as well as all action alternatives). These two alternatives perform well for domestic entitlement holders at lower volumes of delivery because they use pro rata distributions.

Under the Representative Preferred Alternative, there are no potential futures in which there is any percentage of normal domestic water delivery to Arizona CAP M&I and Priority 4(i) priorities. However, the modeling results in 2027-2039 for the Representative Preferred Alternative displayed in **Figure TA 17-2**, are not necessarily the anticipated impacts in 2027-2028 under the Preferred Alternative for Arizona CAP M&I and Priority 4(i) based on the May 1 proposal by Lower Division States, which represents the best available information at the time of publication. This proposal would distribute shortage according to the LB Priority approach. While the Representative Preferred Alternative does model shortages up to 1.5 maf using the LB Priority approach in 2027 and 2028, the results are heavily influenced by shortages in 2029-2039, which are distributed according to the Priority distribution. See **Chapter 2** and **Appendix C**, **Table C-1** for additional information. Refer to **Appendix C**, **Table C-28** for domestic shortage impacts for each entitlement holder under the LB Priority distribution (up to 1.5 maf shortage).

**Figure TA 17-3**, below, presents potential shortage impacts on domestic water deliveries to Arizona Priorities 2 and 3.

Across the first decade of the full modeling period (2027 – 2039), greater than 80 percent of normal domestic water delivery to Arizona Priorities 2 and 3 would occur in 100 percent of potential futures under all the alternatives, excluding the Enhanced Coordination, Maximum Operational Flexibility, Supply Driven (LB Pro Rata approach), and Representative Preferred Alternatives. Under the Maximum Operational Flexibility and Representative Preferred Alternatives, on average over the first decade of the modeling period, greater than 80 percent of normal delivery occurs in 26 percent and 54 percent of potential futures, respectively. This is because the Maximum Operational Flexibility and Representative Preferred Alternatives apply priority-based distribution with higher maximum shortage volumes. Under the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives, greater than 80 percent of normal delivery to Arizona Priorities 2 and 3 occurs in no potential futures. This is because the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives use a pro rata distribution, thus shortage is distributed evenly across entitlement holders regardless of the seniority of water entitlements. Overall, the Supply Driven Alternative (LB Pro Rata approach) is the least robust for these users, followed by the Enhanced Coordination Alternative compared with the other alternatives. Under these alternatives, shortages would be higher, and domestic deliveries would not be consistent with normal annual delivery.

**Figure TA 17-3**
**Arizona Priorities 2 and 3: Robustness**
**Percentage of futures in which annual delivery is the percentage of normal domestic delivery specified in each row in at least 90 percent of years**




Across the first decade of the modeling period (2027–2039), under the No Action, Basic Coordination, and Supply Driven (LB Priority approach) Alternatives and the CCS Comparative Baseline, greater than 80 percent of normal domestic water is delivered to Arizona Priorities 2 and 3 in 100 percent of potential futures. There would be no impacts on domestic shortage for Arizona Priorities 2 and 3, except under the Enhanced Coordination, Maximum Operational Flexibility, Supply Driven (LB Pro Rata approach), and Representative Preferred Alternatives. Therefore, the No Action, Basic Coordination, and Supply Driven (LB Priority approach) Alternatives and the CCS Comparative Baseline would result in similar impacts on shortage for Arizona Priorities 2 and 3. However, if dead pool–related reductions, which may impact these users, are considered, the Supply Driven Alternative (LB Priority approach) is the most robust alternative compared with the CCS Comparative Baseline and No Action Alternative (as well as all action alternatives).

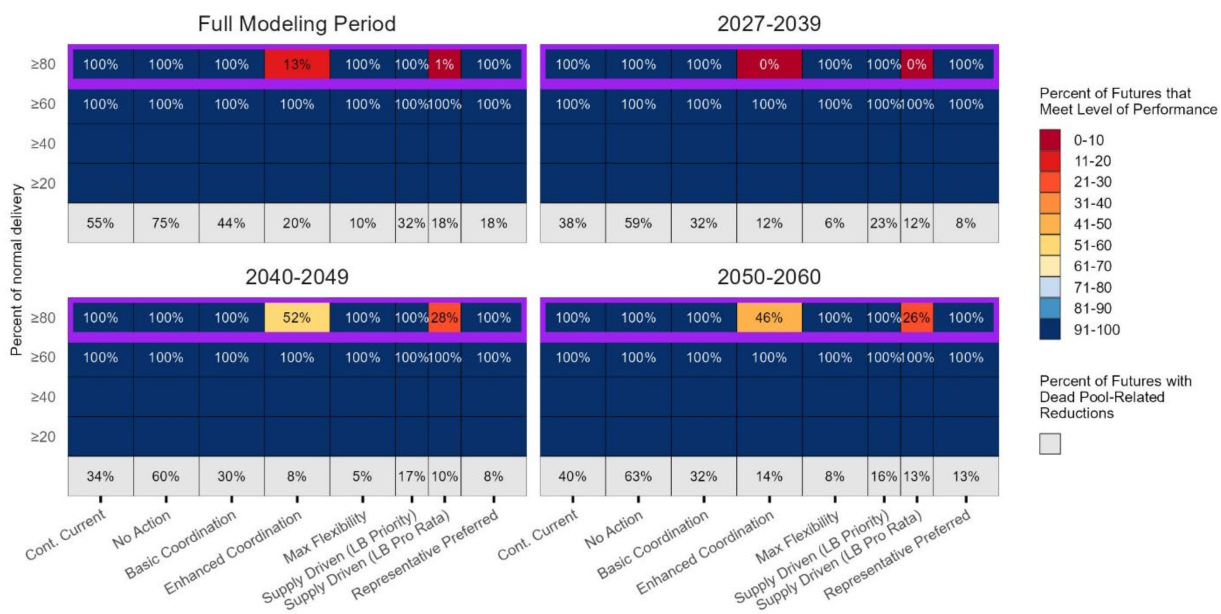
Across the first decade of the modeling period (2027–2039), greater than 80 percent of normal domestic water is delivered to Arizona Priorities 2 and 3 in 54 percent of potential futures under the Representative Preferred Alternative. Greater than 60 percent of normal domestic water is delivered to Arizona Priorities 2 and 3 in 58 percent of potential futures. However, the modeling results in 2027-2039 for the Representative Preferred Alternative displayed in **Figure TA 17-3**, above, are not necessarily the anticipated impacts in 2027-2028 under the Preferred Alternative for Arizona Priorities 2 and 3 based on the May 1 proposal by Lower Division States, which represents the best available information at the time of publication. This proposal would distribute shortage according to the LB Priority approach. While the Representative Preferred Alternative does model shortages up to 1.5 maf using the LB Priority approach in 2027 and 2028, the results are heavily influenced by shortages in 2029-2039, which are distributed according to the Priority distribution. See **Chapter 2** and **Appendix C**, **Table C-1** for additional information. Refer to **Appendix C**, **Table C-28** for domestic shortage impacts for each entitlement holder under the LB Priority distribution (up to 1.5 maf shortage).

**Figure TA 17-4**, below, presents potential shortage impacts on domestic water deliveries to Arizona PPR.

Across the first decade of the modeling period (2027–2039),  greater than 80 percent of normal domestic water delivery to Arizona PPR occurs in 100 percent of potential futures under all alternatives, excluding the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives. Under the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives, greater than 80 percent delivery to Arizona PPR occurs in no potential futures. However, greater than 60 percent of normal delivery occurs in 100 percent of potential futures under the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives. This is because the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives apply a pro rata distribution, thus shortage is distributed evenly across entitlement holders regardless of the seniority of water entitlements. Under the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives (the least robust alternatives for these users), shortages would be higher, and domestic deliveries would not be consistent with annual normal delivery. Under the No Action, Basic Coordination, Maximum Operational Flexibility, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives and the CCS Comparative Baseline, greater than 80 percent of normal delivery to Arizona PPR occurs in 100 percent of futures. There would be no impacts on shortage for Arizona PPR, except under the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives. Therefore, the No Action, Basic Coordination, Maximum Operational Flexibility, and Supply Driven (LB Priority approach) Alternatives and the CCS Comparative Baseline would result in similar impacts on shortage for Arizona PPR. However, if dead pool–related reductions, which may impact these users, are considered, the Maximum Operational

Flexibility Alternative is the most robust compared with the CCS Comparative Baseline and the No Action Alternative (as well as all the action alternatives).

**Figure TA 17-4**
**Arizona Present Perfected Rights: Robustness**
**Percentage of futures in which annual delivery is the percentage of normal domestic delivery specified in each row in at least 90 percent of years**

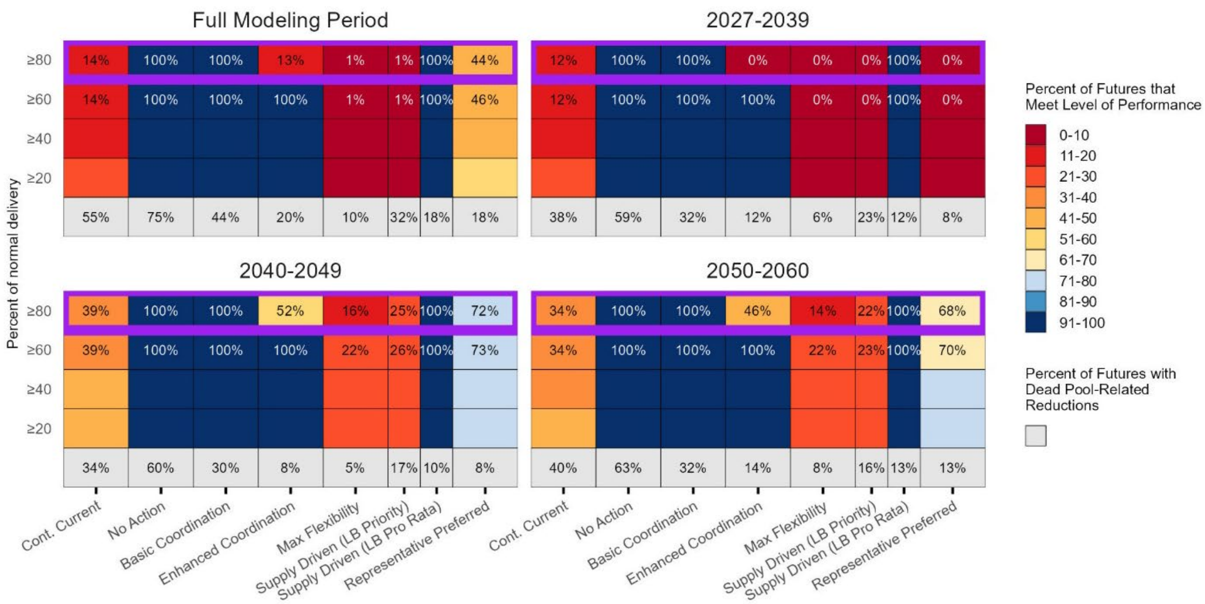



Across the first decade of the modeling period (2027–2039), greater than 80 percent of normal domestic water is delivered to Arizona PPR priority holders in 100 percent of potential futures under the Representative Preferred Alternative. Under this alternative, modeled shortages occur less frequently, and domestic deliveries remain consistent with annual normal delivery for these users.

