Technical Appendix 7

Air Quality

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Acronyms and Abbreviations

Acronym or Abbreviation	Full Phrase
°F	degrees Fahrenheit
°C	degrees Celsius
ADEQ	Arizona Department of Environmental Quality
CAA	Clean Air Act
CCS	Continued Current Strategies
CEQA	California Environmental Quality Act
CH_4	methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CRSS	Colorado River Simulation System
DAQ	Division of Air Quality
dv	Deciview
eGrid	Emissions and Generation Resource Integrated Database
EIA	United States Energy Information Administration
EPA	United States Environmental Protection Agency
g CO_2e/kWh	grams of carbon dioxide equivalent per kilowatt-hour
H_2S	Hydrogen sulfide
HAP	Hazardous Air Pollutant
kg	kilograms
km^2	square kilometers
LADWP	City of Los Angeles Department of Water and Power
LB Priority	Lower Basin Priority
LB Pro Rata	Lower Basin Pro Rata
maf	million acre-feet
$\mu g/m^3$	micrograms per cubic meter
MWh	megawatt-hour

N_2O	Nitrous oxide
NAAQS	National Ambient Air Quality Standards
NAVD 88	North American Vertical Datum of 1988
NDEP	Nevada Division of Environmental Protection
NEI	National Emissions Inventory
NLR	National Laboratory of the Rockies
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
NPS	National Park Service
O_3	Ozone
PM	particulate matter
ppb	parts per billion
ppm	parts per million
PSD	Prevention of Significant Deterioration
Reclamation	Bureau of Reclamation
SCRD	Supplemental Control Requirements Determination
SIB	Southerly International Boundary
SO_2	Sulfur dioxide
UAC	Utah Air Conservation Act
U.S.	United States
USDA	United States Department of Agriculture
USDI	United States Department of Interior
USGS	United States Geological Survey
VOC	Volatile Organic Compound
WRCC	Western Regional Climate Center
WY	water year

TA 7. Air Quality

TA 7.1 Affected Environment

This section presents the existing conditions, regulatory framework and applicable laws, and available existing studies and resources pertaining to air quality. The geographic scope consists of Lake Powell to Southerly International Boundary (SIB), which includes the Arizona counties of Yuma, La Paz, Mohave, Coconino, Yavapai, and Navajo; the Utah counties of Washington, San Juan, and Kane; and Clark County, Nevada. These counties encompass the direct, indirect, and cumulative effects associated with air pollutant dispersal into the atmosphere. Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and carbon dioxide equivalent (CO_2e) emissions and climate trends would be analyzed for the state, which would include every major hydropower facility along the Colorado River, from Lake Powell to the SIB. The geographic scope for analysis is referred to as the "analysis area" throughout this section.

TA 7.1.1 Criteria Pollutants

The Clean Air Act (CAA) was implemented to ensure acceptable and nonhazardous air quality for the people of the United States (U.S.) Subsequently, the U.S. Environmental Protection Agency (EPA) established the National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment, referred to as criteria pollutants (**Table TA 7-1**). Unlike the rest of the criteria pollutants, ground-level ozone is typically not directly emitted into the atmosphere from an emissions source. Instead, ozone is formed when emissions of nitrogen oxides (NO_x) and volatile organic compounds (VOCs) mix in the presence of sunlight. **Table TA 7-1** shows the current primary and secondary NAAQS and averaging period for each pollutant. Primary standards are set to protect the public health with a margin of safety, and secondary standards are meant to protect environmental concerns such as air quality related values, which are resources that may be adversely affected by a change in air quality (visibility, vegetation, water quality, soils, fish and wildlife, etc.). The applicable NAAQS have fully been adopted by Utah, Arizona, and Nevada (Clark County Division of Air Quality [DAQ] jurisdiction) and are provided in **Table TA 7-1**.

In addition, each state implements regulations that further govern fugitive dust. In Arizona, Arizona Administrative Code (Title 18, Chapter 2), enforced by the Arizona Department of Environmental Quality (ADEQ), applies to owners and operators of nonresidential construction sites in designated Dust Visibility Protection Areas and requires dust controls, vehicle speed limits and monitoring and recordings. Utah rules that address fugitive dust and particulate matter (PM) include Title R307 of the Utah Administrative Code, which applies to all new or existing sources of fugitive dust greater than one-fourth acres in size and are also in areas designated as nonattainment or maintenance for the federal PM_{10} and $PM_{2.5}$ standards. Title R307 also applies statewide outside nonattainment or maintenance areas and establishes minimum work practices and emission standards for fugitive dust. Fugitive dust controls for Nevada are outlined in Nevada Administrative Code 445B.22037. These include best practical methods pertaining to fugitive dust and the requirement to obtain a surface disturbance operating permit for disturbance of 5 acres or more of land. These measures are generally adopted by permit conditions or compliance agreements with the Nevada Division of Environmental Protection (NDEP) and apply to regulated activities that can generate dust.

Table TA 7-1
National Ambient Air Quality Standards

Criteria Pollutant	Averaging Period	Primary NAAQS	Secondary NAAQS
Nitrogen Dioxide (NO_2)	1 hour	0.100 ppm[*]	N/A
	Annual	0.053 ppm[†]	0.053 ppm[†]
Sulfur Dioxide (SO_2)	1 hour	0.075 ppm[‡]	N/A
	3 hours	N/A	0.50 ppm[§]
	24 hours	N/A	N/A
	Annual	N/A	10 ppb[††]
Particulate Matter with a diameter of 10 microns or less (PM_{10})	24 hours	150 $\mu g/m^3$ [#]	150 $\mu g/m^3$ [#]
	Annual	N/A	N/A
Particulate Matter with a diameter of 2.5 microns or less ($PM_{2.5}$)	24 hours	35 $\mu g/m^3$ [**]	35 $\mu g/m^3$ [**]
	Annual	9 $\mu g/m^3$ [†, ††]	15 $\mu g/m^3$ [†, ††]
Carbon Monoxide (CO)	1 hour	35 ppm[§]	N/A
	8 hours	9 ppm[§]	N/A
Lead (Pb)	3 months	0.15 $\mu g/m^3$ [¶]	0.15 $\mu g/m^3$ [¶]
Ozone (O_3)	8 hours	0.070 ppm[§§]	0.070 ppm[§§]
	1 hour	N/A	N/A
Hydrogen Sulfide (H_2S)	1 hour	N/A	N/A
Visibility reducing particles	8 hours	N/A	N/A
Sulfates	24 hours	N/A	N/A
Vinyl Chloride	1 hour	N/A	N/A

Source: EPA 2025a
Note: N/A = not applicable; ppm = parts per million; ppb = parts per billion; $\mu g/m^3$ = micrograms per cubic meter/
[*] The standard is based on the 3-year average of the 98th percentile of the daily maximum 1-hour average.
[†] Annual mean value.
[‡] The standard is based on the 3-year average of the 99th percentile of the daily maximum 1-hour average.
[§] Not to be exceeded more than once per calendar year.
[¶] Not to be exceeded.
[#] Not to be exceeded more than once per calendar year on average over 3 years.
[**] The standard is based on the 3-year average of the 98th percentile of the 24-hour average.
[††] The standard is based on the 3-year average of the weighted annual mean.
[‡‡] The standard is 9 ppm for areas with an elevation less than 5,000 feet above mean sea level.
[§§] The standard is based on the annual fourth-highest daily maximum 8-hour concentration averaged over 3 years.
[¶¶] 30-day average.

For each criteria pollutant, the EPA classifies areas as in “attainment” if the area is in compliance with NAAQS or as “nonattainment,” if one or more NAAQS is exceeded. Areas for which available data are not sufficient to make an attainment status designation are listed as unclassifiable. Air quality within the Arizona counties of La Paz, Mohave, Coconino, Yavapai, and Navajo is considered in “attainment” or “unclassifiable” for Carbon Monoxide (CO), lead, Nitrogen Dioxide

(NO_2), ozone (O_3), PM_{10}, $PM_{2.5}$, and Sulfur Dioxide (SO_2). Air quality within the Arizona county of Yuma has been designated as marginal nonattainment for the 2015 eight-hour O_3 standard, moderate nonattainment for PM_{10}, and considered in "attainment" or "unclassifiable" for all other pollutants. Air quality within the Utah counties of Washington, Kane, and San Juan is considered in "attainment" or "unclassifiable" for CO, lead, NO_2, O_3, PM_{10}, $PM_{2.5}$, and SO_2. Clark County, Nevada has been designated as serious nonattainment for the 2015 eight-hour O_3 standard and a maintenance area for CO and PM_{10}, and considered in "attainment" or "unclassifiable" for all other pollutants (EPA 2025b).

Therefore, the General Conformity Rule, which is designed to protect ambient air quality within nonattainment and maintenance areas against further degradation, would apply for O_3, CO, and PM_{10}. The general conformity de minimis thresholds for all pollutants pursuant to 40 CFR 93.153 (b)(1) are presented in **Table TA 7-2**.

Table TA 7-2
General Conformity De Minimis Levels

	Tons/Year	Nonattainment Area	Analysis Area Nonattainment
O_3 (VOCs or NO_x)	100	Other outside an ozone transport region	N/A
O_3 (VOCs or NO_x)	50	Serious	Clark County, NV
O_3 (VOCs or NO_x)	25	Severe	N/A
O_3 (VOCs or NO_x)	10	Extreme	N/A
SO_2 or NO_2	100	All	N/A
CO	100	All Maintenance Areas	Clark County, NV
PM_{10}	100	Moderate	Clark County, NV (maintenance)
PM_{10}	70	Serious	N/A
$PM_{2.5}$ (direct emissions, SO_2, VOCs, NO_x, ammonia)	100	Moderate	N/A
$PM_{2.5}$ (direct emissions, SO_2, VOCs, NO_x, ammonia)	70	Serious	N/A

Source: EPA 2025c
Notes: VOC = volatile organic compound

TA 7.1.2 Hazardous Air Pollutants

CAA regulations also control the release of hazardous air pollutants (HAPs): chemicals that are known or suspected to cause cancer or other serious health effects, such as reproductive effects, birth defects, or adverse environmental effects. EPA currently lists 187 compounds as HAPs, including benzene, toluene, and formaldehyde, which may be emitted from oil and gas development operations but are generally minimal in solar development operations. NAAQS have not been set for HAPs; rather HAP emissions are controlled by source type– or industrial sector–specific regulations by developing standards for controlling emissions of air toxics known as maximum achievable control technology standards. There are no project-specific applicable maximum achievable control technology requirements regarding HAPs, as these standards only apply to stationary sources within specific industrial groups.

TA 7.1.3 Existing Conditions

Air Quality Monitors and Design Values

Criteria pollutants are monitored throughout various parts of the country. Monitors measure concentrations of pollutant in the atmosphere, and the results are often presented in parts per million (ppm) or micrograms per cubic meter ($\mu g/m^3$). Pursuant to 40 CFR 58.14 (c)(1), the EPA and states periodically analyze and review monitor locations, discontinue monitoring at locations where pollutant concentrations have been well below the standards, and add monitors in areas where pollutant concentrations may be approaching air quality standards. Instantaneous on-demand monitored outdoor air quality data collected from state, local, and tribal monitoring agencies can be obtained from EPA's Air Data web page and interactive tool (EPA 2025d).

The EPA uses the criteria pollutant monitoring data to determine a "design value" for each pollutant and associated averaging time. A design value is a statistic representing the monitored concentration of a given pollutant in a given location, expressed in the manner of its standard, which can be compared to the NAAQS. Design values are updated annually and posted to the EPA's Air Quality Design Value website (EPA 2025d). The most recent available 2024 design values for the analysis area counties in Arizona, Nevada, and Utah are provided in **Table TA 7-3**, **Table TA 7-4**, and **Table TA 7-5**. Rural counties may not have existing monitors; therefore, no data are available, and it is assumed that pollutant concentrations meet ambient air quality standards. Other counties may have monitors that record only certain pollutants. With the exception of Kane and San Juan Counties, criteria pollutant monitoring data are available for at least one criteria air pollutant and available criteria pollutant monitoring data are reported. Design values are typically used to designate and classify nonattainment areas, as well as to assess progress toward meeting the NAAQS. The design value for O_3 for Clark County exceeds the NAAQS for O_3 (0.70 ppm), and the number of exceedances of the PM_{10} NAAQS exceed the standard for Clark County and Yuma County. None of the other design values listed in **Table TA 7-3**, **Table TA 7-4,** and **Table TA 7-5** exceed or approach proximity to the NAAQS (EPA 2025e).

Table TA 7-3
2024 Design Values for Mohave, Coconino, Navajo, and Yavapai Counties, Arizona

Pollutant	Yuma	La Paz	Mohave	Coconino	Navajo	Yavapai	Averaging Time	NAAQS
O_3	0.069	0.068	N/A	0.065	0.064	0.061	8-hour*	0.070 ppm
NO_2	N/A	N/A	N/A	N/A	N/A	N/A	Annual†	53 ppb
NO_2	N/A	N/A	N/A	N/A	N/A	N/A	1-hour¶	100 ppb
CO	N/A	N/A	N/A	N/A	N/A	N/A	8-hour**	9 ppm
CO	N/A	N/A	N/A	N/A	N/A	N/A	1-hour**	35 ppm
SO_2	N/A	N/A	N/A	N/A	N/A	N/A	1-hour†	0.075 ppm

Pollutant	Yuma	La Paz	Mohave	Coconino	Navajo	Yavapai	Averaging Time	NAAQS
$PM_{2.5}$	8.1	3.5	N/A	N/A	N/A	N/A	Annual§	9 μg/m^3
$PM_{2.5}$	21	11	N/A	N/A	N/A	N/A	24-hour¶	35 μg/m^3
PM_{10}	6.0 2022-2024 Ave. Est. Exceed-ances	0.7 2022-2024 Ave. Est. Exceed-ances	0.7 2022-2024 Ave. Est. Exceed-ances	N/A	N/A	N/A	24-hour††	150 μg/m^3

Source: EPA 2025e
Note: N/A = not available, monitors do not report. Many rural counties have no monitoring data and are assumed under the CAA to be in attainment. ppb = parts per billion.
* Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years.
† 99th percentile of 1-hour daily maximum concentrations, averaged over 3 years.
‡ Annual fourth-highest daily maximum 1-hour concentration, averaged over 3 years.
§ Annual mean, averaged over 3 years.
¶ 98th percentile, averaged over 3 years.
** Not to be exceeded more than once per year
†† Not to be exceeded more than once per year on average over 3 years.

Table TA 7-4
2024 Design Values for Washington County, Utah

Pollutant	Washington	Averaging Time	NAAQS
O_3	0.065	8-hour*	0.070 ppm
NO_2	4 ppb	Annual†	53 ppb
NO_2	28 ppb	1-hour¶	100 ppb
CO	N/A	8-hour**	9 ppm
CO	N/A	1-hour**	35 ppm
SO_2	N/A	1-hour†	0.075 ppm
$PM_{2.5}$	5.1	Annual§	9 μg/m^3
$PM_{2.5}$	14	24-hour¶	35 μg/m^3
PM_{10}	N/A	24-hour††	150 μg/m^3

Source: EPA 2025e
Note: N/A = not available, monitors do not report. Many rural counties have no monitoring data and are assumed under the CAA to be in attainment. San Juan and Kane Counties have no monitoring data.
ppb = parts per billion.
* Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years.
† 99th percentile of 1-hour daily maximum concentrations, averaged over 3 years.
‡ Annual fourth-highest daily maximum 1-hour concentration, averaged over 3 years.
§ Annual mean, averaged over 3 years.
¶ 98th percentile, averaged over 3 years.
** Not to be exceeded more than once per year
†† Not to be exceeded more than once per year on average over 3 years.

Table TA 7-5
2024 Design Values for Clark County, Nevada

Pollutant	Clark County	Averaging Time	NAAQS
O_3	0.074 ppm	8-hour*	0.070 ppm
NO_2	20 ppb	Annual†	53 ppb
NO_2	51 ppb	1-hour¶	100 ppb
CO	2.4 ppm	8-hour**	9 ppm
CO	2.8 ppm	1-hour**	35 ppm
SO_2	4 ppb	1-hour†	0.075 ppm
$PM_{2.5}$	8.7 μg/m³	Annual§	9 μg/m³
$PM_{2.5}$	29 μg/m³	24-hour¶	35 μg/m³
PM_{10}	4.0 2022-2024 Average Estimated Exceedances	24-hour††	150 μg/m³

Source: EPA 2025e.
Note: N/A = not available, monitors do not report. Many rural counties have no monitoring data and are assumed under the CAA to be in attainment. ppb = parts per billion.
* Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years.
† 99th percentile of 1-hour daily maximum concentrations, averaged over 3 years.
‡ Annual fourth-highest daily maximum 1-hour concentration, averaged over 3 years.
§ Annual mean, averaged over 3 years.
¶ 98th percentile, averaged over 3 years.
** Not to be exceeded more than once per year
†† Not to be exceeded more than once per year on average over 3 years.

National Emissions Inventory

Triennially, the EPA publishes a comprehensive summary of air emissions data, known as the National Emissions Inventory (NEI). The most recent NEI data available are from 2020. **Table TA 7-6** through **Table TA 7-10** provide the 2020 emissions for the six criteria air pollutants and HAPs for the U.S.; the State of Arizona; Nevada; and Utah; and all of counties in the analysis area. The EPA uses the NEI to develop and review regulations, conduct air quality modeling, and conduct risk assessments to understand how air pollution may affect the health in communities across the country. Therefore, the nonattainment status for some of the counties in the analysis area indicate the NEI data presented below are only a concern for those pollutants in nonattainment (EPA 2023).

Table TA 7-6
National Emissions Inventory 2020 Emissions Data for U.S., Nevada, Arizona, and Utah (tons)

Pollutant	U.S.	Nevada	Arizona	Utah
NO_x	8,814,608	80,106	147,990	110,291
CO	66,065,689	412,095	1,265,343	862,864
VOC	46,140,059	267,402	680,519	465,409
PM_{10}	16,761,114	117,964	183,742	183,966
$PM_{2.5}$	5,815,036	29,738	80,611	68,285
SO_2	1,838,518	4,807	17,102	12,704
HAPs	5,964,882	57,126	114,811	83,712

Source: EPA 2023

Table TA 7-7
National Emissions Inventory 2020 Emissions Data for Nevada and Clark County (tons)

Pollutant	Nevada	Clark County	% of State
NO_x	80,106	24,426	30.5%
CO	412,095	187,398	45.5%
VOC	267,402	51,867	19.4%
PM_{10}	117,964	15,733	13.3%
$PM_{2.5}$	29,738	5,882	19.8%
SO_2	4,807	404	8.4%
HAPs	57,126	10,138	17.7%

Source: EPA 2023

Table TA 7-8
National Emissions Inventory 2020 Emissions Data for Arizona and Yuma, La Paz and Navajo Counties (tons)

Pollutant	Arizona	Yuma County	% of State	La Paz County	% of State	Navajo County	% of State
NO_x	147,990	5,792	3.9%	3,145	2.1%	8,798	5.9%
CO	1,265,343	27,492	2.1%	12,982	1.0%	21,237	1.7%
VOC	680,519	15,287	2.3%	10,727	1.6%	34,443	5.1%
PM_{10}	183,742	5,324	2.9%	2,626	1.4%	5,910	3.2%
$PM_{2.5}$	80,611	1,407	1.8%	680	0.8%	1,484	1.8%
SO_2	17,102	104	0.6%	16	0.1%	1,887	11.0%
HAPs	114,811	3,000	2.6%	1,924	1.7%	5,806	5.1%

Source: EPA 2023

Table TA 7-9
National Emissions Inventory 2020 Emissions Data for Arizona and Coconino, Mohave and Yavapai Counties (tons)

Pollutant	Arizona	Coconino County	% of State	Mohave County	% of State	Yavapai County	% of State
NO_x	147,990	12,455	8.4%	9,863	6.7%	10,411	7.0%
CO	1,265,343	102,877	8.1%	49,112	3.9%	68,627	5.4%
VOC	680,519	105,740	15.5%	37,626	5.5%	44,088	6.5%
PM_{10}	183,742	14,435	7.9%	6,384	3.5%	12,358	6.7%
$PM_{2.5}$	80,611	7,462	9.3%	2,109	2.6%	4,833	6.0%
SO_2	17,102	651	3.8%	142	0.8%	2,721	15.9%
HAPs	114,811	16,615	14.5%	7,339	6.4%	7,270	6.3%

Source: EPA 2023

Table TA 7-10
National Emissions Inventory 2020 Emissions Data for Utah and Kane, San Juan and Washington Counties (tons)

Pollutant	Utah	Kane County	% of State	San Juan County	% of State	Washington County	% of State
NO_x	110,291	791	0.7%	1,671	1.5%	3,029	2.7%
CO	862,864	7,224	6.5%	8,619	7.8%	23,078	20.9%
VOC	465,409	15,162	13.7%	20,813	18.9%	14,397	13.1%
PM_{10}	183,966	2,566	2.3%	4,206	3.8%	5,563	5.0%
$PM_{2.5}$	68,285	532	0.5%	720	0.7%	1,314	1.2%
SO_2	12,704	25	0.0%	48	0.0%	61	0.1%
HAPs	83,712	2,813	2.6%	4,025	3.6%	2,513	2.3%

Source: EPA 2023

Air Pollution Associated Diseases

Air pollution is associated with many respiratory diseases. These effects come from inhaling particulate matter, O_3, NO_X, SO_2, and other pollutants. For example, Valley Fever or coccidioidomycosis is a lung disease that is prevalent in the southwestern U.S. The fungus *Coccidioides immitis* causes Valley Fever, which grows in soils with low rainfall, high summer temperatures, and moderate winter temperatures. When the soil is disturbed by winds, construction, farming, or other activities, these fungal spores become airborne. Infection occurs when a spore is inhaled by a susceptible person or animal. Construction, agriculture, and archaeology workers are at a higher risk of exposure and disease because their jobs cause soil disturbance, which can lead to the presence of fungal spores. The analysis area counties are all areas that may harbor the fungus that causes the disease Valley Fever (CDC 2024). Depending on the level of exposure, breathing O_3 can also trigger a variety of health problems. Effects of O_3 inhalation can include coughing and sore or scratchy throat; difficulty breathing deeply and vigorously and pain when taking deep breaths; inflammation of and damage to the airways; increased susceptibility to lung infections; aggravation of lung diseases such as asthma, emphysema, and chronic bronchitis; and an increase in the frequency of asthma attacks. Some of these effects have been found even in healthy people, but effects are more serious in people with lung diseases such as asthma. O_3 exposure may lead to increased school absences, medication use, visits to doctors and emergency rooms, and hospital admissions. Long-term exposure to O_3 is linked to aggravation of asthma and is likely to be one of many causes of asthma development. Studies in locations with elevated O_3 concentrations also report associations of O_3 with deaths from respiratory causes. Asthma often starts during childhood when the immune system is still developing. Multiple factors may work together to cause asthma. These factors include allergens in the environment that affect babies or young children, including cigarette smoke and certain germs; viral infections that affect breathing; and family history, such as a parent (in particular, a mother) who has asthma. Common triggers for asthma include indoor allergens, such as dust mites, mold, and pet dander or fur; outdoor allergens, such as pollens and mold; emotional stress; physical activity (although with treatment, most individuals can still be active); infections, such as colds, influenza (flu), or COVID-19; certain medicines, such as aspirin, which may cause serious breathing problems in people with severe asthma; poor air quality (such as high levels of O_3); or very cold air (National Heart, Lung, and Blood Institute 2024).

