COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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TO: Colorado Water Conservation Board Members

FROM: Amy Ostdiek, Michelle Garrison and Brian Macpherson

DATE: May 16, 2024

SUBJECT: Agenda Item 22: Colorado River Hydrology and Other Updates

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This is an informational item with no board action requested.

1. Hydrology and operations update

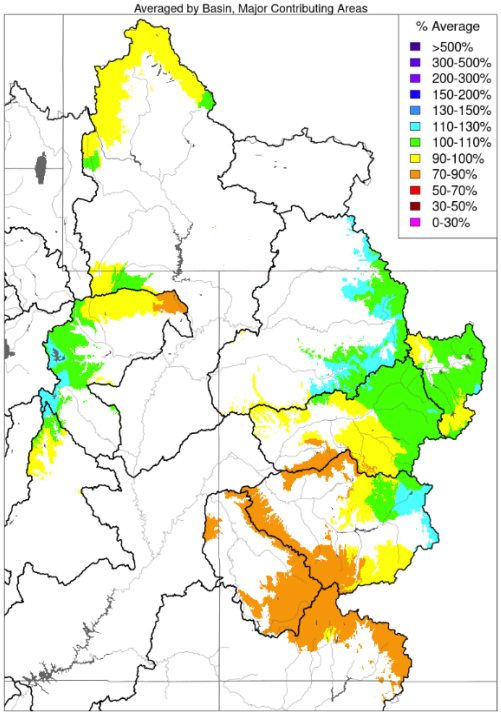
Hydrology

Streamflow for Water Years 2021 and 2022 was well below average throughout the basin, placing significant strain on basin storage and on water users in the Upper Basin. WY 2023 precipitation and streamflow were slightly above average, with well above average snowpack and high spring runoff followed by warm and dry summer conditions. WY 2024 precipitation has been slightly below average. A series of storms starting in January improved snowpack to normal through March, followed by dry conditions in April. Snowpack peaked near average in April, with below average conditions in the southern subbasins in Colorado. Soil moisture conditions have improved but remain below normal in most basins in western Colorado. Inflow into Lake Powell has been slightly below normal. Inflow forecasts of 80% - 85% of average for Lake Powell reflect current snowpack and soil moisture conditions.

Drought and reservoir storage conditions have improved; however, long-term impacts from depleted storage are expected to continue, as indicated in current forecasts for reservoir operations.

Water Year Precipitation, October 2023 - April 2024

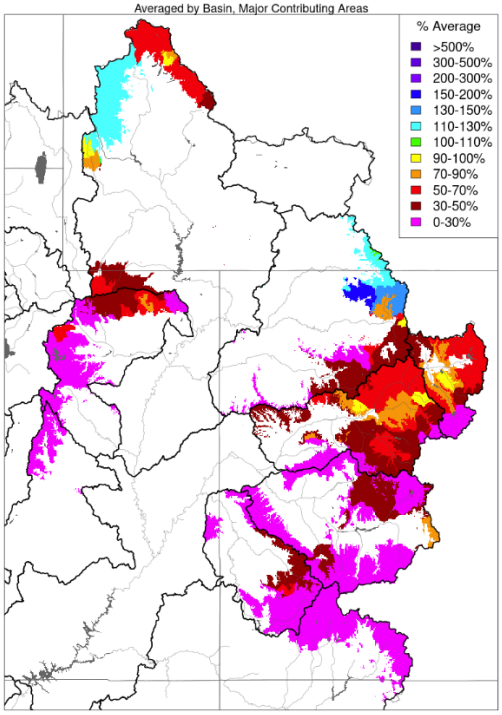
Averaged by Basin, Major Contributing Areas



Prepared by NOAA, Colorado Basin River Forecast Center
Salt Lake City, Utah, www.cbrfc.noaa.gov

Month to Date Precipitation - May 03 2024

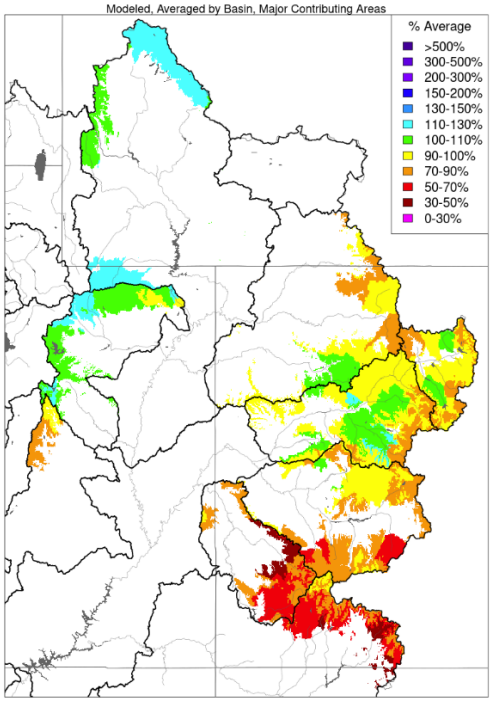
Averaged by Basin, Major Contributing Areas



