BUREAU OF RECLAMATION

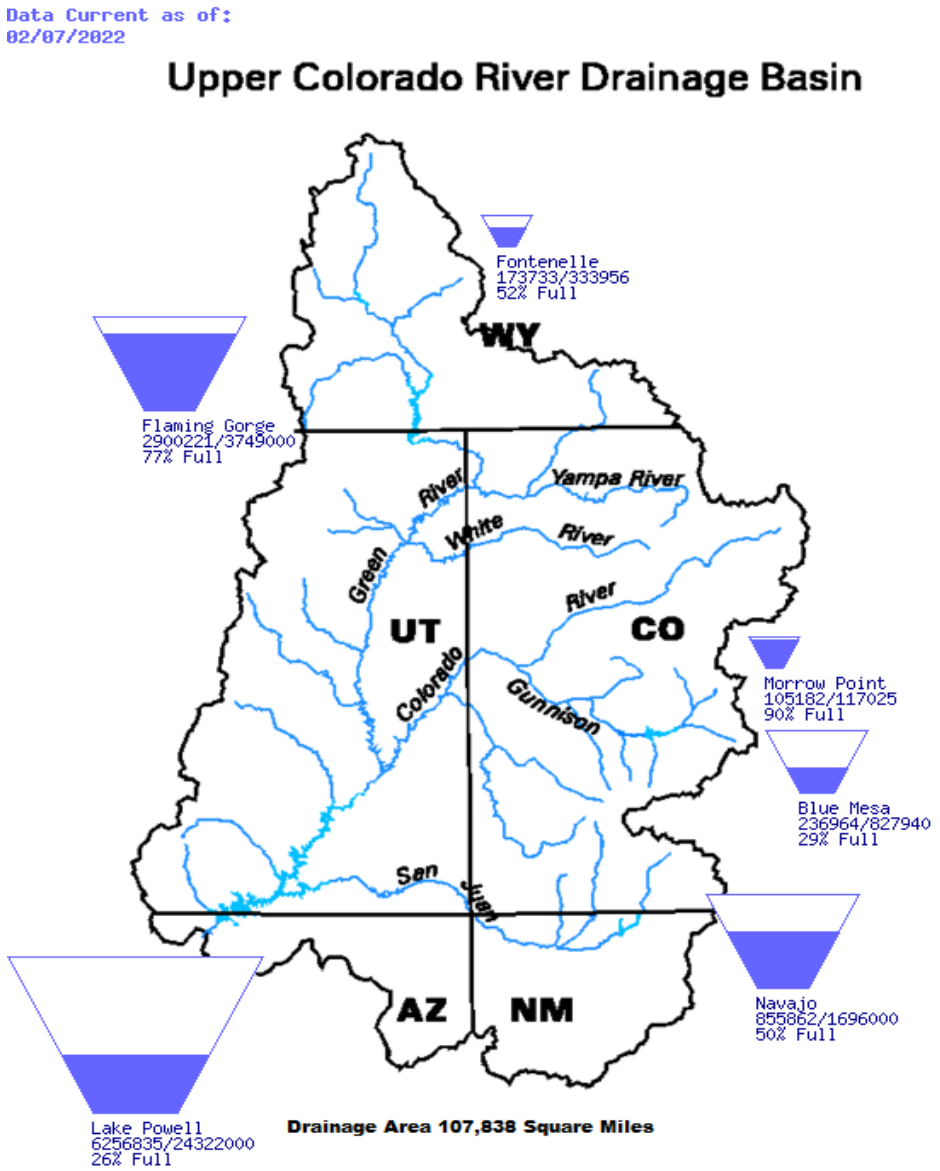
# Basin Hydrology and Operations

## Glen Canyon Adaptive Management Working Group

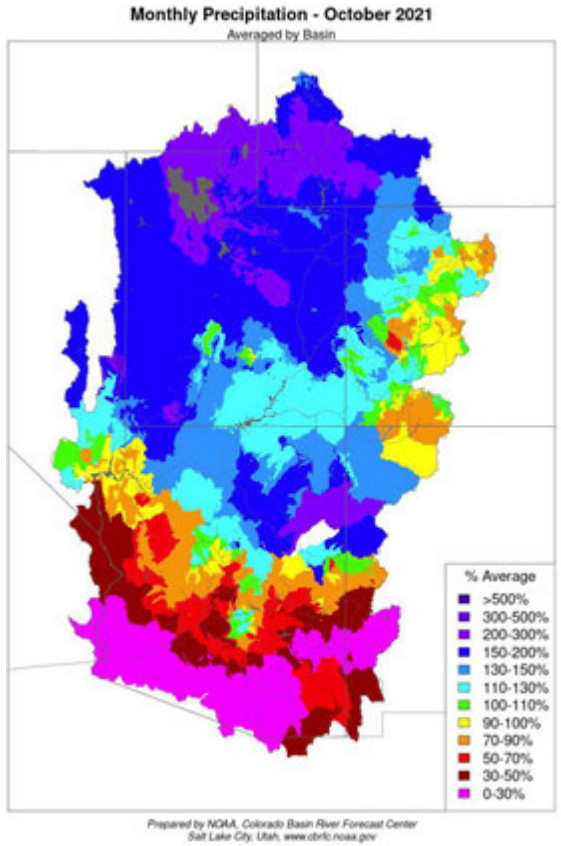
February 9, 2022

# Upper Basin Storage (as of February 7, 2022)

| Reservoir | Percent Current Live Storage | Current Live Storage (maf) | Live Storage Capacity (maf) | Elevation (feet) |
|---|---|---|---|---|
| Fontenelle | 52 | 0.17 | 0.33 | 6,482.77 |
| Flaming Gorge | 77 | 2.90 | 3.75 | 6,017.73 |
| Blue Mesa | 29 | 0.24 | 0.83 | 7,435.71 |
| Navajo | 50 | 0.86 | 1.70 | 6,018.84 |
| Lake Powell | 26 | 6.26 | 24.32 | 3,530.29 |
| UC System Storage | 34 | 10.55 | - | |
| Total System Storage | 37 | 21.75 | - | |

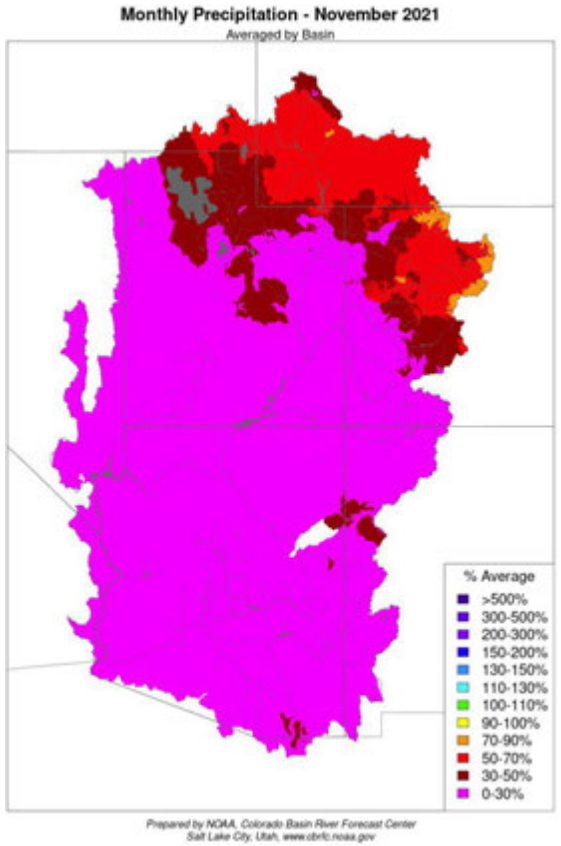


# Water Year 2022 (October - December) Monthly Precipitation Summary



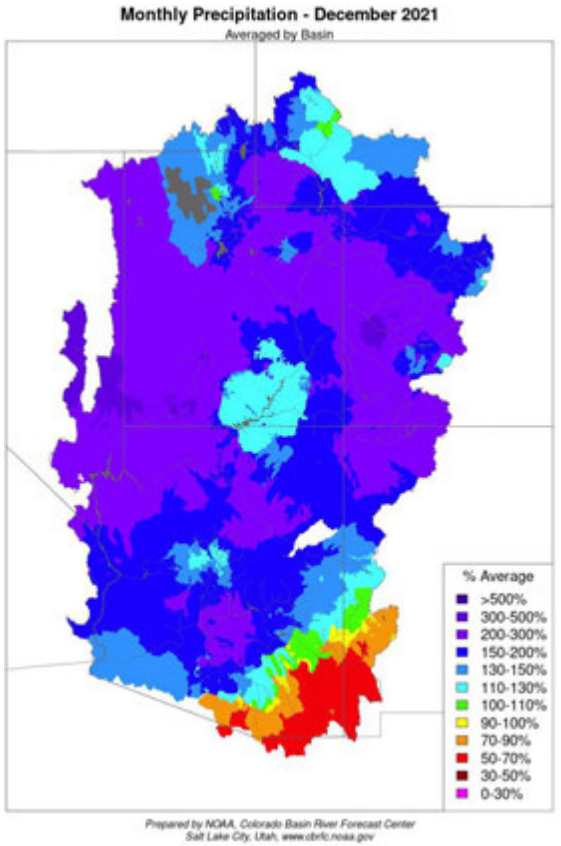

October precipitation was well above average across much of the region including southwest Wyoming, most of Utah, and northern Arizona.

Western Colorado had near average October precipitation while southern Arizona had below average precipitation during the month.




November's weather pattern was mostly very warm and dry with much below average monthly precipitation across most of the region.

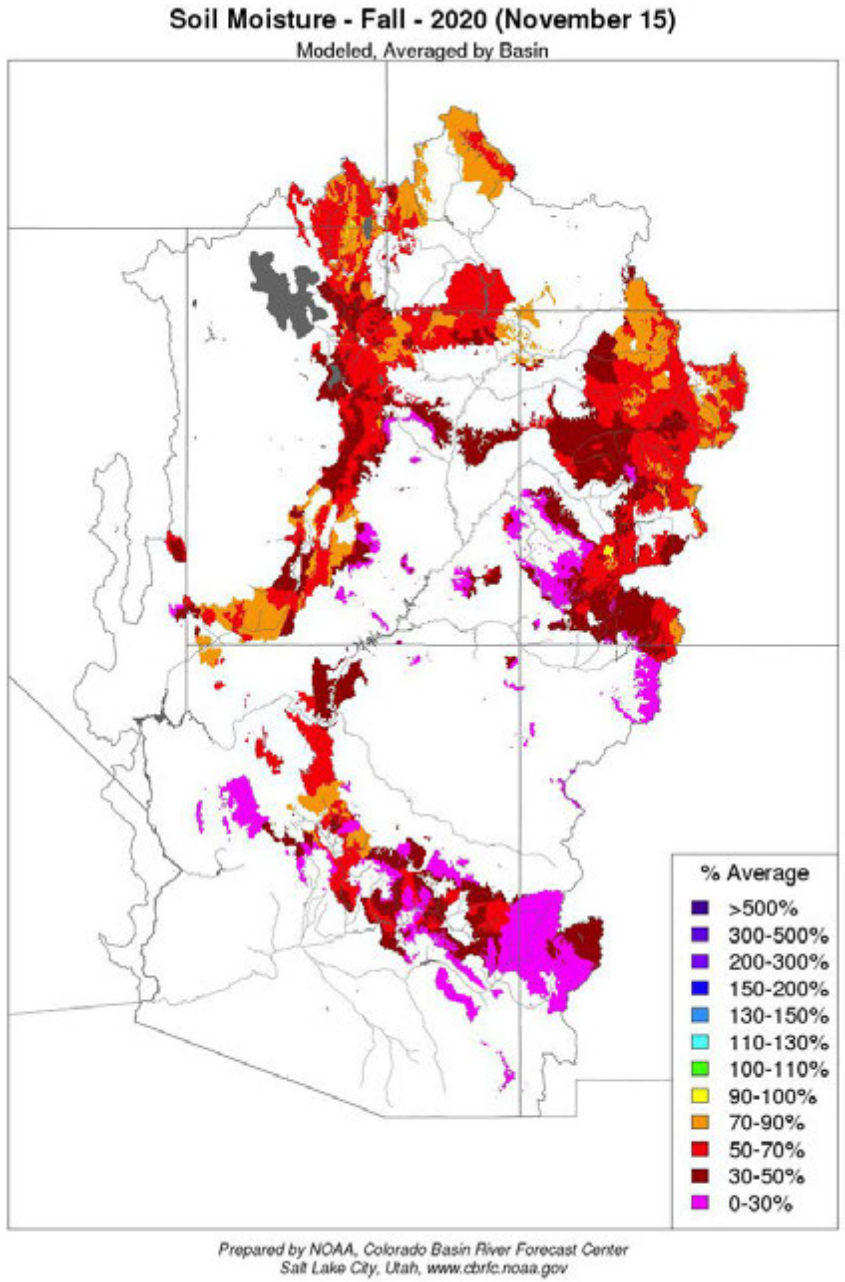
November precipitation fell in the bottom five at numerous SNOTEL stations across Utah, southwest Colorado, and central Arizona.