Prevention of Significant Deterioration and Air Quality Related Values

As set forth in the CAA, the Prevention of Significant Deterioration (PSD) regulations were developed and implemented to protect public health and welfare and to preserve, protect, and enhance the air quality in national parks, wilderness areas, monuments, and other areas of special value. The regulations apply to permitting for new or modified *major*[1] stationary sources in attainment areas. As part of the PSD, the EPA classifies airsheds as Class I or Class II. Class I areas are areas of special national or regional natural, scenic, recreational, or historic value for which the PSD regulations provide special protection. All other areas are designated Class II areas, which allow for moderate pollution increases and reasonable growth, while still applying stringent air quality constraints (NPS 2023a). Class I areas are also defined as national parks over 6,000 acres and wilderness areas and memorial parks over 5,000 acres that were established as of 1977. **Table TA 7-11** presents the Class I areas located within the analysis area, as well as those located in counties adjacent to the analysis area. For those Class I areas that are national parks, the U.S. Department of the Interior National Park Service (NPS) compiles visibility data, which are also provided in **Table TA 7-11**.

Air quality related values were established to address impacts such as acid deposition, regional haze, and the degradation of sensitive species in Class I areas.

[1] Major sources are defined as a source that emits 100 tons per year or more of any criteria pollutant for pollutants specifically listed source categories in 40 CFR 51.166(b)(a)(i)(a) or that emit 250 tons per year of any criteria pollutants and are not specifically listed sources.

Table TA 7-11
Class I Areas

State	Class I Area	Agency	County	NPS Visibility Summary
Utah	Arches National Park	USDI-NPS	Grand	Visibility is fair at Arches National Park based on the 5-year average (2018–2022) measured visibility (haze index) on mid-range days of 5.3 dv compared to NPS visibility benchmarks. This is 2.3 dv above the estimated natural condition of 3.0 dv. In 2022, the measured visual range is between 88 and 179 miles. Without the effects of pollution, estimated visual range would be between 123 to 201 miles.
	Bryce Canyon National Park	USDI-NPS	Garfield and Kane	Visibility is fair at Bryce Canyon National Park based on the 5-year average (2018–2022) measured visibility (haze index) on mid-range days of 5 dv compared to NPS visibility benchmarks. This is 2.2 dv above the estimated natural condition of 2.8 dv. In 2022, the measured visual range is between 76 and 187 miles. Without the effects of pollution, estimated visual range would be between 120 to 210 miles.
	Canyonlands National Park	USDI-NPS	Wayne, Garfield, San Juan	Visibility is fair at Canyonlands National Park based on the 5-year average (2018–2022) measured visibility (haze index) on mid-range days of 5.3 dv compared to NPS visibility benchmarks. This is 2.3 dv above the estimated natural condition of 3.0 dv. In 2022, the measured visual range is between 88 and 179 miles. Without the effects of pollution, estimated visual range would be between 123 to 201 miles.
	Capitol Reef National Park	USDI-NPS	Wayne, Garfield	Visibility is fair at Capitol Reef National Park based on the 5-year average (2018–2022) measured visibility (haze index) on mid-range days of 5.6 dv compared to NPS visibility benchmarks. This is 2.5 dv above the estimated natural condition of 3.1 dv. In 2022, the measured visual range is between 82 and 171 miles. Without the effects of pollution, estimated visual range would be between 127 to 197 miles.

State	Class I Area	Agency	County	NPS Visibility Summary
Utah *(cont.)*	Zion National Park	USDI-NPS	Washington, Iron, and Kane	Visibility is fair at Zion National Park based on the 5-year average (2018–2022) measured visibility (haze index) on mid-range days of 7 dv compared to NPS visibility benchmarks. This is 3.3 dv above the estimated natural condition of 3.7 dv. In 2022, the measured visual range is between 81 and 158 miles. Without the effects of pollution, estimated visual range would be between 122 to 203 miles.
Arizona	Petrified Forrest National Park	USDI-NPS	Apache and Navajo	Visibility is fair at Petrified Forest National Park based on the 5-year average (2018–2022) measured visibility (haze index) on mid-range days of 6.4 dv compared to NPS visibility benchmarks. This is 3.5 dv above the estimated natural condition of 2.9 dv. In 2022, the measured visual range is between 86 and 161 miles. Without the effects of pollution, estimated visual range would be between 123 to 200 miles.
	Grand Canyon National Park	USDI-NPS	Coconino and Mohave	Visibility is good at Grand Canyon National Park based on the 5-year average (2018–2022) measured visibility (haze index) on mid-range days of 4.8 dv compared to NPS visibility benchmarks. This is 1.9 dv above the estimated natural condition of 2.9 dv. In 2022, the measured visual range is between 100 and 194 miles. Without the effects of pollution, estimated visual range would be between 117 to 215 miles.
	Sycamore Canyon Wilderness	USDA-Forest Service	Yavapai and Coconino	N/A
	Pine Mountain Wilderness	USDA-Forest Service	Yavapai	N/A
	Mazatzal Wilderness	USDA-Forest Service	Yavapai and Gila	N/A
	Superstition Wilderness	USDA-Forest Service	Maricopa	N/A
	Sierra Ancha Wilderness	USDA-Forest Service	Gila	N/A

State	Class I Area	Agency	County	NPS Visibility Summary
Arizona *(cont.)*	Mount Baldy Wilderness	USDA-Forest Service	Apache	N/A
Nevada	Great Basin National Park	USDI-NPS	White Pine	Visibility is fair at Big Bend National Park based on the 5-year average (2018–2022) measured visibility (haze index) on mid-range days of 9.8 dv compared to NPS visibility benchmarks. This is 6.1 dv above the estimated natural condition of 3.7 dv. In 2022, the measured visual range is between 58 and 140 miles. Without the effects of pollution, estimated visual range would be between 120 to 207 miles.

Source: EPA 2025d; NPS 2023a
N/A – Not available as only National Parks have a NPS Visibility Summary
dv – deciviews
USDA – U.S. Department of Agriculture
USDI – U.S. Department of the Interior

Visibility is monitored using methodologies established by the Interagency Monitoring of Protected Visual Environments Program. The particulates that contribute to haze are collected on filters at each Interagency Monitoring of Protected Visual Environments site. Samples are then measured to determine how visibility is affected over time and by which pollutants. A deciview (dv) is a unit of measurement to quantify human perception of visibility. Because visibility at any one location is highly variable throughout the year, it is characterized by three groupings: the clearest 20 percent days, average 20 percent days, and haziest 20 percent days. Visibility degradation is primarily due to sulfate, nitrate, and PM in the atmosphere, with contributions from both anthropogenic and natural sources. Measuring progress in air pollution control can be challenging, because natural sources beyond human control, such as dust storms and wildfires, can produce significant visibility impairment over large areas for days to weeks at a time. Under the 2017 Regional Haze Rule revisions, the EPA proposed a new visibility tracking metric—"most impaired days"—to better characterize visibility conditions and trends. The most impaired days are those with the most impairment from anthropogenic sources, whereas the haziest grouping now better represents days with haze from natural sources. Total haze on the most impaired days is used to track progress toward Regional Haze Rule goals. Comparing trends in the 20 percent haziest days with the 20 percent most impaired days provides a method to assess impacts from episodic events, like wildfires, which have greatly affected visibility throughout the western U.S. in recent years (Burke et al. 2021).

Visibility information can be found at the Federal Land Managers Environmental Database (FED CIRA 2023). Visibility trends for Class I areas are determined for the clearest, haziest, and most impaired categories. Visibility on the clearest days improved consistently, whereas haziest days have shown little improvement due to many years with large wildfire smoke episodes. The difference between the haziest and most impaired days has increased since the beginning of the monitoring record, indicating that episodic events are now exerting a larger impact on visibility.

Atmospheric deposition occurs when gaseous and particulate air pollutants are deposited on the ground, waterbodies, or vegetation. The NPS monitors and evaluates deposition to determine the parks that are most at risk and where conditions are declining or improving (NPS 2024). Nitrogen deposition conditions are fair to poor with no trend data available (**Table TA 7-12**). Sulfur deposition conditions are good with trend data unavailable for most locations.

Table TA 7-12
Nitrogen and Sulfur Deposition Conditions at National Parks

State	Class I Area	Nitrogen (Conditions 2018–2022/Trend 2013–2022)	Sulfur (Conditions 2018–2022//Trend 2013–2022)
Utah	Arches National Park	Poor / Trend Not Available	Good / Trend Not Available
	Bryce Canyon National Park	Fair / Relatively Unchanging	Good / Relatively Unchanging
	Canyonlands National Park	Poor / Relatively Unchanging	Good / Improving
	Capitol Reef National Park	Fair / Trend Not Available	Good / Trend Not Available
	Zion National Park	Fair / Trend Not Available	Good / Trend Not Available
Arizona	Petrified Forrest National Park	Poor / Relatively Unchanging	Good / Improving
	Grand Canyon National Park	Poor / Relatively Unchanging	Fair / Improving
Nevada	Great Basin National Park	Poor / Relatively Unchanging	Fair / Improving

Source: NPS 2023b

Historical to Present Lake Powell and Lake Mead Pool Elevations

The Lake Mead pool elevations for 1935 through 2025 are shown in **Figure TA 7-1**.

Regional Modeling and Studies

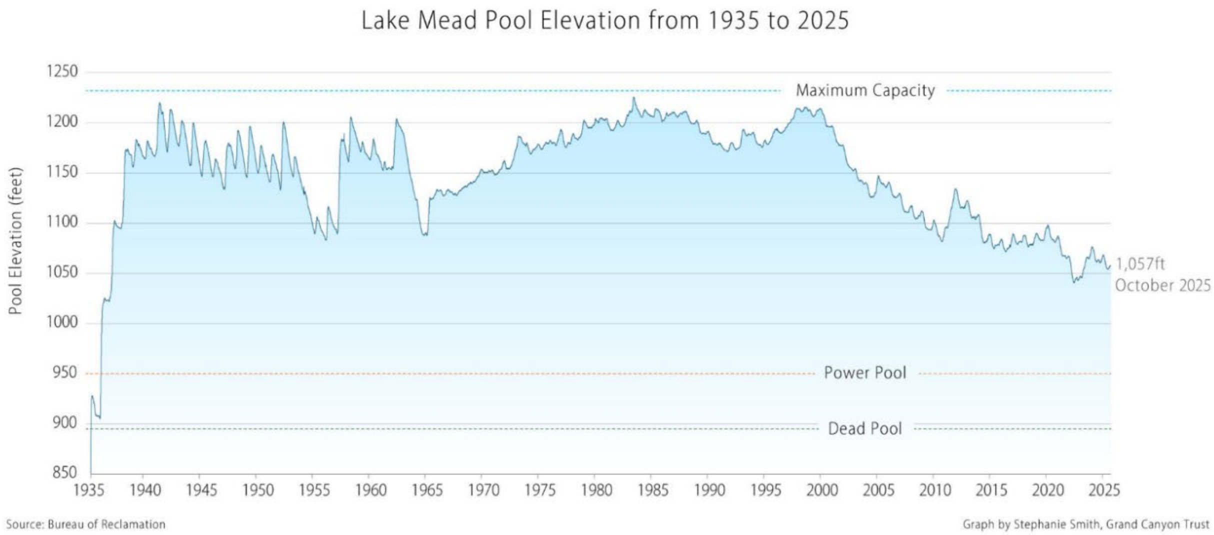
Lake Powell and Lake Mead Modeling

In 2024, U.S. Geological Survey (USGS) initiated a study in cooperation with NPS to model exposed shoreline area and potential dust emissions at Lake Powell and Lake Mead (Sankey et al. 2024).

Lake Mead Annual High and Low Elevations

Annual high and low elevations of Lake Mead for years 1935–2024 are available through the Bureau of Reclamation (Reclamation) with the maximum storage capacity at 1,229 feet. For 2024, the high elevation was 1,077 feet and the low was 1,061 feet. In 2014, the high elevation was 1,109 feet and the low was 1,080 feet (Reclamation 2025a).

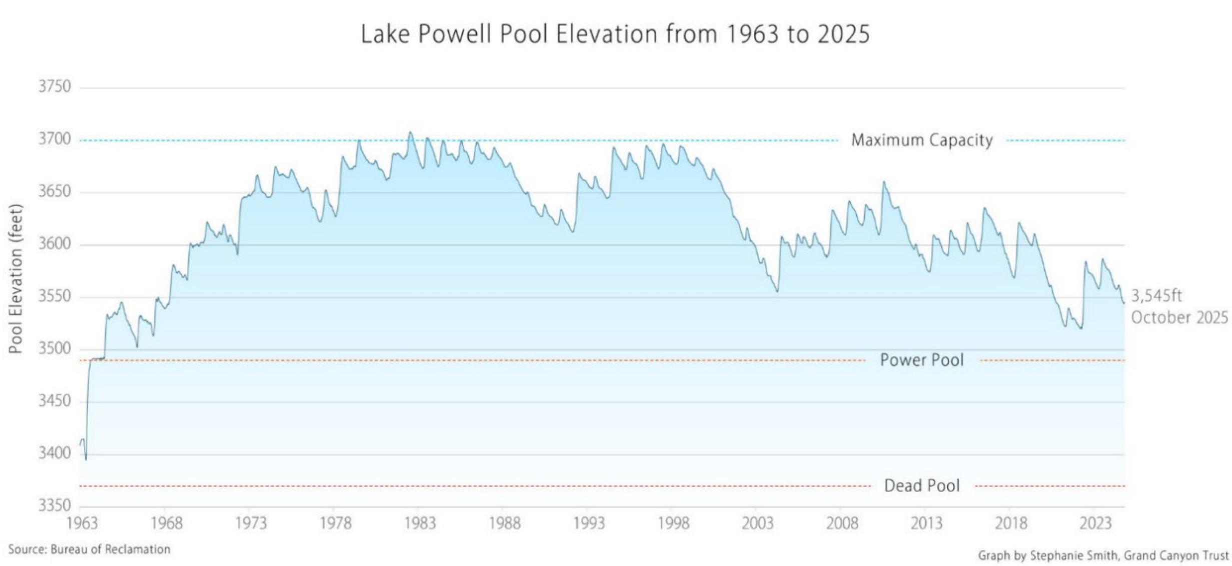
Figure TA 7-1
Lake Mead Pool Elevation from 1935 to 2025



Source: Reclamation 2026a

The Lake Powell pool elevations for 1963 through 2025 are shown in **Figure TA 7-2**.

Figure TA 7-2
Lake Powell Pool Elevation from 1963 to 2025



Source: Reclamation 2026b

Lake Powell Annual High and Low Elevations

Annual high and low elevations of Lake Powell for years 1964–2024 are available through the Reclamation with the maximum storage capacity at 3,700 feet. For 2024, the high elevation was 3,587 feet and the low was 3,558 feet. In 2014, the high elevation was 3,609 feet and the low was 3,574 feet (Reclamation 2025b).

Lake Mead Mapping

The USGS, in cooperation with the Lake Mead/Mohave Research Institute, University of Nevada, Las Vegas, completed a detailed geophysical mapping of the floor of Lake Mead during 1999, 2000, and 2001. The 1999 survey covered the Boulder Basin section of the lake, the 2000 survey focused on the northwestern portion of Las Vegas Bay, and the 2001 survey covered the eastern part of the lake. Results from these surveys have been presented in several reports. In 2003 the three datasets were integrated and presented as a composite of the entire lake in the "Mapping the floor of Lake Mead (Nevada and Arizona): Preliminary discussion and GIS data release," USGS Open-File Report 03-320. Also provided is a brief geologic overview of the floor of Lake Mead and a summary of some of the findings that have resulted from these surveys to provide a geologic perspective for the geographic information systems, which is also provided in this report.

Overall, analysis of the seismic-reflection data indicates that a large volume of sediment carried by the Colorado River has accumulated in Lake Mead since impoundment in 1935. The sediment is not uniformly distributed; rather, it is concentrated in the deepest parts of the lake and covers the floors of the valleys cut by the Colorado River and the other tributary streams that originally flowed through the area (Twichell et al. 1999, 2001, 2002, and 2003). The sediment forms a continuous cover along the entire length of the pre-impoundment Colorado River valley from the eastern extremity of the survey just east of Iceberg Canyon to the Hoover Dam at the west end of the study area. Sediment also covers the floors of the larger tributary valleys that feed the Colorado River (USGS 2003).

Lake Powell Mapping

The USGS, in cooperation with Reclamation, surveyed Lake Powell between fall 2017 and spring 2018 to produce an integrated topobathymetric dataset, which comprises topographic light detection and ranging (lidar) data (land elevation) and multibeam bathymetry (bed elevation of a waterbody), for the purposes of calculating the elevation-area-capacity relationships in Lake Powell. In 2017 and 2018, the USGS and Reclamation completed extensive surveys of the reservoir utilizing high-resolution multibeam bathymetry and lidar. These data were merged into a seamless topobathymetric dataset, which was subsequently revised to calculate new elevation-area-capacity relationships. This collaborative effort provided a revised and high-resolution estimate of storage capacity in Lake Powell and an updated topobathymetric surface to support water availability studies amid prolonged drought. The report summarizes the updated elevation-area-capacity relationships, describes the surveying methods and elevation-area-capacity calculations, and provides comparisons of the updated elevation-area-capacity relationships with previous estimates.

Storage capacity and areal extent of Lake Powell were determined for a range of elevations from 3,120 to 3,717.20 feet above the North American Vertical Datum of 1988 (NAVD 88). The updated elevation-area-capacity relationships indicate Lake Powell has lost 1,833,000 acre-feet or 6.79 percent of its storage capacity at full pool (3,702.91 feet above NAVD 88) since construction was completed in 1963 through 2018. With consideration to potential error in the topobathymetric dataset, the loss of storage capacity ranges between 1,607,000 and 2,059,000 acre-feet. The reduction in storage capacity is attributed to sedimentation at the deltas of the Colorado and San Juan Rivers. Decreases in storage capacity were largest for the reservoir at elevations above 3,600 feet above NAVD 88, which coincide with frequent reservoir elevations since the 1970s.

Historical surveys were limited by comparatively coarser survey techniques than those used for the 2017–18 topobathymetric digital elevation model, though the average annual storage loss between surveys remained similar since impoundment in 1963. With increasing demands on water in the Colorado River Basin amid a decadal-scale drought, these results provide critical information to support water resource management in Lake Powell and beyond (Root and Jones 2022).

Impact of Lost Generation at the Glen Canyon Powerplant

This report was prepared by Argonne National Laboratory and the National Renewable Energy Laboratory (now known as National Laboratory of the Rockies [NLR]) in support of an economic and financial analysis conducted for the U.S. Department of Energy's Western Area Power Administration of the loss in Glen Canyon power generation due to the environmental requirements for the years 2024 to 2027. This report presents data showing the changes in generation sources for each of the years (2024–2027). These figures show that when there is a reduction in hydropower, the replacement generation from mostly Natural Gas Fired generation (Gas Combined Cycle) generation and Gas Combustion Turbine, with a small portion also coming from coal-fired generation. However, the compensation of natural gas and coal vary by month and year (Veselka et al. 2024).

Owens Lake California Environmental Quality Act (CEQA) Initial Study

The 2011 Supplemental Control Requirements Determination (SCRD) and 2012 SCRD projects have the objective to implement dust control measures on Owens Lake to reduce emissions, in accordance with applicable laws, without increasing water commitments while, to the extent feasible, maintaining existing habitat values; maintaining aesthetics values; providing safe, limited public access; preserving cultural resources; and utilizing existing infrastructure.

The City of Los Angeles Department of Water and Power (LADWP) is currently implementing the Owens Lake Dust Mitigation Program on Owens Lake to reduce PM_{10} emissions. LADWP constructs and operates dust control measures on the lake, in compliance with orders from the Great Basin Unified Air Pollution Control District under the authority of California Health and Safety Code Section 42316, legal settlement agreements with the Great Basin Unified Air Pollution Control District, lease agreements for use of state lands (administered by the California State Lands Commission), and other regulatory approvals.

In 2014, LADWP prepared an initial study to address the impacts of construction and operation of the Owens Lake 2011 SCRD and 2012 SCRD dust control measures projects. The initial study was prepared in accordance with the CEQA, Public Resources Code Section 21000 et seq., and the State CEQA Guidelines (Title 14 California Code of Regulations Section 15000 et seq.). The initial study serves to identify the site-specific impacts, evaluate their potential significance, and determine the appropriate document needed to comply with the CEQA.