Prepared by NOAA, Colorado Basin River Forecast Center
Salt Lake City, Utah, www.cbrfc.noaa.gov

Soil Moisture - Fall - 2023 (November 15)

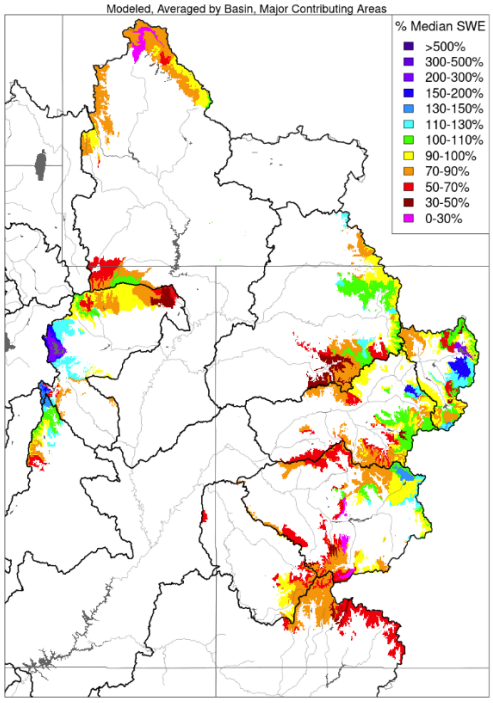
Modeled, Averaged by Basin, Major Contributing Areas



Prepared by NOAA, Colorado Basin River Forecast Center
Salt Lake City, Utah, www.cbrfc.noaa.gov

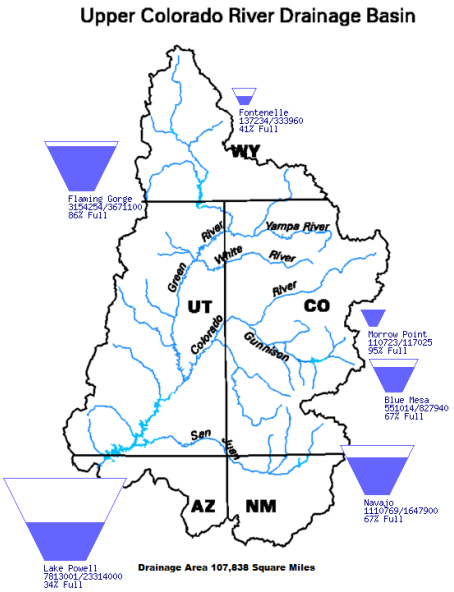
Snow Conditions - May 02 2024

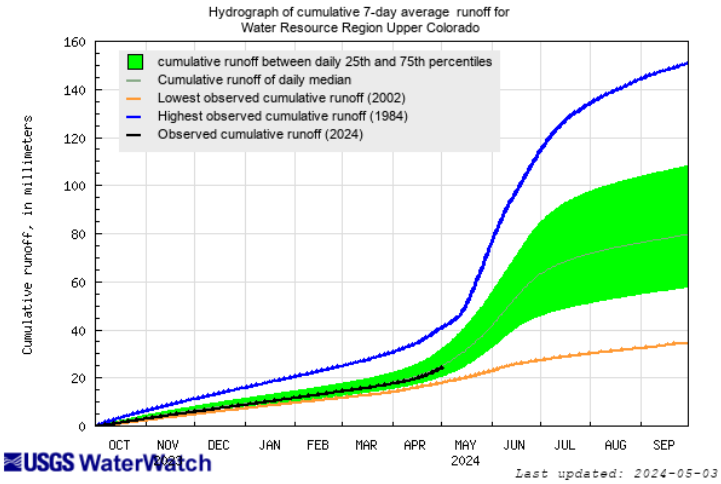
Modeled, Averaged by Basin, Major Contributing Areas