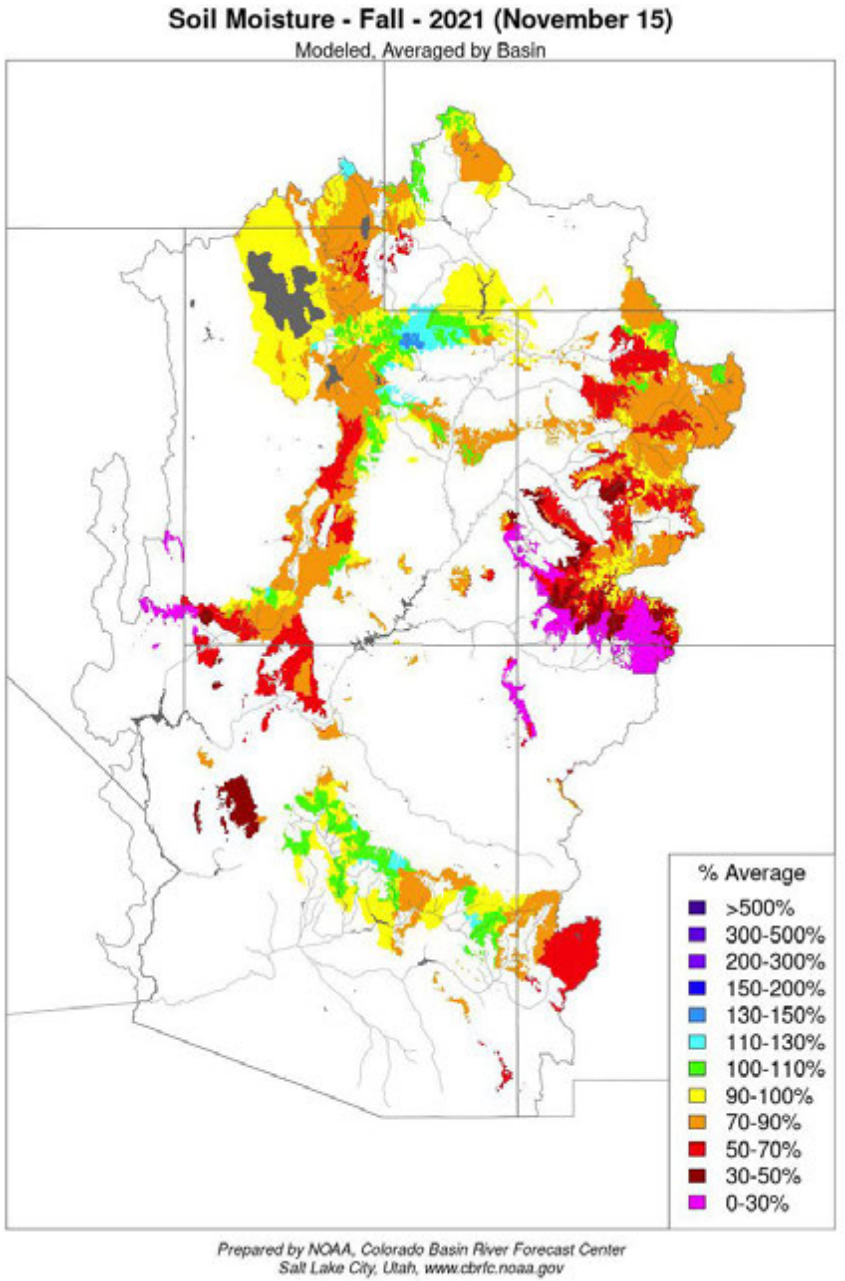

The weather pattern shifted during the second week of December towards colder and wetter conditions and featured multiple storm systems that brought widespread precipitation to most of the region during the last three weeks of the month.

The majority of SNOTEL sites across Utah and western Colorado and a few sites across central Arizona reported December precipitation values that ranked in the wettest five on record.

# Fall Model Soil Moisture Conditions: 2020 vs. 2021

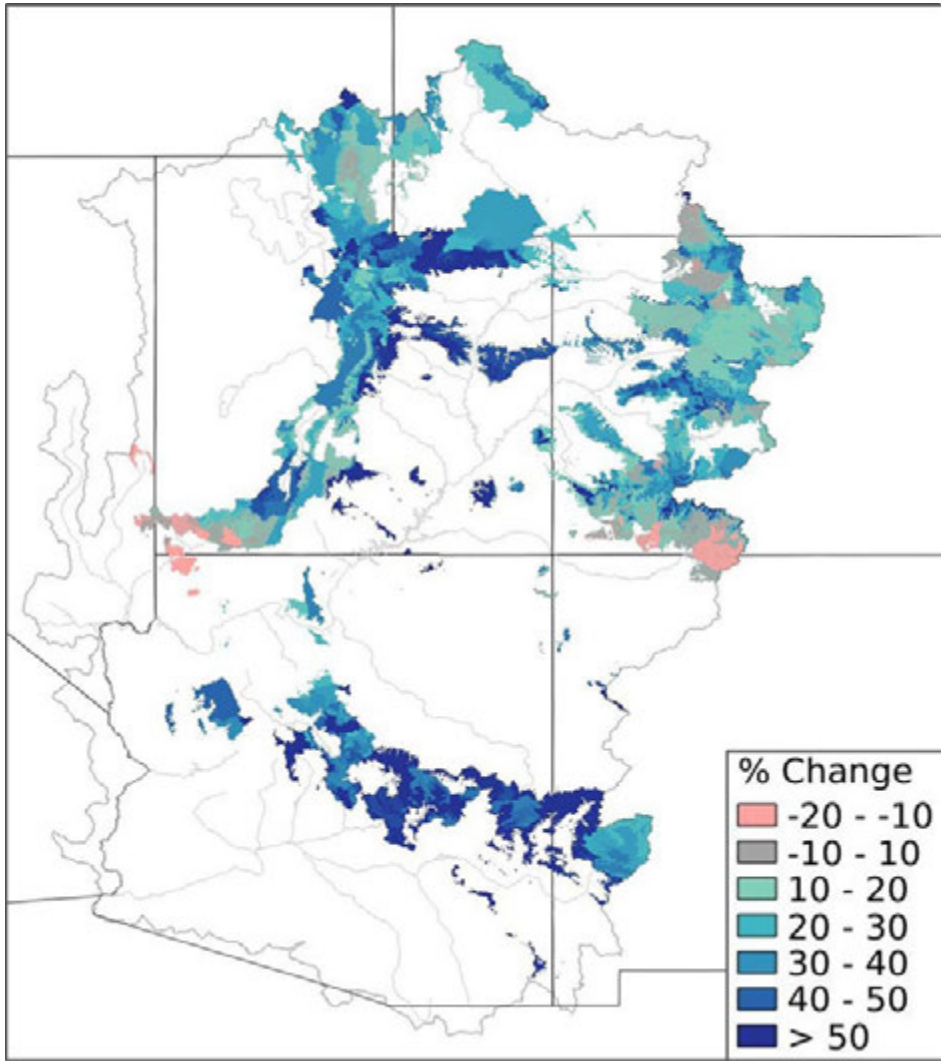



CBRFC model soil moisture conditions are improved from their record/near record dry levels a year ago but remain below to well below normal across many of the major runoff producing areas, notably western Colorado.



# Fall Model Soil Moisture Conditions: 2020 vs. 2021

**Soil Moisture - Fall (November 15)**
Modeled, %Change
(2021-2020)

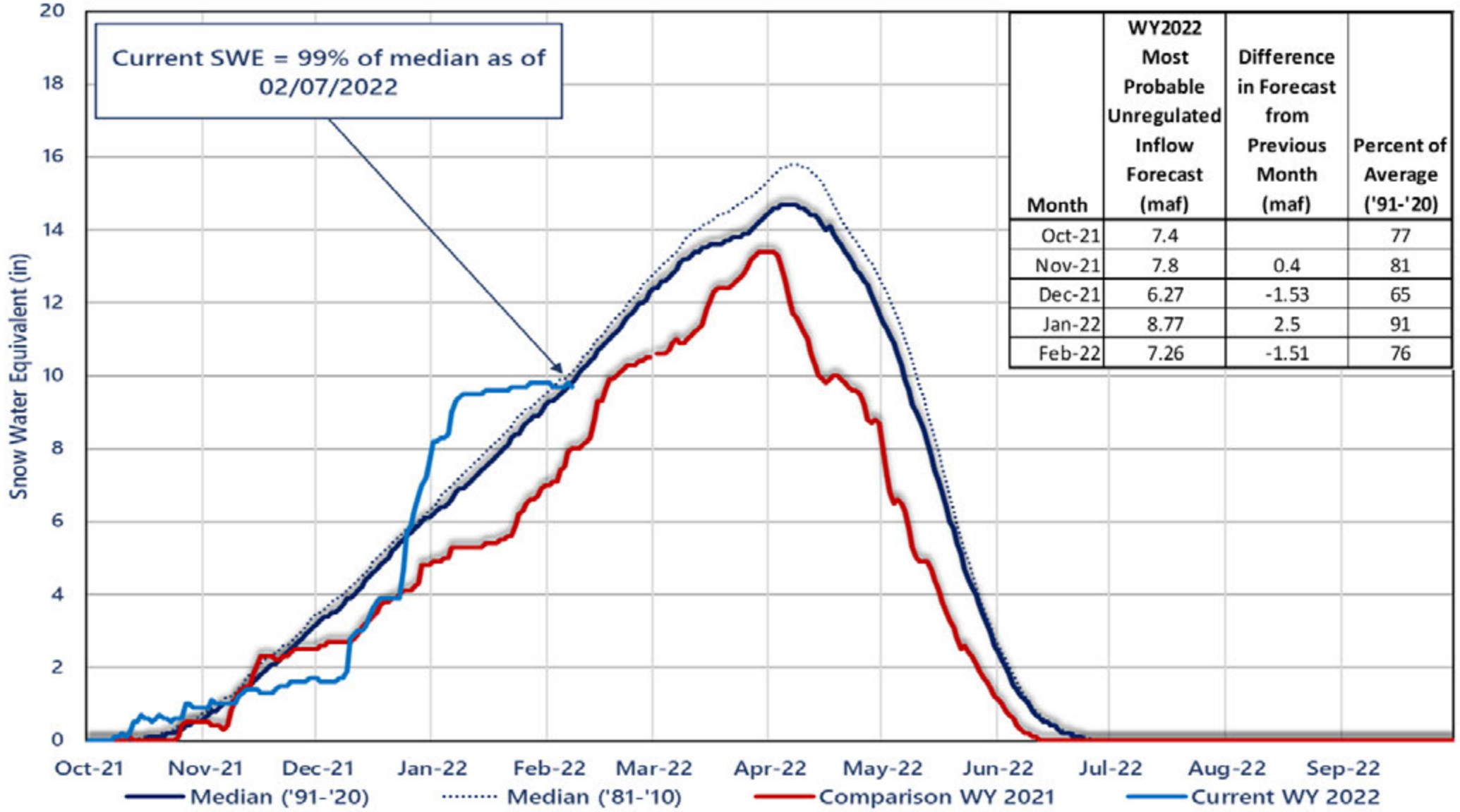



*Prepared by NOAA, Colorado Basin River Forecast Center*
*Salt Lake City, Utah, www.cbrfc.noaa.gov*

This is an experimental CBRFC soil moisture graphic.