However, the modeling results in 2027-2039 for the Representative Preferred Alternative displayed in **Figure TA 17-4**, above, are not necessarily the anticipated impacts in 2027–2028 under the Preferred Alternative for Arizona PPR based on the May 1 proposal by Lower Division States, which represents the best available information at the time of publication. This proposal would distribute shortage according to the LB Priority approach. While the Representative Preferred Alternative does model shortages up to 1.5 maf using the LB Priority approach in 2027 and 2028, the results are heavily influenced by shortages in 2029-2039, which are distributed according to the Priority distribution. See **Chapter 2** and **Appendix C**, **Table C-1** for additional information. Refer to **Appendix C**, **Table C-28** for domestic shortage impacts for each entitlement holder under the LB Priority distribution (up to 1.5 maf shortage).

**Figure TA 17-5**, below, presents potential shortage impacts on domestic water deliveries to California Priority 4.

**Figure TA 17-5**
**California Priority 4: Robustness**
**Percentage of futures in which annual delivery is the percentage of normal domestic delivery specified in each row in at least 90 percent of years**

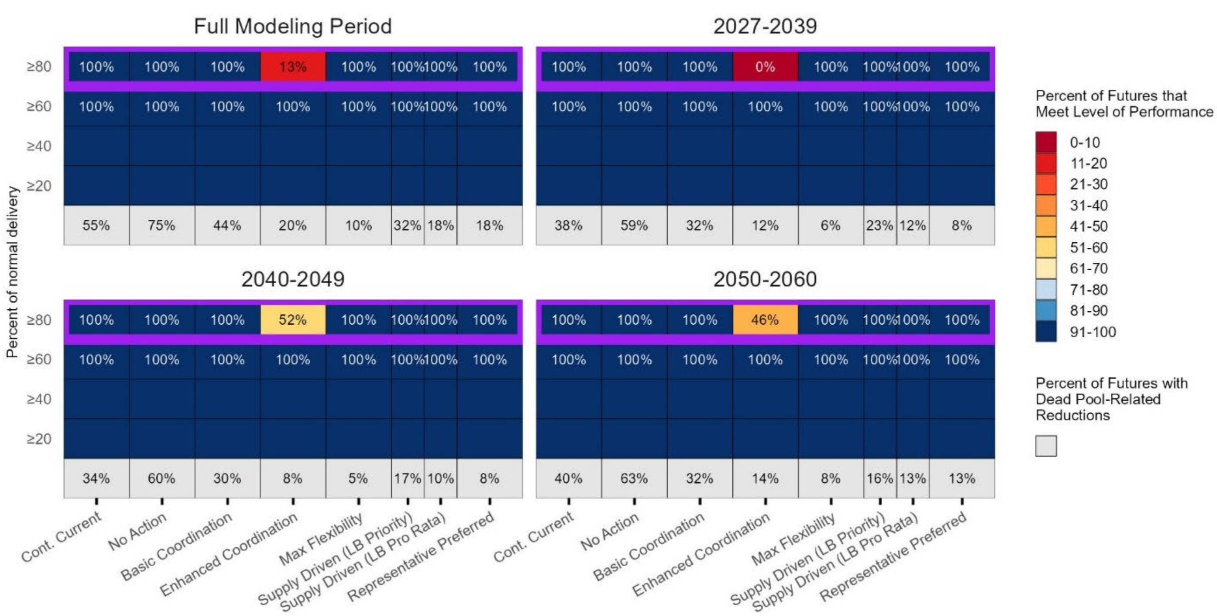


Across the first decade of the modeling period (2027–2039), greater than 80 percent of normal domestic water is delivered to California Priority 4 under the No Action, Basic Coordination, and Supply Driven (LB Pro Rata approach) Alternatives. Under the CCS Comparative Baseline, greater than 80 percent delivery to California Priority 4 occurs in 12 percent of potential futures. Under the Enhanced Coordination, Maximum Operational Flexibility, Supply Driven (LB Priority approach), and Representative Preferred Alternatives, greater than 80 percent delivery to California Priority 4 occurs in zero percent of potential futures. When compared with the No Action Alternative and the CCS Comparative Baseline, the Supply Driven (LB Pro Rata approach) and Basic Coordination Alternatives are the most robust action alternatives. However, an additional alternative is robust when looking at the next row of normal water delivery: greater than 60 percent of normal delivery. When considering this next level of performance, the No Action, Basic Coordination, Enhanced Coordination, and Supply Driven (LB Pro Rata approach) Alternatives would result in similar impacts on shortage for California Priority 4, with greater than 60 percent of normal domestic water delivery occurring 100 percent of futures across the first decade of the modeling period. However, it is important to note that under the No Action Alternative, there are 59 percent of futures with dead pool–related reductions across the first decade of the modeling period. In contrast, there are 32 percent, 12 percent, and 12 percent of futures with dead pool–related reductions under the Basic Coordination, Enhanced Coordination, and Supply Driven (LB Pro Rata approach) Alternatives across the first decade of the modeling period. When considering dead pool–related reductions, which may impact these users, the Supply Driven Alternative (LB Pro Rata approach) is the most robust, followed by the Basic Coordination Alternative, compared with the CCS Comparative Baseline and the No Action Alternative (as well as all action alternatives).

Across the first decade of the modeling period (2027–2039), there are no potential futures in which there is any percentage of normal domestic water delivery to California Priority 4 under the Representative Preferred Alternative. Under this alternative, modeled shortages occur more frequently, and domestic deliveries would not be consistent with normal annual delivery for these users. However, the modeling results in 2027-2039 for the Representative Preferred Alternative displayed in **Figure TA 17-5,** above are not necessarily the expected impacts in 2027–2028 under the Preferred Alternative for California Priority 4 based on the May 1 proposal by Lower Division States, which represents the best available information at the time of publication. This proposal would distribute shortage according to the LB Priority approach. While the Representative Preferred Alternative does model shortages up to 1.5 maf using the LB Priority approach in 2027 and 2028, the results are heavily influenced by shortages in 2029-2039, which are distributed according to the Priority distribution. See **Chapter 2** and **Appendix C**, **Table C-1** for additional information. Refer to **Appendix C**, **Table C-28** for domestic shortage impacts for each entitlement holder under the LB Priority distribution (up to 1.5 maf shortage).

**Figure TA 17-6**, below, presents potential shortage impacts on domestic water deliveries to California PPR.

**Figure TA 17-6**
**California Present Perfected Rights: Robustness**
**Percentage of futures in which annual delivery is the percentage of normal domestic delivery specified in each row in at least 90 percent of years**




Across the first decade of the modeling period (2027–2039), greater than 80 percent of normal domestic water is delivered to California PPR in 100 percent of potential futures under all alternatives, excluding the Enhanced Coordination Alternative. While there are no potential futures in which greater than 80 percent delivery to California PPR occurs under the Enhanced Coordination Alternative, greater than 60 percent delivery to California PPR occurs in 100 percent of potential futures under this alternative. Again, this is because the Enhanced Coordination Alternative uses a pro rata distribution, thus shortage is distributed evenly across entitlement holders regardless of the seniority of water entitlements. Because the No Action, Basic Coordination, Maximum Operational Flexibility, Supply Driven (both LB Priority and LB Pro Rata approaches), and Representative Preferred Alternatives and the CCS Comparative Baseline meet the preferred minimum performance in 100 percent of futures, there is no domestic shortage to California PPR, except under the Enhanced Coordination Alternative. While the all alternatives, excluding the Enhanced Coordination Alternative, would result in similar impacts on shortage, if dead pool–related reductions, which may impact these users, are considered, the Maximum Operational Flexibility Alternative followed by the Representative Preferred Alternative, are the most robust alternatives compared with the CCS Comparative Baseline and the No Action Alternative (as well as all action alternatives).

Across the first decade of the modeling period (2027–2039), greater than 80 percent of normal domestic water is delivered to California PPR priority holders in 100 percent of potential futures under the Representative Preferred Alternative. Under this alternative, modeled shortages occur less frequently, and domestic deliveries remain consistent with annual normal delivery for these users. However, the modeling results in 2027-2039 for the Representative Preferred Alternative displayed in **Figure TA 17-6**, above are not necessarily the expected impacts in 2027–2028 under the Preferred Alternative for California PPR based on the May 1 proposal by Lower Division States, which represents the best available information at the time of publication. This proposal would distribute shortage according to the LB Priority approach. While the Representative Preferred Alternative does model shortages up to 1.5 maf using the LB Priority approach in 2027 and 2028, the results are heavily influenced by shortages in 2029-2039, which are distributed according to the Priority distribution. See **Chapter 2** and **Appendix C**, **Table C-1** for additional information. Refer to **Appendix C**, **Table C-28** for domestic shortage impacts for each entitlement holder under the LB Priority distribution (up to 1.5 maf shortage).

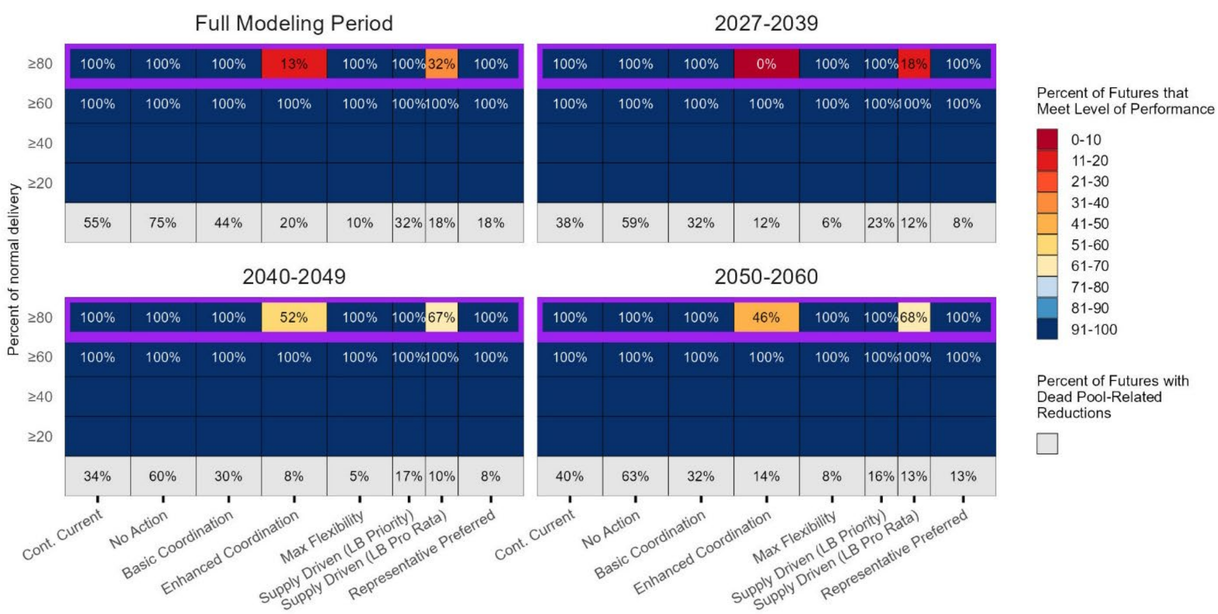
**Figure TA 17-7**, below, presents potential shortage impacts on domestic water deliveries to Nevada Priorities 1-7.