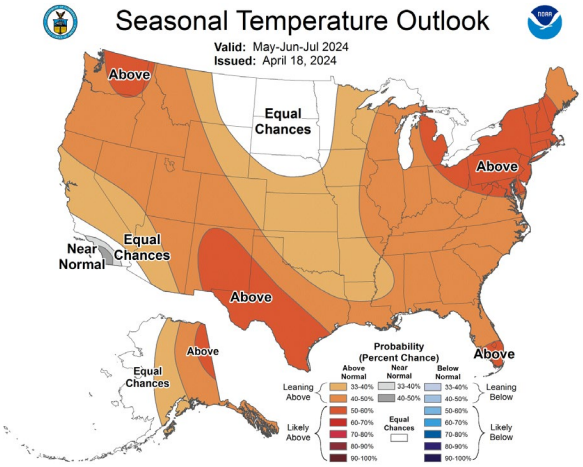


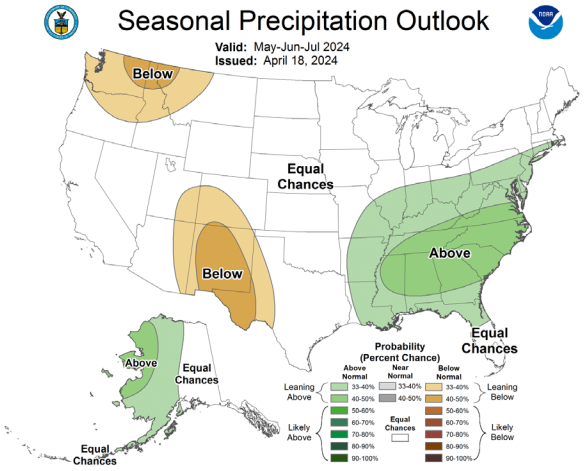
Prepared by NOAA, Colorado Basin River Forecast Center
Salt Lake City, Utah, www.cbrfc.noaa.gov