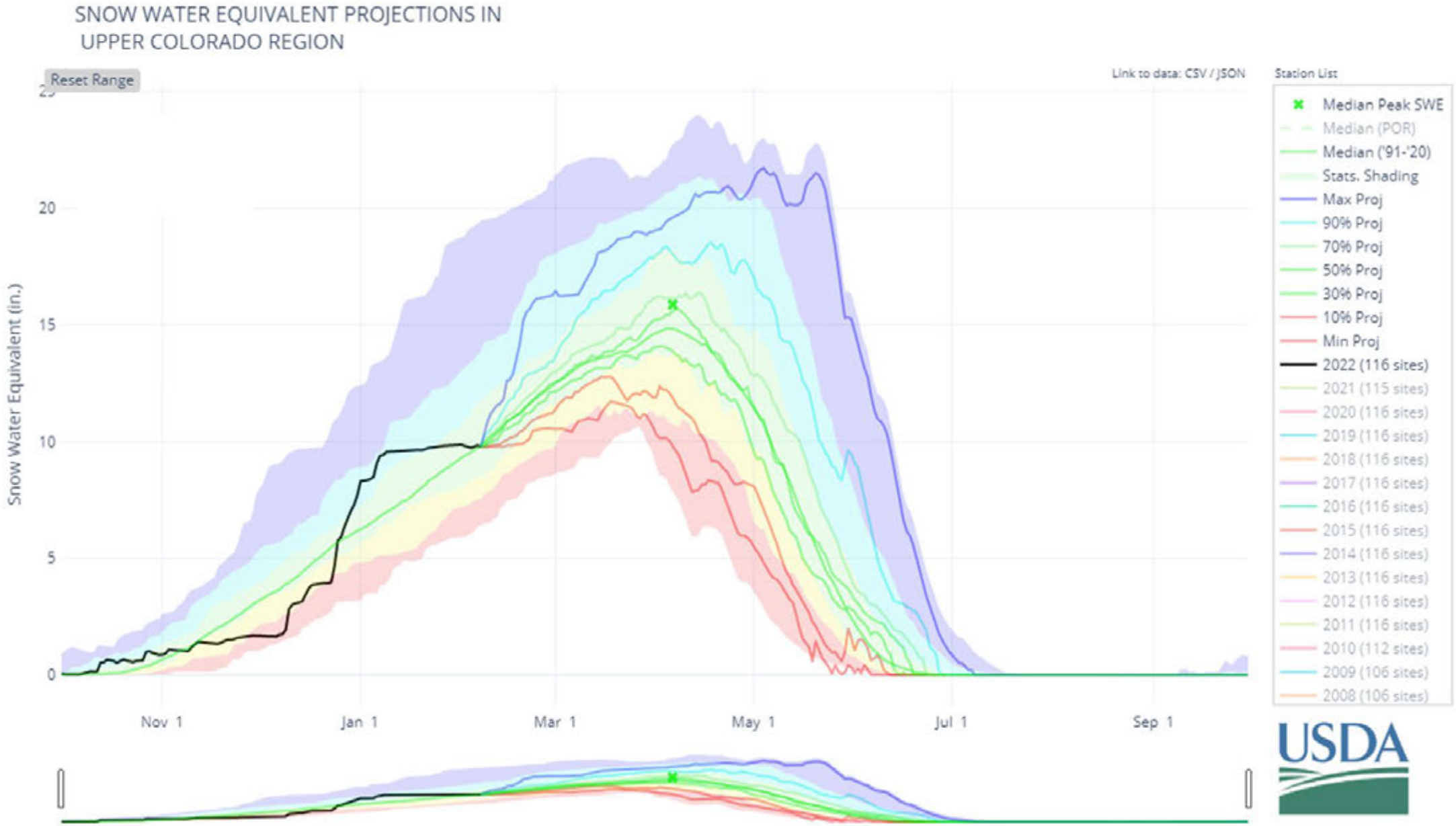
Utah & Arizona model soil moisture conditions improved more compared to southwest Wyoming & western Colorado.

# Colorado River Basin Above Lake Powell Snow Water Equivalent



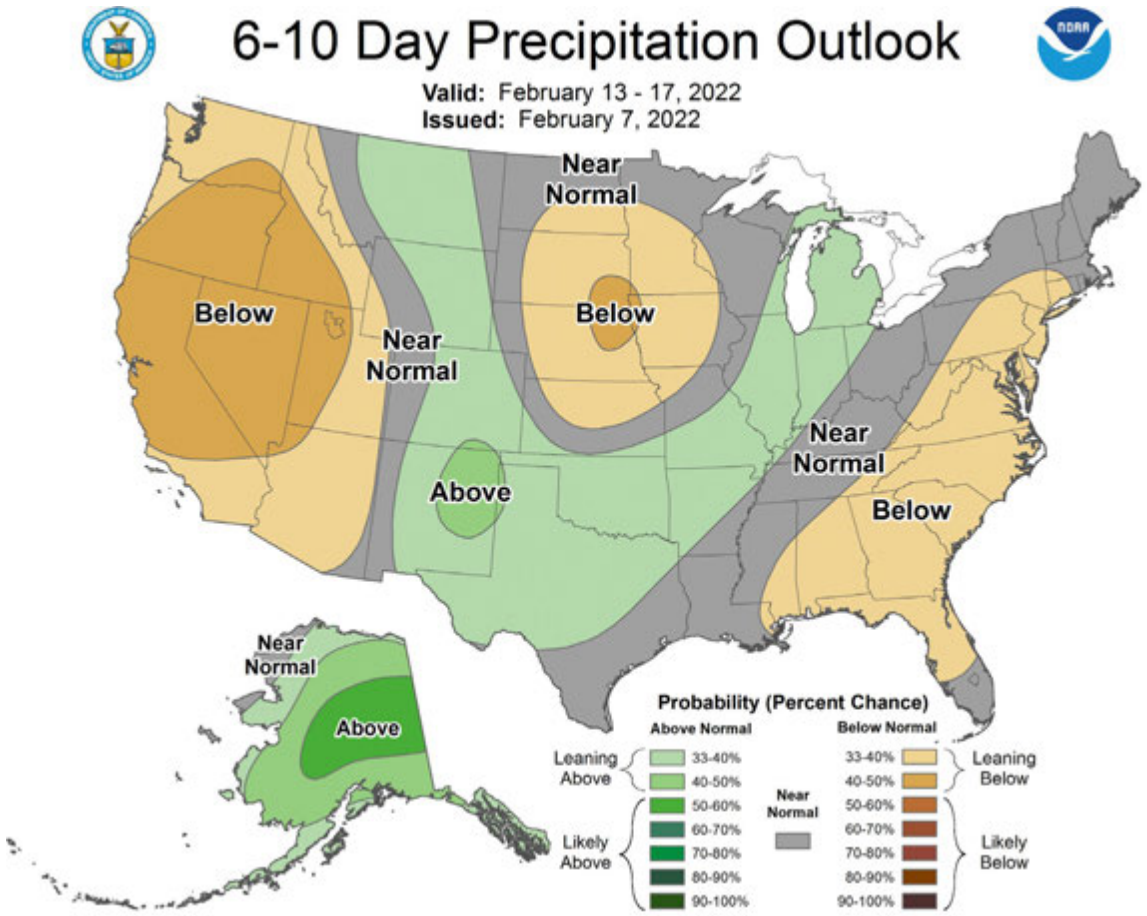

| Month | WY2022 Most Probable Unregulated Inflow Forecast (maf) | Difference in Forecast from Previous Month (maf) | Percent of Average ('91-'20) |
|---|---|---|---|
| Oct-21 | 7.4 | | 77 |
| Nov-21 | 7.8 | 0.4 | 81 |
| Dec-21 | 6.27 | -1.53 | 65 |
| Jan-22 | 8.77 | 2.5 | 91 |
| Feb-22 | 7.26 | -1.51 | 76 |

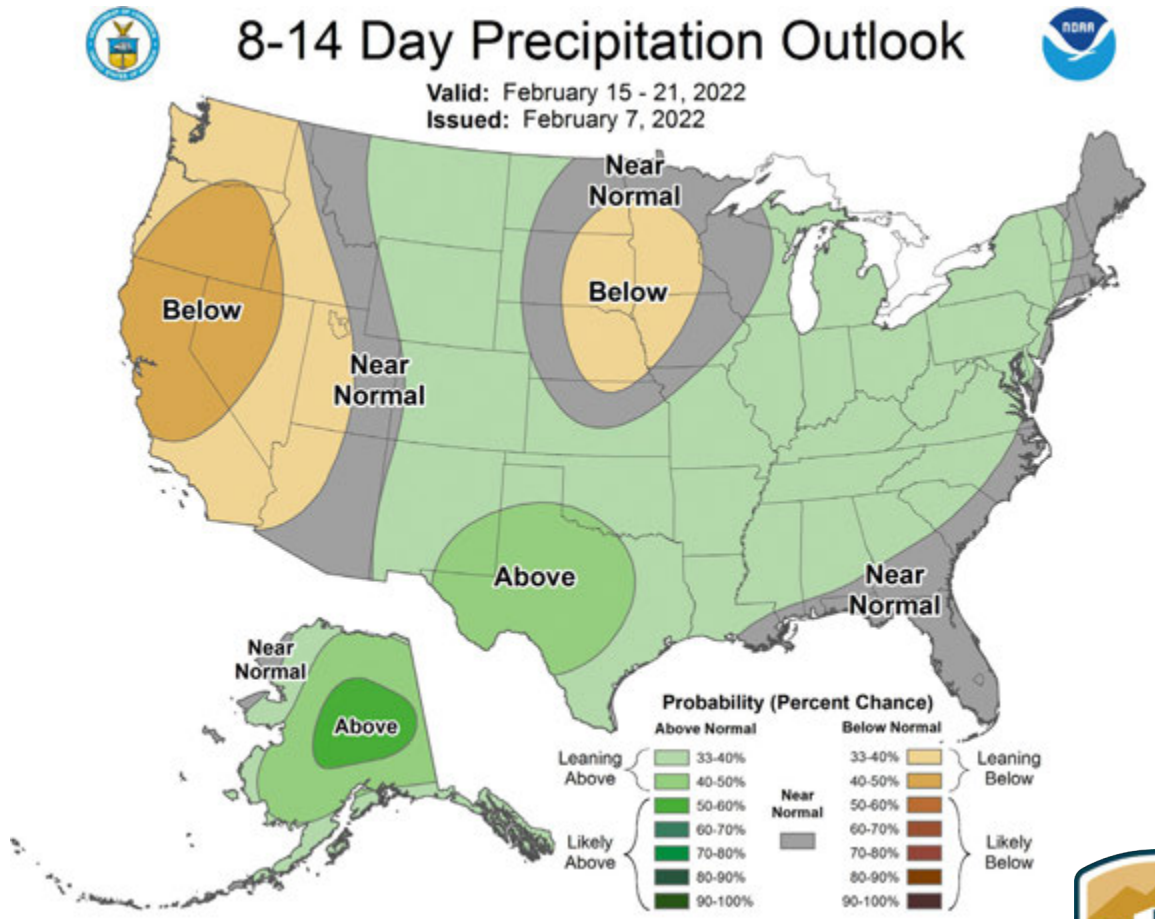
https://www.nrcs.usda.gov/Internet/WCIS/AWS_PLOTS/basinCharts/POR/WTEQ/assocHUC2/14_Upper_Colorado_Region.html



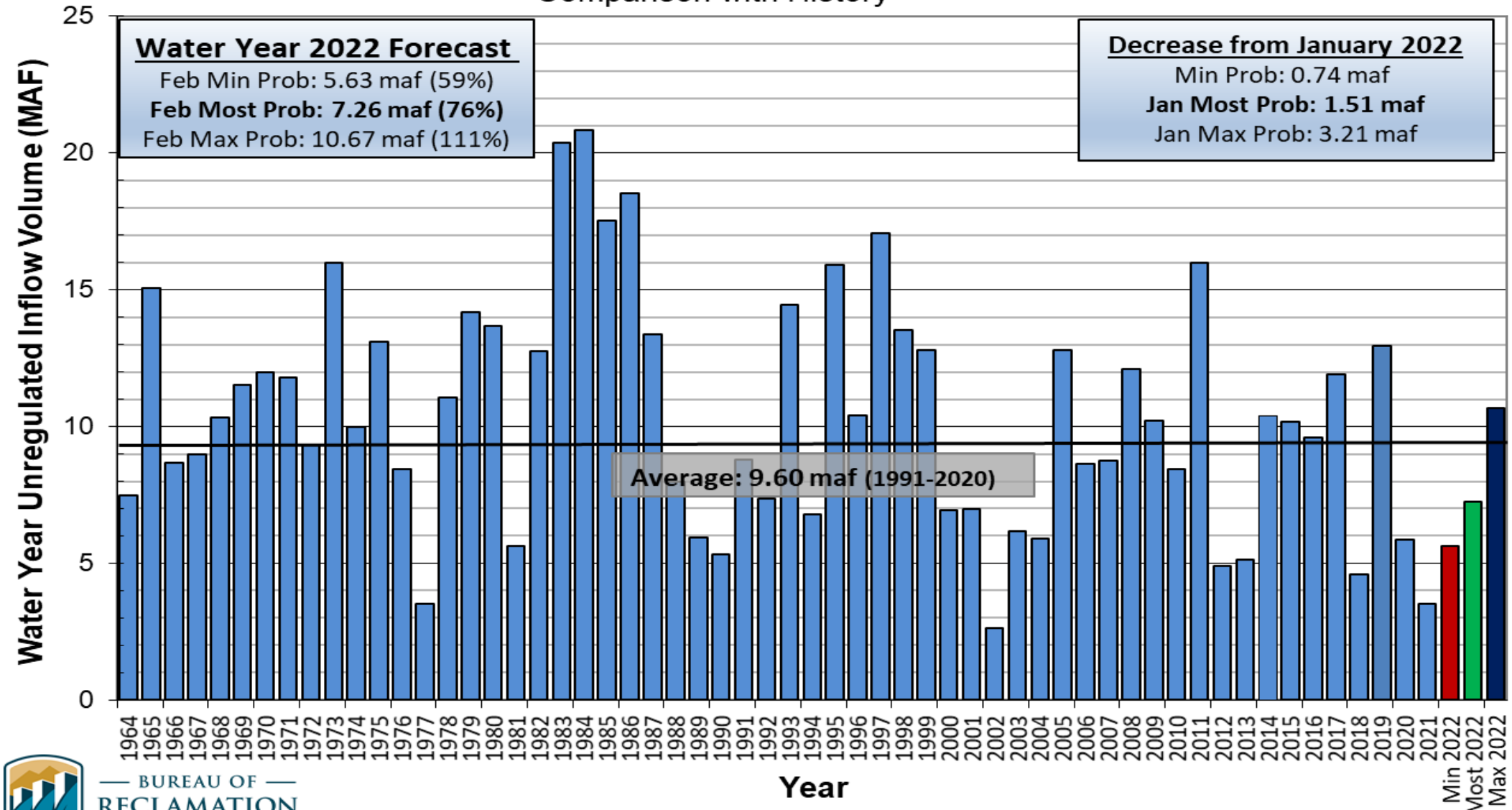

https://www.nrcs.usda.gov/Internet/WCIS/AWS_PLOTS/basinCharts/Proj/WTEQ/stdHUC2/14_Upper_Colorado_Region.html