Across the first decade of the modeling period (2027–2039), greater than 80 percent of normal delivery to Nevada Priorities 1-7 occurs in 100 percent of potential futures under all alternatives, excluding the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives. Under the Enhanced Coordination and Supply Driven (LB Priority approach) Alternatives, greater than 80 percent delivery to Nevada Priorities 1-7 occurs in 0percent and 18 percent of potential futures, respectively. This makes sense because the Enhanced Coordination and Supply Driven (LB Priority approach) Alternatives apply a pro rata distribution, where shortage is distributed evenly across all entitlements regardless of the seniority of water entitlements. Under all alternatives, greater than 60 percent of normal delivery occurs in 100 percent of futures.

Across the first decade of the modeling period (2027–2039), greater than 80 percent delivery occurs in 100 percent of potential futures under the CCS Comparative Baseline and the No Action, Basic Coordination, Maximum Operational Flexibility, Supply Driven (LB Priority approach), and Representative Preferred Alternatives. Therefore, there would be no impacts on shortage to Nevada

Priorities 1-7, except under the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives. While the No Action, Basic Coordination, Maximum Operational Flexibility, Supply Driven (LB Priority approach), and Representative Preferred Alternatives would result in similar impacts on shortage, if dead pool–related reductions, which may impact these users, are considered, the Maximum Operational Flexibility Alternative followed by the Representative Preferred Alternative, are the most robust alternatives compared with the CCS Comparative Baseline and the No Action Alternative (as well as all action alternatives).

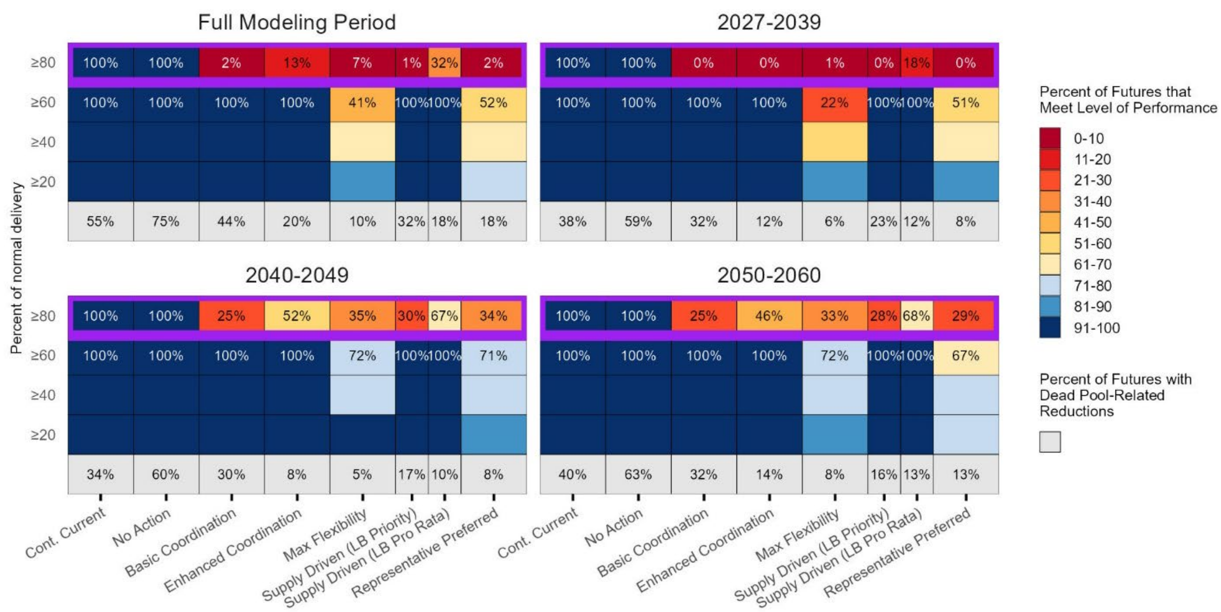
**Figure TA 17-7**
**Nevada Priorities 1-7: Robustness**
**Percentage of futures in which annual delivery is the percentage of normal domestic delivery specified in each row in at least 90 percent of years**




Across the first decade of the modeling period (2027–2039), greater than 80 percent of normal domestic water is delivered to Nevada Priorities 1-7 in 100 percent of potential futures under the Representative Preferred Alternative. Under this alternative, modeled shortages occur less frequently, and domestic deliveries remain consistent with annual normal delivery for these users. However, the modeling results in 2027-2039 for the Representative Preferred Alternative displayed in **Figure TA 17-7**, above are not necessarily the expected impacts in 2027–2028 under the Preferred Alternative for Nevada Priorities 1-7 based on the May 1 proposal by Lower Division States, which represents the best available information at the time of publication. This proposal would distribute shortage according to the LB Priority approach. While the Representative Preferred Alternative does model shortages up to 1.5 maf using the LB Priority approach in 2027 and 2028, the results are heavily influenced by shortages in 2029-2039, which are distributed according to the Priority distribution. See **Chapter 2** and **Appendix C**, **Table C-1** for additional information. Refer to **Appendix C**, **Table C-28** for domestic shortage impacts for each entitlement holder under the LB Priority distribution (up to 1.5 maf shortage).

**Figure TA 17-8,** below, presents potential shortage impacts on domestic water deliveries to Nevada Priority 8.

**Figure TA 17-8**
**Nevada Priority 8 (Including Balance and Surplus): Robustness**
**Percentage of futures in which annual delivery is the percentage of normal domestic delivery specified in each row in at least 90 percent of years**




Across the first decade of the modeling period (2027–2039), greater than 80 percent delivery to Nevada Priority 8 (including Balance and Surplus) occurs in 100 percent of futures under the CCS Comparative Baseline and the No Action Alternative. For all other alternatives, the percentage of potential futures in which greater than 80 percent of normal delivery occurs varies. Under both the Basic Coordination, Enhanced Coordination, Supply Driven (LB Priority approach), and Representative Preferred Alternatives greater than 80 percent of normal delivery occurs in no potential futures. Under the Maximum Operational Flexibility and Supply Driven (LB Pro Rata approach) Alternatives, greater than 80 percent delivery to Nevada Priority 8 occurs in 1 percent and 18 percent of potential futures, respectively. Generally, deeper shortages do not occur for the CCS Comparative Baseline and the No Action and Basic Coordination Alternatives. For the CCS Comparative Baseline and the No Action Alternative, this is because the shortages do not extend far into Nevada's apportionment. However, it is important to note that for the CCS Comparative Baseline and the No Action Alternative, the percentage of futures with dead pool–related reductions are 38 percent and 59 percent, respectively, across the first decade of the modeling period.

The next level below the preferred minimum performance is greater than 60 percent of normal domestic water delivery to Nevada Priority 8. Across the first decade of the modeling period, greater than 60 percent of normal delivery occurs in 100 percent of futures for all alternatives except the Maximum Operational Flexibility and Representative Preferred Alternatives. The Maximum Operational Flexibility Alternative, followed by the Representative Preferred Alternative, are the least robust compared with the other alternatives, because Maximum Operational Flexibility and Representative Preferred Alternatives apply a priority-based distribution with higher maximum shortage volumes. When considering this next level (greater than 60 percent delivery), and considering dead pool–related reductions, the Basic Coordination, Enhanced Coordination, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives are the most robust compared with the other alternatives, with greater than 60 percent of normal domestic water delivery occurring in 100 percent of futures across the first decade of the modeling period. Additionally, when considering dead pool–related reductions, which may impact these users, dead pool–related reductions would be lowest under the Enhanced Coordination and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives. Overall, the Enhanced Coordination, Basic Coordination, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives would result in similar impacts on shortage. However, when considering dead pool–related reductions, which may impact these users, the Supply Driven Alternative (LB Pro Rata approach) and the Enhanced Coordination Alternative would be the most robust compared with the CCS Comparative Baseline and the No Action Alternative (as well as all action alternatives). Under these alternatives, modeled shortages occur less frequently, and domestic deliveries remain consistent with normal annual delivery for these users.

Across the first decade of the modeling period (2027–2039), there are no potential futures in which greater than 80 percent of normal domestic water is delivered to Nevada Priority 8 under the Representative Preferred Alternative. Greater than 60 percent of normal domestic water is delivered to Nevada Priority 8 in 51 percent of potential futures. Under this alternative, modeled shortages occur more frequently, and domestic deliveries would not be consistent with normal annual delivery for these users. However, the modeling results in 2027-2039 for the Representative Preferred Alternative displayed in **Figure TA 17-8**, above are not necessarily the expected impacts in 2027–2028 under the Preferred Alternative for California Priority 4 based on the May 1 proposal by Lower Division States, which represents the best available information at the time of publication. This proposal would distribute shortage according to the LB Priority approach. While the Representative Preferred Alternative does model shortages up to 1.5 maf using the LB Priority approach in 2027 and 2028, the results are heavily influenced by shortages in 2029-2039, which are distributed according to the Priority distribution. See **Chapter 2** and **Appendix C**, **Table C-1** for additional information. Refer to **Appendix C**, **Table C-28** for domestic shortage impacts for each entitlement holder under the LB Priority distribution (up to 1.5 maf shortage).

### TA 17.2.3 DMDU Analysis Summary

The DMDU analysis allows for comparison of the alternatives in terms of potential shortage impacts on domestic entitlements. When comparing the domestic water impacts, it is important to note that a more robust alternative results in a higher percentage of potential futures where domestic water delivery remains consistent with normal conditions and shortages occur less frequently. Conversely, a less robust alternative yields fewer futures with normal domestic water delivery and a higher frequency of shortages.

The SAMs used to inform the DMDU analysis do not incorporate water management measures such as conservation programs or demand-reduction strategies. These measures do not change entitlement amounts or shortages; however, as described in the affected environment section, conservation programs and other management strategies can influence domestic water demand and help mitigate the operational pressures associated with shortage, uncertain supply, and population growth. Therefore, while the model results presented here do not capture these measures, the potential impacts of shortages on domestic water supply for the Lower Basin would also depend in part on existing and future conservation and management actions implemented by states, local water providers, and individual users. Potential impacts would also depend on other external factors such as environmental and economic conditions.

Communities and municipal providers may respond to shortages through a range of adaptation measures, which could include increased conservation and demand management, use of existing storage or water banking arrangements where available, investments in infrastructure (for example, treatment upgrades, reuse, interconnections), operational changes, or pursuit of alternative supplies and agreements. The feasibility, timing, and effectiveness of these measures would vary by location and provider, and may be constrained by physical and geographic availability of replacement water, jurisdictional and legal limitations (including state-law and contractual considerations), the time required for planning, permitting, financing, and construction, and constraints related to existing infrastructure configurations and prior investments. Adaptation measures may also involve direct and indirect economic costs to providers and ratepayers and may require trade-offs among objectives under different future conditions. Consistent with the DMDU framework, these uncertainties and constraints should be considered when interpreting robustness results and evaluating the extent to which an alternative can reduce both direct delivery impacts and potential secondary effects on development patterns and land use. **Table TA 17-17**, Summary of Potential Effects on Domestic Water by Alternative, below, provides an overview of impacts on domestic water by alternative based on the DMDU figures discussed in detail above. The table demonstrates how the different alternatives perform in terms of percentage of normal delivery in potential futures. **Table TA 17-17** includes two performance indicators: greater than 80 percent of normal delivery and greater than 60 percent of normal delivery in 90 percent of potential futures, across the first decade of the modeling period. The table displays how each alternative performs for these two performance indicators, by priority group. The performance indicators illustrate how each alternative performs in maintaining domestic water deliveries under a wide range of uncertain future conditions. The alternatives that would achieve greater than 80 percent of normal delivery in 90 percent of years demonstrate strong robustness, indicating that domestic deliveries would remain near normal levels across most modeled futures. These alternatives would result in fewer and less severe shortages, which would provide greater reliability for domestic water users. This performance indicator is difficult to achieve under many alternatives. To show further variation across the alternatives, **Table TA 17-17** includes greater than 60 percent of normal delivery in 90 percent of years. The alternatives that only meet the greater than 60 percent of normal delivery in 90 percent of years threshold demonstrate lower robustness. Under these conditions, more frequent domestic delivery reductions or shortages could occur in modeled futures, particularly for junior priority groups. Such outcomes could increase the likelihood of secondary socioeconomic impacts, including constraints on growth or secondary changes in land development patterns.