For this project, LADWP has determined, based on the information reviewed and contained herein, that the proposed projects could potentially have a significant environmental impact. Based on this initial study, an environmental impact report is the appropriate CEQA document for evaluating the potential environmental impacts of the Owens Lake 2011 SCRD and 2012 SCRD projects. After environmental review, if the 2011 SCRD and 2012 SCRD projects are adopted, the projects may be constructed at the same time or constructed separately, or one or both projects may not be implemented, pending further legal decisions (LADWP 2014). The potential future change for Lake Powell and Lake Mead may also highlight the need for a similar dust mitigation program, should water levels decrease below 500 square kilometers (km^2) (123,553 acres), for each lake.

TA 7.1.4 NAAQS: Regulatory Framework/Applicable Laws, Regulations, Plans, and Policies

As discussed, Section 176 of the federal CAA requires federal agencies that fund, permit, or approve an activity to ensure that the activity complies with the applicable State Implementation Plan adopted to eliminate or reduce air quality violations (42 USC 7506). In order to ensure that air pollutant emissions associated with federally approved or funded activities do not exceed emission budgets established in the applicable State Implementation Plan and do not interfere with the state's ability to attain and maintain the NAAQS in areas working to attain or maintain the standard, the EPA passed federal conformity rules. The General Conformity Rule applies to all projects that are not related to transportation. According to 40 CFR 51(W), a detailed determination of the General Conformity Rule's applicability is required when federal actions or funding of non-transportation-related activities in nonattainment areas result in emissions that exceed de minimis threshold levels (EPA 2024a). Also discussed, are the PSD regulations that are developed and implemented to protect public health and welfare and to preserve, protect, and enhance the air quality in national parks, wilderness areas, national monuments, and other areas of special value.

Arizona

Air pollutant sources in Yuma, La Paz, Coconino, Yavapai, Mohave, and Navajo Counties fall under the jurisdiction of the ADEQ Air Quality Division. ADEQ operates a network of ambient air quality monitors throughout Arizona for a variety of federal and state monitoring programs. The primary monitoring objective is to measure criteria pollutants regulated under the CAA for compliance with the NAAQS. In addition, ADEQ Air Quality Division's 'Air Permits and Compliance' section issues air quality permits to industrial facilities that emit significant quantities of air pollutants to ensure that the emissions do not harm public health or cause a significant deterioration in air quality.

Nevada

The Nevada Revised Statutes Chapter 445B focuses on air pollution in Nevada. Under this, each county in the state with a population equal to or greater than 100,000 people must establish a board of county commissioners to establish and implement an air pollution control program (NRS 445B.500). In 2001, the Clark County Board of County Commissioners established the Clark County DAQ to carry out the mandated program. There are 17 counties in the state of Nevada. All but two counties are overseen by the NDEP for the implementation of the CAA. Washoe and Clark Counties have a delegated authority by the governor of Nevada for the implementation of the CAA. The Clark County DAQ under the Clark County Department of Environment and Sustainability is responsible for administering the air pollution control program for Clark County under the provisions of the Clark County Air Quality Regulations and the EPA-approved State Implementation Plan for Clark County, Nevada (Clark County Air Quality Regulations Sections 00 through 94 as adopted in 40 CFR 52(DD)). In Nevada, the NDEP Bureau of Air Pollution Control and Air Quality Planning has primary responsibility under Nevada Revised Statutes 445B.100 through 445B.825 for managing air quality through state regulations. Within Clark County, emissions are regulated by the Clark County DAQ. Construction activities impacting greater than 0.25 acre in Clark County would require a dust control operating permit from Clark County DAQ. Projects larger than 10 acres would also require completion of a Dust Mitigation Plan Supplement for Clark County DAQ (Clark County 2023). In addition, Section 12.1 of the Clark County Air Quality Regulations requires the issuance of a Minor Stationary Source Permit for any applicable source located in Clark County that has a potential to emit a regulated pollutant that is equal to or greater than the thresholds listed in that section. Any mechanical equipment (e.g., backup generators, boilers, cooling towers) may trigger air quality "stationary source" permitting in accordance with Clark County Air Quality Regulations Section 12.1. Therefore, stationary source permits are obtained before commencing construction of any emissions unit when collectively (i.e., emissions from all emissions units in aggregate) meeting the thresholds for any of the regulated pollutants. The NDEP Bureau of Air Pollution Control and Air Quality Planning and Clark County DAQ have both been delegated authority by the EPA to implement federal programs of the CAA.

Utah

The EPA has delegated authority to Utah DAQ, under the Utah Department of Environmental Quality, for regulating air quality in all areas of Utah, with the exception of tribal lands, which remain under the authority of the EPA. The Utah DAQ has primary responsibility for managing air quality through state regulations. The Utah DAQ's responsibility is to ensure that the air in Utah meets the health and visibility standards established under the CAA. To fulfill this responsibility, Utah DAQ is required by the federal government to oversee compliance with the NAAQS statewide and visibility standards at Class I airsheds. Utah DAQ enacts rules pertaining to air quality standards, develops plans to meet federal standards, when necessary, administers emissions reductions incentive programs, issues preconstruction and operating permits to stationary sources, and enforces compliance with state and federal air quality rules. The Utah Air Conservation Act (UAC 19-2) delegates rulemaking power to the Utah Air Quality Board to promulgate rules pertaining to air quality issues. As of August 2020, Utah Department of Environmental Quality does not require a fugitive dust control plan for the analysis area. The UAC does not specifically require the development of a fugitive dust control plan in attainment areas. However, the UAC does require that operators take measures to limit PM emissions during construction and demolition activities greater than 0.25 acres in size (UAC R307-205). UAC R307-205 also requires fugitive dust to be controlled (regardless of the size or amount of acreage disturbed) to maintain a specified opacity.

Past and Present, and Projected Climate Trends and Impacts

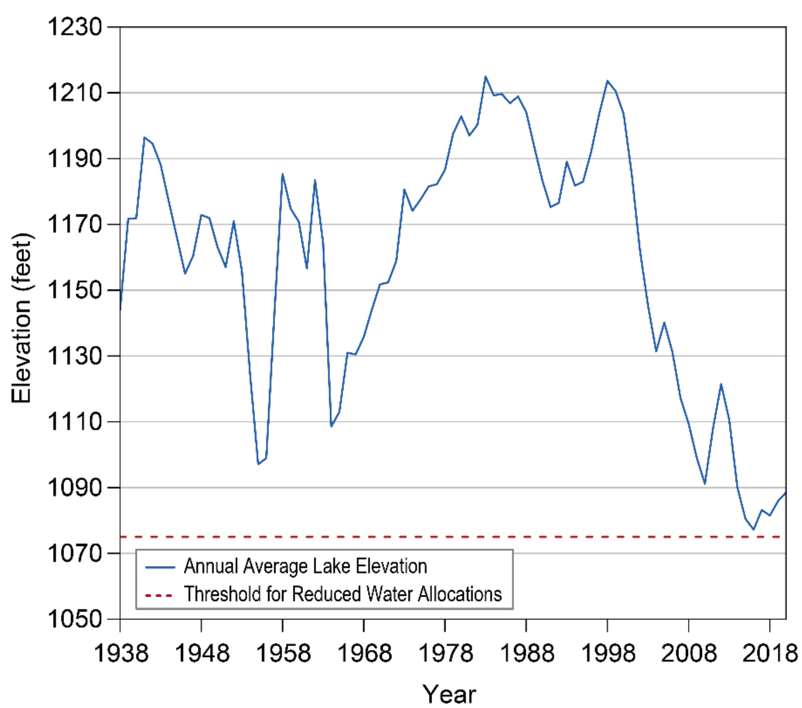
An analysis of regional climate impacts concluded that the rate of average annual temperature increases in the southwest U.S. was among the most rapid nationally (IPCC 2021). This temperature increase is causing a decline in spring snowpack and reducing flow in the four major southwest rivers. Projections of future climate trends indicate that further increases in average annual temperature could reduce precipitation. Analysis of past records and future projections indicates an overall increase in regional temperatures, including in the analysis area. The observed increase is largely the result of the warmer nights and effectively higher average daily minimum temperatures at many of the measurement sites in the region.

National Oceanic and Atmospheric Administration National Centers for Environmental Information released its climate summaries by state in 2022. The climate summaries for the analysis area states are summarized. More detailed climate discussions for each state can be found through the State Climate Summaries web page (NOAA 2022).

Arizona

Temperatures in Arizona have risen about 2.5 degrees Fahrenheit (°F; -16.4 degrees Celsius [°C]) since the beginning of the 20th century. The first 21 years of this century have been the warmest period on record for the state. The historical record indicates periodic prolonged wet and dry periods. Arizona is currently in a long-term drought that has lasted more than 20 years. Multiyear periods of high and low precipitation can cause significant variations in reservoir supplies. The latest western U.S. drought has resulted in record-low water levels in Lake Mead, which is a critical water resource for Arizona, as well as southern Nevada, southern California, and northern United Mexican States (Mexico). Since reaching high levels in the late 1990s, water levels have been falling, reaching historic lows in 2015 and 2016 (**Figure TA 7-3**). Long-term droughts also raise the risk of wildfires, already a concern for this arid state.

Figure TA 7-3
Lake Mead Water Levels at Hoover Dam



Source: Reclamation 2025a

Figure TA 7-3 shows the time series of the annual average water level (blue line) of Lake Mead at Hoover Dam from 1938 to December 2020. Water levels in Lake Mead have varied widely over the years. Low levels in the 1950s and 1960s were due to drought and the filling of Lake Powell, respectively. Recent years have seen the lowest recorded levels since the original filling of Lake Mead. The red-dashed line indicates the threshold (1,075 feet) below which a federal shortage will be declared, resulting in reduced water allocations for Nevada and Arizona. Unlike many areas of the U.S., Arizona and other southwestern states have not experienced an upward trend in the frequency of extreme precipitation events.

Under the higher and lower emissions pathways, annual average temperatures are projected to exceed historical record levels by the middle of this century. A large range of temperature increases is projected under both pathways, and under the lower pathway, a few projections are only slightly warmer than historical records.

Although projections of overall annual precipitation are uncertain, there is a risk of decreases in spring precipitation. Additionally, projected rising temperatures will raise the snow line—the average lowest elevation at which snow falls. This will increase the probability that precipitation will fall as rain instead of snow, reducing water storage in the snowpack, particularly at lower mountain elevations that are now on the margins of reliable snowpack accumulation. Higher spring temperatures will also result in earlier melting of the snowpack, further decreasing water resources needed for irrigation during the hot summer months.

Naturally occurring droughts are expected to become more intense during the cool season. Even if precipitation does not decrease, higher temperatures will intensify naturally occurring droughts by increasing water evaporation. This will further reduce streamflow, soil moisture, and water supplies. Drought will not only challenge limited agricultural resources but also increase the frequency of dust storms and the frequency of the risk of very large wildfires.

Nevada

Temperatures in Nevada have risen almost 2.4 °F (-16.4 °C) since the beginning of the 20th century. After wet conditions in the late 1990s, total annual precipitation has been near or below average since 2000 but shows no overall trend across the 126-year period of record. Seasonal precipitation patterns vary across the state, with most locations receiving the majority of their precipitation during the winter months. However, eastern and southern areas, including Clark County, can experience intense summer rainfall from the North American Monsoon system. Since 2004, the state has received multiple federal disaster declarations for wildfire events.

Drought is a critical climate threat for this arid state. Since 2000, the Colorado River Basin, the source of water for the southern part of the state, has experienced drought conditions, with impacts on Lake Mead. In addition, winter precipitation was well below average from the 2011–12 through the 2014–15 water years (WYs; October–September), and all of those years were abnormally warm. This led to a strain on water supplies in agricultural areas that rely on surface water. The majority of the counties in the state have been designated as natural disaster areas due to extreme drought conditions. Lake Mead, the largest man-made reservoir in the U.S., provides water for southern Nevada, as well as Arizona, southern California, and northern Mexico. As of October 25, 2021, water storage in Lake Mead was at 34 percent capacity, and water levels have been dropping since 2000 (**Figure TA 7-3**). Due to aggressive conservation policies, metropolitan areas have been able to manage the reductions in water supplies. Parallel declines in snowpack have been observed over this same time period (**Figure TA 7-3**). Snowpack refills Lake Tahoe every spring, and lake levels slowly decrease throughout the year. Warm and/or dry years lead to low snowpack and associated decreases in the lake's water levels. Since 1900, the lake has fallen below the natural rim 21 times.

Under the higher and lower emissions pathway, annual average temperatures are projected to exceed historical record levels by the middle of this century. A large range of temperature increases is projected under both pathways, and under the lower pathway, a few projections are only slightly warmer than historical records. Extreme high temperatures are projected to increase, with potentially large impacts in the very hot southern deserts, particularly the Las Vegas metro area, where 70 percent of the state's population resides.

Projected rising temperatures in Nevada will raise the snow line—the average lowest elevation at which snow falls. This will increase the probability that precipitation will fall as rain rather than snow, reducing water storage in the snowpack, particularly at those lower mountain elevations that are now on the margins of reliable snowpack accumulation. Higher spring temperatures will also result in earlier melting of the snowpack, further decreasing water availability during the already dry summer months.

Projections of annual precipitation for Nevada are uncertain throughout this century, but warmer temperatures could decrease the amount of water in the mountain snowpack and increase the demand for water. Higher temperatures will also increase the evaporation rate, which will reduce streamflow and soil moisture. Thus, the intensity of future droughts is anticipated to increase, as will the risk of wildfires in some ecosystems. Increases in population and potentially decreased water flow from the Colorado River may lead to future water security issues across the state.

Utah

Temperatures in Utah have risen more than 2.5 °F (-16.4 °C) since the beginning of the 20th century. Unlike many areas of the U.S., Utah and other southwestern states have not experienced an upward trend in the frequency of extreme precipitation events. Although floods are rare in the state, both heavy rainfall and snowmelt can result in severe flooding.

Under the higher and lower emissions pathway, annual average temperatures are projected to exceed historical record levels by the middle of this century. A large range of temperature increases is projected under both pathways, and under the lower pathway, a few projections are only slightly warmer than historical records.

Climate models are not consistent in their projections of precipitation for Utah, including winter precipitation. However, projected rising temperatures will also raise the snow line—the average lowest elevation at which snow falls. Continuing recent trends, this will increase the probability that precipitation will fall as rain instead of snow, reducing water storage in the snowpack, particularly at lower elevations that are currently on the margins of reliable snowpack accumulation. In addition, extreme precipitation is projected to increase, potentially increasing the frequency and intensity of floods.

Droughts, a natural part of Utah's climate, are expected to become more intense. Higher temperatures will amplify the effects of naturally occurring dry spells by increasing the rate of loss of soil moisture. Most of Utah's water is supplied by the snowpack; observed trends toward more winter precipitation falling as rain and less as snow could result in less water storage. Additionally, higher spring temperatures can cause early melting of the snowpack, decreasing water availability during the already dry summer months.

TA 7.2 Environmental Consequences

This section provides an analysis of the extent and magnitude of potential impacts on air quality resources for the No Action Alternative, four action alternatives, and the Continued Current Strategies (CCS) Comparative Baseline. More detail on the alternatives can be found in **Chapter 2**, Description of Alternatives, and **Appendix S**, Additional Description of Alternatives.

TA 7.2.1 Methodology

This section examines potential effects on air quality resources under the action alternatives and the No Action Alternative, compared to the CCS Comparative Baseline. Potential impacts are considered for the following air quality resources: shoreline exposure area, fugitive dust emissions, changes in CO_2e due to hydropower, and climate trends.

To support evaluating how potential changes in reservoir water storage might affect potential dust emissions from subaerially exposed reservoir sediment, the subaerial shoreline area and potential dust emissions within Lake Powell and Lake Mead were modeled for this analysis. Methods used in this modeling combined previously published topographic and bathymetric surveys and geologic mapping (Hirschberg and Pitts 2000; Jones and Root 2021, 2022; Ferrari 2001; Root et al. 2019; Root and Jones 2022; Twichell et al. 2003; Twichell and Cross 2009; Wilson et al. 1969) with new predictions of potential dust emissions using the FENGSHA model (Mallia et al. 2017). FENGSHA is an English analog of the Mandarin term for windblown dust. Resource modeling predicts (1) the area of subaerial shoreline exposed as a function of monthly water surface elevations at Lake Powell and Lake Mead, respectively, and (2) potential dust emissions (kilograms [kg] per square meter per hour) as a function of monthly water surface elevations at Lake Powell and Lake Mead modeled using FENGSHA with sustained winds for 15 meters per second (approximately 35 miles per hour) for 6 hours. The results are presented as Glen Canyon and Lake Mead exposed shoreline area and associated emission rates (Fischella et al. 2026).

Impacts on shoreline exposure area and fugitive dust emissions are described in the following section using conditional box plots and Decision Making under Deep Uncertainty robustness heat maps and vulnerability bar plots. The conditional box plots have been developed based on the Colorado River Simulation System (CRSS) model outputs and are framed using the five flow condition categories for the preceding 3-year average Lees Ferry natural flow, as described above. In a conditional box plot, the bold center line of each box represents the median value, the top and bottom of each box captures the 25th to 75th percentile of the modeled results, the lines extend to the 10th and 90th percentiles, and the outliers are represented as dots beyond these lines.

Additional background and technical details about the Decision Making under Deep Uncertainty framework are provided in **Appendix E**, DMDU Overview and Approach. Refer to **Chapter 3**, **Section 3.2.6**, for an overview of how to interpret the Decision Making under Deep Uncertainty robustness heat maps and vulnerability bar plots.

The conditional box plot for each dam compares the median CCS Comparative Baseline generation to the median generation for each alternative and multiple natural flow groups (e.g., dry, moderately dry, and normal hydrology). In each year of every modeled future, the difference in annual hydropower generation between the CCS Comparative Baseline and each alternative was computed to determine the change in generation, whether that be an increase or decrease. The annual change in generation was multiplied by the Emissions and Generation Resource Integrated Database (eGrid)/NLR emission factor to obtain the potential CO_2e for both 2025 and 2050. **Table TA 7-13** and **Table TA 7-14** shows how the 2025 and 2050 emission factors were calculated. This emission factor represents the potential CO_2e from each resource type per megawatt-hour (MWh) and the resource mix percentages for the Western Regional Climate Center (WRCC) energy production.

As time passes and more alternative resources enter the grid, energy will be produced by a different mix of resources; therefore, the 2050 emission factor in **Table TA 7-14** shows the projected mix of resources in 2050 from the U.S. Energy Information Administration (EIA) Annual Energy Outlook 2023. However, the projected mix does not take into account more recent studies that show that when there is a reduction in hydropower, the replacement generation would most likely be from natural gas.

These NLR metric tons of CO_2e per MWh and the eGrid 2023 and EIA 2050 WRCC resource mix percentages were utilized to calculate a weighted average emission factor for 2025 and 2050. The weighted emission factors are multiplied by the changes in MWh for each alternative and flow category. Analyses for other pollutants (sulfur oxide, nitrogen oxide, and particulate matter) are not included due to limitations in the emission factor data from NLR.

Impact Analysis Area

The geographic scope of the air quality resources analysis differs for each issue but includes the Lake Powell to the SIB, which includes the Arizona counties of Mohave, Coconino, Yavapai, and Navajo; the Utah counties of Washington, San Juan, and Kane; and Clark County, Nevada. However, air pollutants tend to disperse into the atmosphere, becoming less concentrated as they travel away from a source of pollution; therefore, they cannot be confined within defined boundaries, such as county lines. Specifically, the shoreline exposure analysis area includes Lake Powell and Lake Mead. The changes in CO_2e due to hydropower generation analysis areas include Glen Canyon Glen Canyon Dam, Hoover Dam, Parker Dam, and Davis Dam. The climate trends analysis area is discussed for the western U.S.

Table TA 7-13
2025 Emission Factor Information

Units	Coal	Natural Gas	Biomass	Oil	Geothermal	Wind	Concentrating Solar Power	Hydro	Nuclear
NLR CO_2e Emission Factors for Comparison of Electrical System Energy Sources									
metric tons CO_2e/MWh	1.00	0.49	0.05	0.84	0.04	0.01	0.04	0.02	0.01
EGrid 2023 WRCC Resource Percentages									
Percentage of the mix	14.00%	35.50%	1.10%	0.10%	2.20%	10.20%	9.50%	19.80%	7.70%
Weighted 2025 Emission Factor (metric tons CO_2e/MWh)	**0.33**								

Sources: EPA 2025f; EIA 2023; NLR 2021

Table TA 7-14
2050 Emission Factor Information

Units	Coal	Natural Gas	Biomass	Oil	Geothermal	Wind	Concentrating Solar Power	Hydro	Nuclear
NLR CO_2 Emission Factors for Comparison of Electrical System Energy Sources									
metric tons CO_2e/MWh	1.00	0.49	0.05	0.84	0.04	0.01	0.04	0.02	0.01
EIA 2050 WRCC Resource Percentages									
Percentage of the mix	4.00%	20.00%	1.50%	2.00%	2.50%	22.00%	35.00%	9.00%	4.00%
Weighted 2050 Emission Factor (metric tons CO_2e/MWh)	**0.18**								

Sources: EPA 2025f; EIA 2023; NLR 2021

Assumptions

- The hydrologic resources results are direct results from the CRSS model. Refer to **Appendix A**, CRSS Model Documentation, for more details related to model assumptions and documentation.
- NLR publishes life cycle assessments, which quantify environmental burdens from "cradle to grave" and based on several different studies, estimates CO_2e emission factors associated with each type of electricity generation. They are provided in grams of CO_2e per kilowatt-hour (g CO_2e/kWh; NLR 2021).
- The eGrid was utilized to determine the North American Electric Reliability Corporation resource mix (coal, natural gas, oil, nuclear, hydropower, biomass, wind, solar, and geothermal) for the Western Electricity Coordinating Council region, which includes the analysis area (EPA 2025f).

- EIA Annual Energy Outlook 2023 (EIA 2023) provide the potential generation mix for year 2050.
- Equivalency Calculator is used to convert emissions into concrete, understandable terms such as the annual CO_2 emissions of cars, households, and power plants (EPA 2025g).