# NOAA Precipitation Outlook Comparison



# Lake Powell Unregulated Inflow
## Water Year 2022 Forecast *(issued February 3)*
Comparison with History

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# Most Probable February Forecast Water Year 2022

## Water Year 2022 Forecasted Unregulated Inflow
as of February 3, 2022

| Reservoir | Unregulated Inflow (kaf) | 1991-2020 Percent of Avg |
|---|---|---|
| Fontenelle | 911 | 85 |
| Flaming Gorge | 1,125 | 80 |
| Blue Mesa | 810 | 90 |
| Navajo | 624 | 69 |
| Powell | 7,257 | 76 |

## April – July 2022 Forecasted Unregulated Inflow
as of February 3, 2022

| Reservoir | Unregulated Inflow (kaf) | 1991-2020 Percent of Avg |
|---|---|---|
| Fontenelle | 615 | 84 |
| Flaming Gorge | 750 | 78 |
| Blue Mesa | 585 | 92 |
| Navajo | 455 | 72 |
| Powell | 5,000 | 78 |

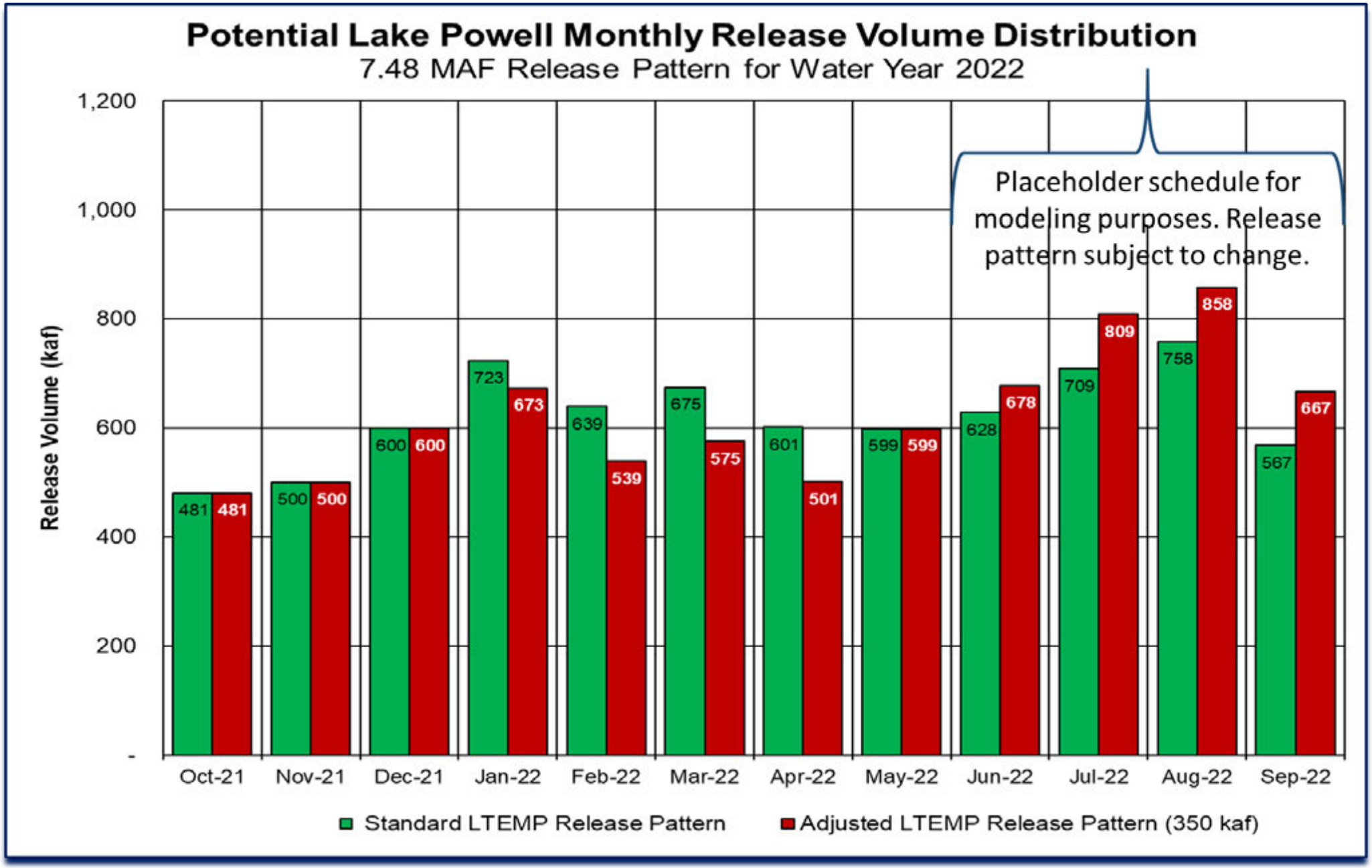
# Current Upper Colorado Drought Response Activities

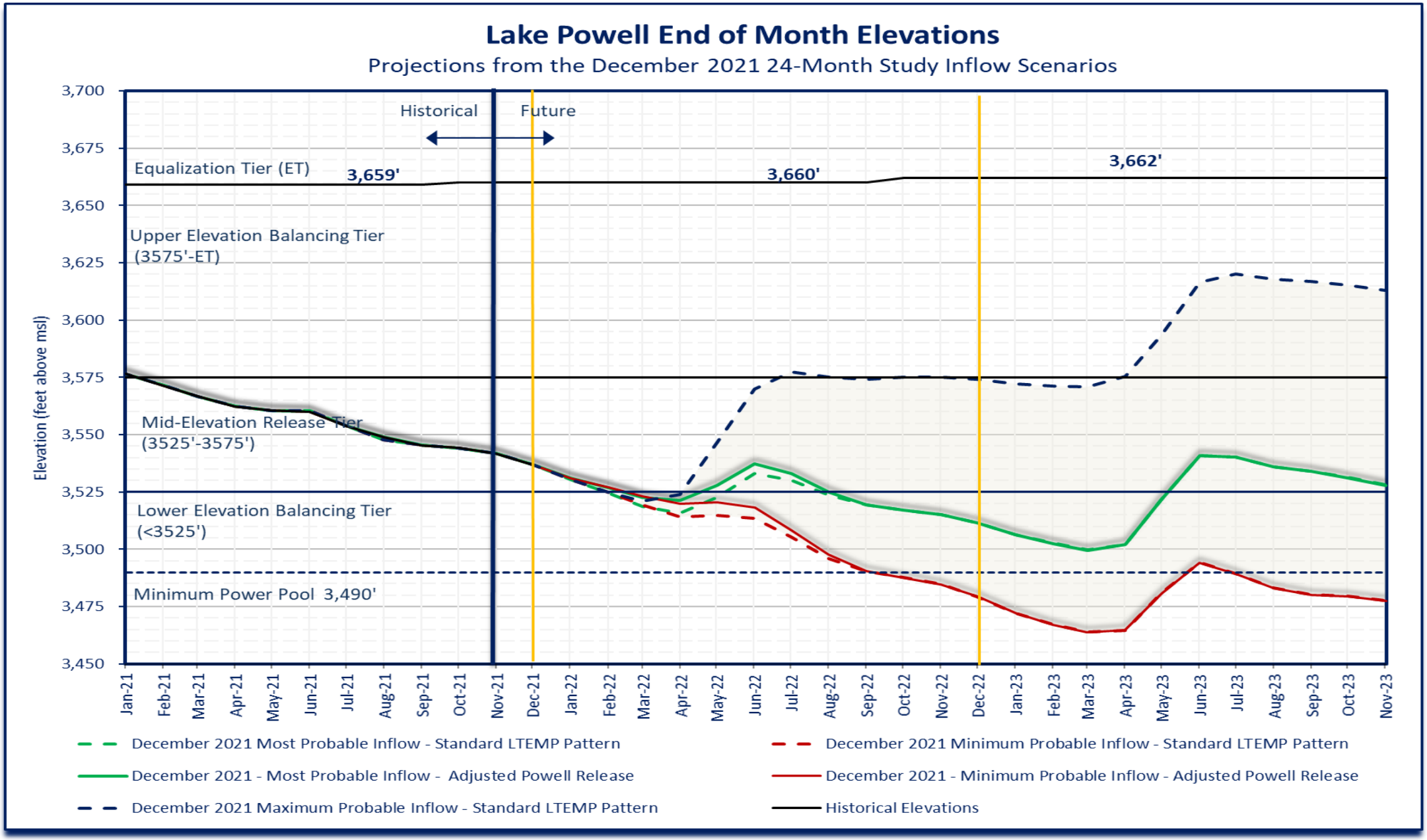
## Drought Response Operations Agreement

- Effective May 2019
- Continues through 2026 (except recovery)
- 2021 DROA release volumes of 161 kaf completed in October 2021
- Glen Canyon Dam release adjustments under LTEMP flexibility beginning in January 2022

## Drought Response Operations Plan

- Scheduled to be finalized in April 2022
- Draft framework document circulating for review
- Webinar in late January to be followed by comment period
- 2022 operational plans based on actual hydrology to be developed February through April


Potential Lake Powell Monthly Release Volume Distribution
7.48 MAF Release Pattern for Water Year 2022
Release Volume (kaf)
1,200
1,000
800
600
400
200
-
Placeholder schedule for modeling purposes. Release pattern subject to change.
481 481
500 500
600 600
723 673
639 539
675 575
601 501
599 599
628 678
709 809
758 858
567 667
Oct-21
Nov-21
Dec-21
Jan-22
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Standard LTEMP Release Pattern
Adjusted LTEMP Release Pattern (350 kaf)