As shown in **Table TA 17-17**, for the No Action, Basic Coordination, Maximum Operational Flexibility, Supply Driven (LB Priority approach), and Representative Preferred Alternatives, which apply a priority-based distribution of shortage, under most modeled futures, water users with senior entitlements would likely continue to experience relatively consistent domestic water deliveries, as these entitlements are contractually prioritized during periods of reduced supply. However, junior entitlements could face greater reductions in water deliveries during Shortage Conditions. Consequently, while senior entitlement holders may maintain service levels closer to normal, junior entitlement holders could experience more frequent or severe delivery constraints.

As shown in **Table TA 17-17**, the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives, which apply pro rata distribution of shortage, under most modeled futures, would generally allow a larger number of priority groups to receive domestic water deliveries closer to normal conditions. While a pro rata approach would change the distribution of water across all users during shortages, this section solely focuses on the distribution of water to domestic users. This approach would deviate from the priority-based distribution, resulting in some modeled reductions to domestic deliveries for some senior entitlement holders who would otherwise maintain normal domestic delivery under the existing priority system. In contrast, more domestic junior priority water entitlement holders continue to receive some level of water supply under this approach. In general, the pro rata method would result in more existing users receiving moderate water deliveries during shortages through a redistribution of water from senior entitlements.

As described in **Section TA 17.1**, Affected Environment, peer-reviewed studies document that domestic water availability significantly influences population dynamics and land use. To provide a high-level overview of potential impacts on domestic water and the associated impacts on population and land-use patterns, key summaries are also provided below for Arizona, California, and Nevada.

Table TA 17-17
Summary of Potential Effects on Domestic Water by Alternative

| Impact Category | Performance Indicator | Impacts Summary | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | No Action Alternative | Basic Coordination Alternative | Enhanced Coordination Alternative | Maximum Operational Flexibility Alternative | Supply Driven Alternative (LB Priority approach) | Supply Driven Alternative (LB Pro Rata approach) | Representative Preferred Alternative |
| Priority Group: Arizona CAP NIA-A and NIA-B | Percentage of potential futures in which greater than 80 percent of normal domestic delivery occurs 90 percent of the time, across the first decade of the modeling period. The higher the percentage, the more robust an alternative is with respect to achieving normal domestic deliveries.[1] | **0 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. |
| | Percentage of potential futures in which greater than 60 percent of normal delivery occurs 90 percent of the time, across the first decade of the modeling period. The higher the percentage, the more robust an alternative is with respect to achieving normal domestic deliveries. | **0 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. |
| Priority Group: Arizona CAP Indian, M&I, and 4(i) | Percentage of potential futures in which greater than 80 percent of normal domestic delivery occurs 90 percent of the time, across the first decade of the modeling period.. The higher the percentage, the more robust an alternative is with respect to achieving normal domestic deliveries. | **13 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. |

[1] Normal delivery refers to a full supply of Colorado River water throughout this table.

| Impact Category | Performance Indicator | Impacts Summary | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | No Action Alternative | Basic Coordination Alternative | Enhanced Coordination Alternative | Maximum Operational Flexibility Alternative | Supply Driven Alternative (LB Priority approach) | Supply Driven Alternative (LB Pro Rata approach) | Representative Preferred Alternative |
| | Percentage of potential futures in which greater than 60 percent of normal domestic delivery occurs 90 percent of the time, across the first decade of the modeling period. The higher the percentage, the more robust an alternative is with respect to achieving normal domestic deliveries. | **100 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. |
| Priority Group: Arizona Priorities 2 and 3 | Percentage of potential futures in which greater than 80 percent of normal domestic delivery occurs 90 percent of the time, across the first decade of the modeling period. The higher the percentage, the more robust an alternative is with respect to achieving normal domestic deliveries. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **26 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **54 percent** of modeled futures meet the performance definition. |
| | Percentage of potential futures in which greater than 60 percent of normal domestic delivery occurs 90 percent of the time, across the first decade of the modeling period. The higher the percentage, the more robust an alternative is with respect to achieving normal domestic deliveries. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **35 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **58 percent** of modeled futures meet the performance definition. |

| Impact Category | Performance Indicator | Impacts Summary | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | No Action Alternative | Basic Coordination Alternative | Enhanced Coordination Alternative | Maximum Operational Flexibility Alternative | Supply Driven Alternative (LB Priority approach) | Supply Driven Alternative (LB Pro Rata approach) | Representative Preferred Alternative |
| Priority Group: Arizona PPR | Percentage of potential futures in which greater than 80 percent of normal domestic delivery occurs 90 percent of the time, across the first decade of the modeling period. The higher the percentage, the more robust an alternative is with respect to achieving normal domestic deliveries. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. |
| | Percentage of potential futures in which greater than 60 percent of normal domestic delivery occurs 90 percent of the time, across the first decade of the modeling period. The higher the percentage, the more robust an alternative is with respect to achieving normal domestic deliveries. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. |
| Priority Group: California Priority 4 | Percentage of potential futures in which greater than 80 percent of normal domestic delivery occurs 90 percent of the time, across the first decade of the modeling period. The higher the percentage, the more robust an alternative is with respect to achieving normal domestic deliveries. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. |
| | Percentage of potential futures in which greater than 60 percent of normal domestic delivery occurs 90 percent of the time, across the first decade of the modeling period. The higher the percentage, the more robust an alternative is with respect to achieving normal domestic deliveries. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. |

| Impact Category | Performance Indicator | Impacts Summary | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | No Action Alternative | Basic Coordination Alternative | Enhanced Coordination Alternative | Maximum Operational Flexibility Alternative | Supply Driven Alternative (LB Priority approach) | Supply Driven Alternative (LB Pro Rata approach) | Representative Preferred Alternative |
| Priority Group: California PPR | Percentage of potential futures in which greater than 80 percent of normal domestic delivery occurs 90 percent of the time, across the first decade of the modeling period. The higher the percentage, the more robust an alternative is with respect to achieving normal domestic deliveries. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. |
| | Percentage of potential futures in which greater than 60 percent of normal domestic delivery occurs 90 percent of the time, across the first decade of the modeling period. The higher the percentage, the more robust an alternative is with respect to achieving normal domestic deliveries. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. |
| Priority Group: Nevada Priorities 1-7 | Percentage of potential futures in which greater than 80 percent of normal domestic delivery occurs 90 percent of the time, across the first decade of the modeling period. The higher the percentage, the more robust an alternative is with respect to achieving normal domestic deliveries. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **18 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. |
| | Percentage of potential futures in which greater than 60 percent of normal domestic delivery occurs 90 percent of the time, across the first decade of the modeling period. The higher the percentage, the more robust an alternative is with respect to achieving normal domestic deliveries. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. |

| Impact Category | Performance Indicator | Impacts Summary | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | No Action Alternative | Basic Coordination Alternative | Enhanced Coordination Alternative | Maximum Operational Flexibility Alternative | Supply Driven Alternative (LB Priority approach) | Supply Driven Alternative (LB Pro Rata approach) | Representative Preferred Alternative |
| Priority Group: Nevada Priority 8 | Percentage of potential futures in which greater than 80 percent of normal domestic delivery occurs 90 percent of the time, across the first decade of the modeling period. The higher the percentage, the more robust an alternative is with respect to achieving normal domestic deliveries. | **100 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **1 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. | **18 percent** of modeled futures meet the performance definition. | **0 percent** of modeled futures meet the performance definition. |
| | Percentage of potential futures in which greater than 60 percent of normal domestic delivery occurs 90 percent of the time, across the first decade of the modeling period. The higher the percentage, the robust an alternative is with respect to achieving normal domestic deliveries. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **22 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **100 percent** of modeled futures meet the performance definition. | **54 percent** of modeled futures meet the performance definition. |
| What are the trade-offs between alternatives? | Shortage to domestic water users across the first decade of the modeling period (2027–2039). | N/A | >80 percent of normal domestic water delivery to some senior entitlements (AZ P2 & P3; AZ PPR; CA PPR; and NV P1-7 priority groups) and some junior entitlements (CA P4 priority group) occur in all potential futures. In contrast, for junior entitlements (AZ CAP NIA-A and NIA-B; AZ CAP Indian, M&I, and 4(i); and NV P8 priority groups) there are no potential futures in which >80 percent normal domestic water delivery occurs.<br>NV P8 receives >60 percent of normal domestic water delivery in all potential futures. | >60 percent of normal domestic water delivery to all Arizona, California, and Nevada priority groups occurs in all potential futures.<br>While this alternative results in more priority groups receiving domestic water delivery closer to normal conditions, it results in domestic shortage impacts on Arizona, California, and Nevada senior entitlements that would otherwise receive domestic water deliveries consistent with normal conditions. | >80 percent of normal domestic water delivery to some senior priority groups (AZ PPR; CA PPR; and NV P1-7 priority groups) occurs in all potential futures. In contrast, for all Arizona, California, and Nevada junior entitlements (AZ CAP NIA-A and NIA-B; AZ CAP Indian, M&I, and 4(i); CA P4; and NV P8 priority groups) there are no potential futures, in which >80 percent of normal domestic water delivery occurs.<br>AZ P2 & P3 receives >60 percent and >80 percent of normal delivery in 26 percent and 35 percent | >80 percent of normal domestic delivery to some senior entitlements (AZ P2 & P3; AZ PPR; CA PPR; and NV P1-7 priority groups) occur in all potential futures. In contrast, for junior entitlements (AZ CAP NIA-A and NIA-B; AZ CAP Indian, M&I, and 4(i); CA P4; and NV P8 priority groups), there are no potential futures, in which >80 percent of normal domestic water delivery occurs.<br>NV P8 receives >60 percent of normal domestic water delivery in all potential futures. | >80 percent normal domestic water delivery occurs in all potential futures for all California priority groups.<br>>60 percent of normal domestic delivery to all Arizona and Nevada priority groups occurs in all potential futures.<br>While this alternative results in more Arizona junior priority groups receiving domestic delivery closer to normal conditions, it results in domestic shortage impacts on Arizona and Nevada senior entitlements that would otherwise receive | >80 percent of normal domestic water delivery to some senior priority groups (AZ PPR; CA PPR; and NV P1-7 priority groups) occurs in all potential futures. In contrast, for all Arizona, California, and Nevada junior entitlements (AZ CAP NIA-A and NIA-B; AZ CAP Indian, M&I, and 4(i); CA P4; and NV P8 priority groups) there are no potential futures, in which >80 percent of normal domestic water delivery occurs.<br>AZ P2 & P3 receives >60 percent and >80 percent of normal delivery in 54 percent and 58 percent |