Impact Indicators

Specific impact indicators were selected to help frame the air quality resources analysis for each of the alternatives. The following indicators were used to assess impacts:

- **Shoreline Exposure**: effects on the areas of shoreline exposure due to operational activities
- **Shoreline Dust Emissions**: effects on shoreline dust emissions due to operational activities
- **Potential change of CO_2e Emissions Due to a Fluctuation of Hydropower Generation**: effects on CO_2e emissions due to operational activities

TA 7.2.2 Issue 1: How would changing flow characteristics affect the potential exposed shoreline, fallowed agricultural lands and fugitive dust?

Changes in water storage in lakes can affect the area of shoreline sediment exposed subaerially and potentially available for aeolian transport. Lake Powell and Lake Mead are two of the largest reservoirs in the United States (U.S.). Both are formed by impoundment of the Colorado River by hydroelectric dams. Lake Mead was closed by Hoover Dam in 1935. Lake Powell was closed by Glen Canyon Dam in 1963. Both reservoirs reached maximum observed water storage (water surface elevation) in 1983. Since 2020, both reservoirs have reached minimums in water storage not observed since filling. This resource modeling evaluates how potential changes in reservoir water storage might affect potential dust emissions from subaerially exposed reservoir sediment. Relationships between potential dust emissions and water storage could be useful to evaluate air quality and related resource impacts associated with Colorado River water management decisions.

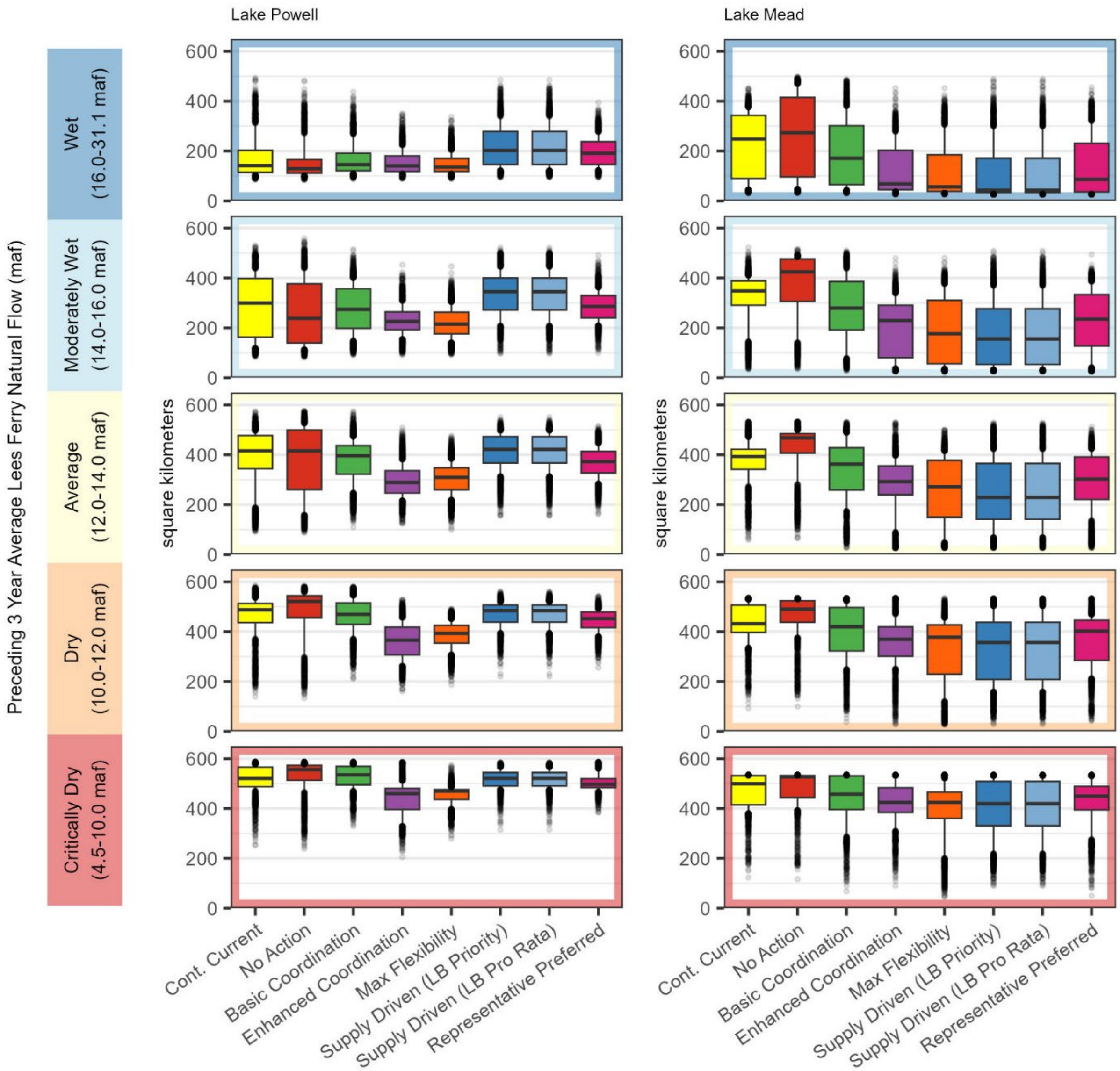
Subaerially exposed shoreline area and potential dust emissions increase as water storage decreases. However, the relationships differ at the two reservoirs due to surficial geology, deposition of reservoir sediment, and topographic and bathymetric terrain; Glen Canyon Dam impounded a deep canyon-bound segment of the Colorado River at Lake Powell, whereas Hoover Dam impounded a comparably broader valley of the river at Lake Mead.

Figure TA 7-4 shows the WY maximum exposed shoreline area for Lake Powell and Lake Mead, in km^2, broken out by hydrologic conditions and categorized by the preceding three-year average Lees Ferry natural flows.

In wetter conditions, the median maximum exposed shoreline was lowest at both reservoirs across all alternatives, as higher preceding three-year average Lees Ferry flows tend to result in higher pool elevations. In the Average Flow Category, Lake Powell alternatives have varying distributions, with the 25th to 75th percentiles across all alternatives spanning from 225 to 500 km^2 (55,598 to 123,552 acres) of maximum exposed shoreline. The CCS Comparative Baseline, as well as the No Action, Basic Coordination, Representative Preferred and Supply Driven (both Lower Basin [LB] Priority and LB Pro Rata approaches) Alternatives, all show similar medians of roughly 400 km^2 (98,842 acres) of maximum exposed shoreline. The Enhanced Coordination and Maximum Operational

Flexibility Alternatives have lower and comparable medians of about 300 km^2 (74,132 acres) of maximum exposed shoreline.

Figure TA 7-4
Water Year Maximum Exposed Shoreline Area for Lake Powell and Lake Mead (square kilometers)



The Lake Mead alternatives have varying Average Flow Category distributions, with the 25th to 75th percentiles across all alternatives spanning from 125 to 500 km^2 (30,888 to 123,552 acres) of maximum exposed shoreline. The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) has the lowest median maximum exposed shoreline, at about 230 km^2 (56,834 acres). The No Action Alternative has the highest median value at roughly 470 km^2 (66,718 acres). The Representative Preferred Alternative has a median maximum exposed shoreline of about 300 km^2

(74,132 acres), with the 25th to 75th percentiles across all alternatives spanning from 220 to 390 km^2 (54,363 to 96,371 acres) of maximum exposed shoreline.

In the Dry Flow Category, the 25th to 75th percentiles across all Lake Powell alternatives span from approximately 300 to 545 km^2 (74,132 to 134,672 acres) of maximum exposed shoreline. The Enhanced Coordination and No Action Alternatives have the lowest and highest median maximum exposed shoreline at about 365 and 520 km^2 (90,194 and 128,495 acres), respectively. For Lake Mead, the 25th to 75th percentiles across all alternatives span from approximately 200 to 530 km^2 (49,421 to 130,966 acres) of maximum exposed shoreline. The Supply Driven (both LB Priority and LB Pro Rata approaches) and No Action Alternatives have the lowest and highest median maximum exposed shoreline at about 360 and 490 km^2 (88,598 and 121,082 acres), respectively.

The Representative Preferred Alternative exhibits the following outcomes with respect to the Dry Flow Category: For the Lake Powell maximum exposed shoreline, the median maximum exposed shoreline is about 450 km^2 (111,197 acres), with the 25th to 75th percentiles across all alternatives spanning from 415 to 475 km^2 (102,549 to 117,375 acres) of maximum exposed shoreline. The Representative Preferred Alternative exhibits the following outcomes with respect to the Critically Dry Flow Category: For the Lake Powell maximum exposed shoreline, the median maximum exposed shoreline is about 495 km^2 (122,317 acres), with the 25th to 75th percentiles across all alternatives spanning from 484 to 520 km^2 (119,599 to 128,495 acres) of maximum exposed shoreline.

The Representative Preferred Alternative exhibits the following outcomes with respect to the Dry Flow Category: For the Lake Mead maximum exposed shoreline, the median maximum exposed shoreline is about 400 km^2 (98,842 acres), with the 25th to 75th percentiles across all alternatives spanning from 280 to 445 (69,190 to 109,962) km^2 of maximum exposed shoreline. The Representative Preferred Alternative exhibits the following outcomes with respect to the Critically Dry Flow Category: For the Lake Mead maximum exposed shoreline, the median maximum exposed shoreline is about 450 km^2 (111,197 acres), with the 25th to 75th percentiles across all alternatives spanning from 395 to 489 km^2 (97,606 to 120,835 acres) of maximum exposed shoreline.

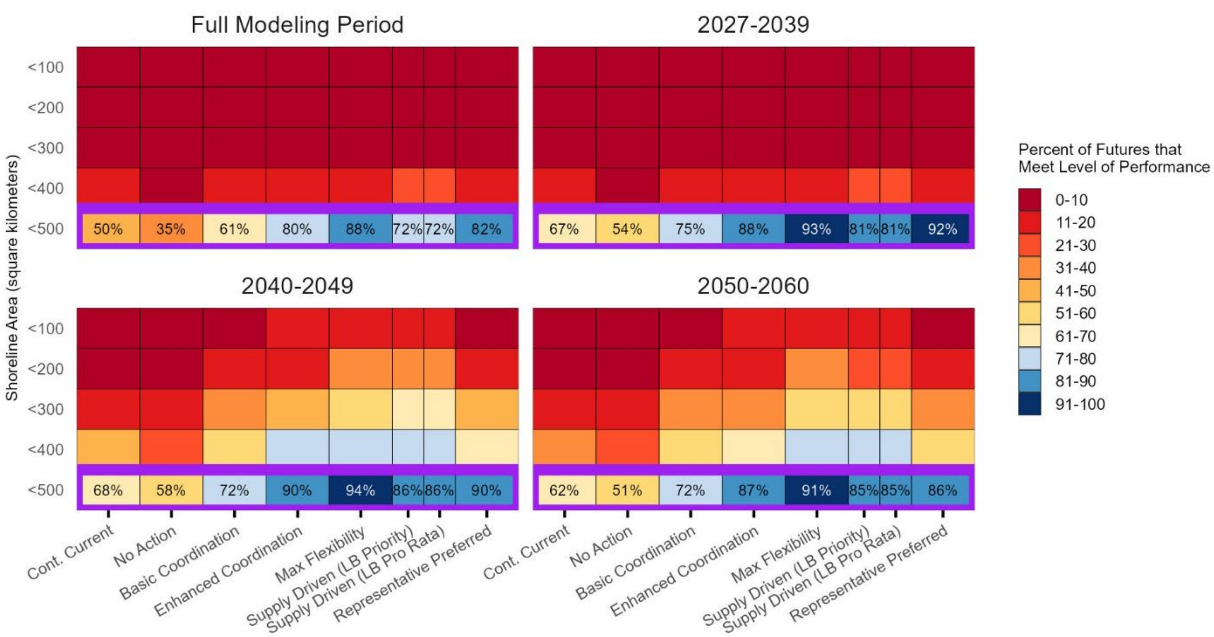
In the Critically Dry Flow Category, the median maximum exposed shoreline values for all alternatives at Lake Powell and Lake Mead are above 450 and 400 km^2 (98,842 acres and 111,197 acres), respectively. Generally, both reservoirs exhibit smaller interquartile ranges in comparison to the other flow categories. At Lake Powell, the CCS Comparative Baseline, as well as No Action, Basic Coordination, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives show relatively similar median maximum exposed shoreline, ranging from roughly 520 to 535 km^2 (128,495 to 132,301 acres). At Lake Mead, the Enhanced Coordination, Maximum Operational Flexibility, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives display similar medians, ranging from 420 to 425 km^2 (103,784 to 105,020 acres). For all alternatives and both locations, the km^2 of maximum shoreline exposure shift higher relative to their respective medians as conditions get drier.

Lake Mead Robustness

Figure TA 7-5, below depicts the ability of each alternative to maintain Lake Mead shoreline exposure below the specified area in every month. The preferred minimum performance is shown in the purple highlighted row, which represents the percentage of futures in which the exposed shoreline area for each alternative remains below 500 km^2 (123,553 acres) in every month. For Lake Mead, 500 km^2 (123,553 acres) is a very rough approximation of the area of shoreline exposed when the reservoir is filled to minimum power pool (950 feet). Keeping the Lake Mead shoreline exposure below 500 km^2 (123,553 acres) ensures that fugitive dust will be minimized.

Four modeling periods are shown to capture the full modeling period, 2027-2039, 2040-2049, and 2050-2060. The color of a heat map square corresponds with the percent of futures that meet the specified level of performance, which increases from a red color representing less than 10 percent of futures keeping the Lake Mead shoreline exposure area below the specified value in every month (least robust), to a dark blue color representing greater than 91 percent of futures keeping the Lake Mead shoreline exposure area below the specified value in every month (most robust).

Figure TA 7-5
Lake Mead Shoreline Area in Lake Mead National Recreation Area: Robustness. Percent of futures in which the exposed shoreline area is below the value specified in each row in every month



The comparison described here focuses on the preference to stay below 500 km^2 (123,553 acres) of exposed shoreline every month. The selected value accounts for variability, while mathematically limiting the number of instances exceeding 500 km^2 (123,553 acres), which signifies likely fugitive dust minimization.

In the full modeling period, the Enhanced Coordination, Representative Preferred, and Maximum Operational Flexibility Alternatives meet the preferred minimum performance in 80 percent, 82 percent, and 88 percent of modeled futures, respectively, which is more robust than the other alternatives. The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) meets the preferred minimum performance in 72 percent of modeled futures. The CCS Comparative Baseline, as well as No Action and Basic Coordination Alternatives, are only able to meet the preferred minimum performance in 50 percent, 35 percent, and 61 percent of futures, respectively. Therefore, the Maximum Operational Flexibility and Enhanced Coordination Alternatives are the most robust at staying below 500 km^2 (123,553 acres) of exposed shoreline over the full modeling period. The No Action Alternative has the worst performance over the full modeling period.

In the first decadal breakout (2027 – 2039), the Representative Preferred, Maximum Operational Flexibility, and Enhanced Coordination Alternatives meet the preferred minimum performance in 92 percent, 93 percent and 88 percent of modeled futures, respectively, which is more robust than the other alternatives. The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) meets the preferred minimum performance in 81 percent of modeled futures. The CCS Comparative Baseline, as well as No Action and Basic Coordination Alternatives, are only able to meet the preferred minimum performance in 67 percent, 54 percent, and 75 percent of futures, respectively. Therefore, the Maximum Operational Flexibility and Enhanced Coordination Alternatives are the most robust at staying below 500 km^2 (123,553 acres) of exposed shoreline over the 2027 – 2039 modeling period. The No Action Alternative has the worst performance over the 2027 – 2039 modeling period. Based on the planned length of this decision, it is important to note that the Representative Preferred Alternative meets the preferred minimum performance level in 92 percent of futures in the 2027-2039 modeling period.

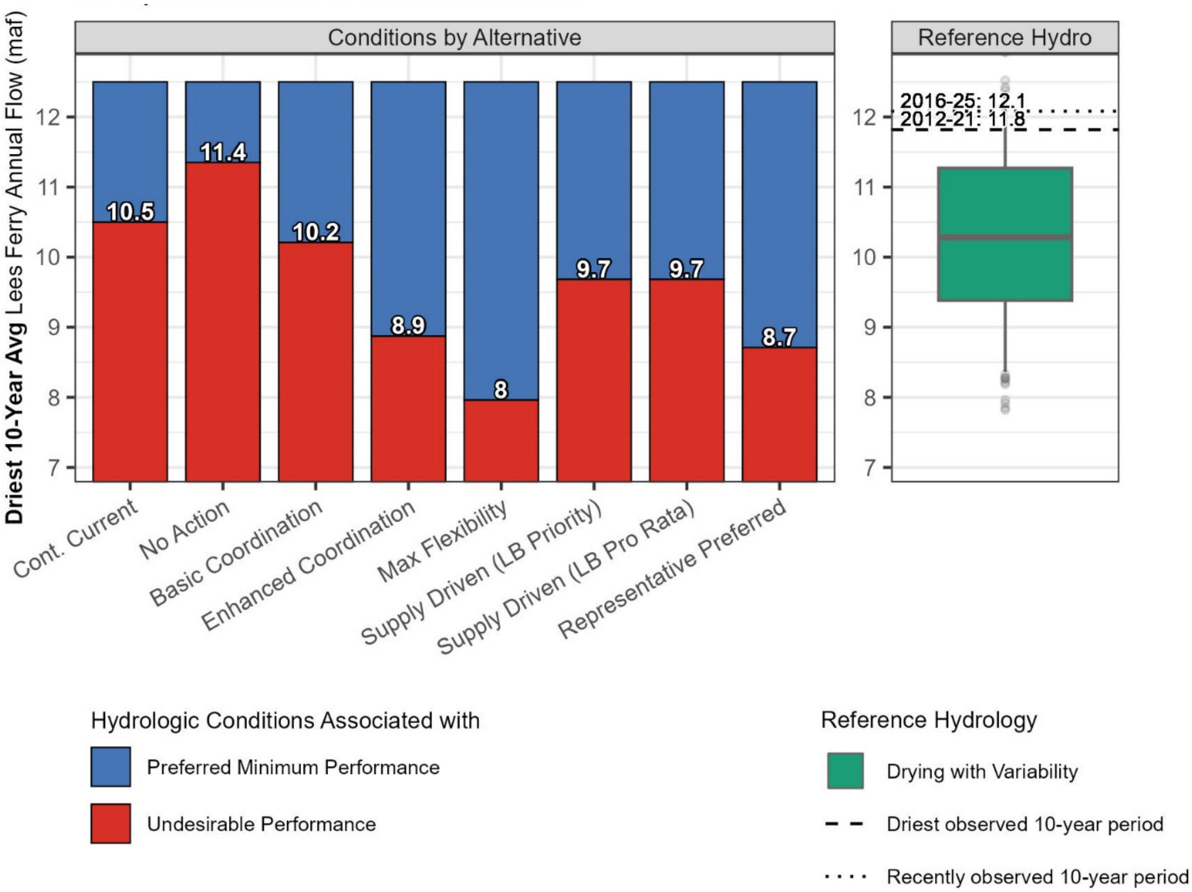
The Representative Preferred Alternative meets staying below 500 km^2 (123,553 acres) of exposed shoreline robustness criteria in 82 percent of modeled futures in the full modeling period. Based on the planned length of this decision, it's important to note that it meets the preferred minimum performance level in 92 percent of futures in the first modeling period.

In the three subperiods, the alternatives meet the preferred minimum level of performance in greater percentages of futures because the preferred standard is easier to meet over shorter time spans than over the full 34 years. The robustness ranking across the three alternatives in each subperiod is consistent with the ranking in the full modeling period. The 2040–2049 modeling period generally has the most successful futures with all alternatives meeting the preferred minimum performance level in over 58 percent of futures.

Figure TA 7-6 below shows what flow conditions are likely to cause Lake Mead exposed shoreline area to exceed 500 km^2 (123,553 acres) in one or more months. This definition of undesirable performance is based on the highlighted row in **Figure TA 7-5** above, which defined a future as successful when exposed shoreline area for an alternative remains below 500 km^2 (123,553 acres) in every month.

For this vulnerability analysis, the driest 10-year average Lees Ferry annual flow was determined to be skillful at predicting undesirable performance. The vulnerability threshold for each alternative is described and compared to the Drying with Variability ensemble using this streamflow summary statistic. The driest observed 10-year average flow from 2012-2021 (11.8 million acre-feet [maf]) and the average flow from 2016-2025 (12.1 maf) are also provided as dashed and dotted lines, respectively, for comparison.

Figure TA 7-6
Lake Mead Shoreline Area in Lake Mead National Recreation Area: Vulnerability. Conditions that Could Cause Lake Mead Exposed Shoreline Area Above 500 Square Kilometers (123,553 acres) in One or More Months



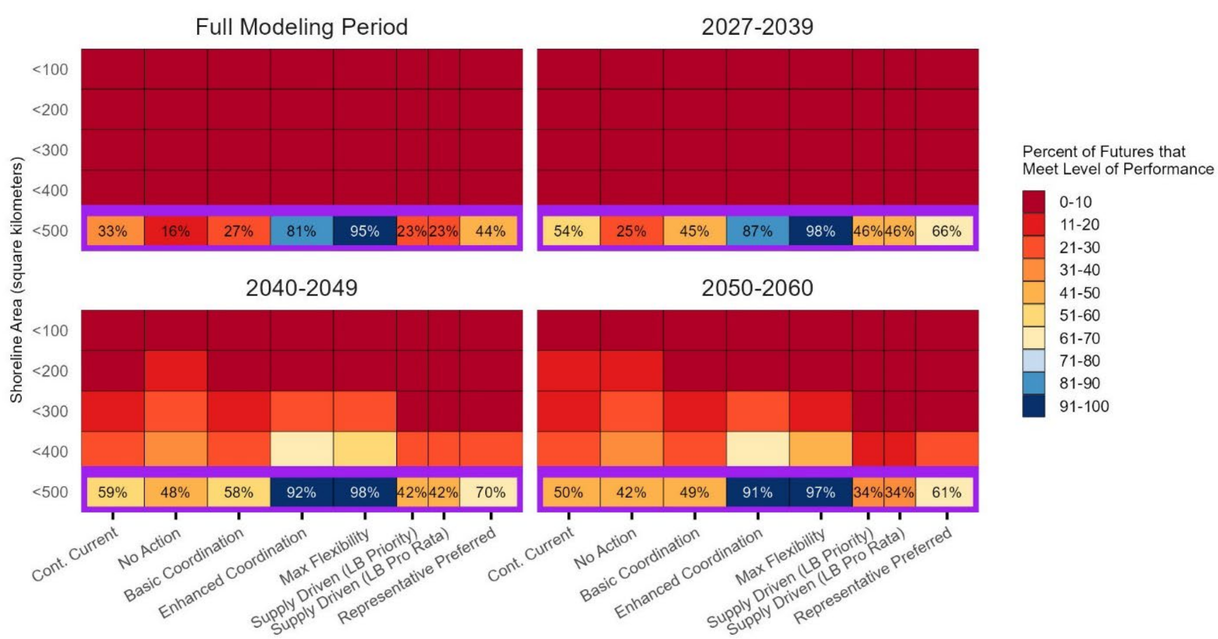
The Basic Coordination Alternative would likely be vulnerable to a Lake Mead exposed shoreline area greater than 500 km^2 (123,553 acres) under a 10-year average Lees Ferry natural flow of 10.2 maf or drier, which is slightly less vulnerable than the CCS Comparative Baseline, which is likely to be vulnerable if the 10-year average is 10.5 maf or drier. The No Action Alternative is vulnerable to a 10-year average of 11.4 maf, which is similar to the driest observed 10-year average of 11.8 maf. The Enhanced Coordination, Maximum Operational Flexibility, and Supply Driven Alternatives are not likely to be vulnerable to undesirable performance unless the 10-year average flow is much drier than any observed conditions and fewer than 50 percent of the traces in the Drying with Variability ensemble include conditions that would be likely to cause vulnerability in these alternatives.