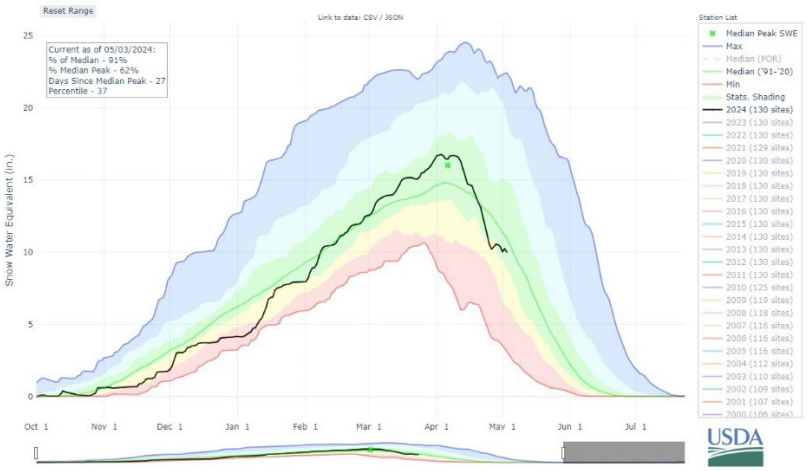
Data Current as of:
05/02/2024

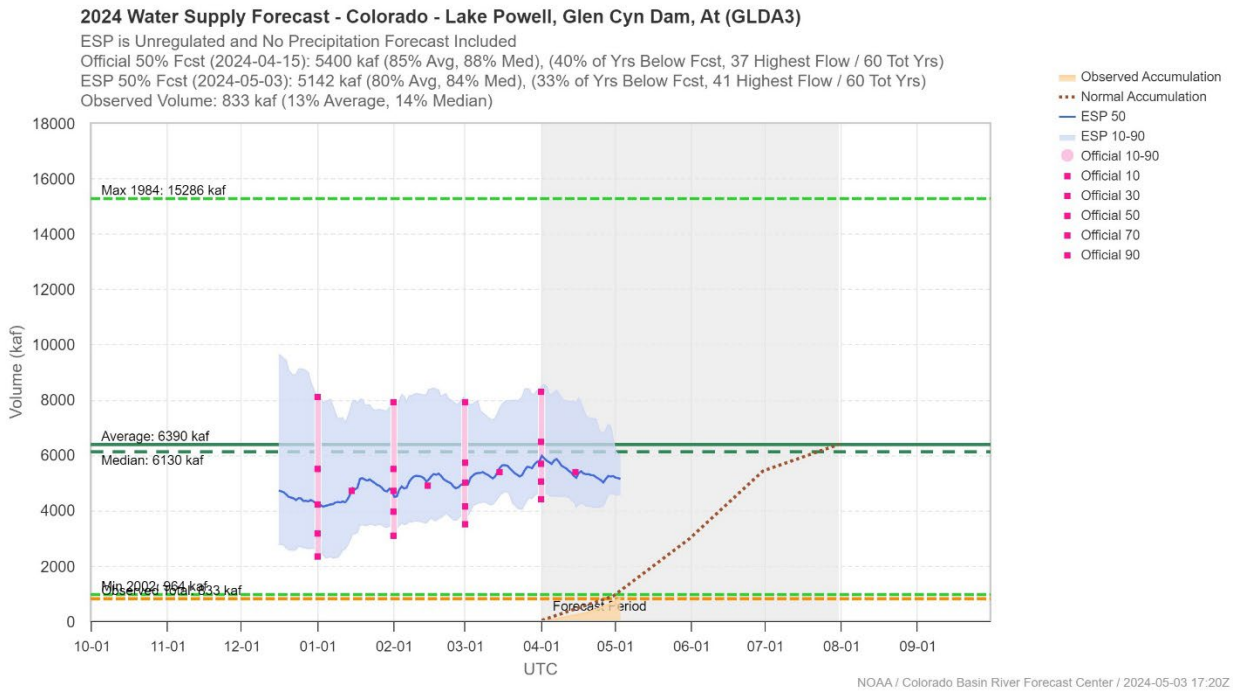


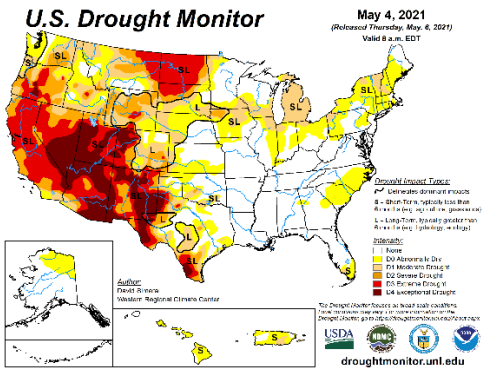


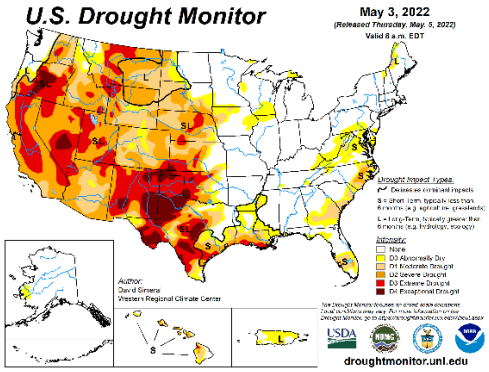


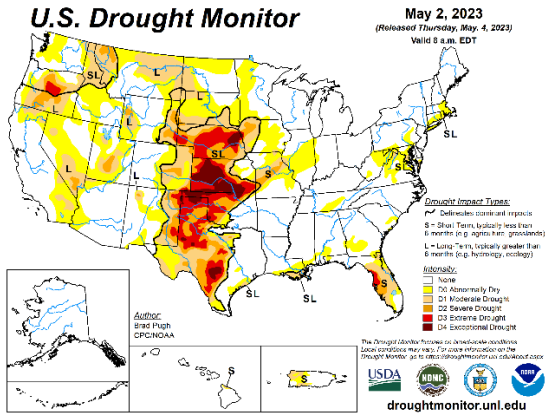


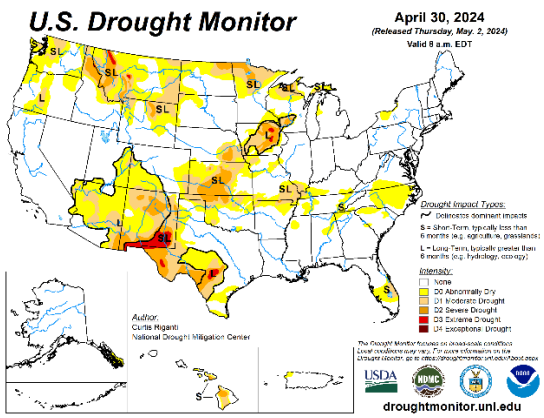



2024 Water Supply Forecast - Colorado - Lake Powell, Glen Cyn Dam, At (GLDA3)
ESP is Unregulated and No Precipitation Forecast Included
Official 50% Fcst (2024-04-15): 5400 kaf (85% Avg, 88% Med), (40% of Yrs Below Fcst, 37 Highest Flow / 60 Tot Yrs)
ESP 50% Fcst (2024-05-03): 5142 kaf (80% Avg, 84% Med), (33% of Yrs Below Fcst, 41 Highest Flow / 60 Tot Yrs)
Observed Volume: 833 kaf (13% Average, 14% Median)
Observed Accumulation
Normal Accumulation
ESP 50
ESP 10-90
Official 10-90
Official 10
Official 30
Official 50
Official 70
Official 90
Max 1984: 15286 kaf
Average: 6390 kaf
Median: 6130 kaf
Min 2002: 964 kaf
Observed Total: 833 kaf
Forecast Period
Volume (kaf)
UTC
NOAA / Colorado Basin River Forecast Center / 2024-05-03 17:20Z


U.S. Drought Monitor
May 4, 2021
(Released Thursday, May. 6, 2021)
Valid 8 a.m. EDT
droughtmonitor.unl.edu


U.S. Drought Monitor
May 3, 2022
(Released Thursday, May. 5, 2022)
Valid 8 a.m. EDT
droughtmonitor.unl.edu


U.S. Drought Monitor
May 2, 2023
(Released Thursday, May. 4, 2023)
Valid 8 a.m. EDT
droughtmonitor.unl.edu


U.S. Drought Monitor
April 30, 2024
(Released Thursday, May. 2, 2024)
Valid 8 a.m. EDT
droughtmonitor.unl.edu

Operations

Low inflows and reservoir storage prompted multiple reservoir operation changes and Upper Basin Drought Contingency Plan (DCP) activities in WY 2022 and 2023. To protect critical infrastructure in Lake Powell, Reclamation decreased WY 2022 Lake Powell releases. May 2022 – April 2023 Flaming Gorge reservoir releases were increased as part of the Drought Response Operations Plan. Lake Powell rose above elevation 3525' in May 2022 and fell below that threshold elevation in December 2022. Due to improved hydrologic conditions in WY 2023, Lake Powell elevations rose significantly in April 2023 and remain above the 3525' threshold.