| Impact Category | Performance Indicator | Impacts Summary | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **No Action Alternative** | **Basic Coordination Alternative** | **Enhanced Coordination Alternative** | **Maximum Operational Flexibility Alternative** | **Supply Driven Alternative (LB Priority approach)** | **Supply Driven Alternative (LB Pro Rata approach)** | **Representative Preferred Alternative** |
| What are the trade-offs between alternatives? *(continued)* | *(see above)* | *(see above)* | There are no potential futures in which Arizona junior priority receive any percentage of normal domestic water delivery. While this alternative results in all senior priority groups and some California junior priority groups receiving domestic water delivery closest to normal conditions, it results in severe domestic shortage impacts to Arizona junior priority groups. | *(see above)* | of potential futures, respectively. NV P8 receives >60 percent and >80 percent of normal domestic water delivery in 1 percent and 22 percent of potential futures, respectively. There are no potential futures in which Arizona and California junior entitlements receive any percentage of normal domestic water delivery. While this alternative results in Arizona and California PPR and Nevada senior priority groups receiving domestic water delivery closest to normal conditions, it results in severe domestic shortage impacts to all Arizona and California junior priority groups. | AZ CAP Indian, M&I, and 4(i) receives >20 percent of normal domestic water delivery in 31-40 percent of potential futures. There are no potential futures in which Arizona CAP NIA-A and NIA-B and CA P4 priority groups receive any percentage of normal domestic water delivery. While this alternative results in all senior priority groups receiving domestic water delivery closest to normal conditions, it results in severe domestic shortage impacts to some Arizona and California junior priority groups. | deliveries consistent with normal conditions. | of potential futures, respectively. NV P8 receives >60 percent and >80 percent of normal domestic water delivery in 0 percent and 51 percent of potential futures, respectively. There are no potential futures in which Arizona and California junior entitlements receive any percentage of normal domestic water delivery. While this alternative results in Arizona and California PPR and Nevada senior priority groups receiving domestic water delivery closest to normal conditions, it results in domestic shortage impacts to all Arizona and California junior priority groups. |

| Impact Category | Performance Indicator | Impacts Summary | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | No Action Alternative | Basic Coordination Alternative | Enhanced Coordination Alternative | Maximum Operational Flexibility Alternative | Supply Driven Alternative (LB Priority approach) | Supply Driven Alternative (LB Pro Rata approach) | Representative Preferred Alternative |
| How would operational changes affect irrigated agricultural land-use patterns? | Acres of irrigated agricultural land within the corridor and potential for changes based on agricultural water availability. | Frequent and severe shortages for junior priority irrigation users likely lead to fallowing, crop switching, and long-term land retirement in Arizona CAP counties; Imperial Valley remains protected. | Capped shortages reduce extreme outcomes but concentrated impacts in Arizona still drive significant agricultural land-use changes; California remains insulated. | Pro rata distribution mitigates concentrated impacts but introduces broader reductions, increasing risk of widespread crop switching and fallowing in both Arizona and California. | Large shortage volumes and reliance on conservation participation create high uncertainty; potential for extensive land retirement if participation is low. | Concentrates impacts on junior users, preserving senior districts but accelerating land-use change in Arizona CAP counties. | Distributes shortages broadly, increasing exposure for California and potentially leading to widespread fallowing and crop switching across the Basin. | The representative preferred alternative for 2027-2028 would result in shortages, with impacts concentrated on junior users. In the longer term (2029-2060) modeled outcomes indicate potential for additional fallowing land and crop switching, with impacts concentrated on junior users. However, the distribution of shortage under any specific operating guidelines adopted under the Preferred Alternative decision framework may differ from the priority distribution method reflected here for the Representative Preferred Alternative, as a result, the potential for fallowing, crop switching, and other associated long term land - use patterns in any given area may vary and impacts may be mitigated in part by specific operational guidelines. |

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**Arizona: Figure TA 17-1** through **Figure TA 17-4** display potential impacts on domestic water deliveries for Arizona priority groups**.** Across the first decade of the modeling period, the No Action, Basic Coordination, and Supply Driven (LB Priority approach) Alternatives would result in similar impacts on water supply for more senior entitlements (Arizona Priorities 2 and 3 and Arizona PPR), with greater than 80 percent of normal delivery occurring in 100 percent of potential futures. In other words, there would be no domestic shortage impacts for Arizona PPR and Priorities 2 and 3 under these alternatives. However, potential impacts do vary under the other action alternative for these two priority groups. Under all alternatives, excluding the Enhanced Coordination Alternative, 100 percent of normal delivery to Arizona PPR occurs in 100 percent of potential futures. Under the Maximum Operational Flexibility and Representative Preferred Alternatives, greater than 80 percent of normal delivery to Arizona Priorities 2 and 3 occurs in 26 percent and 54 percent of potential futures, respectively. Compared with the No Action, Basic Coordination, and Supply Driven (LB Priority approach) Alternatives, the Maximum Operational Flexibility and Representative Preferred Alternatives are more robust with respect to achieving normal domestic deliveries to Arizona PPR and less robust with respect to achieving normal domestic deliveries to Arizona Priorities 2 and 3. When considering dead pool–related reductions, which may impact these users, the Supply Driven Alternative (LB Priority approach) is the most robust of the alternatives, followed by the Basic Coordination Alternative, with respect to achieving normal domestic deliveries to more senior entitlements (Arizona Priorities 2 and 3 and PPR). Under these alternatives, there is a higher percentage of potential futures where domestic water delivery to Arizona PPR, Priority 2, and Priority 3 remains consistent with normal conditions. A higher percentage of potential futures with greater than 80 percent of normal delivery could support existing communities, future population growth, water demand, and development in areas serviced by these priority groups. Because the Basic Coordination and Supply Driven (LB Priority approach) Alternatives have greater robustness for Arizona PPR, Priority 2, and Priority 3, there could be fewer potential indirect impacts on population and land-use-related outcomes for existing communities and on future population growth and land development.

In contrast, the CCS Comparative Baseline, and the Basic Coordination, Maximum Operational Flexibility Supply Driven (LB Priority approach), and Representative Preferred Alternatives would result in similar impacts on shortage for more junior entitlements (Arizona CAP NIA-A, CAP NIA-B, CAP Indian, M&I, and 4(i)), with greater than 80 percent delivery occurring between 0 and 1 percent of potential futures. Further, under the Basic Coordination, Enhanced Coordination, and Representative Preferred Alternatives, there are no potential futures in which Arizona CAP NIA-A, CAP NIA-B, CAP Indian, M&I, and 4(i)) priority groups receive any percentage of normal domestic water delivery. Under these alternatives, there is a higher frequency of shortage and no potential futures in which normal domestic delivery to these priorities occurs. Shortages could manifest as reduced water allocations, delivery restrictions, or the need for additional conservation measures, limiting the capacity to meet domestic water demand. A higher frequency of shortages and fewer potential futures with normal domestic delivery to these junior priorities could result in potential impacts on municipalities and communities that rely on domestic water delivery under these entitlements. Under the No Action, Basic Coordination, Maximum Operational Flexibility, Supply Driven (LB Priority approach), and Representative Preferred Alternatives, Arizona CAP NIA-A, CAP NIA-B, CAP Indian, M&I, and 4(i)) could experience less reliable water delivery for existing populations and future population growth, secondary impacts on land use and development patterns, and decreased capacity to respond to water demands. As described in **TA 4**, Water Deliveries, maximum shortage to junior entitlements is highest under the Maximum Operational Flexibility Alternative. Should shortages result in a reduction or elimination of legal access to municipal water, widespread impacts on social and economic conditions may also be possible. Further, the shortage distributions applied under these alternatives could result in the complete loss of domestic water for these users. Some third-party studies evaluate potential socioeconomic impacts under specific scenarios and assumptions. For example, a 2026 report describes categories of potential economic impacts that could occur under reduced CAP deliveries (WestWater 2026)[2]. While the WestWater 2026 report is scenario-specific, it is cited here to provide examples of the nature and types of potential impacts and pathways that may occur under reduced CAP deliveries (that is, direct, indirect, and induced economic impacts affecting employment, population, and housing). In some scenarios, municipalities may find the need to pursue adaptation measures including alternative water sources, or hauled water if available, as an alternative to support continued services. However, adaptation measures (for example, new supplies, infrastructure, treatment, interconnections, and related financing) can require substantial time and resources and may not be available on the same schedule for all communities. While these specific local project decisions would occur outside the scope of this Final EIS, it is important to note the potential for impacts. In addition, indirect social costs may occur as a result of a reduction in ecosystem services, or benefits to people provided by the environment. For example, trees in urban areas have been shown to provide high levels of benefits to people in the form of shade, which mitigates impacts of urban heat (that is, heat-related illness),[3] local air quality improvements, and enhancement of the visual setting. Should a reduction in domestic water supply result in die-offs of urban and suburban area trees, this could represent a loss of value that would take decades to recapture, due to the growth time required for trees (see, for example, Bloome et al. 2016).

The DMDU figures do not capture individual years within the modeling period, however, they are modeled. The modeling assumptions for the Representative Preferred Alternative in the first two years (2027–2028) are described in **Chapter 2** and the shortages up to 1.5 maf are distributed via LB Priority. Refer to **Appendix C**, **Table C-28** for domestic shortage impacts for each entitlement holder under the LB Priority distribution (up to 1.5 maf shortage). **TA 4**, Water Deliveries, shows analysis of the Representative Preferred Alternative for 2027 and 2028 at the state distribution level. The potential 2027 and 2028 operating guidelines modeling is compared to the Representative Preferred Alternative in **Appendix T,** Preliminary Description and Analysis of Anticipated Operating Guidelines for 2027 and 2028. The results for the Representative Preferred Alternative in 2029–2036, in which the Priority distribution is applied, would result in more shortage impacts on Arizona junior entitlements. Impacts beyond 2028 under the Preferred Alternative may be different from what is shown in the DMDU figures for the Representative Preferred Alternative, as this

[2] Because this study is scenario-specific and not directly comparable to the Draft EIS modeling framework, the Final EIS does not adopt quantified estimates from this study.
[3] Sudeep Sinha et al., Variation in Estimates of Heat-Related Mortality Reduction Due to Tree Cover in U.S. Cities, 301 J. Envtl. Mgmt. 113751 (2022); Darin J. Jenerette et al., Micro-Scale Urban Surface Temperatures Are Related to Land-Cover Features and Residential Heat-Related Health Impacts in Phoenix, AZ (USA), 31 Landscape Ecology 745-60 (2016); Peder Ibsen et al., Urban Tree Cover Provides Consistent Mitigation of Extreme Heat in Arid but Not Humid Cities, 113 Sustainable Cities & Soc'y 105677 (2024).

alternative provides a framework that allows for shortages to be distributed based on agreements among states that may arise, consistent with sideboards described in **Chapter 2**.