The Representative Preferred Alternative is likely to be vulnerable if the driest 10-year average Lees Ferry annual flow is 8.7 maf or less. Compared to the historical periods shown in the reference hydrology panel, this flow has not occurred before. Compared to the Drying with Variability Ensemble that represents potential future hydrologic conditions, 100 percent of the traces have a 10-year period drier than the vulnerability threshold for the Representative Preferred Alternative.

Lake Powell Robustness

Figure TA 7-7 below depicts the ability of each alternative to maintain Lake Powell shoreline exposure below the specified area in every month. The preferred minimum performance is shown in the purple highlighted row, which represents the percentage of futures in which the exposed shoreline area for each alternative remains below 500 km^2 (123,553 acres) in every month. For Lake Powell, 500 km^2 (123,553 acres) is a very rough approximation of the area of shoreline exposed when the reservoir is filled to minimum power pool (3,490 feet). Keeping the Lake Powell shoreline exposure below 500 km^2 (123,553 acres) ensures that fugitive dust will be minimized.

Figure TA 7-7
Lake Powell Shoreline Area in Glen Canyon National Recreation Area: Robustness. Percent of futures in which the exposed shoreline area is below the value specified in each row in every month



Four modeling periods are shown to capture the full modeling period, 2027-2039, 2040-2049, and 2050-2060. The color of a heat map square corresponds with the percent of futures that meet the specified level of performance, which increases from a red color representing less than 10 percent of futures keeping the Lake Powell shoreline exposure area below the specified value in every month (least robust), to a dark blue color representing greater than 91 percent of futures keeping the Lake Powell shoreline exposure area below the specified value in every month (most robust).

The comparison described here focuses on the preference to stay below a maximum value of 500 km^2 (123,553 acres) of exposed shoreline. The selected value accounts for variability, while mathematically limiting the number of instances exceeding 500 km^2 (123,553 acres), which signifies likely fugitive dust minimization.

In the full modeling period, the Enhanced Coordination and Maximum Operational Flexibility Alternatives meet the preferred minimum performance in 81 percent and 95 percent of modeled futures, respectively. The No Action Alternative meets the preferred minimum performance in 16 percent of modeled futures. The CCS Comparative Baseline, as well as the Basic Coordination and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives meet the preferred minimum performance in 33 percent, 27 percent, and 23 percent of futures, respectively. Therefore, the Maximum Operational Flexibility and Enhanced Coordination Alternatives are the most robust at staying below 500 km^2 (123,553 acres) of shoreline exposure over the full modeling period, while the No Action Alternative has the worst performance over the full analysis period.

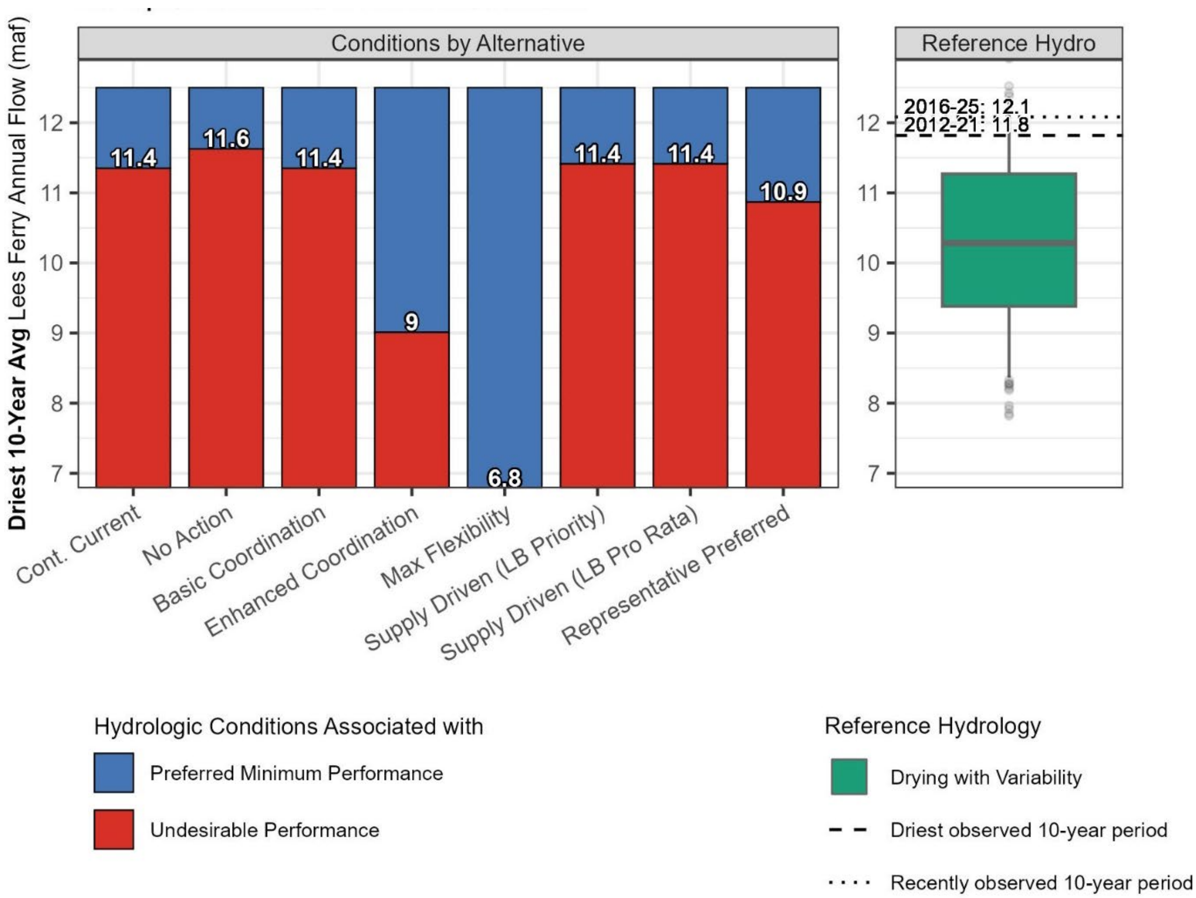
In the first decadal breakout (2027 – 2039), the Enhanced Coordination and Maximum Operational Flexibility Alternatives meet the preferred minimum performance in 87 percent and 98 percent of modeled futures, respectively. The No Action Alternative meets the preferred minimum performance in 25 percent of modeled futures. The CCS Comparative Baseline, as well as the Basic Coordination and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives meet the preferred minimum performance in 54 percent, 45 percent, and 46 percent of futures, respectively. Therefore, the Maximum Operational Flexibility and Enhanced Coordination Alternatives are the most robust at staying below 500 km^2 (123,553 acres) of shoreline exposure over the 2027 – 2039 modeling period, while the No Action Alternative has the worst performance over the 2027 – 2039 analysis period. Based on the planned length of this decision, it is important to note that the Representative Preferred Alternative meets the preferred minimum performance level in 66 percent of futures in the 2027-2039 modeling period.

The Representative Preferred Alternative meets staying below 500 km^2 (123,553 acres) of exposed shoreline robustness criteria in 44 percent of modeled futures in the full modeling period. Based on the planned length of this decision, it’s important to note that it meets the preferred minimum performance level in 66 percent of futures in the first modeling period.

In the three subperiods, the alternatives meet the preferred minimum level of performance in greater percentages of futures because the preferred standard is easier to meet over shorter time spans than over the full 34 years. In the three subperiods, the Enhanced Coordination and Maximum Operational Flexibility Alternatives can meet the preferred minimum performance in more than 87 percent of futures, which is considerably more robust than the other alternatives. The robustness ranking across the three alternatives in each subperiod is largely consistent with the ranking in the full modeling period.

Figure TA 7-8 below shows what flow conditions are likely to cause Lake Powell exposed shoreline area to exceed 500 km^2 (123,553 acres) in one or more months. This definition of undesirable performance is based on the highlighted row in **Figure TA 7-7** above, which defined a future as successful when exposed shoreline area for an alternative remains below 500 km^2 (123,553 acres) in every month.

Figure TA 7-8
Lake Powell Shoreline Area in Glen Canyon National Recreation Area: Vulnerability. Conditions that Could Cause Lake Powell Exposed Shoreline Area Above 500 Square Kilometers in One or More Months



For this vulnerability analysis, the driest 10-year average Lees Ferry annual flow was determined to be skillful at predicting undesirable performance. The vulnerability threshold for each alternative is described and compared to the Drying with Variability ensemble using this streamflow summary statistic. The driest observed 10-year average flow from 2012-2021 (11.8 maf) and the average flow from 2016-2025 (12.1 maf) are also provided as dashed and dotted lines, respectively, for comparison.

If the future includes a 10-year average flow of 11.6 maf or lower, the No Action Alternative results indicate undesirable performance. The CCS Comparative Baseline, as well as the Basic Coordination and Supply Driven (both LB Priority and LB Pro Rata) Alternatives, are similar to the No Action Alternative, reaching undesirable performance when the 10-year average flow is 11.4 maf or lower. These conditions correspond to undesirable performance levels comparable to the driest observed

10-year average flow of 11.8 maf, with roughly 75 to 90 percent of the Drying with Variability traces occurring below these thresholds.

The Enhanced Coordination Alternative modeling results indicate undesirable performance at a 10-year average flow of 9 maf or drier, which occurs in less than 25 percent of the Drying with Variability traces. The Maximum Operational Flexibility Alternative is least vulnerable, with no Drying with Variability traces occurring below the undesirable performance level of 6.8 maf.

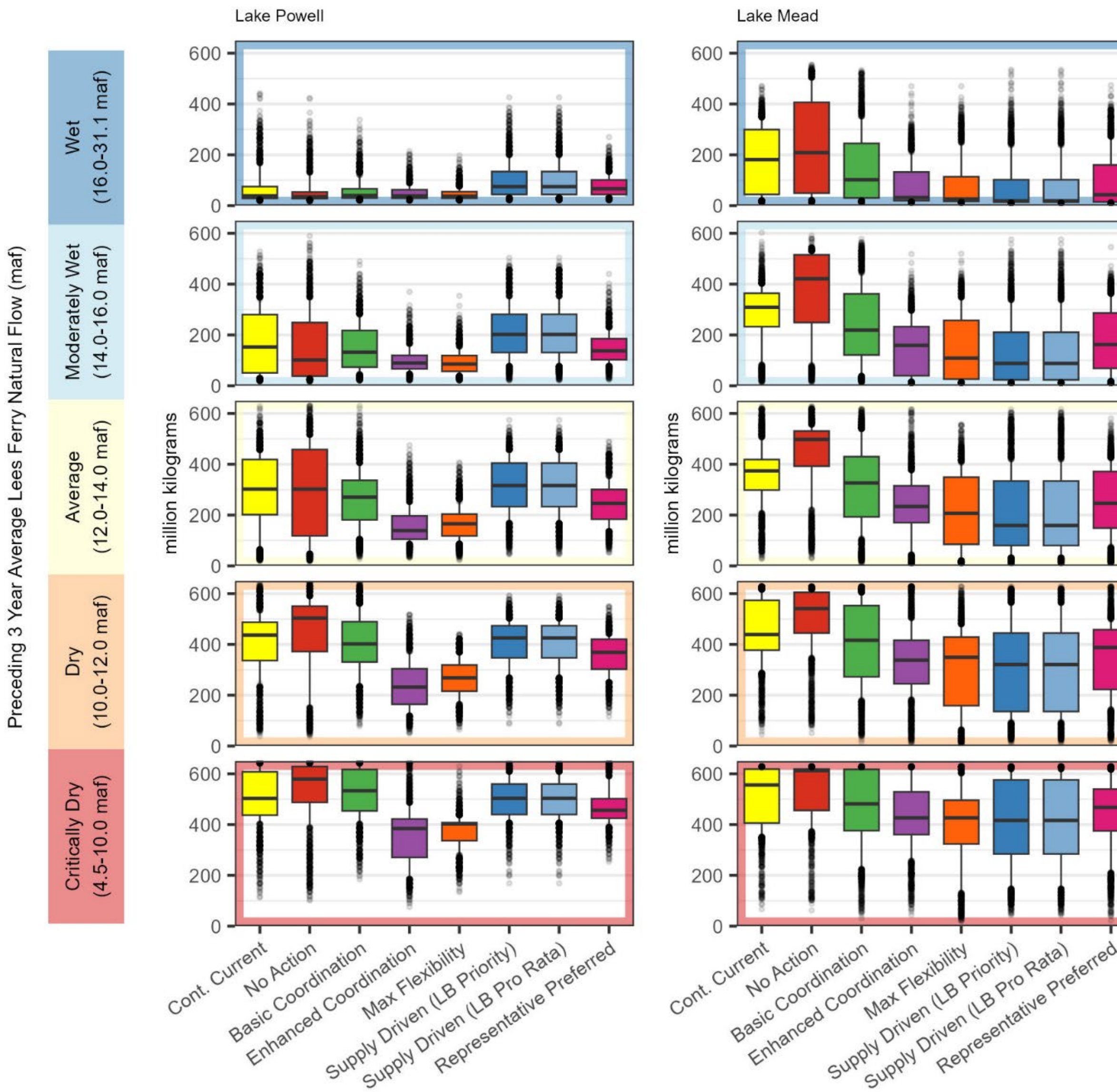
The Representative Preferred Alternative is likely to be vulnerable if the driest 10-year average Lees Ferry annual flow is 10.9 maf or less. Compared to the historical periods shown in the reference hydrology panel, this flow has not occurred before. Compared to the Drying with Variability Ensemble that represents potential future hydrologic conditions, 30 percent of the traces have a 10-year period drier than the vulnerability threshold for the Representative Preferred Alternative.

Figure TA 7-9 shows the WY maximum monthly shoreline dust emission for Lake Powell and Lake Mead, in million kg of $PM_{2.5}$, and broken out by hydrologic conditions and categorized by the preceding three-year average Lees Ferry natural flows.

In the Average Flow Category, Lake Powell alternatives have varying distributions, with the 25th to 75th percentiles across all alternatives spanning from approximately 105 to 460 million kg (231 to 1,014 million pounds) of $PM_{2.5}$ emissions as a result of shoreline exposure. The CCS Comparative Baseline, as well as No Action, Basic Coordination, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives, have similar median maximum monthly emission rates of around 300 million kg (661 million pounds) of $PM_{2.5}$ as a result of shoreline exposure, while the Enhanced Coordination and Maximum Operational Flexibility Alternatives display lower medians of around 150 million kg (331 million pounds) of $PM_{2.5}$. The Lake Mead alternatives have varying distributions, with the 25th to 75th percentiles across all alternatives spanning from 80 to 540 million kg (176 to 1,190 million pounds) of $PM_{2.5}$ emissions as a result of shoreline exposure. In comparison to Lake Powell, the median monthly emission rates are more variable for Lake Mead, with the No Action and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives displaying the highest and lowest values at about 500 and 160 million kg (1,102 and 353 million pounds) of $PM_{2.5}$, respectively.

The Representative Preferred Alternative exhibits the following outcomes with respect to the Dry Flow Category: For the Lake Powell $PM_{2.5}$ emissions as a result of shoreline exposure, the median $PM_{2.5}$ emissions is about 369 million kg (814 million pounds), with the 25th to 75th percentiles across all alternatives spanning from 303 to 421 million kg (668 to 928 million pounds) of $PM_{2.5}$ emissions as a result of shoreline exposure. The Representative Preferred Alternative exhibits the following outcomes with respect to the Critically Dry Flow Category: For the Lake Powell $PM_{2.5}$ emissions as a result of shoreline exposure, the median $PM_{2.5}$ emissions is about 456 million kg (1,005 million pounds), with the 25th to 75th percentiles across all alternatives spanning from 425 to 502 million kg (937 to 1,107 million pounds) of $PM_{2.5}$ emissions as a result of shoreline exposure.

Figure TA 7-9
Water Year Maximum Monthly Shoreline Dust Emissions for Lake Powell and Lake Mead (million kilograms)



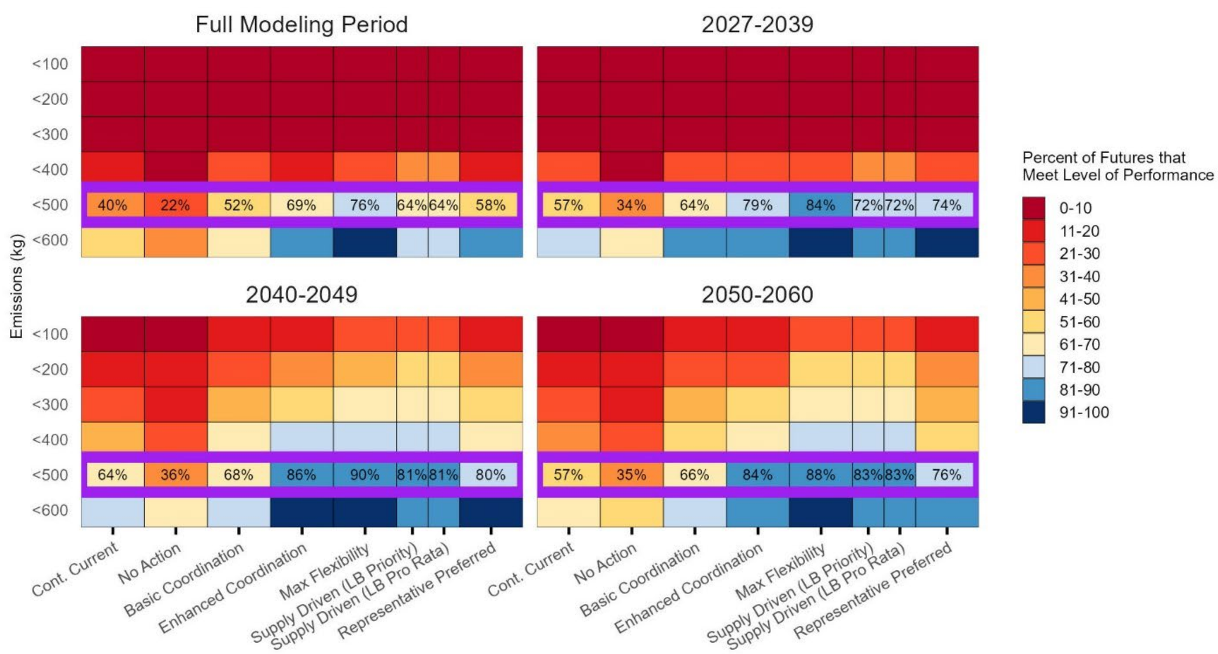
The Representative Preferred Alternative exhibits the following outcomes with respect to the Dry Flow Category: For the Lake Mead $PM_{2.5}$ emissions as a result of shoreline exposure, the median $PM_{2.5}$ emissions is about 388 million kg (855 million pounds), with the 25th to 75th percentiles across all alternatives spanning from 223 to 458 million kg (492 to 1,010 million pounds) of $PM_{2.5}$ emissions as a result of shoreline exposure. The Representative Preferred Alternative exhibits the following outcomes with respect to the Critically Dry Flow Category: For the Lake Mead $PM_{2.5}$ emissions as a result of shoreline exposure, the median $PM_{2.5}$ emissions is about 468 million kg (1,032 million pounds), with the 25th to 75th percentiles across all alternatives spanning from 375 to 540 million kg (827 to 1,191 million pounds) of $PM_{2.5}$ emissions as a result of shoreline exposure.

As conditions become wetter, the maximum monthly shoreline dust emissions show lower median rates, with the Wet Flow Category also displaying the smallest interquartile ranges. On the other hand, maximum monthly shoreline dust emissions shift higher during drier conditions when more shoreline is exposed.

Lake Mead Robustness

Figure TA 7-10, below depicts the performance of each alternative to maintain Lake Mead shoreline dust ($PM_{2.5}$) emissions below the specified value in every month. The preferred minimum performance is shown in the purple highlighted row, which represents the percentage of futures in which the shoreline dust emissions are less than 500 million kg (1,102 million pounds) in every month. Keeping the Lake Mead emissions below 500 million kg (1,102 million pounds) minimizes fugitive dust; therefore, protecting air quality in the area and represents the reasonable approximation of the emission value that would occur when the lake is full enough with water to operate the dam to generate power.