Lake Powell End of Month Elevations
Projections from the December 2021 24-Month Study Inflow Scenarios
Historical
Future
Equalization Tier (ET)
3,659'
3,660'
3,662'
Upper Elevation Balancing Tier
(3575'-ET)
Mid-Elevation Release Tier
(3525'-3575')
Lower Elevation Balancing Tier
(<3525')
Minimum Power Pool 3,490'
Elevation (feet above msl)
3,700
3,675
3,650
3,625
3,600
3,575
3,550
3,525
3,500
3,475
3,450
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21
Jan-22
Feb-22
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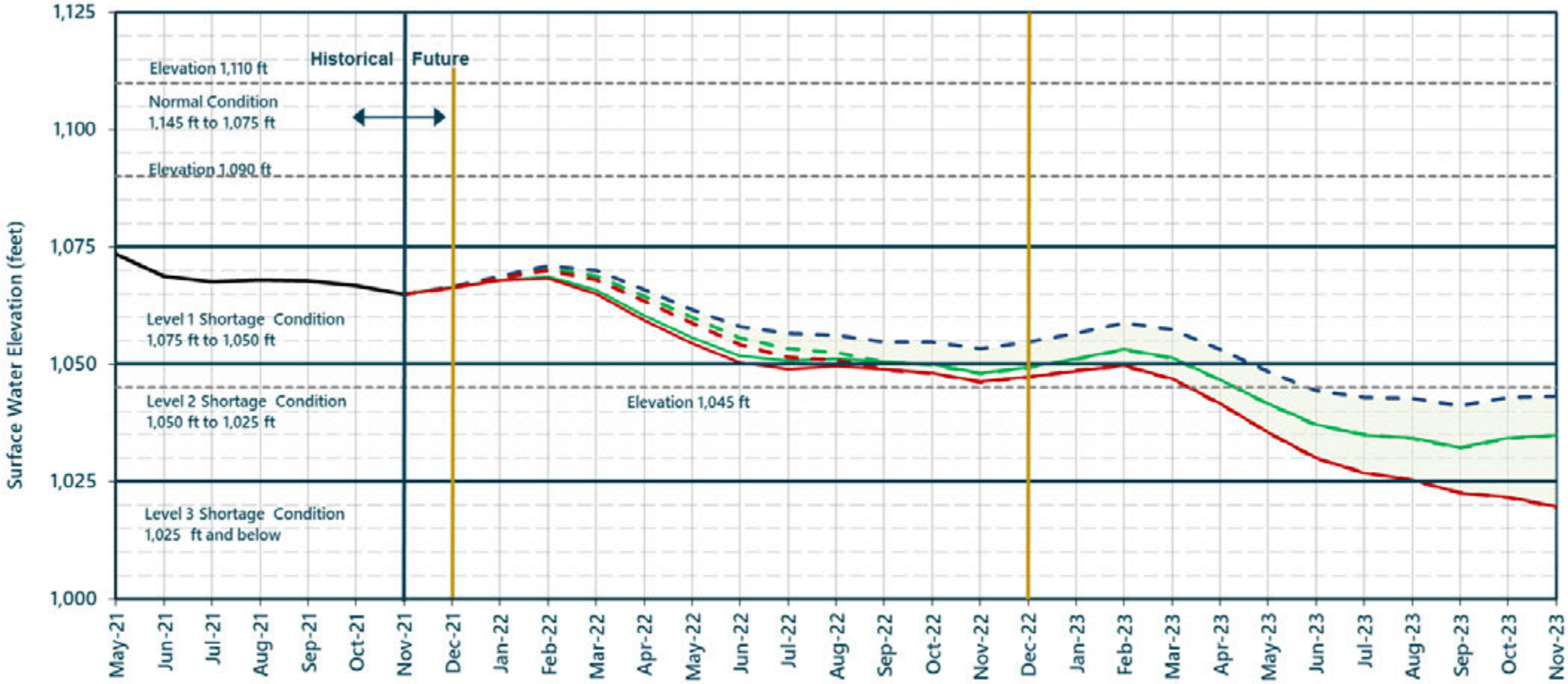
Dec-22
Jan-23
Feb-23
Mar-23
Apr-23
May-23
Jun-23
Jul-23
Aug-23
Sep-23
Oct-23
Nov-23
December 2021 Most Probable Inflow - Standard LTEMP Pattern
December 2021 Minimum Probable Inflow - Standard LTEMP Pattern
December 2021 - Most Probable Inflow - Adjusted Powell Release
December 2021 - Minimum Probable Inflow - Adjusted Powell Release
December 2021 Maximum Probable Inflow - Standard LTEMP Pattern
Historical Elevations

# Lake Mead End of Month Elevations

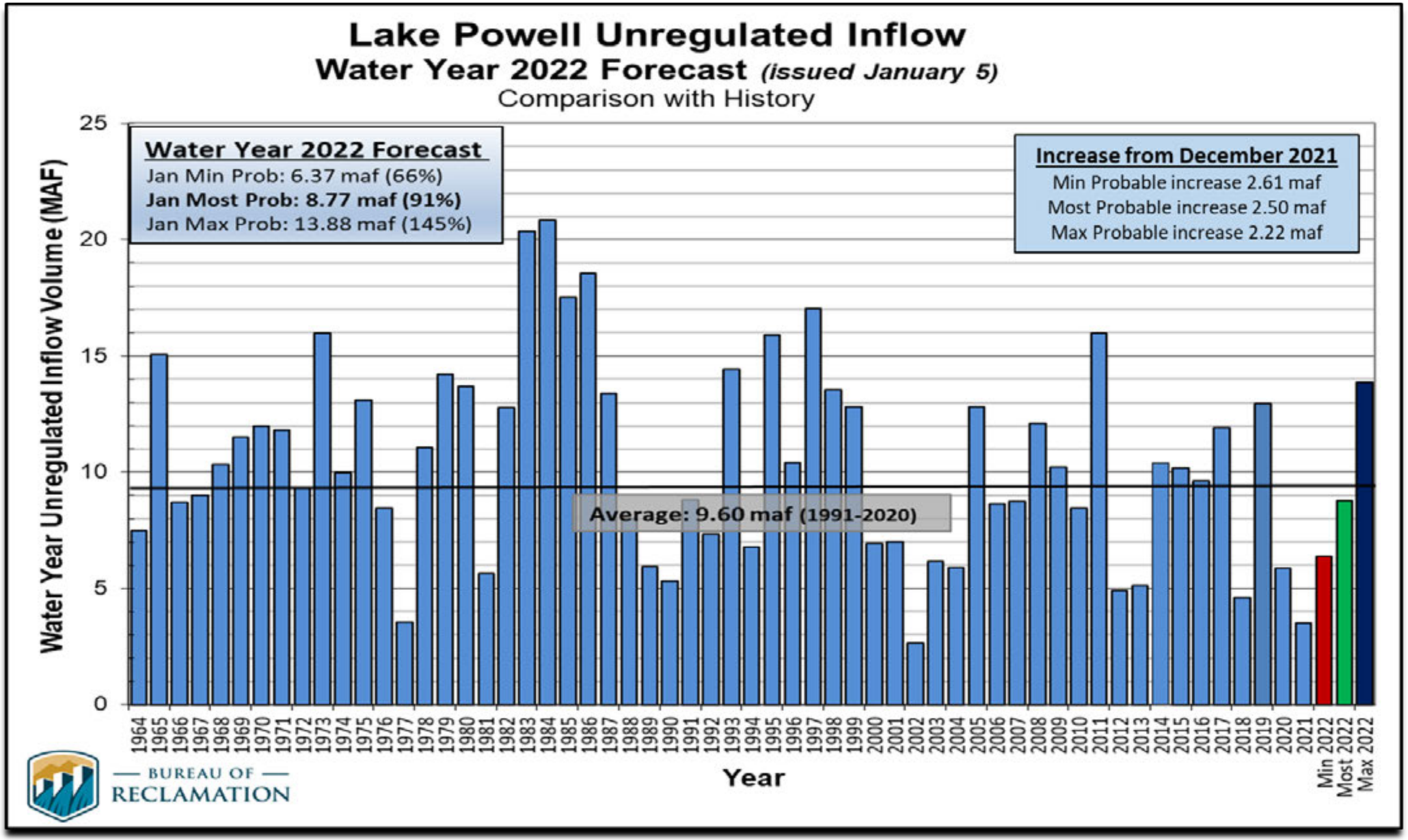
## Projections from the December 2021 24-Month Study Inflow Scenarios




The Drought Response Operations Agreement (DROA) is available online at: https://www.usbr.gov/dcp/finaldocs.html.

# Upper Colorado Basin

# Projected Operations for Water Year 2022 Based on January 2022 Modeling


Lake Powell Unregulated Inflow
Water Year 2022 Forecast (issued January 5)
Comparison with History
Water Year 2022 Forecast
Jan Min Prob: 6.37 maf (66%)
Jan Most Prob: 8.77 maf (91%)
Jan Max Prob: 13.88 maf (145%)
Increase from December 2021
Min Probable increase 2.61 maf
Most Probable increase 2.50 maf
Max Probable increase 2.22 maf
Average: 9.60 maf (1991-2020)
Water Year Unregulated Inflow Volume (MAF)
Year
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# Most Probable January Forecast
# Water Year 2022

## Water Year 2022
## Forecasted Unregulated Inflow
as of January 5, 2022

| Reservoir | Unregulated Inflow (kaf) | 1991-2020 Percent of Avg |
|---|---|---|
| Fontenelle | 942 | 88 |
| Flaming Gorge | 1,216 | 86 |
| Blue Mesa | 880 | 97 |
| Navajo | 725 | 80 |
| Powell | 8,767 | 91 |

## April – July 2022
## Forecasted Unregulated Inflow
as of January 5, 2022

| Reservoir | Unregulated Inflow (kaf) | 1991-2020 Percent of Avg |
|---|---|---|
| Fontenelle | 650 | 88 |
| Flaming Gorge | 840 | 87 |
| Blue Mesa | 650 | 102 |
| Navajo | 550 | 88 |
| Powell | 6,300 | 99 |

Powell January midmonth = 6.1 maf (95%)

# Lake Powell & Lake Mead Operational Table

| Lake Powell | | |
|---|---|---|
| **Elevation (feet)** | **Operation According to the Interim Guidelines** | **Live Storage (maf)[1]** |
| 3,700 | **Equalization Tier**<br>Equalize, avoid spills or release 8.23 maf | 24.3 |
| 3,636 - 3,666 (2008-2026) | | 15.5 - 19.3 (2008-2026) |
| | **Upper Elevation Balancing Tier[3]**<br>Release 8.23 maf;<br>if Lake Mead < 1,075 feet, balance contents with a min/max release of 7.0 and 9.0 maf | |
| 3,575 | | 9.5 |
| | **Mid-Elevation Release Tier**<br>Release 7.48 maf;<br>if Lake Mead < 1,025 feet, release 8.23 maf<br>***3,535.40 ft*** | |
| 3,525 | ***Jan 1, 2022 Projection*** | 5.9 |
| | **Lower Elevation Balancing Tier**<br>Balance contents with a min/max release of 7.0 and 9.5 maf | |
| 3,490 | | 4.0 |
| 3,370 | | 0 |

| Lake Mead | | |
|---|---|---|
| **Elevation (feet)** | **Operation According to the Interim Guidelines** | **Live Storage (maf)[1]** |
| 1,220 | **Flood Control Surplus or Quantified Surplus Condition**<br>Deliver > 7.5 maf | 25.9 |
| 1,200 (approx.)[2] | | 22.9 (approx.)[2] |
| | **Domestic Surplus or ICS Surplus Condition**<br>Deliver > 7.5 maf | |
| 1,145 | | 15.9 |
| 1,105 | **Normal or ICS Surplus Condition**<br>Deliver ≥ 7.5 maf | 11.9 |
| 1,075 | ***1,065.85 ft*** | 9.4 |
| 1,050 | Shortage Condition<br>Deliver 7.167[4] maf<br>***Jan 1, 2022 Projection*** | 7.5 |
| | **Shortage Condition**<br>Deliver 7.083[5] maf | |
| 1,025 | | 5.8 |
| 1,000 | **Shortage Condition**<br>Deliver 7.0[6] maf<br>Further measures may be undertaken[7] | 4.3 |
| 895 | | 0 |

**Diagram not to scale**

[1] Acronym for million acre-feet

[2] This elevation is shown as approximate as it is determined each year by considering several factors including Lake Powell and Lake Mead storage, projected Upper Basin and Lower Basin demands, and an assumed inflow.

[3] Subject to April adjustments which may result in a release according to the Equalization Tier

[4] Of which 2.48 maf is apportioned to Arizona, 4.4 maf to California, and 0.287 maf to Nevada

[5] Of which 2.40 maf is apportioned to Arizona, 4.4 maf to California, and 0.283 maf to Nevada

[6] Of which 2.32 maf is apportioned to Arizona, 4.4 maf to California, and 0.280 maf to Nevada

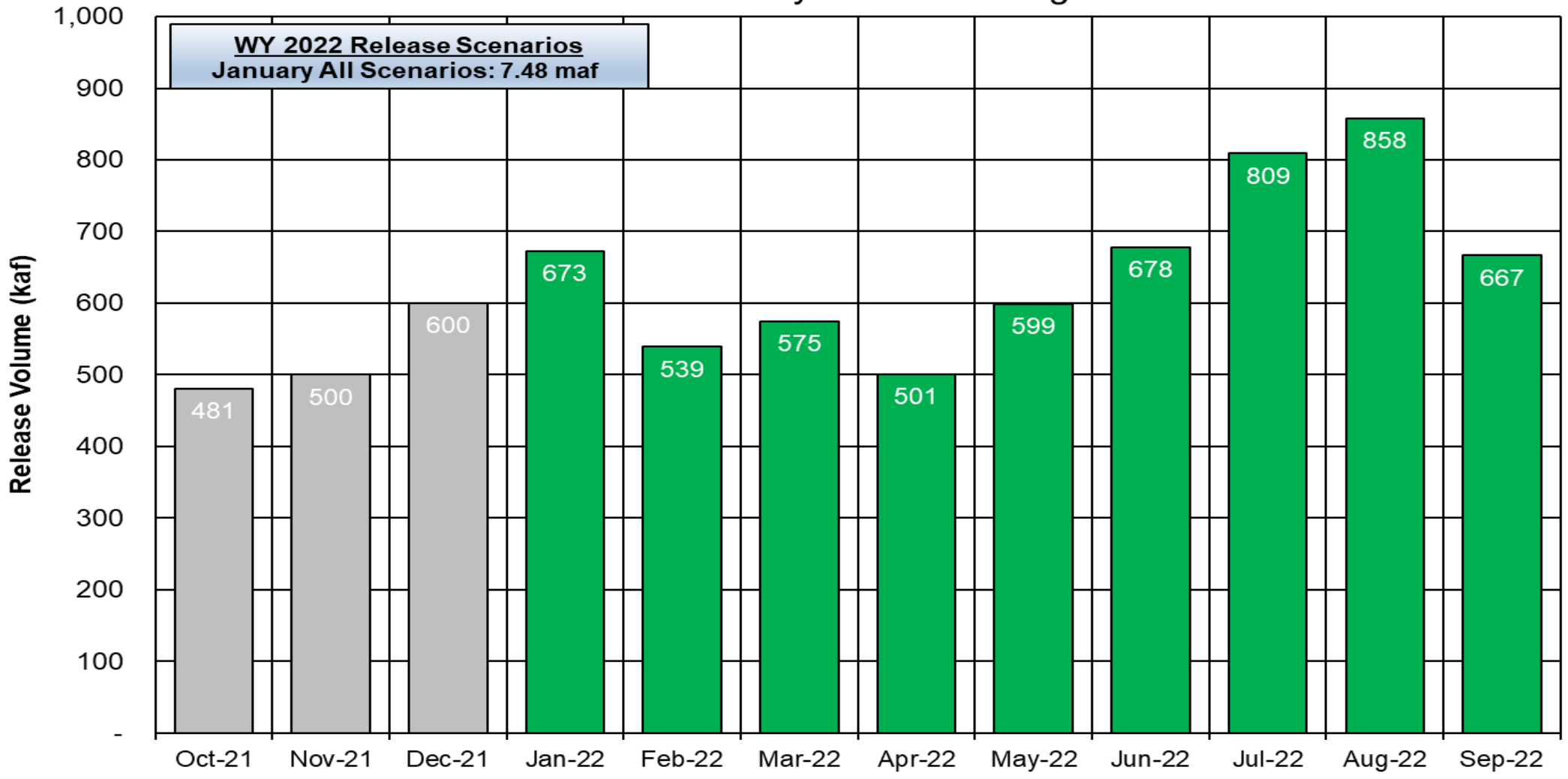
[7] Whenever Lake Mead is below elevation 1,025 feet, the Secretary shall consider whether hydrologic conditions together with anticipated deliveries to the Lower Division States and Mexico is likely to cause the elevation at Lake Mead to fall below 1,000 feet. Such consideration, in consultation with the Basin States, may result in the undertaking of further measures, consistent with applicable Federal law.