When considering all Arizona priority groups, the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives generally demonstrate the most robust performance for domestic water entitlements, based on maintaining greater than 60 percent of normal delivery in at least 90 percent of years across the first decade of the modeling period, for the greatest number of users. Compared with the CCS Comparative Baseline and the No Action Alternative, under the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives, 60 percent or more of normal domestic water delivery occurs across the largest percentage of potential futures and for the greatest number of priority groups. While this approach maximizes delivery reliability for more users overall, it involves a trade-off: senior entitlements would experience delivery reductions that would not occur under a priority distribution, whereas more junior entitlements may continue to receive near-normal deliveries, across the modeled futures. This allocation reflects a balance between broad delivery coverage and the reallocation of shortage risk across the priority groups.

**California: Figure TA 17-5** through **Figure TA 17-6** display potential impacts on domestic water deliveries for California priority groups**.** Under the No Action, Basic Coordination, and Supply Driven (LB Pro Rata approach) Alternatives, greater than 80 percent of normal delivery occurs in 100 percent of potential futures for California PPR and Priority 4. In other words, there would be no impacts on domestic shortage for California PPR and Priority 4, under these alternatives. However, potential impacts do vary under the other action alternative for these two priority groups. Under all alternatives, excluding the Enhanced Coordination Alternative, 100 percent of normal delivery to California PPR occurs in 100 percent of potential futures. Under all alternatives, excluding the Enhanced Coordination Alternative, there would be no shortage to California PPR across modeled futures. When considering dead pool–related reductions, which may impact California PPR, the Maximum Operational Flexibility and the Representative Preferred Alternatives are the most robust compared with other alternatives, with the lowest percent of potential futures with dead pool–related reductions (6 percent and 8 percent across the first decade of the modeling period, respectively). Therefore, with the greatest frequency of normal domestic water delivery, these alternatives would result in the least potential impacts on domestic water for California PPR. However, for California Priority 4, deliveries greater than 80 percent of normal delivery occurs in no potential futures under the Maximum Operational Flexibility, Supply Driven (LB Priority approach), and Representative Preferred Alternatives. Therefore, under these alternatives modeled delivery reductions could result in impacts to existing residents, economic sectors, and essential services reliant on domestic deliveries. Communities could experience increased constraints on existing and new residential and commercial development, need for additional adaptation measures, and greater pressure to accelerate development of replacement supplies. When evaluating both California priority groups together, the Supply Driven Alternative (LB Pro Rata approach) is the most robust compared with the No Action Alternative and all other action alternatives. It provides 100 percent of normal delivery to California PPR and California Priority 4 in 90 percent of years across 100 percent of potential futures. Additionally, considering the dead pool–related reductions, which could affect these users, the Supply Driven Alternative (LB Pro Rata approach) has the third lowest percentage of futures with constrained releases (12 percent) across the first decade of the modeling period, compared with all other alternatives. Reliable domestic water deliveries under the Supply

Driven Alternative (LB Pro Rata approach) would support existing communities, continued population growth, and land development in areas served by California PPR and Priority 4. Maintaining near-normal deliveries across modeled futures supports the capacity for planned and new development, housing availability, and municipal services that rely on water supply. In contrast, the alternatives with lower reliability or greater exposure to dead pool–related reductions could limit opportunities for residential and commercial growth, particularly areas experiencing high population growth, intensive development, or elevated municipal water demand, and could influence land-use patterns or delay new construction. Ensuring robust water delivery across multiple futures is therefore an important factor supporting existing communities, sustainable population growth, and land-use planning in California.

The DMDU figures do not capture individual years within the modeling period, however, they are modeled. The modeling assumptions for the Representative Preferred Alternative in the first two years (2027–2028) are described in **Chapter 2** and the shortages up to 1.5 maf are distributed via LB priority. Refer to **Appendix C**, **Table C-28** for domestic shortage impacts for each entitlement holder under the LB Priority distribution (up to 1.5 maf shortage). **TA 4**, Water Deliveries, shows analysis of the Representative Preferred Alternative for 2027 and 2028 at the state distribution level. The potential 2027 and 2028 operating guidelines modeling is compared to the Representative Preferred Alternative in **Appendix T,** Preliminary Description and Analysis of Anticipated Operating Guidelines for 2027 and 2028. The results for the Representative Preferred Alternative in 2029–2036, in which Priority distribution is applied, would result in more shortage impacts on Arizona junior entitlements. Impacts beyond 2028 under the Preferred Alternative may be different from what is shown in the DMDU figures for the Representative Preferred Alternative, as this alternative provides a framework that allows for shortages to be distributed based on agreements among states that may arise, consistent with sideboards described in **Chapter 2**. Nevada: Figure TA 17-7 and **Figure TA 17-8,** display potential impacts on domestic water deliveries for Nevada priority groups**.** Under all alternatives, except the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives, 100 percent of normal delivery to Nevada Priorities 1–7 occurs in 90 percent of years across 100 percent of potential futures. Under the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives, deliveries greater than 80 percent of normal to both priority groups occurs in only 13 percent and 32 percent of potential futures, respectively.

The CCS Comparative Baseline and No Action Alternative result in similar outcomes for both Nevada priority groups—Priorities 1–7 and Priority 8—with 100 percent of normal delivery to each group occurring in 90 percent of years across 100 percent of potential futures. However, it is important to note that for the No Action Alternative and the CCS Comparative Baseline, across the first decade of the modeling period the percentage of futures with dead pool–related reductions are 38 percent and 59 percent, respectively.

For Nevada Priorities 1–7 specifically, the Maximum Operational Flexibility Alternative is the most robust, followed by the Representative Preferred Alternative, compared with the No Action Alternative and the other action alternatives. In contrast, for Nevada Priority 8, these same alternatives are some of the least robust, with deliveries greater than 80 percent of normal occurring in only 1 percent of potential futures (Maximum Operational Flexibility Alternative) and no potential futures (Representative Preferred Alternative).

When considering both Nevada priority groups together, the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives provides the most robust performance. These alternatives deliver greater than 60 percent of normal domestic water across the largest percentage of potential futures and for the greatest number of priority groups. Robust domestic water deliveries are critical to supporting existing communities and population growth and land development in Nevada. The alternatives that maintain more reliable deliveries across modeled futures for both priority groups support the capacity for existing and new housing, commercial development, and essential municipal services that depend on water supply. Conversely, alternatives with lower reliability, particularly for Nevada Priority 8, could result in impacts to the capacity to support existing residents, economic sectors, and essential services reliant on domestic deliveries. Communities could experience increased constraints on existing and new residential and commercial development, impacts on the capacity of communities to expand, and effects on land-use patterns or delays to new construction projects. Modeled delivery reductions could result in the need for additional adaptation measures, and greater pressure to accelerate development of replacement supplies. By sustaining domestic water availability across a broad range of potential futures, the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives may help support existing residents, economies, and essential services; stable population growth; and more predictable land-use planning across the state, where modeled deliveries remain reliable.

The DMDU figures do not capture individual years within the modeling period, however, they are modeled. The modeling assumptions for the Representative Preferred Alternative in the first two years (2027–2028) are described in **Chapter 2** and the shortages up to 1.5 maf are distributed via LB Priority. Refer to **Appendix C**, **Table C-28** for domestic shortage impacts for each entitlement holder under the LB Priority distribution (up to 1.5 maf shortage). **TA 4**, Water Deliveries, shows analysis of the Representative Preferred Alternative for 2027 and 2028 at the state distribution level. The potential 2027 and 2028 operating guidelines modeling is compared to the Representative Preferred Alternative in **Appendix T**, Preliminary Description and Analysis of Anticipated Operating Guidelines for 2027 and 2028. The results for the Representative Preferred Alternative in 2029–2036, in which Priority distribution is applied, would result in more shortage impacts on Arizona junior entitlements. Impacts beyond 2028 under the Preferred Alternative may be different from what is shown in the DMDU figures for the Representative Preferred Alternative, as this alternative provides a framework that allows for shortages to be distributed based on agreements among states that may arise, consistent with sideboards described in **Chapter 2**.

### TA 17.2.4 Issue 2: How would operational changes affect irrigated agricultural land-use patterns?

This issue examines how different operational strategies may influence land-use patterns associated with irrigated agriculture, and the potential for long-term changes to these land uses based on Colorado River water availability for this use. While agricultural producers may pursue adaptive responses such as crop switching in response to reduced water availability, the feasibility of these responses may be constrained by local conditions and may involve additional costs or risks. Additional discussion of the economic implications of agricultural responses, including fallowing, is provided in the **TA 16,** Socioeconomics.

Estimated water shortages for Lower Basin agricultural users are shown in **Table TA 17-18**, by modeling approach and alternative. Additional details related to the shortage allocation model estimates are included in **Appendix C**, Shortage Allocation Model and Alternative Distribution Model Documentation. An overview of state levels shortages for all uses is included in **TA 4**, Water Deliveries. Potential broader market responses (for example, production shifts to other regions, imports, and price effects) are uncertain and were not explicitly modeled in this analysis, which focuses on irrigation water availability and potential land-use response in the analysis area.

The analysis of impacts to irrigation water deliveries relies on data outputs from the SAM. Irrigation shortage and subsequent impacts to users is directly correlated to reservoir releases: please see **TA 3** Hydrologic Resources, **Section 3.2.3.**, for a detailed analysis of reservoir releases.

The CCS Comparative Baseline reflects Colorado River operations from recent years, incorporating the 2007 Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead, the 2019 Drought Contingency Plan, Minute 323 of the 1944 United States-Mexico Water Treaty on Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande, and related agreements. These strategies have supported a mix of voluntary conservation, Intentionally Created Surplus (ICS) banking, and coordinated shortage responses that have helped buffer impacts on land use, particularly in urban and agricultural areas. While shortages still occur under the CCS Comparative Baseline, the framework provides more predictability and flexibility than the No Action Alternative, which reverts to pre-2007 operations. As a result, land-use patterns, including irrigated agriculture and urban development, are more likely to remain stable under the CCS Comparative Baseline, especially in areas with access to ICS or conservation programs. However, long-term viability of water-dependent land uses may still be challenged by declining reservoir elevations and increasing demand pressures.

While the CCS Comparative Baseline framework offers structure and predictability, modeled results illustrate how these outcomes vary between states and across different shortage levels, reflecting the continued vulnerability of certain user groups. Irrigation users in Arizona experience greater reductions under alternatives with pro rata distribution approaches at lower to mid-level system shortage volumes because currently most irrigators hold higher priority entitlements, and allocating reductions proportionally results in larger volumetric impacts than the priority-based framework. Although existing conservation and management measures help moderate impacts, irrigation reductions are still expected and may influence land use decisions such as fallowing or crop switching. Existing literature supports these findings, showing that sustained irrigation reductions in Arizona, particularly among junior priority users, have already led to reduced farm income and localized economic contraction (Arizona Extension 2024). In contrast, California's agricultural users experience relatively greater shortages only under higher system shortage volumes, consistent with the state's senior water rights structure that provides protection under moderate conditions but may require larger contributions during more severe shortages. Studies in California similarly indicate that even modest reductions in irrigation can result in shifts toward drought tolerant crops and eventual land retirement in more vulnerable areas (Prakash 2023). Overall, while the CCS Comparative Baseline provides greater predictability than the No Action Alternative, the long-term viability of irrigated agriculture in Arizona and California may still be challenged by persistent shortages and declining reservoir conditions.