Figure TA 7-10
Lake Mead Shoreline Dust (PM 2.5) Emissions in Lake Mead National Recreation Area: Robustness.
Percent of futures in which emissions are less than the value specified in each row in every month



Four modeling periods are shown to capture the full modeling period, 2027-2039, 2040-2049, and 2050-2060. The color of a heat map square corresponds with the percent of futures that meet the specified level of performance, which increases from a red color representing less than 10 percent of futures keeping the Lake Mead shoreline dust emissions below the specified value in every month (least robust), to a dark blue color representing greater than 91 percent of futures keeping the Lake Mead shoreline dust emissions below the specified value in every month (most robust).

The comparison described here focuses on the preference to stay below 500 million kg (1,102 million pounds) of shoreline dust emissions. The selected value accounts for variability, while mathematically limiting the number of instances exceeding 500 million kg (1,102 million pounds), which signifies likely fugitive dust minimization.

In the full modeling period, the Enhanced Coordination and Maximum Operational Flexibility Alternatives can meet the preferred minimum performance in 69 percent and 76 percent of modeled futures, respectively, which is more robust than the other alternatives. The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) can meet the preferred minimum performance in 64 percent of modeled futures. The CCS Comparative Baseline, as well as the No Action and Basic Coordination Alternatives, are only able to meet the preferred minimum performance in 40 percent, 22 percent, and 52 percent of futures, respectively.

In the first decadal breakout (2027 – 2039), the Enhanced Coordination and Maximum Operational Flexibility Alternatives can meet the preferred minimum performance in 79 percent and 84 percent of modeled futures, respectively, which is more robust than the other alternatives. The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) can meet the preferred minimum performance in 72 percent of modeled futures. The CCS Comparative Baseline, as well as the No Action and Basic Coordination Alternatives, are only able to meet the preferred minimum performance in 57 percent, 34 percent, and 64 percent of futures, respectively. Based on the planned length of this decision, it is important to note that the Representative Preferred Alternative meets the preferred minimum performance level in 74 percent of futures in the 2027-2039 modeling period.

The Representative Preferred Alternative meets staying below 500 million kg (1,102 million pounds) of shoreline dust emissions robustness criteria in 58 percent of modeled futures in the full modeling period. Based on the planned length of this decision, it's important to note that it meets the preferred minimum performance level in 74 percent of futures in the first modeling period.

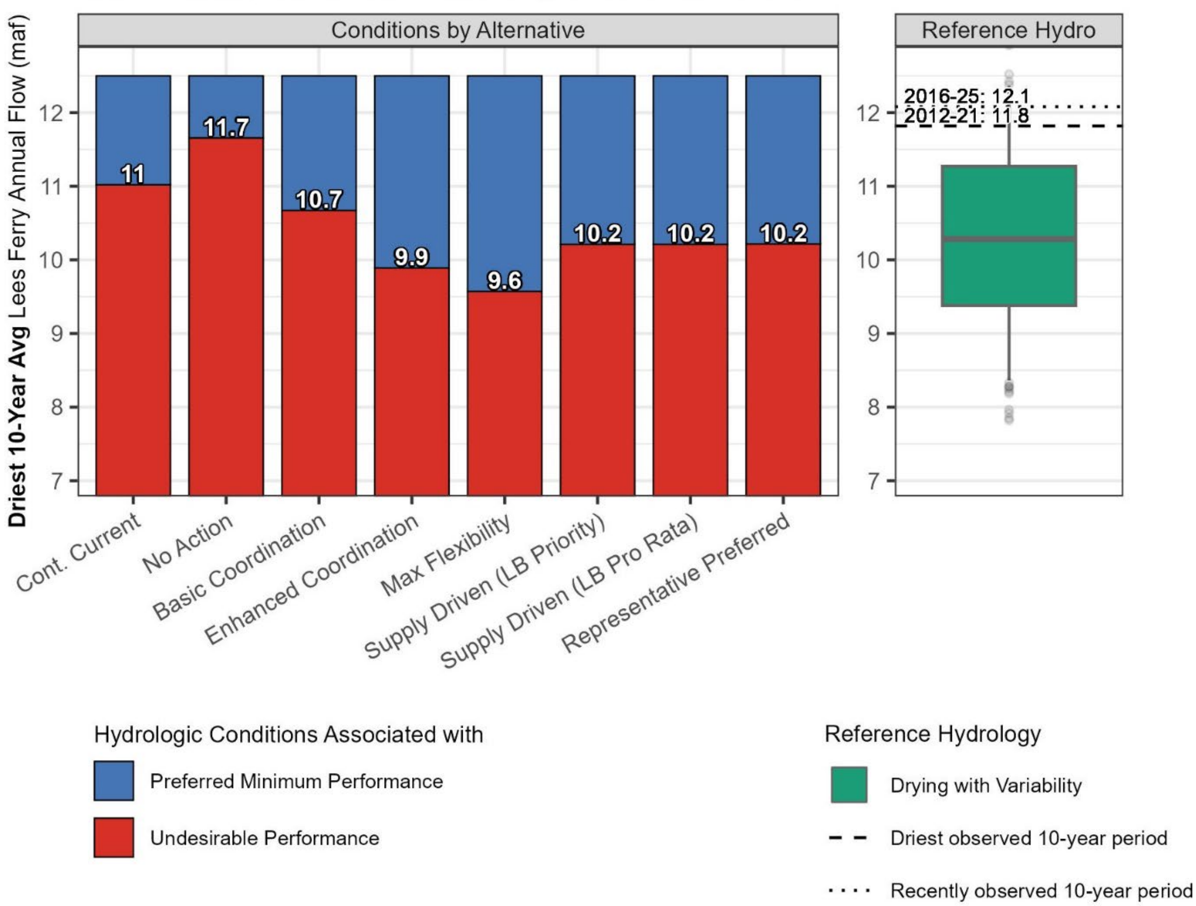
In the three subperiods, the alternatives meet the preferred minimum level of performance in greater percentages of futures because the preferred standard is easier to meet over shorter time spans than over the full 34 years. The robustness ranking across the three alternatives in each subperiod is consistent with the ranking in the full modeling period.

Figure TA 7-11 below shows what flow conditions are likely to cause Lake Mead shoreline dust ($PM_{2.5}$) emissions to exceed 500 million kg (1,102 million pounds) in one or more months. This definition of undesirable performance is based on the highlighted row in **Figure TA 7-10** above, which defined a future as successful when shoreline dust emissions for an alternative are less than 500 million kg (1,102 million pounds) in every month.

For this vulnerability analysis, the driest 10-year average Lees Ferry annual flow was determined to be skillful at predicting undesirable performance. The vulnerability threshold for each alternative is described and compared to the Drying with Variability ensemble using this streamflow summary statistic. The driest observed 10-year average flow from 2012-2021 (11.8 maf) and the average flow from 2016-2025 (12.1 maf) are also provided as dashed and dotted lines, respectively, for comparison.

The No Action Alternative would likely be vulnerable to undesirable shoreline dust emissions under a driest 10-year average Lees Ferry flow of 11.7 maf or drier, which is similar to the driest observed 10-year average of 11.8 maf. The CCS Comparative Baseline, as well as Basic Coordination and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives reach undesirable performance at a driest 10-year average flow that occurs in 50 to 75 percent of the Drying with Variability traces, suggesting these alternatives are reasonably likely to be vulnerable. The Enhanced Coordination and Maximum Operational Flexibility Alternatives are not likely to be vulnerable to undesirable performance unless the 10-year average flow is much drier than any observed conditions, and fewer than 50 percent of the traces in the Drying with Variability ensemble include conditions that would be likely to cause vulnerability in these alternatives.

Figure TA 7-11
Lake Mead Shoreline Dust (PM 2.5) Emissions in Lake Mead National Recreation Area: Vulnerability.
Conditions that Could Cause Lake Mead Emissions Above 500 million kilograms in One or More Months



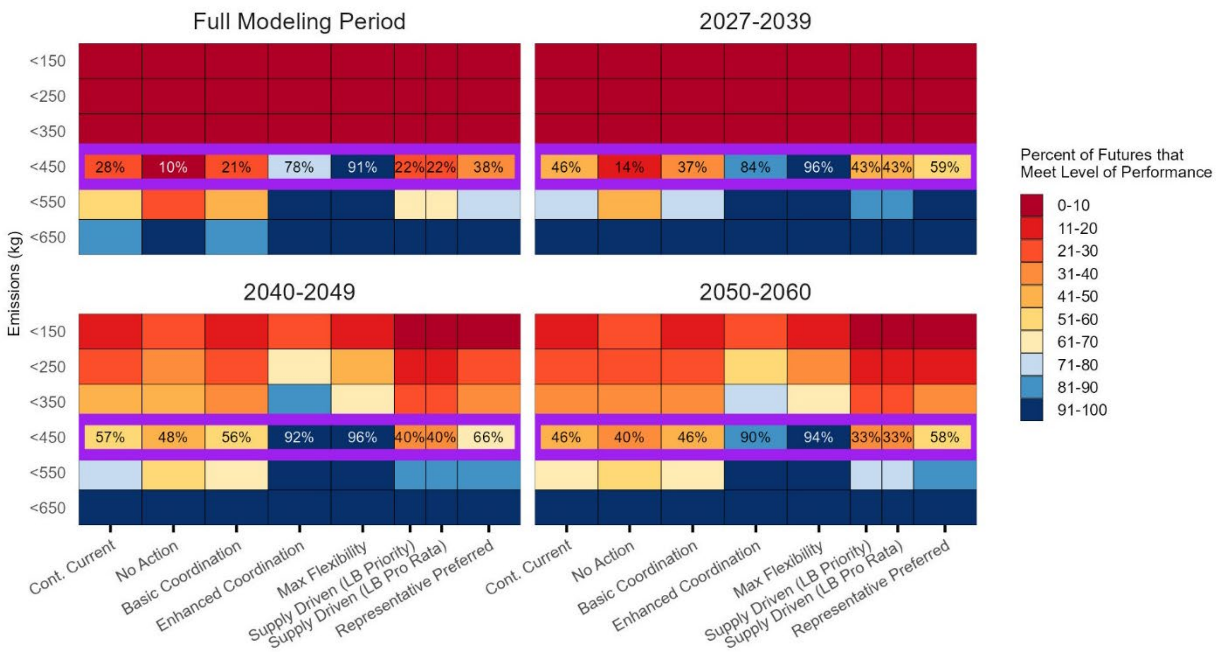
The Representative Preferred Alternative is likely to be vulnerable if the driest 10-year average Lees Ferry annual flow is 10.2 maf or less. Compared to the historical periods shown in the reference hydrology panel, this flow has not occurred before. Compared to the Drying with Variability

Ensemble that represents potential future hydrologic conditions, 20 percent of the traces have a 10-year period drier than the vulnerability threshold for the Representative Preferred Alternative.

Lake Powell Robustness

Figure TA 7-12, below depicts the performance of each alternative to maintain Lake Powell shoreline dust ($PM_{2.5}$) emissions below the specified value in every month. The preferred minimum performance is shown in the purple highlighted row, which represents the percentage of futures in which the shoreline dust emissions are less than 450 million kg (992 million pounds) every month. Keeping the Lake Powell emissions below 450 million kg (992 million pounds) ensures that fugitive dust would be minimized protecting air quality in the area and represents the reasonable approximation of the emission value that would occur when the lake is full enough with water to operate the dam to generate power.

Figure TA 7-12
Lake Powell Shoreline Dust (PM 2.5) Emissions in Glen Canyon National Recreation Area: Robustness.
Percent of futures in which emissions are less than the value specified in each row in every month



Four modeling periods are shown to capture the full modeling period, 2027-2039, 2040-2049, and 2050-2060. The color of a heat map square corresponds with the percent of futures that meet the specified level of performance, which increases from a red color representing less than 10 percent of futures keeping the Lake Powell shoreline dust emissions below the specified value in every month (least robust), to a dark blue color representing greater than 91 percent of futures keeping the Lake Powell shoreline dust emissions below the specified value in every month (most robust).

The comparison described here focuses on the preference to stay below a maximum value of 450 million kg (992 million pounds) of shoreline dust emissions. The selected value accounts for variability, while mathematically limiting the number of instances exceeding 450 million kg (992 million pounds), which signifies likely fugitive dust minimization.

In the full modeling period, the Enhanced Coordination and Maximum Operational Flexibility Alternatives meet the preferred minimum performance in 78 percent and 91 percent of modeled futures, respectively, which is considerably more robust than the other alternatives. The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) can meet the preferred minimum performance in 22 percent of modeled futures. The CCS Comparative Baseline, as well as No Action and Basic Coordination Alternatives, are only able to meet the preferred minimum performance in 28 percent, 10 percent, and 21 percent of futures, respectively.

In the first decadal breakout (2027 – 2039), the Enhanced Coordination and Maximum Operational Flexibility Alternatives meet the preferred minimum performance in 84 percent and 96 percent of modeled futures, respectively, which is considerably more robust than the other alternatives. The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) can meet the preferred minimum performance in 43 percent of modeled futures. The CCS Comparative Baseline, as well as No Action and Basic Coordination Alternatives, are only able to meet the preferred minimum performance in 46 percent, 14 percent, and 37 percent of futures, respectively. Based on the planned length of this decision, it is important to note that the Representative Preferred Alternative meets the preferred minimum performance level in 59 percent of futures in the 2027-2039 modeling period.

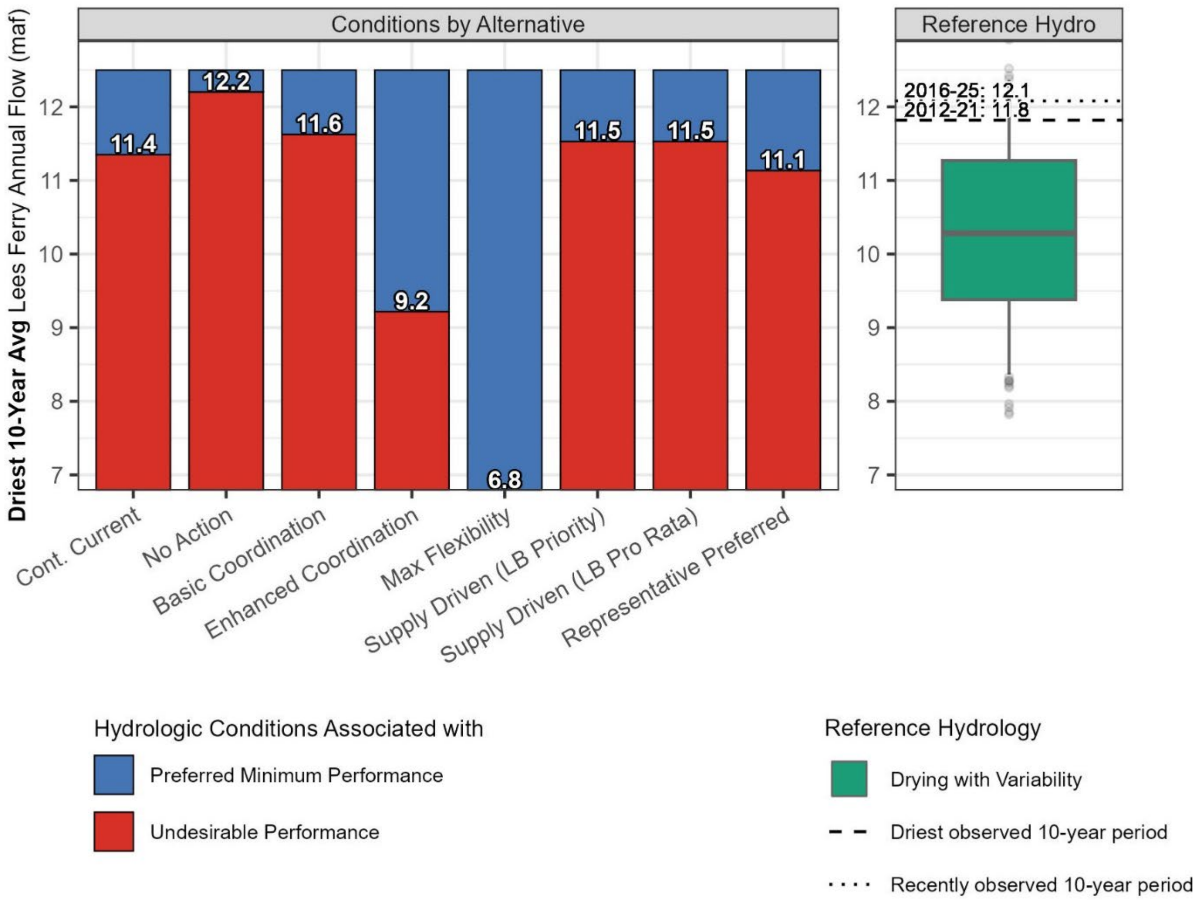
The Representative Preferred Alternative meets staying below 450 million kg (992 million pounds) of shoreline dust emissions robustness criteria in 38 percent of modeled futures in the full modeling period. Based on the planned length of this decision, it's important to note that it meets the preferred minimum performance level in 59 percent of futures in the first modeling period.

In the three subperiods, the alternatives meet the preferred minimum level of performance in greater percentages of futures because the preferred standard is easier to meet over shorter time spans than over the full 34 years. In the three subperiods, the Enhanced Coordination and Maximum Operational Flexibility Alternatives can meet the preferred minimum performance in more than 80 percent of futures, which is considerably more robust than the other alternatives.

Figure TA 7-13 below shows what flow conditions are likely to cause Lake Powell shoreline dust ($PM_{2.5}$) emissions to exceed 450 million kg (992 million pounds) in one or more months. This definition of undesirable performance is based on the highlighted row in **Figure TA 7-12** above, which defined a future as successful when shoreline dust emissions for an alternative are less than 450 million kg (992 million pounds) in every month.

For this vulnerability analysis, the driest 10-year average Lees Ferry annual flow was determined to be skillful at predicting undesirable performance. The vulnerability threshold for each alternative is described and compared to the Drying with Variability ensemble using this streamflow summary statistic. The driest observed 10-year average flow from 2012-2021 (11.8 maf) and the average flow from 2016-2025 (12.1 maf) are also provided as dashed and dotted lines, respectively, for comparison.

Figure TA 7-13
Lake Powell Shoreline Dust (PM 2.5) Emissions in Glen Canyon National Recreation Area: Vulnerability.
Conditions that Could Cause Lake Powell Emissions Above 450 million kilograms in One or More Months



The No Action Alternative would likely be vulnerable to undesirable shoreline dust emissions under a 10-year average Lees Ferry natural flow of 12.2 maf or drier, which is similar to the recently observed 10-year average of 12.1 maf. The CCS Comparative Baseline, as well as Basic Coordination and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives, have similar results, indicating undesirable performance during a 10-year average flow ranging from 11.4–11.6 maf or lower. These results are also similar to the driest observed 10-year average flow (11.8 maf), with roughly 75 to 90 percent of the Drying with Variability traces including conditions that would be likely to cause vulnerability in these alternatives. The Enhanced Coordination Alternative modeling results indicate undesirable performance at a 10-year average flow of 9.2 maf or lower, which occurs in less than 25 percent of the Drying with Variability traces. The Maximum Operational Flexibility

Alternative is least vulnerable, with no Drying with Variability traces occurring below the undesirable performance level of 6.8 maf.

The Representative Preferred Alternative is likely to be vulnerable if the driest 10-year average Lees Ferry annual flow is 11.1 maf or less. Compared to the historical periods shown in the reference hydrology panel, this flow has not occurred before. Compared to the Drying with Variability Ensemble that represents potential future hydrologic conditions, 40 percent of the traces have a 10-year period drier than the vulnerability threshold for the Representative Preferred Alternative.

When reservoir elevations are low and there is more dust mobilization and potential acceleration of runoff, snow in locations like the Rockies could be subject to dust on snow effects. Dust darkens the snow surface, reducing its albedo (reflectivity). Clean snow reflects up to 90 percent of sunlight, but when dust is present, more sunlight is absorbed instead of reflected. As a result, snow melts faster, even if temperatures remain low. This effect is especially pronounced in spring, when the sun is stronger. This has the potential to alter water timing in the watersheds. Because snow melts earlier and faster due to dust, the rivers and streams may experience earlier peak flows. This can lead to less water availability in summer when it is most needed (e.g., for agriculture, ecosystems, and human consumption).

Changing flow characteristics can affect the fallowing of agricultural lands, especially in regions that rely on consistent irrigation from reservoirs. If the changing flows result in reduced dam releases, there could be less irrigation water available to downstream farmers. Reduced dam releases could also result in forced fallowing, which occurs when water is insufficient and farmers fallow (intentionally leave idle) some or all of their fields to conserve water for high-value crops and avoid costs associated with planting and irrigation they cannot support.

Information on potential fallowed acreage is presented in **TA 16.2.2** in **TA 16**, Socioeconomics, including **Figure TA 16-1**. As described in that section, estimates of fallowed acreage are based on simplifying assumptions regarding water availability, crop profitability, and agricultural decision-making, and are intended to support regional-scale economic analysis. These estimates are inherently uncertain and do not represent site-specific or on-the-ground predictions of fallowing patterns, which would vary based on localized conditions, such as water availability, soil characteristics, market conditions, and individual farm management decisions.

Fallowed agricultural lands may be a source of fugitive dust emissions, particularly under dry and unvegetated conditions. At a screening level, windblown dust emissions from fallow lands can be estimated using generalized emission factors derived from U.S. EPA AP-42 guidance (EPA 2026). Typical emission factors for fallow or bare agricultural lands range from approximately 0.1 to 0.5 tons of PM_{10} per acre per year, depending on site-specific conditions. Lower emissions within this range would be expected where soils are crusted, vegetated, or otherwise stabilized, while higher emissions may occur in areas with dry, loose soils and greater wind exposure, such as arid environments in the Southwest. $PM_{2.5}$ emissions are generally a fraction of PM_{10} emissions (commonly on the order of 10 to 20 percent), though this proportion may also vary.

Actual emissions from fallowed lands would depend on numerous factors not known at this programmatic stage of analysis, including soil type, surface disturbance, vegetation cover, wind speed, and the presence or absence of dust control measures (e.g., irrigation, soil stabilizers, or conservation practices). In addition, the spatial distribution and timing of fallowing are uncertain and cannot be predicted with sufficient specificity to support detailed emissions modeling. Therefore, while the emission factor range provided above offers a general indication of the potential magnitude of fugitive dust emissions, it should be considered a screening-level approximation only.