[1] Lake Powell and Lake Mead operating determinations are based on August 2021 24-Month Study projections consistent with the 2007 Interim Guidelines and 2019 Drought Contingency Plans. These determinations will be documented in the 2022 Annual Operating Plan for Colorado River Reservoirs.

# Potential Lake Powell Monthly Release Volume Distribution

Release Scenarios for Water Year 2022
Based on January 2022 Modeling

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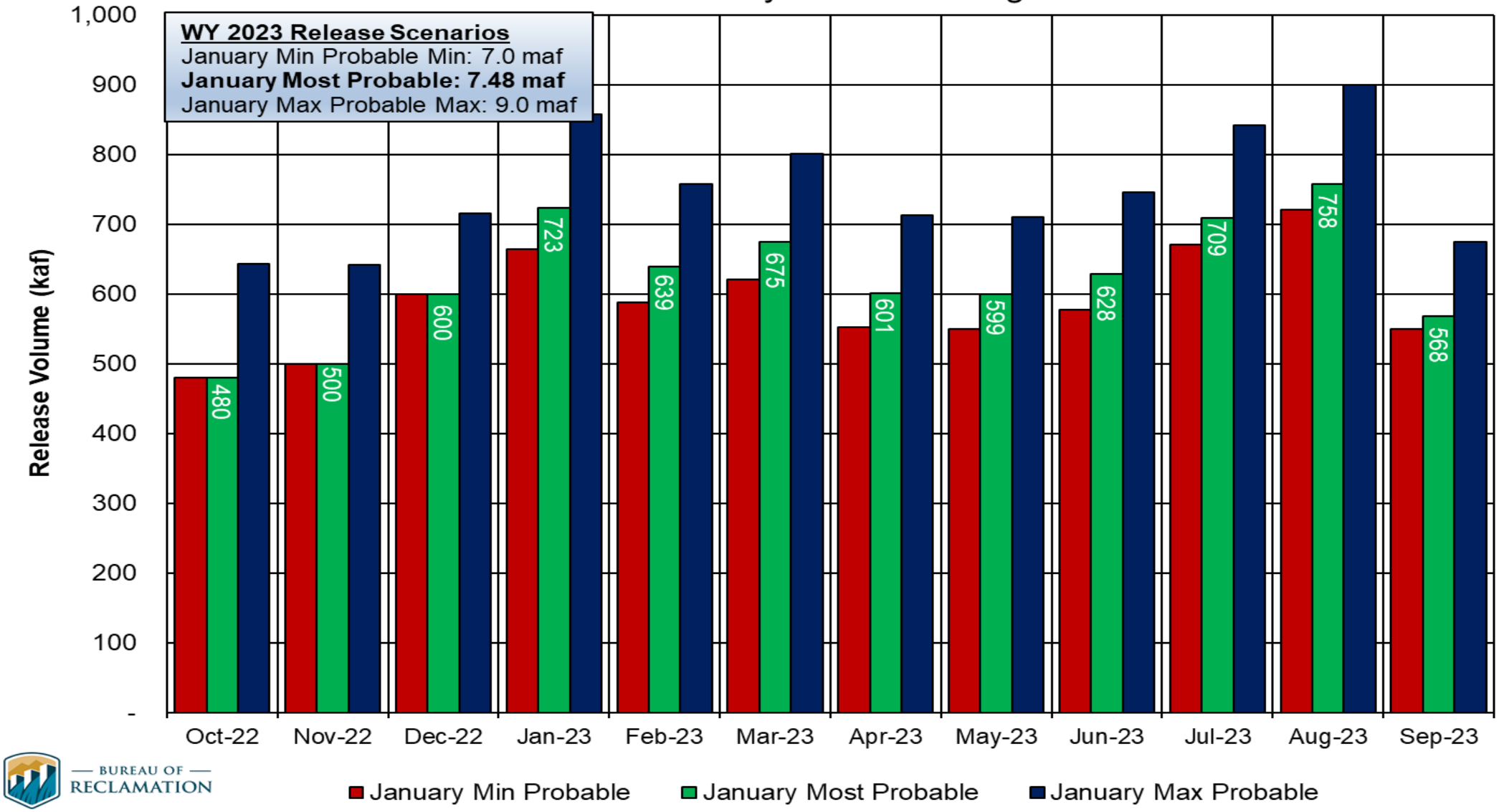
The Drought Response Operations Agreement (DROA) can be found here: https://www.usbr.gov/dcp/finaldocs.html

# Potential Lake Powell Monthly Release Volume Distribution

Release Scenarios for Water Year 2023
Based on January 2022 Modeling

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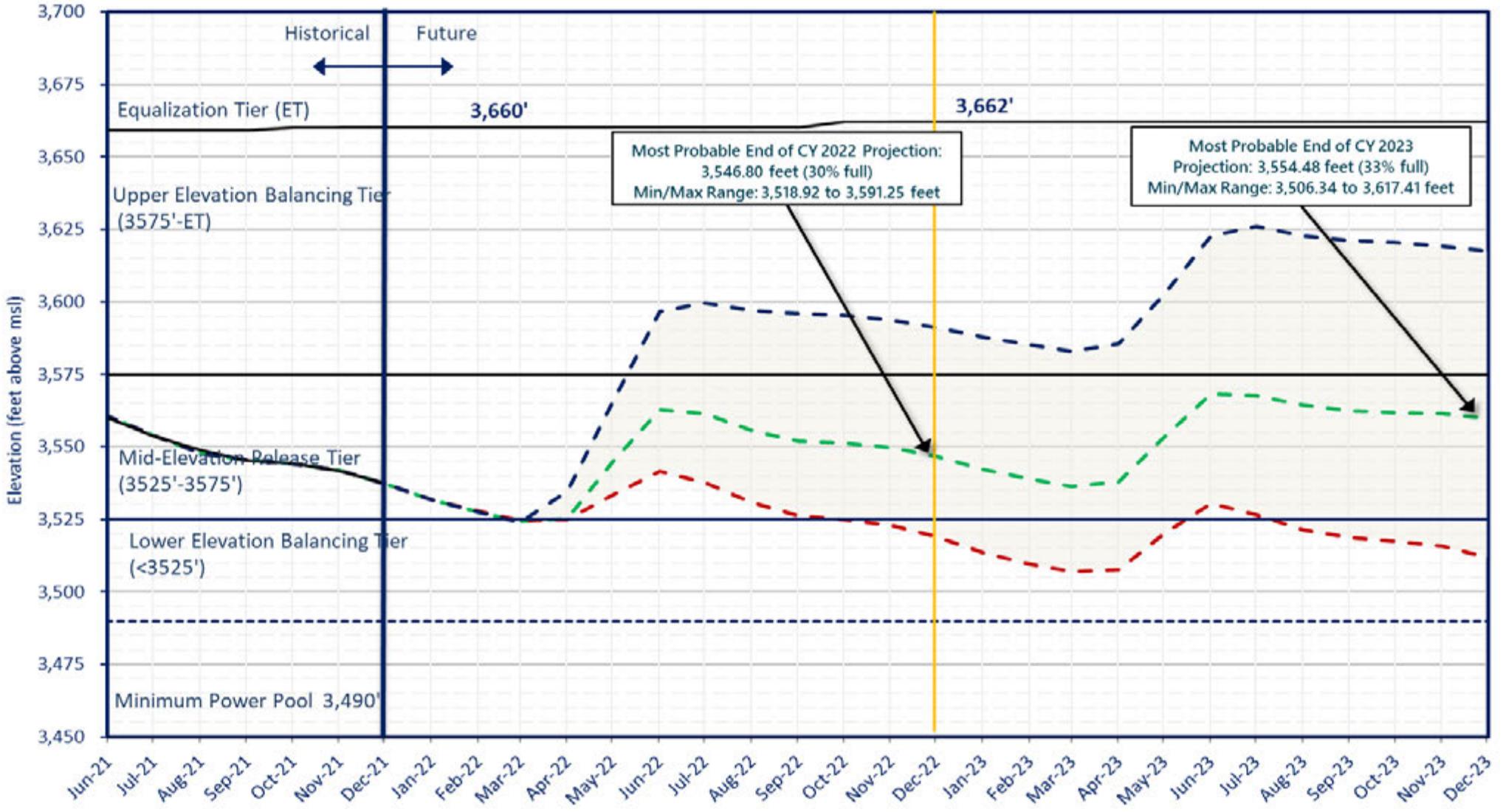
# Reclamation Operational Modeling
## Model Comparison

| | Colorado River Mid-term Modeling System (CRMMS) | | CRSS |
|---|---|---|---|
| | 24-Month Study Mode (Manual Mode) | Ensemble Mode (Rule-based Mode) | |
| Primary Use | AOP tier determinations and projections of current conditions | Risk-based operational planning and analysis | Long-term planning, comparison of alternatives |
| Simulated Reservoir Operations | Operations input manually | Rule-driven operations | |
| Probabilistic or Deterministic | Deterministic – single hydrologic trace | Deterministic OR Probabilistic 30 (or more) hydrologic traces | Probabilistic – 100+ traces |
| Time Horizon (years) | 1 - 2 | 1 - 5 | 1 - 50 |
| Upper Basin Inflow | Unregulated forecast, 1 trace | Unregulated ESP forecast, 35 traces | Natural flow; historical, paleo, or climate change hydrology |
| Upper Basin Demands | Implicit, in unregulated inflow forecast | | Explicit, 2016 UCRC assumptions |
| Lower Basin Demands | Official approved or operational | | Developed with LB users |