High spring runoff and increasing reservoir elevations prompted the cessation of Drought Response Operations Agreement (DROA) releases in March 2023, changing focus to recovery of previously released DROA water for the May 2023 – April 2024 plan, and a substantial increase in WY 2023 releases from Lake Powell. WY 2023 was the first year in which Lake Powell operated in the Lower Elevation Balancing Tier. In that tier, releases from Lake Powell are initially set to 7.0 MAF but can be adjusted up to a maximum of 9.5 MAF based on inflow forecasts. Releases are adjusted monthly from April through September based on inflow and reservoir storage forecasts. Lake Powell releases totaled 8.58 MAF for WY 2023, including the release of the 480,000 acre-feet withheld in Lake Powell in WY 2022. As the inflow forecasts declined quickly due to the warm and dry conditions and Lake Mead projections increased due to precipitation and decreasing demand, Reclamation decreased Lake Powell releases, but still inadvertently released 40,000 acre-feet more from Powell than was required under balancing. They claim to have no authority to correct this inadvertent release in WY 2024.

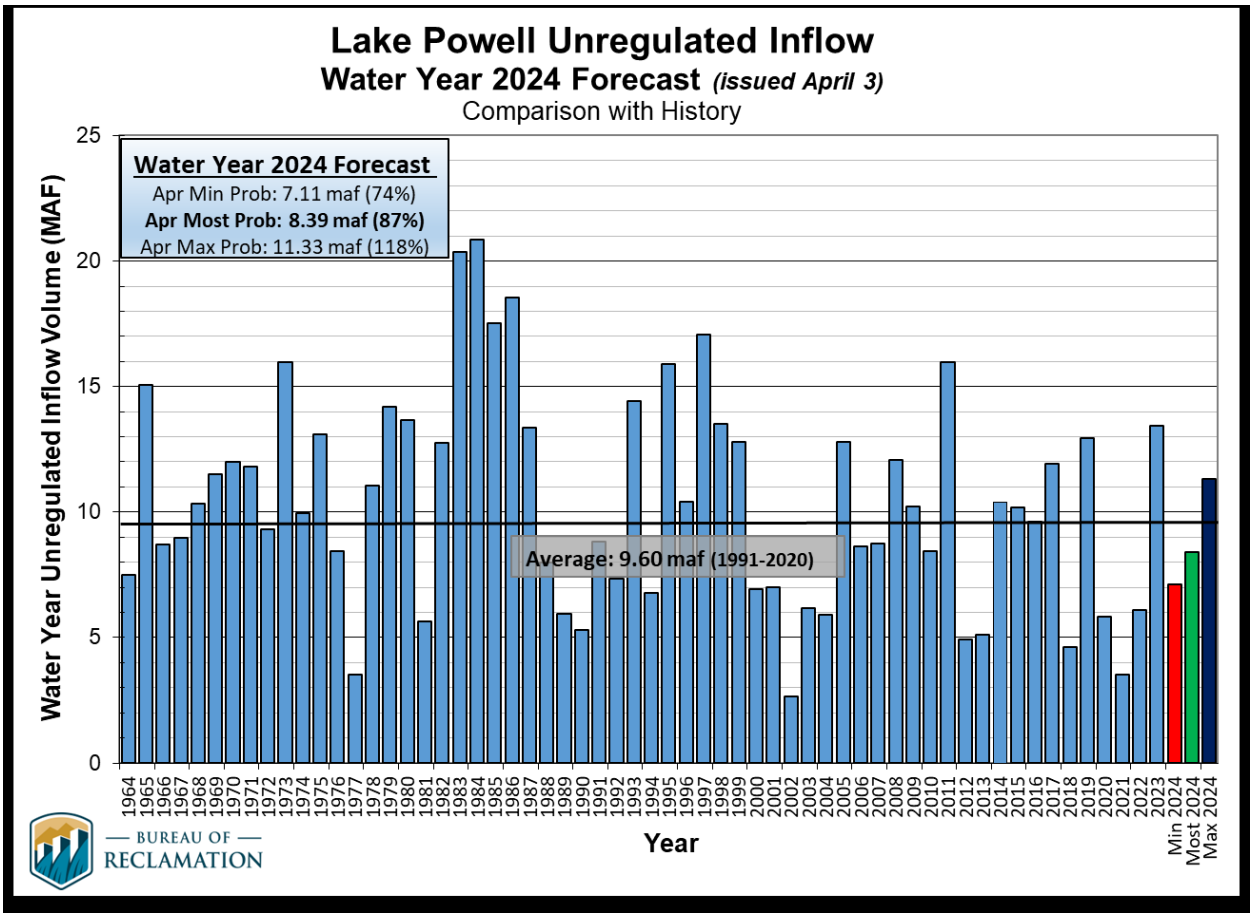
In spring 2023 as Lake Powell elevation was very low but inflow and elevation were rising, Reclamation increased releases significantly for several days to mobilize sediment remaining in the system from tributary inflows below Glen Canyon Dam and deposit it onto eroding sandbars within the Grand Canyon. Reclamation increased powerplant releases and made releases through the bypass tubes similar to a High Flow Experiment (HFE), but this high release was conducted outside the LTEMP protocol for such experiments. This was the first time releases of that magnitude were made through the bypass tubes with Lake Powell at such a low elevation, and the altered hydraulic conditions damaged one of the bypass tubes. Reclamation is evaluating potential short-term limitations to Glen Canyon Dam operations and long-term actions to prevent additional damage to the bypass tubes. Reclamation needs to ensure that the bypass tubes retain sufficient release capacity for short-term operations in the event releases cannot be made through the powerplant for some period of time, and is conducting additional analyses regarding possible future operation of the bypass tubes. Additional details are included below, and staff will present an update regarding this issue.