Clark County, Nevada is the only county in the analysis area that has been designated as serious nonattainment for the 2015 eight-hour O_3 standard and a maintenance area for CO and PM_{10} (EPA 2025b). In addition, the design value for O_3 for Clark County exceeds the NAAQS for O_3 (0.70 ppm) and the Clark County number of exceedances of the PM_{10} NAAQS exceeds the standard (EPA 2024a). Therefore, shoreline exposure that has the potential to increase particulate matter could further exacerbate the current PM_{10} issue in Clark County.

TA 7.2.3 Issue 2: How would lake reservoir elevations and releases impact power generation and CO_2e emissions?

Issue 2 addresses how operational activities for the various alternatives affect reservoir elevations and therefore impact hydropower generation. When there is a reduction of hydropower, there would be a potential increase of CO_2e emissions due to more emissive alternative energy generation compensating for this reduction (Veselka et al. 2024). There will be a comparison of the four action alternatives and the No Action Alternative to the CCS Comparative Baseline. Power generation depends on the same factors as power capacity, but generation reflects the amount of power created over a certain period. The power generation is more dependent on plant operations through scheduled releases, as these releases, along with other natural factors like rainfall and water availability, determine how much water flows through the turbines over a given amount of time. These models simulate releases and lake reservoir elevations to calculate an estimated generation.

Energy capacity is the maximum possible electric output at a given time. Installed hydropower plant capacity is dependent on generator capacity and turbine efficiency, but the actual capacity is also dependent on the flow rate of water moving through the system. Therefore, the reservoir storage and lake elevation impact capacity for hydropower. Capacity for hydropower is dependent on the time of year as well as water availability differs between the summer and winter months. Lake elevation impacts the head, and a larger head leads to greater potential energy. The maximum capacity of hydropower will be the most instantaneous power generated in a second with the highest water flow possible through the turbines of a hydropower plant. The critical elevations for Lake Powell and Lake Mead are presented in tables in **TA 15**, Dams and Electrical Power Resources. At Lake Powell the minimum power pool is 3,490 feet and when water elevations go below this, Glen Canyon Dam is no longer able to produce hydropower. As described in **Chapter 1**, **Section 1.8.4.1**, this threshold is also important to protect critical infrastructure and water supply. At Lake Mead the minimum power pool is 950 feet and when water elevations go below this, Hoover Dam is no longer able to produce hydropower. This is typically measured in megawatts. This section will consider how the different alternatives impact the generation capacities of the hydropower plants at the Glen Canyon, Hoover, Davis, and Parker dams.

The box plots below report metric tons of CO_2e based on the 2025 resource mix emission factor on the left axis and the 2050 resource mix emission factor on the right axis, utilizing the MWh increase or decrease for each alternative and flow category. Only the 2025 resource mix is discussed in detail, as the 2050 resource mix results would have lower metric tons of CO_2e as the emission factor includes more alternative energy resources.

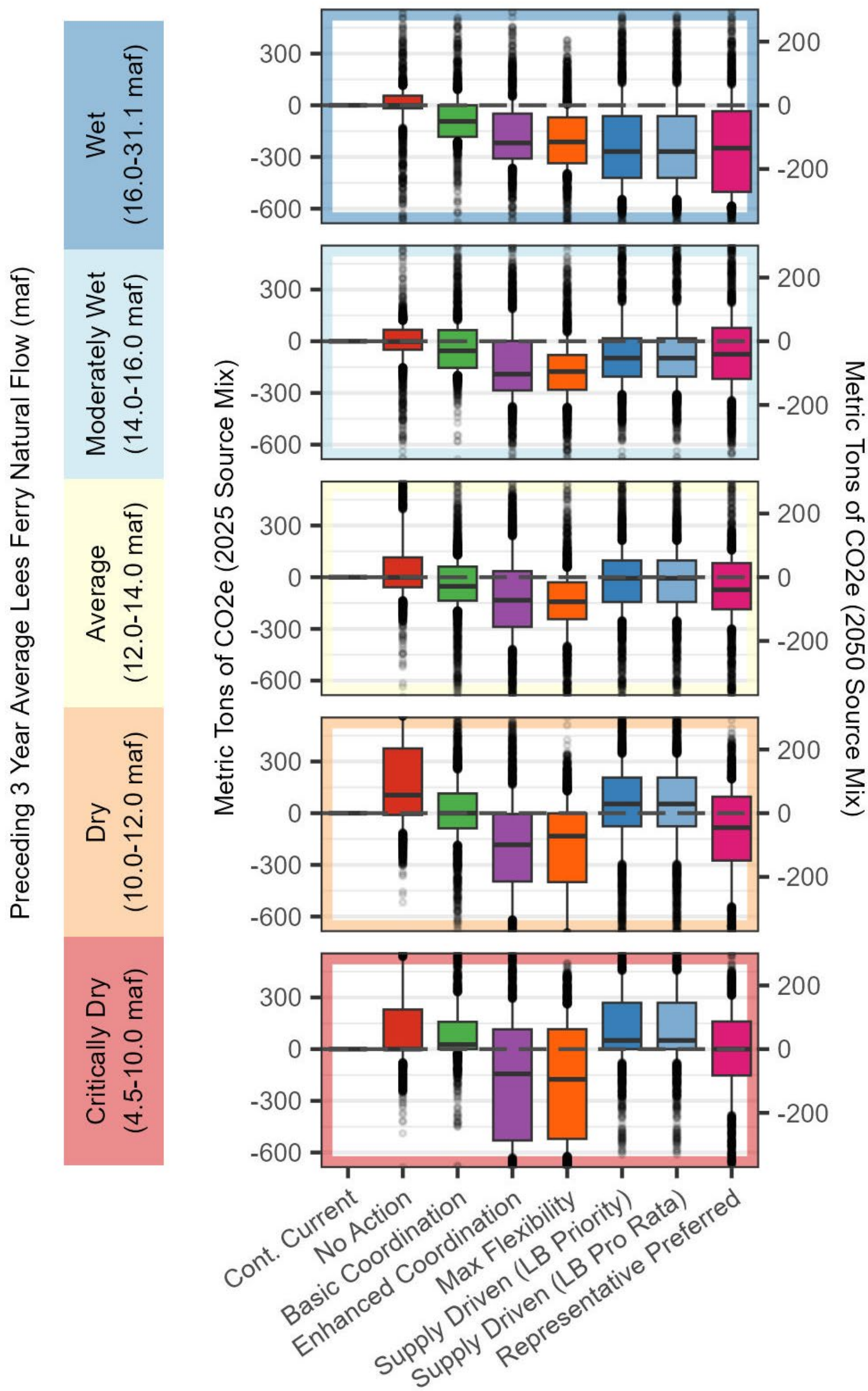
Figure TA 7-14 shows the change of CO_2e emissions due to a fluctuation of hydropower generation at Glen Canyon Dam, broken out by hydrologic conditions and categorized by the preceding three-year average Lees Ferry natural flows.

A positive or negative CO_2e value indicates an increase or decrease in CO_2e compared to the CCS Comparative Baseline, respectively. In the Average Flow Category, the Glen Canyon Dam alternatives have varying distributions of CO_2e emissions, with the 25th to 75th percentiles across all alternatives spanning from a 288-metric-ton decrease to a 115-metric-ton increase of CO_2e emissions. The No Action Alternative has a median close to zero, representing the smallest decrease relative to the CCS Comparative Baseline. The Enhanced Coordination (134 metric tons decrease of CO_2e) and Maximum Operational Flexibility (143 metric tons decrease of CO_2e) Alternatives have similar medians, resulting in the largest decrease in CO_2e emissions relative to the CCS Comparative Baseline. While the Maximum Operational Flexibility Alternative has an interquartile range similar to the other alternatives, the Enhanced Coordination Alternative has the largest interquartile range among all alternatives. The Average Flow Category 75th percentile values result in no more than a 115 metric ton increase in CO_2e emissions, which is equivalent to 23.3 gasoline-powered passenger vehicles driven for 1 year or 20.8 homes' electricity for 1 year.

In the Critically Dry Flow Category, the Glen Canyon Dam alternatives exhibit variations in both their medians and interquartile ranges. The No Action Alternative has a median value of zero CO_2e emissions relative to the CCS Comparative Baseline. The Basic Coordination and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives show medians above zero, indicating an increase in CO_2e emissions relative to the CCS Comparative Baseline. The Enhanced Coordination and Maximum Operational Flexibility Alternatives both result in a decrease in CO_2e emissions, displaying medians below zero. The interquartile range for these two alternatives is the largest among all alternatives, with the middle 50 percent spanning from an approximate decrease of 530 to an increase of 115 metric tons of CO_2e. The Critically Dry Flow Category 75th percentile values result in no more than a 269 metric ton increase in CO_2e (Supply Driven Alternative), which is equivalent to 65.5 gasoline-powered passenger vehicles driven for 1 year or 58.6 homes' electricity for 1 year.

The Representative Preferred Alternative exhibits the following outcomes with respect to the Dry Flow Category: For the Glen Canyon Dam CO_2e emissions resulting from a loss of hydropower generation, the median CO_2e emissions is about an 84-metric-ton decrease of CO_2e emissions, with the 25th to 75th percentiles across all alternatives spanning from a 275-metric-ton decrease to a 96-metric-ton increase of CO_2e emissions. The Representative Preferred Alternative exhibits the following outcomes with respect to the Critically Dry Flow Category: For the Glen Canyon Dam CO_2e emissions resulting from a loss of hydropower generation, the median CO_2e emissions results in a zero-metric-ton increase or decrease of CO_2e emissions, with the 25th to 75th percentiles across all alternatives spanning from a 153-metric-ton decrease to a 160-metric-ton increase of CO_2e emissions.

Figure TA 7-14
Change of CO2e Emissions Due to a Fluctuation of Hydropower Generation at Glen Canyon



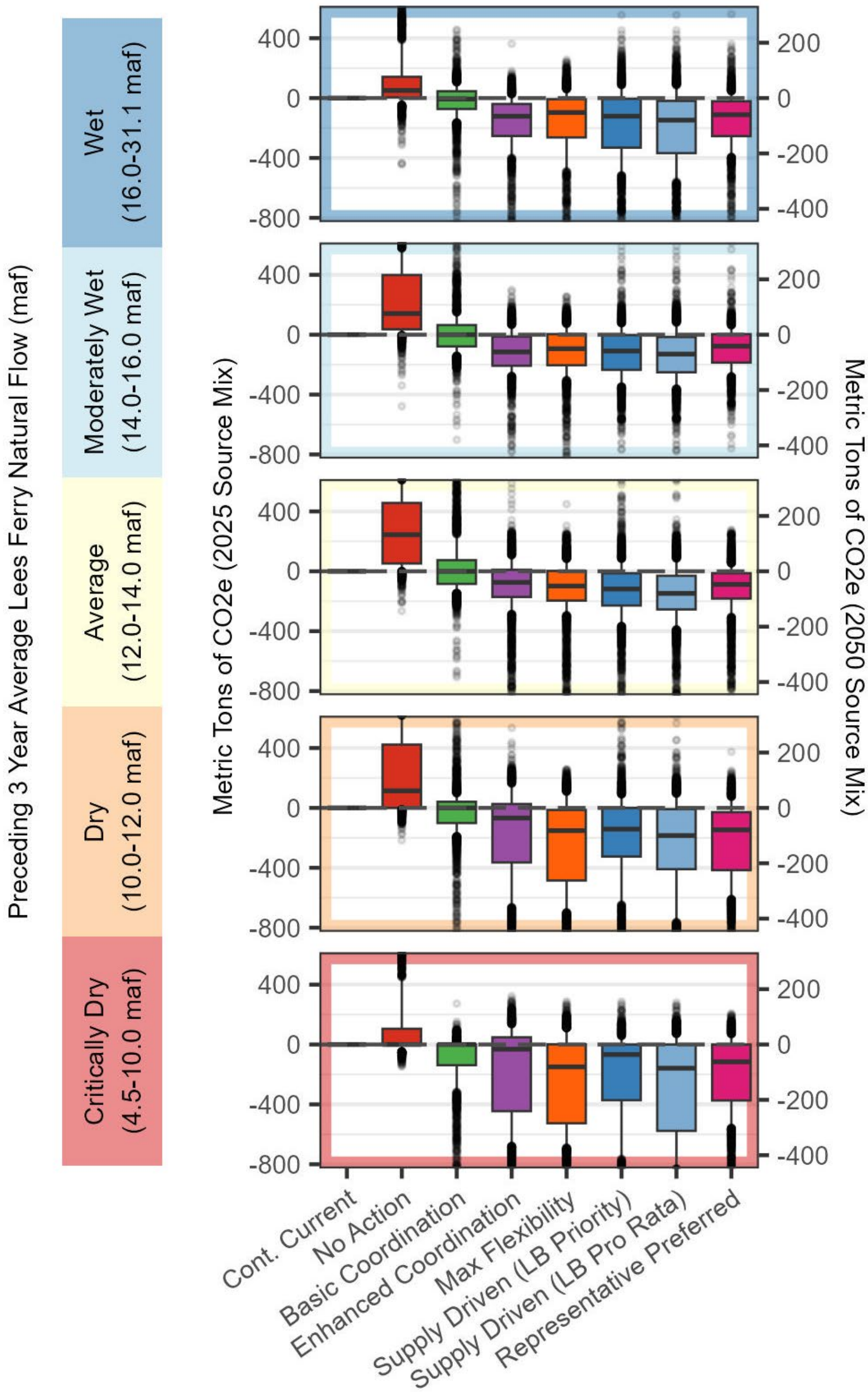
The median change in CO_2e emissions resulting from a loss of hydropower generation at Glen Canyon Dam generally shifts upward as hydrologic conditions move from Wet (16.0–31.1 maf) to Critically Dry (4.46–10.0 maf) Flow conditions; however, the magnitude of this shift varies among alternatives. The Enhanced Coordination and Maximum Operational Flexibility Alternatives exhibit relatively small changes in median CO_2e emissions across flow conditions, whereas the Supply Driven Alternative (both the LB Priority and LB Pro Rata approaches) shows a more substantial increases in median emissions under drier conditions.

Figure TA 7-15 shows the change of CO_2e emissions due to a fluctuation of hydropower generation at Hoover Dam, broken out by hydrologic conditions and categorized by the preceding three-year average Lees Ferry natural flows. The Hoover Dam power plant has 17 commercial generators with a maximum combined capacity of 2,074 megawatts. The power plant requires a minimum Lake Mead elevation of 950 feet to produce power. At minimum power pool, the power plant has an estimated capacity of 117 megawatts. At Lake Mead elevation of 1,035 feet, Hoover Dam's generating capacity is drastically reduced from 1,274 to 382 megawatts.

A positive or negative CO_2e value indicates an increase or decrease in CO_2e compared to the CCS Comparative Baseline, respectively. In the Average Flow Category, the Hoover Dam alternatives have varying distributions of CO_2e emissions, with the 25th to 75th percentiles across all alternatives spanning from a 255-metric-ton decrease to a 456-metric-ton increase in CO_2e emissions. The Enhanced Coordination, Maximum Operational Flexibility, Supply Driven (both LB Priority and LB Pro Rata approaches), and Representative Preferred Alternatives have medians showing a decrease in metric tons of CO_2e emissions. The No Action Alternative has a median showing an increase in metric tons of CO_2e emissions, and the Basic Coordination Alternative shows a median near zero metric tons of CO_2e emissions. The No Action Alternative has the highest median, with a 244-metric-ton increase in CO_2e emissions, and the largest interquartile range, with the 25th percentile at 52 metric tons and the 75th percentile at 456 metric tons of CO_2e. The Average Flow Category 75th percentile values result in no more than a 456 metric ton increase in CO_2e (No Action Alternative), which is equivalent to 90.3 gasoline-powered passenger vehicles driven for 1 year or 80.6 homes' electricity for 1 year.

The Representative Preferred Alternative exhibits the following outcomes with respect to the Dry Flow Category: For the Hoover Dam CO_2e emissions resulting from a loss of hydropower generation, the median CO_2e emissions is about a 146-metric-ton decrease of CO_2e emissions, with the 25th to 75th percentiles across all alternatives spanning from a 416-metric-ton decrease to a 75-metric-ton increase of CO_2e emissions. The Representative Preferred Alternative exhibits the following outcomes with respect to the Critically Dry Flow Category: For the Hoover Dam CO_2e emissions resulting from a loss of hydropower generation, the median CO_2e emissions is about a 115-metric-ton decrease of CO_2e emissions, with the 25th to 75th percentiles across all alternatives spanning from a 374-metric-ton decrease to a zero-metric-ton increase or decrease of CO_2e emissions.

Figure TA 7-15
Change of CO2e Emissions Due to a Fluctuation of Hydropower Generation at Hoover Dam



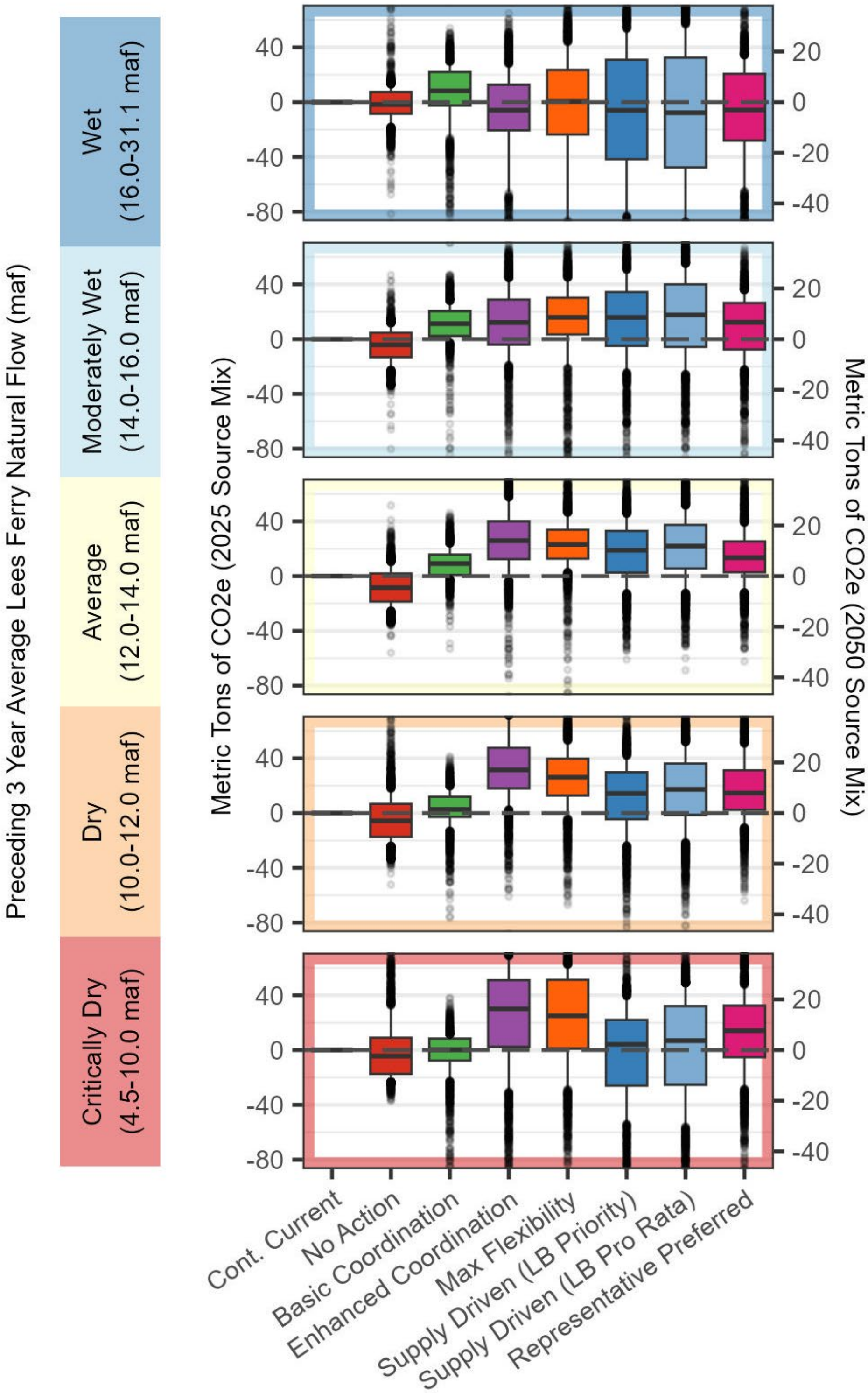
In the Critically Dry Flow Category, Hoover Dam alternatives exhibit variations in both their medians and interquartile ranges. The medians for the No Action and Basic Coordination Alternatives display no change in CO_2e emissions relative to the CCS Comparative Baseline. The Enhanced Coordination, Maximum Operational Flexibility, Supply Driven (both LB Priority and LB Pro Rata approaches), and Representative Preferred Alternatives all have medians showing a decrease in metric tons of CO_2e emissions, with Supply Driven (LB Pro Rata) showing the largest decrease at 158 metric tons of CO_2e. The 25th to 75th percentiles across all alternatives span from a decrease of 577 metric tons to an increase of 105 metric tons of CO_2e emissions. The No Action Alternative has the smallest interquartile range, while the Supply Driven (LB Pro Rata) Alternative has the largest. The Critically Dry Flow Category 75th percentile values result in no more than a 105 metric ton increase in CO_2e (No Action Alternative), which is equivalent to 38.5 gasoline-powered passenger vehicles driven for 1 year or 34.4 homes' electricity for 1 year.

Figure TA 7-16 shows the change of CO_2e emissions due to a fluctuation of hydropower generation at Davis Dam, broken out by hydrologic conditions and categorized by the preceding three-year average Lees Ferry natural flows.