# Lake Powell End of Month Elevations

Projections from the January 2022 24-Month Study Inflow Scenarios

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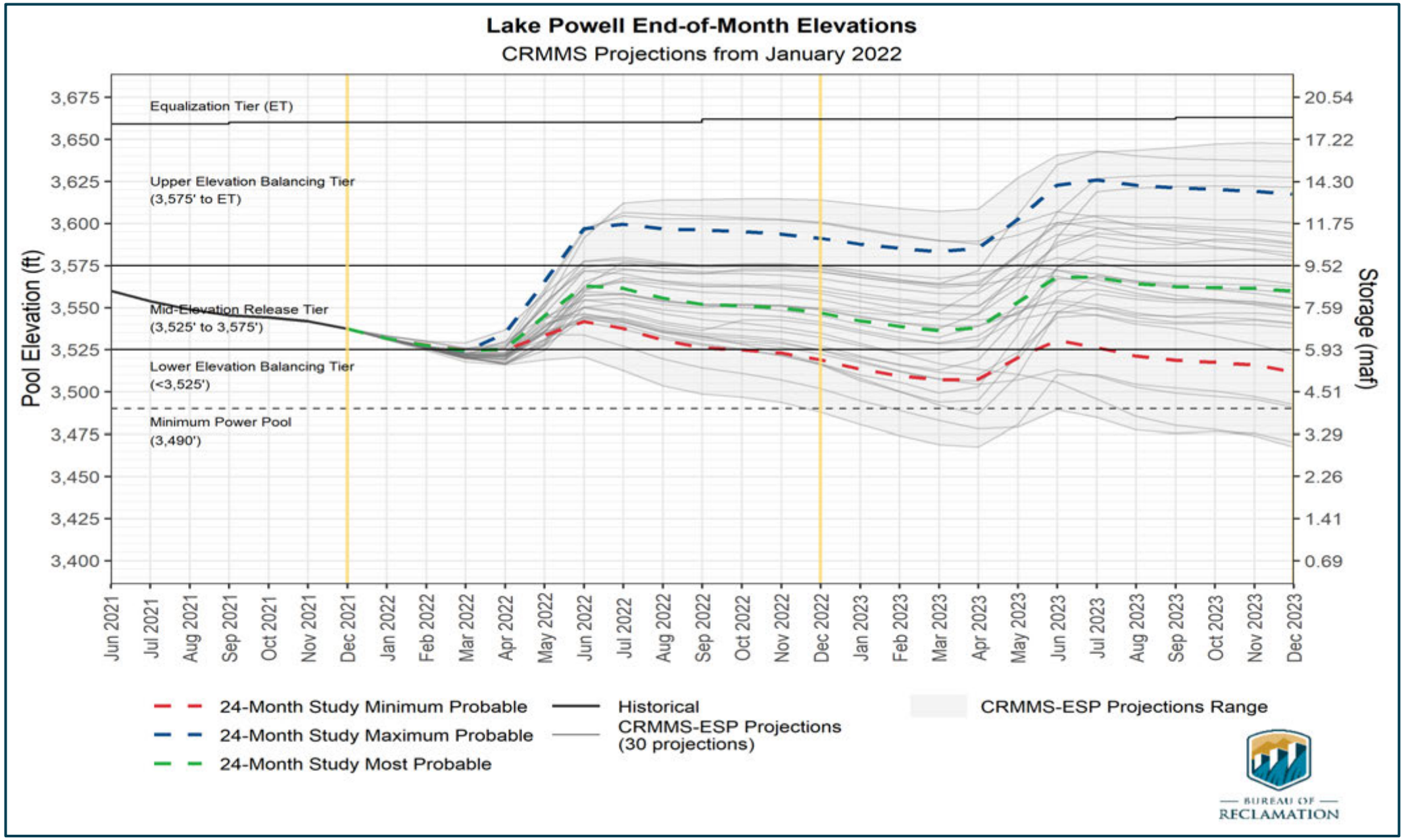
- January 2022 Most Probable Inflow - Lake Powell release of 7.48 maf in WY2022 and 7.48 maf in WY2023
- January 2022 Minimum Probable Inflow - Lake Powell release of 7.48 maf in WY2022 and 7.0 maf in WY2023
- January 2022 Maximum Probable Inflow - Lake Powell release of 7.48 maf in WY2022 and 9.0 maf in WY2023
- Historical Elevations

*The Drought Response Operations Agreement (DROA) can be found here: https://www.usbr.gov/dcp/finaldocs.html

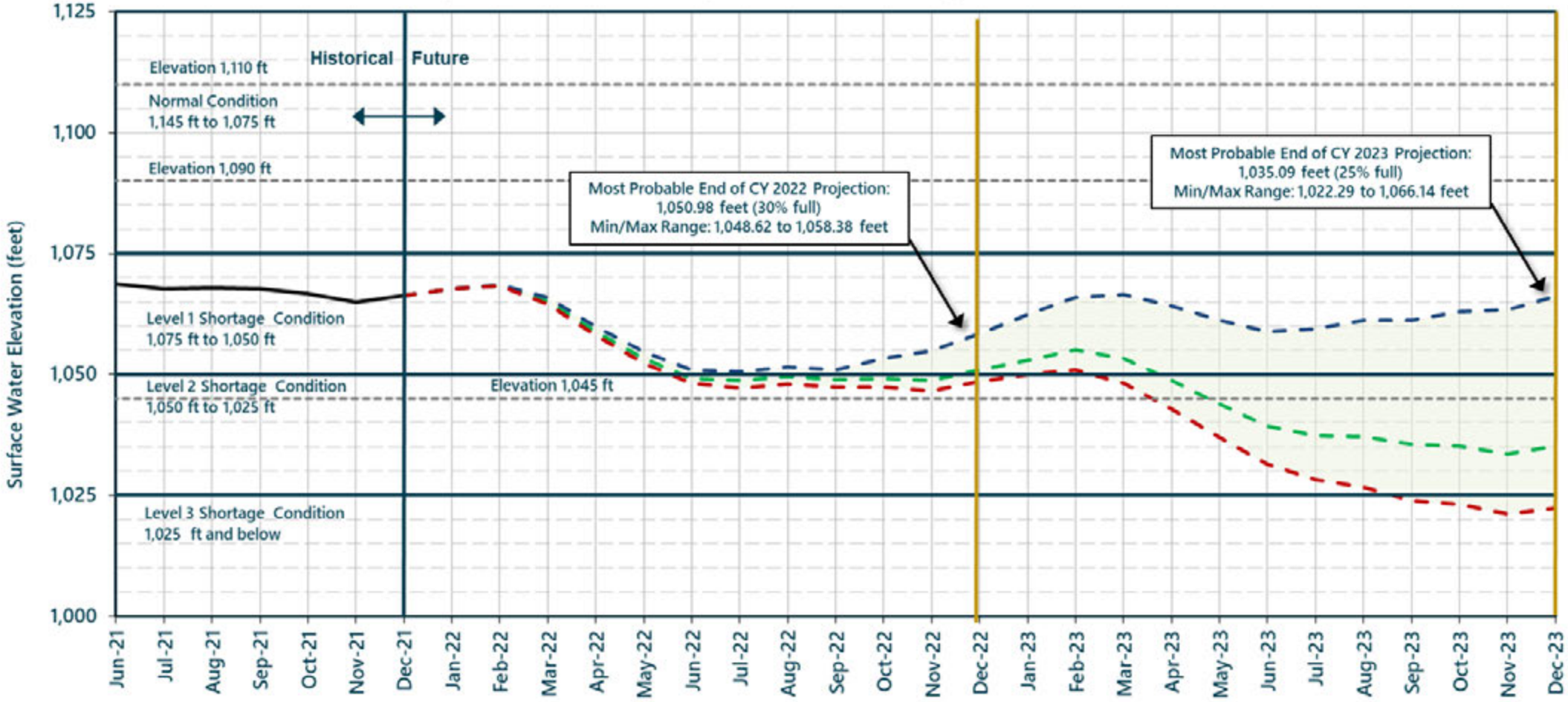





CRMMS 2-Year Probabilistic Projections are available online at: https://www.usbr.gov/lc/region/g4000/riverops/crmms-2year-projections.html

# Lake Mead End of Month Elevations

## Projections from the January 2022 24-Month Study Inflow Scenarios



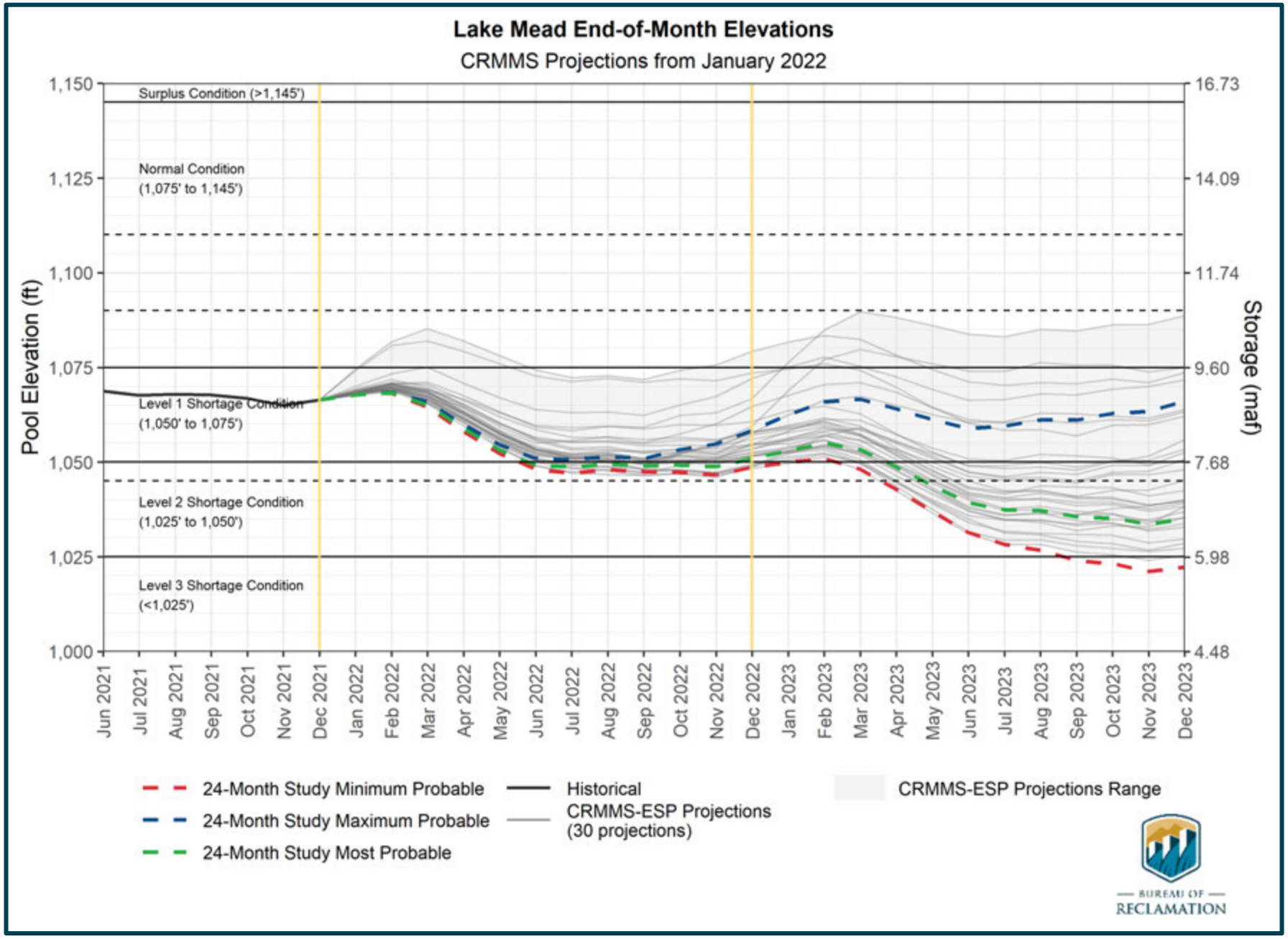

Historical Elevations

January 2022 Most Probable Inflow with a Lake Powell release of 7.48 maf in WY 2022 and 7.48 maf in WY 2023

January 2022 Maximum Probable Inflow with a Lake Powell release of 7.48 maf in WY 2022 and 9.00 maf in WY 2023

January 2022 Minimum Probable Inflow with a Lake Powell release of 7.48 maf in WY 2022 and 7.00 maf in WY 2023

The Drought Response Operations Agreement (DROA) is available online at: https://www.usbr.gov/dcp/finaldocs.html.