As determined by Reclamation's August 2023 24-Month Study, Lake Powell will operate in the Mid-Elevation Release Tier in WY 2024 with a fixed annual release of 7.48 MAF. Streamflow at the Lees Ferry gage includes Lake Powell releases, flow of water around the Glen Canyon dam through bank storage and leakage, and inflows from the Paria River. The 10-year

cumulative streamflow at Lees Ferry through WY 2023 was approximately 86 million acre-feet.

Blue Mesa reservoir achieved recovery of its previously released DROA water in late December 2023. Flaming Gorge reservoir achieved recovery of previously released DROA water in late February 2024. No DROA operations are expected for WY2024.

DROA actions helped protect critical infrastructure in Lake Powell from late 2021 through April 2023. However, half of the DROA water in Lake Powell was released in WY 2023 as part of the balancing releases. Lake Powell elevations are now lower than they would have been without DROA releases, leaving Lake Powell at increased risk of dropping below critical elevations in the future. The lack of long-term effectiveness of the 2021 – 2023 DROA releases does not match the goals and objectives of the DROA and may factor into future Upper Basin DCP decisions.



The table below describes the Interim Guideline Lower Basin shortage tiers, reduction of deliveries to Mexico pursuant to Minute 323, Lower Basin DCP contributions and Binational Water Scarcity Contingency Plan contributions as determined by projected elevations at Lake Mead. In Calendar Year 2023 Lake Mead operated in a Tier 2a shortage condition. As

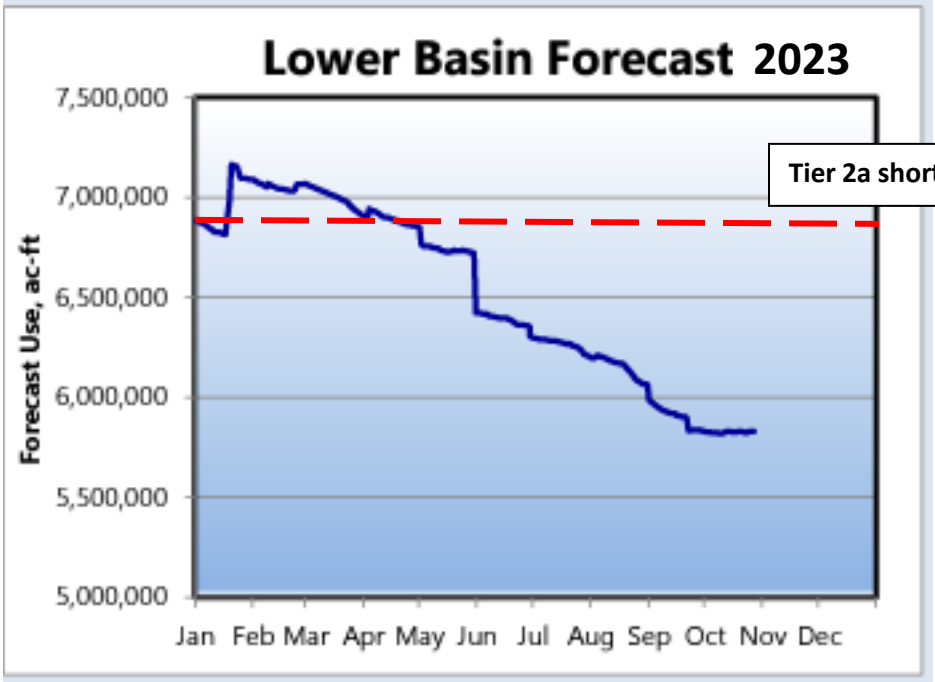
determined by the August 2023 24-Month Study, in CY 2024 Lake Mead will operate in a Tier 1 shortage condition, as it did in CY 2022.