## Table TA 17-18
## Agricultural Water Shortage by State by Alternative

| | Irrigation Shortage Impacts | | Total Shortage Volume (acre-feet) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Modeling Approach** | **EIS Alternative** | **600,000** | **1,000,000** | **1,500,000** | **1,800,000** | **2,000,000** | **2,100,000** | **2,300,000** | **3,000,000** | **3,600,000** | **4,000,000** |
| Arizona | CCS | CCS Comparative Baseline[1] | 7,975 | 13,145 | | | | | | | | |
| Arizona | Priority | No Action Alternative | 6,053 | | | | | | | | | |
| Arizona | Priority | Basic Coordination Alternative[2] | 6,053 | 18,557 | 34,188 | | | | | | | |
| Arizona | ProRata | Enhanced Coordination Alternative | 54,569 | 90,948 | 136,421 | 163,706 | 181,895 | 190,990 | 209,179 | 272,843 | | |
| Arizona | LB Priority | Maximum Operational Flexibility Alternative | 2,240 | 9,240 | 17,991 | 27,231 | 33,391 | 36,471 | 42,631 | 161,121 | 311,267 | 411,364 |
| Arizona | LB Priority | Supply Driven (LB Priority Approach) Alternative | 2,240 | 9,240 | 17,991 | 27,231 | 33,391 | 36,471 | | | | |
| Arizona | LB ProRata | Supply Driven (LB Pro Rata Approach) Alternative | 107,558 | 157,945 | 220,930 | 244,651 | 260,465 | 268,371 | | | | |
| Arizona | LB Priority | Representative Preferred (2027-2028) Alternative[3] | 2,240 | 9,240 | 17,991 | 27,231 | 33,391 | 36,471 | 42,631 | 161,121 | 311,267 | |
| Arizona | Priority | Representative Preferred (2029-2060) Alternative[4] | 6,053 | 18,557 | 34,188 | 43,566 | 44,007 | 56,296 | 97,889 | 243,044 | 367,463 | |
| California | CCS | CCS Comparative Baseline[1] | 0 | 14,000 | | | | | | | | |
| California | Priority | No Action Alternative | 0 | | | | | | | | | |
| California | Priority | Basic Coordination Alternative[2] | 0 | 0 | 0 | | | | | | | |
| California | ProRata | Enhanced Coordination Alternative | 261,020 | 435,034 | 652,551 | 783,061 | 870,068 | 913,571 | 1,000,578 | 1,305,102 | | |
| California | LB Priority | Maximum Operational Flexibility Alternative | 0 | 0 | 51,998 | 51,998 | 51,998 | 51,998 | 51,998 | 347,920 | 618,857 | 799,481 |
| California | LB Priority | Supply Driven (LB Priority Approach) Alternative | 0 | 0 | 51,998 | 51,998 | 51,998 | 51,998 | | | | |
| California | LB ProRata | Supply Driven (LB Pro Rata Approach) Alternative | 98,132 | 228,974 | 392,527 | 533,837 | 628,044 | 675,147 | | | | |
| California | LB Priority | Representative Preferred (2027-2028) Alternative[3] | 0 | 0 | 51,998 | 51,998 | 51,998 | 51,998 | 51,998 | 347,920 | 618,857 | |
| California | Priority | Representative Preferred (2029-2060) Alternative[4] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 224,262 | 534,032 | |

Note: The highlighting shows the values from the smallest (in white or no highlighting) to the largest (in yellow highlighting). The cells with hash-marks represent the values above shortages; these values are outside of the scope of this analysis. See the Shortage Allocation and Alternative Distribution Models (**Appendix C**) for more information on the shortage values for each entitlement holder type above shortages.

[1] Due to its fixed shortage volumes for the CCS Comparative Baseline, shortages for 600,000 acre-feet and 1 million acre-feet (maf) are actually associated with 613,000 acre-feet and 1.013 maf in the CCS Comparative Baseline. Greater shortages are based on an extension of priority beyond the levels of shortage provided by the pertinent documents.

[2] The maximum shortage for the Basic Coordination Alternative is 1.48 maf, however, the table above shows the maximum shortage as 1.5 maf for ease of comparison across the alternatives.

[3] The distribution of shortages up to 1.5 maf in 2027-2028 in the Representative Preferred Alternative reflects the May 1 proposal by the Lower Division States. Although not specified in their proposal, the Representative Preferred assumes shortages and their distribution above 1.5 maf in 2028 as necessary to avoid critically low elevations in Lake Mead. (See **Chapter 2** for more details on the sideboards under the Preferred Alternative and their representation in the Representative Preferred Alternative).

[4] Expected impacts from 2029–2060 under the Preferred Alternative may be different from what is shown for the Representative Preferred (2029–2060) Alternative, as this alternative provides a framework that allows for shortage distributions to be negotiated in different ways, consistent with sideboards described in **Chapter 2**.

Without conservation mechanisms or coordinated flexibility, agricultural users face more severe impacts. Conservation mechanisms can support water deliveries by increasing usable system supply and providing operational buffers, without altering the delivery priority hierarchy unless an alternative explicitly modifies it. Water banking and groundwater savings facilities allow participating entities to reduce immediate diversion, store conserved water in reservoir accounts, and recover water later when needed, helping to maintain deliveries during shortage periods. Under the No Action Alternative, no new conservation mechanisms are introduced, and shortages are distributed by priority. Agricultural users with junior entitlements (i.e. Priority 4(i) users in La Paz, Mohave, and Yuma Counites in Arizona, see **Appendix C**, Shortage Allocation Model and Alternative Distribution Model, for additional details) would likely experience frequent and severe reductions in water deliveries because they rely heavily or entirely on surface water, may also face increased fallowing. The lack of flexibility in water management due to the absence of operational or conservation mechanisms could exacerbate long-term declines in irrigated acreage, especially in counties already showing downward trends in harvested cropland (USDA 2025). Analysis of water productivity across the Colorado River Basin (Basin) shows that Lower Basin counties, particularly in Arizona and California, generate higher crop revenue per acre-foot of water applied than Upper Colorado River Basin regions. This suggests that reductions in agricultural water deliveries in these areas could have disproportionately high economic impacts, reinforcing the need for more adaptive water management strategies (Bickel et al. 2024). Under the No Action Alternative, Lake Mead is projected to fall below dead pool in 75 percent of modeled futures, which could constrain releases to downstream users. These constraints may result in reduced water availability for urban and agricultural land uses, potentially leading to fallowing, development delays, or infrastructure abandonment in affected counties (see **TA 4**, Water Deliveries). The No Action Alternative offers slight improvement in predictability due to capped shortages, but not necessarily meaningful change in agricultural water reliability or land-use outcomes.

These modeled outcomes are further supported by additional analyses that examine how physical and policy-based delivery constraints under deteriorating hydrologic conditions would exacerbate agricultural vulnerabilities. Under the No Action Alternative, modeled capacity constraints occur frequently enough that irrigation users in Arizona and California would face reductions that exceed existing policy-level shortage mechanisms. Without continuation of current shortage-sharing and conservation mechanisms, this alternative exposes Arizona and California to heightened risks of physical delivery constraints as reservoir elevations decline. Literature from USGS, 2019 and Prakash, 2023 indicates that when water availability is constrained by infrastructure or operational limits, agricultural users often experience abrupt and severe reductions in supply, leading to land retirement, fallowing, and associated economic disruption. In Arizona, such outcomes could accelerate land-use changes in Yuma, Mohave, and La Paz counties, while in California, even senior priority districts may be affected if physical shortages become the limiting factor in water supply. These findings highlight the increased vulnerability of irrigated agriculture under conditions of limited operational flexibility and deteriorating hydrologic reliability.

The Basic Coordination Alternative introduces a capped shortage mechanism, offering modest improvements in predictability but few new tools for agricultural resilience. This alternative retains the priority-based shortage distribution of the No Action Alternative but introduces a capped shortage volume of 1.48 maf. While this cap is intended to ensure that an assumed minimum flow is available for infrastructure protection and delivery for municipal use by CAP users and other Fourth Priority mainstem entitlement holders in Arizona when mainstream shortage is distributed by priority, it does not establish new agricultural conservation mechanisms to offset reductions through stored or deferred diversions. As a result, agricultural users in Arizona and California, especially those with junior entitlements, continue to face significant reductions in water deliveries.

The increase in capped volume may reduce the frequency of extreme shortages compared with the No Action Alternative, but the absence of conservation pools means agricultural land use remains highly vulnerable. In Arizona, La Paz, Mohave, and Yuma Counties may see increased fallowing and economic stress in farming communities. California's Imperial Valley would not experience shortages, but other regions could experience similar pressures. The capped shortage volume provides marginal improvement in predictability, but agricultural water reliability and land-use outcomes remain largely unchanged from the No Action Alternative.

Detailed modeling results reinforce this outcome, showing that although the capped shortage slightly moderates total reductions, its benefits remain distributed by priority across states and users. The Basic Coordination Alternative irrigation shortages follow a pattern similar to the No Action Alternative but are capped at a system-wide reduction up to the policy-level cap of 1.48 maf. Within this range, Arizona bears all modeled irrigation shortages, while California experiences none, consistent with the continuation of existing priority structures. Because this alternative maintains the current priority framework and does not change delivery priorities, shortages follow existing priority rules. As a result, junior priority users, including both irrigation and domestic users within Arizona Priority 4, continue to bear the largest reductions. The resulting reductions increase the likelihood of fallowing, crop switching, and economic stress in affected agricultural communities, potentially leading to long-term land-use changes such as farmland retirement (Presson and Eden 2023).

By comparison, the Enhanced Coordination Alternative incorporates conservation pools and reductions that distribute shortages across more users and increase operational flexibility. This alternative introduces coordinated reservoir operations and conservation pools in Lake Powell (2 maf) and Lake Mead (5 maf), with shortages distributed pro rata across Lower Basin water users. This represents a departure from the No Action Alternative's priority-based approach.

Agricultural users in Arizona benefit from a broader distribution of shortages, reducing the likelihood of concentrated fallowing impacts among junior users. Arizona counties (Yuma, Mohave, and La Paz) and California's Imperial Valley see enhanced stability relative to the No Action Alternative due to conservation pool access. The pro rata distribution method ensures that agricultural users across states share reductions more evenly, mitigating the concentrated impacts seen under the No Action Alternative for juniors.

This alternative supports the continuation of some irrigated agriculture across the Basin, with the potential to sustain a measure of productivity across all priorities. Compared with the No Action Alternative, it provides a more resilient framework for some level of irrigated agriculture under a range of hydrologic conditions. Studies suggest that pro rata reductions tend to spread fallowing and crop switching more broadly, whereas priority-based approaches protect senior-rights districts but concentrate impacts on lower-priority users (Lee et al. 2020; Prakash 2023; USDA ERS 2021).

The quantitative results under the Enhanced Coordination Alternative mirror these operational changes, demonstrating how pro rata allocation redistributes impacts across states. Irrigation shortages in Arizona are generally larger than those under the No Action and Basic Coordination Alternatives when total shortage volumes are low. However, when total shortage volumes are above 3.5 maf, irrigation shortages are smaller than under those alternatives because of the coordinated, pro rata shortage allocation across Lower Basin water users. This approach reduces the concentration of impacts on Arizona's junior priority irrigation users but results in a broader distribution of shortages across states, meaning California's agricultural users, typically protected under priority-based operations, would experience increased reductions. Literature suggests that such shared reductions may lessen localized land-use impacts but increase regional exposure. Prakash (2023) found that more equitable shortage sharing often encourages widespread adoption of efficient irrigation practices and crop switching, particularly in regions such as the Imperial Valley and Yuma County. While these adjustments may enhance long-term resilience, the higher overall shortage volumes modeled under this alternative could still contribute to land retirement and economic stress in water-dependent regions (USGS 2019; Arizona Extension 2024).