A positive or negative CO_2e value indicates an increase or decrease in CO_2e compared to the CCS Comparative Baseline, respectively. In the Average Flow Category, the Davis Dam alternatives exhibit varying distributions of CO2e emissions, with the 25th to 75th percentiles across all alternatives spanning from a 19-metric-ton decrease to a 40-metric-ton increase in CO_2e emissions. The Enhanced Coordination, Maximum Operational Flexibility, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives display similar medians ranging from 19 to 26 metric tons of CO_2e increase. The Representative Preferred Alternative and Basic Coordination Alternative medians are similar at around 10 metric tons of CO_2e increase, while the No Action Alternative has an 8 metric ton decrease in CO_2e emissions. The No Action Alternative is the only alternative with both a median and 25th percentile below zero. All other alternatives have medians and 25th to 75th percentiles that result in an increase in CO_2e, with the Basic Coordination Alternative having the smallest interquartile range. The Average Flow Category 75th percentile values result in no more than a 40-metric-ton increase in CO_2e (Enhanced Coordination Alternative), which is equivalent to 10 gasoline-powered passenger vehicles driven for 1 year or 9 homes' electricity for 1 year.

The Representative Preferred Alternative exhibits the following outcomes with respect to the Dry Flow Category: For the Davis Dam CO_2e emissions resulting from a loss of hydropower generation, the median CO_2e emissions is about a 15-metric-ton increase of CO_2e emissions, with the 25th to 75th percentiles across all alternatives spanning from a 2-metric-ton increase to a 31-metric-ton increase of CO_2e emissions. The Representative Preferred Alternative exhibits the following outcomes with respect to the Critically Dry Flow Category: For the Davis Dam CO_2e emissions resulting from a loss of hydropower generation, the median CO_2e emissions is about a 14-metric-ton increase of CO_2e emissions, with the 25th to 75th percentiles across all alternatives spanning from a 5-metric-ton decrease to a 32-metric-ton increase of CO_2e emissions.

Figure TA 7-16
Change of CO2e Emissions Due to a Fluctuation of Hydropower Generation at Davis Dam



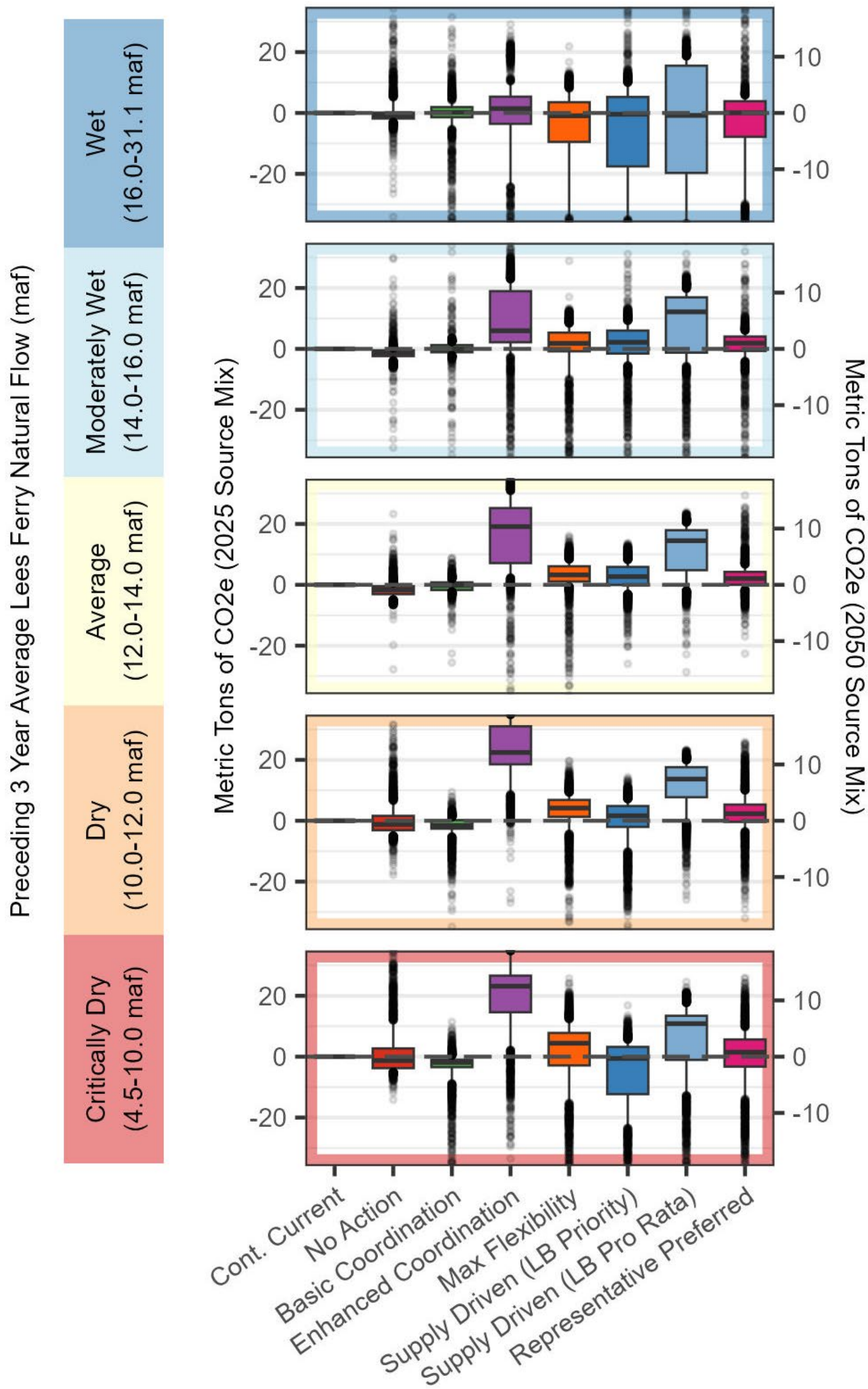
In the Critically Dry Flow Category, Davis Dam alternatives exhibit variations in both their medians and interquartile ranges. The median for the Basic Coordination Alternative displays very little change in CO_2e emissions, while the No Action Alternative shows a 4 metric ton decrease of CO_2e emissions relative to the CCS Comparative Baseline. The Enhanced Coordination, Maximum Operational Flexibility, Supply Driven (both LB Priority and LB Pro Rata approaches), and Representative Preferred Alternatives all have medians showing an increase in CO_2e emissions, ranging from 4 to 30 metric tons. The 25th to 75th percentiles across all alternatives span from a decrease of 26 metric tons of CO_2e to an increase of 51 metric tons of CO_2e emissions. The Basic Coordination Alternative has the smallest interquartile range, while the Maximum Operational Flexibility Alternative has the largest. The Critically Dry Flow Category 75th percentile values result in no more than a 51-metric-ton increase in CO_2e (Enhanced Coordination Alternative), which is equivalent to 11 gasoline-powered passenger vehicles driven for 1 year or 9.8 homes' electricity for 1 year.

Figure TA 7-17 shows the change of CO_2e emissions due to a fluctuation of hydropower generation at Parker Dam, broken out by hydrologic conditions and categorized by the preceding three-year average Lees Ferry natural flows.

A positive or negative CO_2e value indicates an increase or decrease in CO_2e compared to the CCS Comparative Baseline, respectively. In the Average Flow Category, Parker Dam alternatives exhibit varying distributions of CO_2e emissions, with the 25th to 75th percentiles across all alternatives spanning from a 3-metric-ton decrease to a 25-metric-ton increase in CO_2e. Only the No Action and Basic Coordination Alternatives have medians that result in a decrease in CO_2e emissions; though, both are near a zero metric-ton change in CO_2e. The Maximum Operational Flexibility, Supply Driven (LB Priority approach), and Representative Preferred Alternatives have similar medians, ranging from near zero to a 5-metric-ton CO_2e increase. The Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives have the highest medians, exceeding an increase of 14 metric tons of CO_2e emissions. The Enhanced Coordination Alternative has the largest interquartile range, while the Basic Coordination Alternative has the smallest range. The Average Flow Category 75th percentile values result in no more than a 25-metric-ton increase in CO_2e (Enhanced Coordination Alternative), which is equivalent to 5.4 gasoline-powered passenger vehicles driven for 1 year or 4.8 homes' electricity for 1 year.

The Representative Preferred Alternative exhibits the following outcomes with respect to the Dry Flow Category : For the Parker Dam CO_2e emissions resulting from a loss of hydropower generation, the median CO_2e emissions is about a 2-metric-ton increase of CO_2e emissions, with the 25th to 75th percentiles across all alternatives spanning from a zero-metric-ton increase to a 5-metric-ton increase of CO_2e emissions. The Representative Preferred Alternative exhibits the following outcomes with respect to the Critically Dry Flow Category: For the Parker Dam CO_2e emissions resulting from a loss of hydropower generation, the median CO_2e emissions is about a 1-metric-ton increase of CO_2e emissions, with the 25th to 75th percentiles across all alternatives spanning from a 3-metric-ton decrease to a 6-metric-ton increase of CO_2e emissions.

Figure TA 7-17
Change of CO2e Emissions Due to a Fluctuation of Hydropower Generation at Parker Dam



In the Critically Dry Flow Category, Parker Dam alternatives exhibit variations in both their medians and interquartile ranges. The medians for No Action, Basic Coordination, Supply Driven (LB Priority), and Representative Preferred Alternatives are similar, displaying a decrease in CO_2e emissions ranging from 2 to nearly zero metric tons. The Enhanced Coordination, Maximum Operational Flexibility, and Supply Driven (LB Pro Rata) Alternatives all have medians showing an increase in metric tons of CO_2e emissions, with the Enhanced Coordination Alternative showing the largest increase at 23 metric tons of CO_2e. The 25th to 75th percentiles across all alternatives span from a decrease of 12 metric tons of CO_2e to an increase of 27 metric tons of CO_2e. The Basic Coordination Alternative has the smallest interquartile range, while the Supply Driven Alternative (LB Priority) has the largest. The Critically Dry Flow Category 75th percentile values result in no more than a 27-metric-ton increase in CO_2e (Enhanced Coordination Alternative), which is equivalent to 6.1 gasoline-powered passenger vehicles driven for 1 year or 5.4 homes' electricity for 1 year.

TA 7.2.4 Issue 3: How would climate trends affect lake reservoir elevations?

Climate trends affect lake reservoir elevations in several interrelated ways, driven largely by changes in temperature, precipitation patterns, and hydrological cycles. Climate trends typically result in more variability and extremes in lake reservoir elevations—lower lows during droughts, higher highs during storm events, and greater management complexity overall.

Reduced Snowpack and Earlier Snowmelt

In many regions, especially mountainous areas, snowpack acts as a natural reservoir, slowly releasing water into rivers and lakes as it melts. Climate trends may cause warmer temperatures, which can result in less snow accumulation and earlier snowmelt, shifting the timing of runoff. Reservoirs may fill earlier in the season, but levels drop later in summer when demand (especially for irrigation and cooling) is highest.

Increased Evaporation

Potentially higher temperatures increase evaporation rates from both lake surfaces and surrounding land. As a result, greater water loss from reservoirs, especially in arid and semi-arid regions, leads to lower water levels.

Changes in Precipitation Patterns

Climate trends show potential disruption of rainfall patterns with some areas experiencing more intense storms, while others face prolonged droughts. The intense rainstorms may cause runoff that does not efficiently recharge reservoirs, and the droughts reduce inflow from rivers and streams, lowering reservoir levels over time.

Increased Water Demand

Hotter temperatures and more extreme weather increase demand for agricultural irrigation, municipal use, and power generation (cooling). Reservoir drawdown increases, reducing water levels faster, especially in peak summer months.

Decreased Hydropower

As discussed in Issue 2, hydropower may be affected by climate trends. Any reduction in hydropower would require other power generation sources to increase to compensate. The regional power mix can be analyzed to determine the region's potential capacity to replace hydropower with other alternative energy sources. The eGrid is a comprehensive inventory of environmental attributes of electric power systems. The eGrid is based on available plant-specific data for all U.S. electricity generating plants that provide power to the electric grid and report data to the U.S. government. It provides the generation resource mix for the North American Electric Reliability Corporation regions.

The project is located in the Western Electricity Coordinating Council North American Electric Reliability Corporation region. The latest version of eGrid (eGrid 2023) was released in January 2025 with data from 2023 (EPA 2025f). **Table TA 7-15** shows that renewables such as hydropower, biomass, wind, solar, and geothermal are 42.8 percent of the Western Electricity Coordinating Council resource mix compared to nonrenewable resources, such as coal, oil, nuclear, and gas, totaling 57.3 percent. If the 19.8 percent hydropower is reduced, both renewable and nonrenewable resources would compensate. However, as discussed, a recent Argonne National Laboratory study shows that when there is a reduction in hydropower at Glen Canyon Powerplant, the replacement is generated from mostly natural gas–fired generation (gas combined cycle) and gas combustion turbine, with a small portion also coming from coal-fired generation for 2024 through 2027 (Veselka et al. 2024).

In addition, as climate trends are further observed and monitored, Reclamation has opportunity to discuss any strategies to increase management flexibility, enhance climate adaptation planning and improve infrastructure resilience.

Table TA 7-15
eGrid 2023 WRCC Resources Mix Percentages

Resource	Generation Percentage
Coal	14.0%
Oil	0.1%
Gas	35.5%
Nuclear	7.7%
Hydropower	19.8%
Biomass	1.1%
Wind	10.2%
Solar	9.5%
Geothermal	2.2%

Sources: EPA 2025f

TA 7.2.5 Summary of Comparison of Alternatives

Potential impacts on air quality resources for the No Action Alternative, the four action alternatives, and the CCS Comparative Baseline vary depending on the shoreline exposure area and the reduction of hydropower for each alternative.

Issue 1: How would changing flow characteristics affect the potential exposed shoreline, fallowed agricultural lands and fugitive dust?

For the Lake Powell WY maximum exposed shoreline area Average Flow Category, the alternatives all have similar medians and small variabilities, except the Enhanced Coordination and Maximum Operational Flexibility Alternatives, which have the lowest median km^2 of exposed shoreline and the smallest variability. For the Lake Mead WY maximum exposed shoreline area Average Flow Category, the Enhanced Coordination, Maximum Operational Flexibility, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives performed the best, with the lowest median shoreline exposure area. The CCS Comparative Baseline and No Action Alternative perform the worst and have the smallest variability. The Basic Coordination Alternative performs in the middle. These results are within the range analyzed across the other alternatives from the Final Environmental Impact Statement.

For the full modeling period, the Lake Mead shoreline area robustness figure shows that the No Action Alternative performs the worst, with only 35 percent of the futures below 500 km^2 (123,553 acres) of shoreline area. The CCS Comparative Baseline performs slightly better at 50 percent, then the Basic Coordination Alternative at 61 percent, and then the Supply Driven Alternatives (both LB Priority and LB Pro Rata approaches) at 72 percent. The Maximum Operational Flexibility and Enhanced Coordination Alternatives perform the best with 80 percent or more of the futures below 500 km^2 (123,553 acres) of shoreline area. These same trends were seen for the 2027–2039, 2040–2049, and 2050–2060 modeling periods with higher percentages. For the 2027–2039 modeling period and 2040–2049 modeling period, the Maximum Operational Flexibility and Enhanced Coordination Alternatives have 88 percent or more of the futures below 500 km^2 (123,553 acres) of shoreline area.

The Lake Mead vulnerability plot shows that the Enhanced Coordination, Maximum Operational Flexibility, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives are vulnerable to similar conditions and less than 50 percent of the Drying with Variability traces include a driest 10-year average Lees Ferry annual flow this dry or drier. The Basic Coordination Alternative is similar to the median of the Drying with Variability ensemble, and the CCS Comparative Baseline and No Action Alternative are the most vulnerable at 10-year average flows of 10.5 maf and 11.4 maf, respectively.

For the full modeling period, the Lake Powell shoreline area robustness figure shows that the No Action Alternative performs the worst, with only 16 percent of the futures below 500 km^2 (123,553 acres) of shoreline area. The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) performs slightly better at 23 percent, then the Basic Coordination Alternative at 27 percent, and then CCS Comparative Baseline at 33 percent. The Maximum Operational Flexibility and Enhanced Coordination Alternatives perform the best with over 80 percent of the futures below 500 km^2 (123,553 acres) of shoreline area. Similar trends were seen for the 2027–2039, though with higher percentages. The 2040–2049 and 2050–2060 modeling periods show that the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) performs the worst, then the No Action Alternative. For the 2027–2039, 2040–2049, and 2050–2060 modeling periods, the Maximum Operational Flexibility and Enhanced Coordination Alternatives have 87 percent or more of the futures below 500 km^2 (123,553 acres) of shoreline area.

The Lake Powell vulnerability plot shows that the Enhanced Coordination and Maximum Operational Flexibility Alternatives are least vulnerable, as fewer than 25 percent of the Drying with Variability traces include a driest 10-year average Lees Ferry annual flow this dry or drier. The CCS Comparative Baseline, No Action, Basic Coordination, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives are vulnerable under flow conditions associated with more than 75 percent of the Drying with Variability traces and are therefore the most vulnerable.

For the Lake Powell WY maximum shoreline dust emissions Average Flow Category, several alternatives have similar medians, though Enhanced Coordination and Maximum Operational Flexibility Alternatives have the lowest median shoreline dust emissions and the smallest variability.

For the Lake Mead WY maximum shoreline dust emissions Average Flow Category, the Enhanced Coordination, Maximum Operational Flexibility, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives performed the best, with the least shoreline dust emissions. The CCS Comparative Baseline and No Action Alternative perform the worst, with the highest shoreline dust emissions. The Basic Coordination Alternative performs in the middle.

For the full modeling period, the Lake Mead shoreline dust emissions robustness figure shows that the No Action Alternative performs the worst, with only 22 percent of the futures below 500 million kg (1,102 million pounds) of $PM_{2.5}$. The CCS Comparative Baseline performs slightly better at 40 percent, then the Basic Coordination Alternative at 52 percent, and then the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) at 64 percent. The Maximum Operational Flexibility and Enhanced Coordination Alternatives perform the best with 76 percent and 69 percent, respectively, of the futures below 500 million kg (1,102 million pounds) of $PM_{2.5}$. These same trends were seen for the 2027–2039, 2040–2049, and 2050–2060 modeling periods with higher percentages, and the Maximum Operational Flexibility and Enhanced Coordination Alternatives have 79 percent or more of the futures below 500 million kg (1,102 million pounds) of $PM_{2.5}$.

The Lake Mead vulnerability plot shows that the Enhanced Coordination, Maximum Operational Flexibility, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives are least vulnerable, with vulnerability thresholds corresponding to conditions associated with roughly 25 to 50 percent of the Drying with Variability traces. The CCS Comparative Baseline and Basic Coordination Alternative are vulnerable to conditions associated with roughly 50 to 75 percent of the Drying with Variability traces. The No Action Alternative has a vulnerability threshold of 11.7 maf, which is similar to the driest observed 10-year period of 11.8 maf.

For the full modeling period, the Lake Powell shoreline dust emissions robustness figure shows that the No Action Alternative performs the worst, with only 10 percent of the futures below 450 million kg (992 million pounds) of $PM_{2.5}$. The Basic Coordination Alternative performs slightly better at 21 percent, then the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) at 22 percent, and then CCS Comparative Baseline at 28 percent. The Maximum Operational Flexibility and Enhanced Coordination Alternatives perform the best with 78 percent or more of the futures below 450 million kg (992 million pounds) of $PM_{2.5}$. These same trends were seen for the 2027–2039 with higher percentages. The 2040–2049 and 2050–2060 modeling periods show that the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) perform the worst, then the No Action Alternative. For the 2027–2039, 2040–2049, and 2050–2060 modeling periods, the Maximum Operational Flexibility and Enhanced Coordination Alternatives have 84 percent or more of the futures below 450 million kg (992 million pounds) of $PM_{2.5}$.

The Lake Powell vulnerability plot shows that the Enhanced Coordination and Maximum Operational Flexibility Alternatives are vulnerable to conditions associated with less than 25 percent of the Drying with Variability traces. The CCS Comparative Baseline, No Action, Basic Coordination, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives have vulnerability thresholds corresponding to conditions associated with 75 to 100 percent of the Drying with Variability traces and are therefore the most vulnerable alternatives. The No Action Alternative has a vulnerability threshold of 12.2 maf, which is similar to the recently observed 10-year flow of 12.1 maf.

Issue 2: How would lake reservoir elevations and releases impact power generation and CO_2e emissions?

For the Average Flow Category, both Glen Canyon Dam and Hoover Dam show that the Enhanced Coordination and Maximum Operational Flexibility Alternatives have median decreases in CO_2e emissions, with these alternatives having the largest median decrease at Glen Canyon Dam. The Supply Driven Alternatives (both LB Priority and LB Pro Rata approaches) also displays a median decrease in CO_2e emissions, with the LB Pro Rata approach showing the largest median decrease at Hoover Dam. The No Action Alternative displays very little change at Glen Canyon Dam but the largest median increase in CO_2e emissions at Hoover Dam. The Basic Coordination Alternative generally results in smaller median CO_2e emission changes that remain near zero. The Representative Preferred Alternative for both Hoover Dam and Glen Canyon Dam generally result in similar median CO_2e emissions decreases.

For the Average Flow Category, Davis Dam and Parker Dam exhibit similar patterns. The Enhanced Coordination, Maximum Operational Flexibility, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives show median increases in CO_2e emissions and generally the widest interquartile ranges. The No Action, Basic Coordination, and Representative Preferred Alternatives display the smallest median changes in CO_2e emissions, with the No Action Alternative being the only alternative to have a negative median change at both dams.

Issue 3: How would climate trends affect lake reservoir elevations?

Climate trends affects lake reservoir elevations in several interrelated ways, driven largely by changes in temperature, precipitation patterns, and hydrological cycles. Climate trends typically result in more variability and extremes in lake reservoir elevations, which may not be captured specifically in the modeling, but the five flow condition categories help to visualize the different potential states of the system throughout the 34-year period of analysis. Dry flow conditions could represent the lower lows present during droughts and the wet flow conditions could represent the higher highs during storm events. General discussion of the effects of climate trends on lake reservoirs is discussed but due to uncertainty these effects cannot be determined for each specific alternative. In addition, **TA 3**, Hydrologic Resources, details the lake reservoir elevations for flow categories and alternatives.

TA 7.3 References

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