2007 Interim Guidelines, Minute 323, Lower Basin Drought Contingency Plan, and Binational Water Scarcity Contingency Plan
Total Volumes (kaf)

	Lake Mead Elevation (feet msl)	2007 Interim Guidelines Shortages		Minute 323 Delivery Reductions	Total Combined Reductions	DCP Water Savings Contributions			Binational Water Scarcity Contingency Plan Savings	Combined Volumes by Country *US: (2007 Interim Guidelines Shortages + DCP Contributions)* *Mexico: (Minute 323 Delivery Reductions + Binational Water Scarcity Contingency Plan Savings)*					Total Combined Volumes	
		AZ	NV	Mexico	***Lower Basin States + Mexico***	AZ	NV	CA	Mexico	*AZ Total*	*NV Total*	*CA Total*	*Lower Basin States Total*	*Mexico Total*	***Lower Basin States + Mexico***	
2022 Operations →	1,090 - 1,075	0	0	0	***0***	192	8	0	41	192	8	0	*200*	*41*	***241***	← 2022 Operations
	1,075 - 1050	320	13	50	***383***	192	8	0	30	512	21	0	*533*	*80*	***613***	
→ 2023 Operations	1,050 - 1,045	400	17	70	***487***	192	8	0	34	592	25	0	*617*	*104*	***721***	← 2023 Operations
	1,045 - 1,040	400	17	70	***487***	240	10	200	76	640	27	200	*867*	*146*	***1,013***	
	1,040 - 1,035	400	17	70	***487***	240	10	250	84	640	27	250	*917*	*154*	***1,071***	
	1,035 - 1,030	400	17	70	***487***	240	10	300	92	640	27	300	*967*	*162*	***1,129***	
	1,030 - 1,025	400	17	70	***487***	240	10	350	101	640	27	350	*1,017*	*171*	***1,188***	
	<1,025	480	20	125	***625***	240	10	350	150	720	30	350	*1,100*	*275*	***1,375***	

The Secretary of the Interior will take affirmative actions to implement programs designed to create or conserve 100,000 acre-ft per annum or more of Colorado River System water to contribute to conservation of water supplies in Lake Mead and other Colorado River reservoirs in the lower basin. All actions taken by the United States shall be subject to applicable law, including availability of appropriations.

Early in Calendar Year 2023, the Lower Basin was projecting to consumptively use about 320,000 AF more than their allocation under Tier 2a shortage. This would have involved the withdrawal of banked Intentionally Created Surplus (ICS). Extremely high precipitation amounts in 2023 flooded the Arizona tributaries and allowed the California State Water Project to issue a 100% allocation for the first time since 2006. Hurricane Hilary in August 2023 further reduced Lower Basin demands due to heavy local precipitation. The Lower Basin demand dropped approximately 1.4 MAF from their initial CY 2023 water orders, resulting in creation of large volumes of ICS. This "historically low consumptive use" in the Lower Basin was due to local hydrology – it was not caused by significant conservation actions by the Lower Basin contractors.



California State Water Project Allocation

YEAR	DATE	ALLOCATION
2020	12/2/2019	10%
	1/24/2020	15%
	5/22/2020	20%
2021	12/1/2020	10%
	3/23/2021	5%
2022	12/1/2021	0% [3]
	1/20/2022	15%
	3/18/2022	5% [4]
2023	12/1/2022	5% [5]
	1/26/2023	30%
	2/22/2023	35%
	3/24/2023	75%
	4/20/2023	100%

In addition to the shortages agreed to pursuant to the 2007 Guidelines and 2019 Drought Contingency Plans, in December 2021 the Lower Division States also committed to creating an additional 500,000 acre-feet of water per year in 2021-2022, and 2023, of conserved water to remain in Lake Mead on a voluntary basis. The amount of water modeled for each year pursuant to the "500+ Plan" is included in the table below. Planned conservation in late 2022 and 2023 increased by almost 600,000 AF from August 2022 projections, which reflects the improved hydrology in the Lower Basin. Similar to shortage conditions, the amount of water conserved in Lake Mead under the "500+ Plan" may be partially offset by other withdrawals.