While the Enhanced Coordination Alternative emphasizes shared reductions, the Maximum Operational Flexibility Alternative expands management tools even further, allowing for the largest potential shortages (up to 4 maf) and includes a Conservation Reserve (up to 8 maf) shared across basins. While this introduces flexibility not included in the No Action Alternative, it also increases exposure to extreme shortage scenarios. Agricultural users in Yuma, La Paz and Mohave Counites may face high risk of fallowing unless conservation participation is robust. The Conservation Reserve allows users to store water in either Lake Powell or Lake Mead and convert it to system water when needed, offering a buffer against extreme shortages. California's agricultural regions benefit from similar flexibility, though effectiveness depends on participation and reservoir conditions. Compared with the No Action Alternative, this alternative introduces tools for adaptation and resilience, but agricultural outcomes depend heavily on conservation engagement and interbasin cooperation.

Modeling results under this framework underscore the same theme: flexibility can help smooth impacts under moderate conditions but cannot fully offset risks to agricultural viability under prolonged shortages. The Maximum Operational Flexibility Alternative modeled irrigation shortages in Arizona are similar to those under the Supply Driven Alternative (LB Priority approach). This alternative incorporates operational flexibility based on hydrologic conditions and system storage, which helps moderate shortages during less severe periods. California experiences smaller but more consistent irrigation reductions through the middle range of system shortages, though less than under the alternatives using pro rata distribution. Overall, this approach maintains a priority-based structure while introducing adaptive mechanisms that influence the timing and distribution of irrigation impacts across the Colorado River Basin. Literature indicates that the flexibility introduced under this alternative may help buffer irrigation impacts during less severe hydrologic periods, though its effectiveness depends on conservation participation. Conservation programs have helped stabilize water availability, but long-term reductions still pose risks. USDA ERS (2021) notes that irrigated agriculture increasingly relies on adaptive strategies such as deficit irrigation and crop switching to maintain productivity. In both Arizona and California, these adjustments may lead to shifts in land use toward fallowing or land retirement and may reduce the economic viability of certain crops.

The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) decouples Lake Powell and Lake Mead operations and analyzes both priority-based and pro rata shortage distribution schemes. This dual-path approach allows for more nuanced control than the No Action Alternative, which relies solely on priority-based allocation.

Under priority-based allocation, agricultural users with junior entitlements, particularly in Arizona, would face impacts similar to those under the No Action Alternative. However, under pro rata distribution, impacts are more evenly spread, reducing impacts on Arizona counties and increasing impacts on senior priorities, primarily in California. The conservation pools in Lake Powell (3 maf) and Lake Mead (8 maf) offer conservation mechanisms, and the phased conversion of existing ICS may add further flexibility.

Compared with the No Action Alternative, the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) has the potential to improve agricultural outcomes, particularly under the Supply Driven Alternative (LB Pro Rata approach). However, its effectiveness depends on implementation details, stakeholder agreements, and conservation participation. It offers a more tailored approach that distributes shortages across a broader set of users, changing how agricultural water deliveries are managed compared with the other alternatives.

Further detail from the two modeled approaches of the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) clarifies how different allocation schemes affect the scale and distribution of irrigation shortages, revealing important trade-offs between distribution of reductions, magnitude of reductions, and overall agricultural outcomes. Under the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches), modeled irrigation shortages reach the policy-level cap at 2.1 maf. Under the Supply Driven Alternative (LB Priority approach), Arizona and California are modeled as splitting the irrigation reductions unevenly. In contrast, under the Supply Driven Alternative (LB Pro Rata approach), the reductions would be distributed more evenly and more heavily on California as the modeled shortage increases. While this approach reduces concentrated impacts in Arizona, it introduces greater irrigation reductions for California's agricultural users than under the other alternatives. Overall, the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) reflects a trade-off between distribution and magnitude of impact, with broader distribution of shortages but higher total volumes of shortage to irrigators. Literature indicates that pro rata reductions are more likely to result in widespread fallowing and crop switching, while priority-based approaches preserve senior-rights districts but concentrate impacts (Lee et al. 2020; Prakash 2023; USDA ERS 2021). In both cases, sustained irrigation reductions are expected to influence land-use decisions and economic outcomes across the Basin. (Prakash 2023; USDA ERS 2021).

The Preferred Alternative provides additional flexibility to develop operational guidelines based on conditions. Up to 1.5 maf, the Representative Preferred (2027-2028) Alternative would result in shortages similar to those under the Maximum Flexibility and the Supply Driven (LB Priority approach) Alternatives, with impacts concentrated on junior users.

In the longer term (2029-2060) modeled outcomes for the Representative Preferred Alternative follow the priority approach for distribution, indicate potential for fallowing of land as noted under the Basic Coordination Alternative, with impacts concentrated on junior users. Unlike the Basic Coordination Alternative, the Representative Preferred (2029-2060) Alternative policy-level shortage caps are not applied until 3.6 maf, therefore there is the potential for higher levels of shortage with increased potential for fallowing and land use changes. However, the distribution of shortage under any specific operating guidelines adopted under the Preferred Alternative decision framework may differ from the priority distribution method reflected here for the Representative Preferred Alternative, as a result, the potential for fallowing, crop switching, and other associated long term land -use patterns in any given area may vary and impacts may be mitigated in part by specific operational guidelines.

### TA 17.2.5 Summary Comparison of Alternatives

**Population and Developed Land Use** – The alternatives vary in how they distribute domestic shortages and, in their potential, to impact domestic water deliveries and, in turn, indirectly impact population dynamics and land use within the analysis area.

As shown in **Table TA 17-17**, for the No Action, Basic Coordination, Maximum Operational Flexibility, and Supply Driven (LB Priority approach), and Representative Preferred Alternatives, which apply a priority-based distribution of shortage, under most modeled futures, water users with senior entitlements would likely continue to experience relatively consistent domestic water deliveries. This is because these entitlements are contractually prioritized during periods of reduced supply. However, junior entitlements could face greater reductions in water deliveries during Shortage Conditions. Consequently, while senior entitlement holders may maintain service levels closer to normal, junior entitlement holders could experience more frequent or severe delivery constraints.

Under the No Action, Basic Coordination, Maximum Operational Flexibility, Supply Driven (LB Priority approach), and Representative Preferred Alternatives, greater than 80 percent of normal domestic delivery to most senior entitlements occurs in all potential futures. The specific Arizona, California, and Nevada senior entitlements vary by alternative (see **Table TA 17-17**). Because these alternatives have greater robustness for senior priority groups there could be fewer potential indirect impacts on existing communities as well as population growth and land development. A higher percentage of potential futures with greater than 80 percent of normal delivery could support future population growth, water demand, and development in areas serviced by these priority groups.

Under the No Action, Basic Coordination, Maximum Operational Flexibility, Supply Driven (LB Priority approach), and Representative Preferred Alternatives, for junior entitlements there are fewer potential futures, and in some cases no potential futures, in which there is any percentage of normal delivery across the first decade of the modeling period. The specific Arizona, California, and Nevada junior entitlements vary by alternative (see **Table TA 17-17**). Under the Enhanced Coordination, Maximum Operational Flexibility, and Representative Preferred Alternatives, greater than 80 percent of normal domestic delivery to all junior entitlements occurs in no potential futures, across the first decade of the modeling period. Domestic shortages could manifest as reduced water allocations, delivery restrictions, or the need for additional adaptation and conservation measures, which could in turn limit the capacity to meet domestic water demand. Reduced capacity to meet domestic water demand could impact existing residents and essential services, constrain planned and future development, and create conveyance or treatment system challenges. The extent of these effects would vary by community based on local water portfolios, infrastructure, regulatory context, conservation achievements, financing capacity, hydrologic conditions, and adaptation feasibility. Further, the shortage distributions applied under these alternatives could result in the complete loss of domestic water for these users. Should shortages result in a reduction or elimination of legal access to municipal water, widespread impacts on social and economic conditions could also be possible. For example, in some scenarios, municipalities could even find the need to pursue alternative water sources, or hauled water if available, as an alternative to support continued services. However, adaptation measures (for example, new supplies, infrastructure, treatment, interconnections, and related financing) can require substantial time and resources and may not be available on the same schedule for all communities. While these specific local project decisions would occur outside the scope of this Final EIS, it is important to note the potential for impacts.

In addition, indirect social costs could occur as a result of a reduction in ecosystem services; also, indirect social costs could occur from reduction of benefits to people provided by the environment. For example, trees in urban areas have been shown to provide high levels of benefits to people in the form of shade, which mitigates urban heat impacts (that is, heat-related illness), local air quality improvements, and enhancement of the visual setting. Should a reduction in domestic water supply result in die-offs of urban and suburban area trees, this could represent a loss of value that would take decades to recapture, due to the growth time required for trees (see, for example, Bloome et al. 2016).

As shown in **Table TA 17-17**, for the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives, which apply pro rata distribution of shortage, under most modeled futures, would generally allow a larger number of priority groups to receive domestic water deliveries closer to normal conditions. While a pro rata approach would change the distribution of water across all users during shortages, this approach would deviate from the priority-based distribution, resulting in some modeled reductions to domestic deliveries for senior entitlement holders who would otherwise maintain normal domestic delivery under the existing priority system. In contrast, more domestic junior priority water entitlement holders would continue to receive some level of water supply under this approach. In general, the pro rata method would result in more users receiving moderate water deliveries during shortages through a redistribution of water from senior entitlements.

**Agricultural Land Use**: The alternatives vary in how they distribute irrigation shortages and therefore in their potential to influence long-term land-use patterns. The No Action and Basic Coordination Alternatives rely on priority-based distribution and result in concentrated impacts on junior priority users in Arizona (primarily in Yuma, La Paz and Mohave Counites), with limited mitigation tools. These conditions increase the likelihood of fallowing, crop switching, and economic stress in affected communities. The Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives distribute shortages more broadly across the states and users, reducing concentrated impacts on junior priority holders but introducing greater reductions in California, which could lead to more widespread land-use changes. The Maximum Operational Flexibility and Supply Driven (LB Priority approach) Alternatives incorporate adaptive tools and conservation reserves, offering potential buffers against extreme shortages; however, their effectiveness depends on stakeholder participation and hydrologic conditions. The Preferred Alternative provides additional flexibility to develop operational guidelines based on conditions. Up to 1.5 maf, the Representative Preferred Alternative for 2027-2028 would result in shortages similar to that under the Maximum Flexibility and the Supply Driven (LB Priority approach) Alternatives, with impacts concentrated on junior users. In the longer term (2029-2060) modeled outcomes under the Representative Preferred Alternative indicate potential for the greatest level of shortage to junior priority users of any alternative. However, based on  by the potential 2027-2028 agreements among Lower Division States at the time of publication, the distribution of shortage under any specific operating guidelines adopted under the Preferred Alternative decision framework may differ from the priority distribution method reflected here for the Representative Preferred Alternative; as a result, the potential for fallowing, crop switching, and other associated long term land -use patterns in any given area may vary and impacts may be mitigated in part by agreements that may arise during the development of specific operating guidelines under the Preferred Alternative.

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