Additional Water Modeled Under 500 Plus Plan

(as anticipated to be modeled in the April 2023 Most Probable 24-Month Study)

Conservation Activity *(volumes in AF)*	2021	2022 *(Provisional)*	2023 *(Projected)*
CAP ICS delivery offset	6,147	15,876	-10,900
GRIC System Conservation	40,000	58,837	125,000
GRIC ICS creation	0	78,565	0
CRIT System Conservation	4,685	4,685	0
CAWCD System Conservation	0	87,794	0
YMIDD System Conservation	0	8,523	13,670
MVIDD System Conservation	0	9,531	12,819
FMYN System Conservation	0	0	13,933
MWD ICS delivery offset and/or creation	58,134	58,211	107,347
PVID System Conservation	12,305	52,789	58,400
CVWD System Conservation	0	9,083	0
SNWA ICS creation	12,832	28,330	44,000
Annual Total *(Non-Shortage/DCP)*	**134,103**	**412,224**	**364,269**
Cumulative Total	**134,103**	**546,327**	**910,596**

- 2023 volumes reflect executed agreements under the 500+ Plan and LC Conservation Program and current operational projections and are subject to change.
- Additional conservation activities are being considered. After new agreements are finalized and executed, these additional activities will be included in Reclamation's operational planning and modeling.

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The Lower Basin proposed up to 3 million acre-feet of compensated conservation and other activities through 2025 to address drought conditions as part of Reclamation's current Supplemental Environmental Impact Statement (SEIS) process to contemplate additional changes to Lake Powell and Lake Mead reservoir operations through the end of the Interim Guidelines ("near-term operations"). Reclamation released its final Interim Guidelines SEIS in March 2024 and is expected to release a Record of Decision (ROD) soon. The final SEIS analyzed only two alternatives, a No Action alternative and the Lower Basin alternative, removing the previously proposed action alternatives from final consideration. Reclamation is adding the expected conservation volumes to its models as conservation agreements with participating entities are signed, which is increasing projected Lake Mead elevations.

Reclamation recently released a draft SEIS for the Glen Canyon Dam Long-Term Experimental and Management Plan (LTEMP) that explores options for changing monthly and daily releases and release temperatures to help prevent establishment of smallmouth bass and other non-native fish in the Grand Canyon and to alter sediment accounting and implementation windows for high flow experiments to distribute sand higher on sandbars. LTEMP does not

alter annual releases, which are determined according to the Interim Guidelines. A final LTEMP SEIS and ROD are expected by the end of June 2024.

2. **Glen Canyon Dam Infrastructure Updates**

Glen Canyon Dam, which created Lake Powell, has recently been reanalyzed during operations at low elevation conditions. In April 2023, Lake Powell reached a historically low elevation of 3,522'. During the same month, Reclamation released water at a high rate out of the river outlet works. The river outlet works are a secondary outlet mechanism from Glen Canyon Dam and can operate down to elevation 3,370' (dead pool). The primary outlets from Glen Canyon Dam are the penstocks, which send water through hydroelectric turbines, but only operate down to elevation 3,490' (minimum power pool). The reservoir and dam were not designed to be operated below minimum power pool, and the river outlet works were not designed to be the exclusive means of releasing water. Recent hydrology and operations have caused concern, however, that the reservoir will drop below minimum power pool.

After the release from the river outlet works, subsequent examination showed that this release caused cavitation of the steel pipe walls due to the low elevation (hence low pressure) and high velocity of the water. This cavitation poses a risk for dam stability and safety and is continuing to be analyzed. In addition, the HFE caused tailrace sedimentation from the outlet works operation. Reclamation is continuing to analyze the situation through engineering studies, including on a scale model at its Technical Services Center in Lakewood, CO.

On March 26, 2024, Reclamation issued new Interim Operating Guidance for Glen Canyon Dam during Low Reservoir Levels at Lake Powell. The Guidance adopted two new remedial actions:

1) Exercise the full extent of operational capabilities within the Upper Colorado River Basin to attempt to maintain reservoir level at or above elevation 3,490', minimum power pool, to allow redundant downstream delivery of water through the penstocks and river outlet works if needed.
2) To minimize the potential for cavitation damage in the river outlet works, the maximum flow through any one of the four conduits should not exceed the interim maximum flows. These values are based on preliminary estimates of head losses in the conduits and cavitation development in the upper vertical bends.

The first remedial action likely involves exercising the Drought Response Operations Agreement (DROA) to re-time monthly releases from Glen Canyon Dam pursuant to the LTEMP ROD as well as to release water from the CRSP Upper Initial Units (Flaming Gorge, Aspinall, and Navajo Reservoirs) down to Lake Powell. The second remedial action involves reduced releases from the river outlet works in the event Lake Powell falls below minimum power pool.

There is no expiration on the Interim Operating Guidance and the timing of its issuance comes at a pivotal time for the post-2026 process for new guidelines to operate Lakes Powell and Mead. Reclamation has released the Federal Register Notice for post-2026 operations which

initiates the NEPA process and identifies a Purpose and Need for the Proposed Action. This Notice, released in October 2023, did not identify the critical nature of these infrastructure limitations. Reclamation has also requested modeling assumptions for proposed alternatives from stakeholders in early 2024 and only identified these infrastructure limitations days before the due date for modeling alternatives. It remains unclear how Reclamation will assess modeling alternatives that do not conform to these new infrastructure limitations.