CRMMS 2-Year Probabilistic Projections are available online at: https://www.usbr.gov/lc/region/g4000/riverops/crmms-2year-projections.html

# Upper Colorado Basin

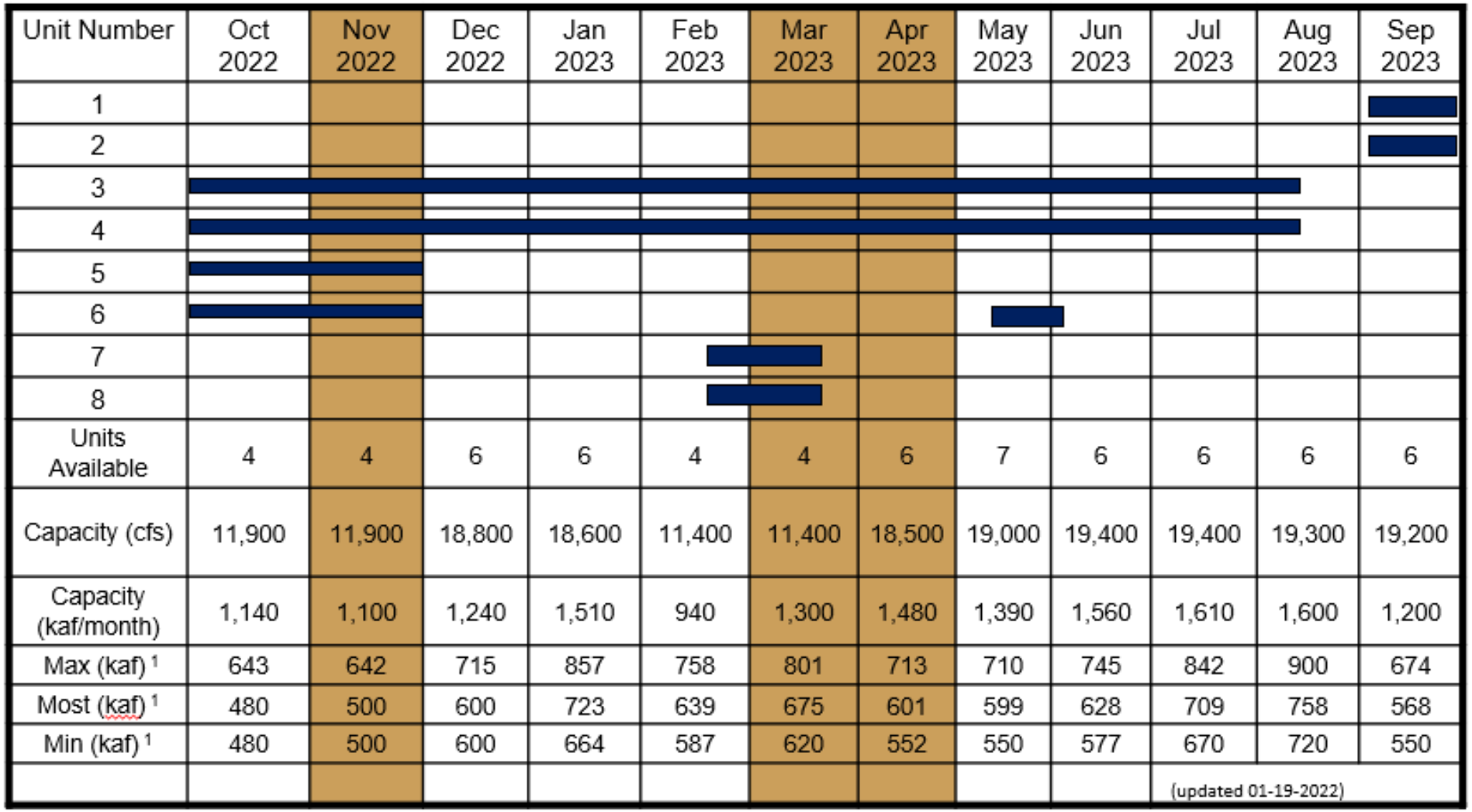
## Hydropower Maintenance

# Glen Canyon Dam Power Plant Unit Outage Schedule for 2022

| Unit Number | Oct 2021 | Nov 2021 | Dec 2021 | Jan 2022 | Feb 2022 | Mar 2022 | Apr 2022 | May 2022 | Jun 2022 | Jul 2022 | Aug 2022 | Sep 2022 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | |
| Units Available | 6 | 6 | 6 | 6 | 5 | 4 | 6 | 5 | 6 | 6 | 6 | 4 | |
| Capacity (cfs) | 18,700 | 18,600 | 11,700 | 18,700 | 14,800 | 11,350 | 18,000 | 15,300 | 19,200 | 19,200 | 19,000 | 12,000 | JAN MOST[2] |
| Capacity (kaf/month) | 1,150 | 1,110 | 1,110 | 1,160 | 890 | 1,050 | 1,070 | 970 | 1,100 | 1,180 | 1,150 | 750 | JAN MOST |
| Max (kaf)[1] | 481 | 500 | 600 | 673 | 539 | 575 | 501 | 599 | 678 | 809 | 858 | 667 | 7.48 maf |
| Most (kaf)[1] | 481 | 500 | 600 | 673 | 539 | 575 | 501 | 599 | 678 | 809 | 858 | 667 | 7.48 maf |
| Min (kaf)[1] | 481 | 500 | 600 | 673 | 539 | 575 | 501 | 599 | 678 | 809 | 858 | 667 | 7.48 maf |
| | | | | | | | | | | (updated 01-19-2022) | | | |

1 Projected release, based on January 2022 minimum, most and maximum probable inflow projections and 24-Month Study model runs.
2 Dependent upon availability to shift contingency reserves, which will increase capacity by 30-40MW (3%) at current efficiency.

# Glen Canyon Dam Power Plant Unit Outage Schedule for 2023

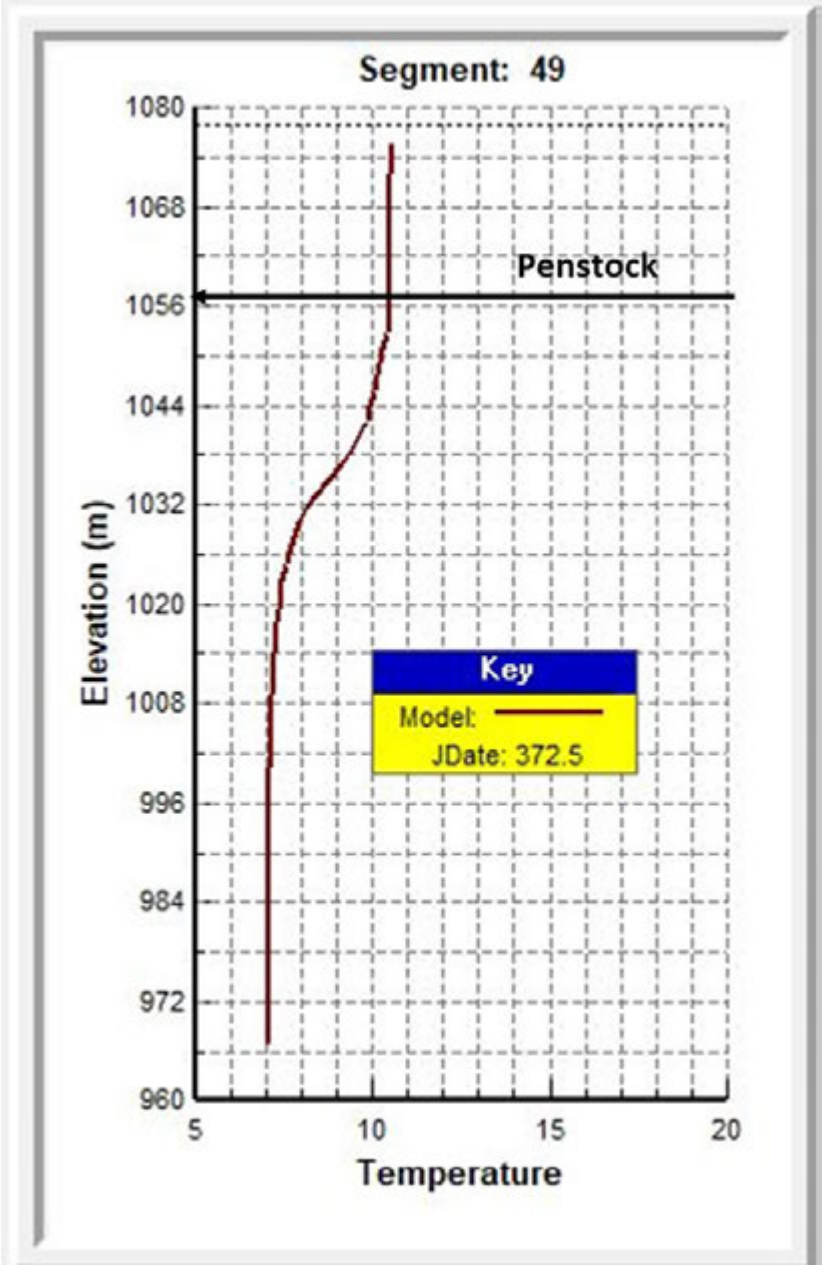


| Unit Number | Oct 2022 | Nov 2022 | Dec 2022 | Jan 2023 | Feb 2023 | Mar 2023 | Apr 2023 | May 2023 | Jun 2023 | Jul 2023 | Aug 2023 | Sep 2023 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Units Available | 4 | 4 | 6 | 6 | 4 | 4 | 6 | 7 | 6 | 6 | 6 | 6 | |
| Capacity (cfs) | 11,900 | 11,900 | 18,800 | 18,600 | 11,400 | 11,400 | 18,500 | 19,000 | 19,400 | 19,400 | 19,300 | 19,200 | JAN MOST[2] |
| Capacity (kaf/month) | 1,140 | 1,100 | 1,240 | 1,510 | 940 | 1,300 | 1,480 | 1,390 | 1,560 | 1,610 | 1,600 | 1,200 | JAN MOST |
| Max (kaf) [1] | 643 | 642 | 715 | 857 | 758 | 801 | 713 | 710 | 745 | 842 | 900 | 674 | 9.0 maf |
| Most (kaf) [1] | 480 | 500 | 600 | 723 | 639 | 675 | 601 | 599 | 628 | 709 | 758 | 568 | 7.48 maf |
| Min (kaf) [1] | 480 | 500 | 600 | 664 | 587 | 620 | 552 | 550 | 577 | 670 | 720 | 550 | 7.0 maf |
| | | | | | | | | | | (updated 01-19-2022) | | | |

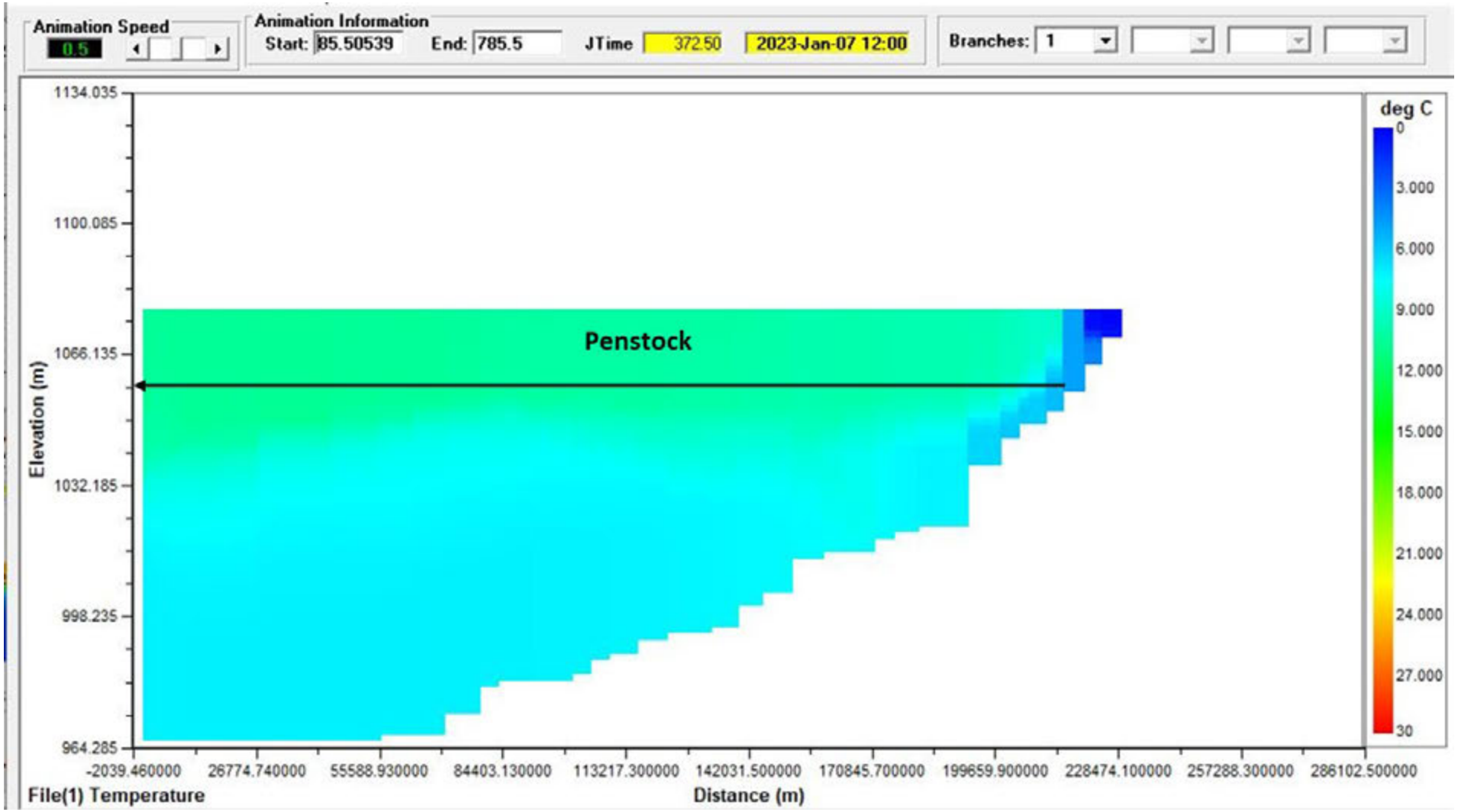
1 Projected release, based on January 2022 minimum, most and maximum probable Inflow Projections and 24-Month Study model runs.
2 Dependent upon availability to shift contingency reserves, which will increase capacity by 30-40MW (3%) at current efficiency.

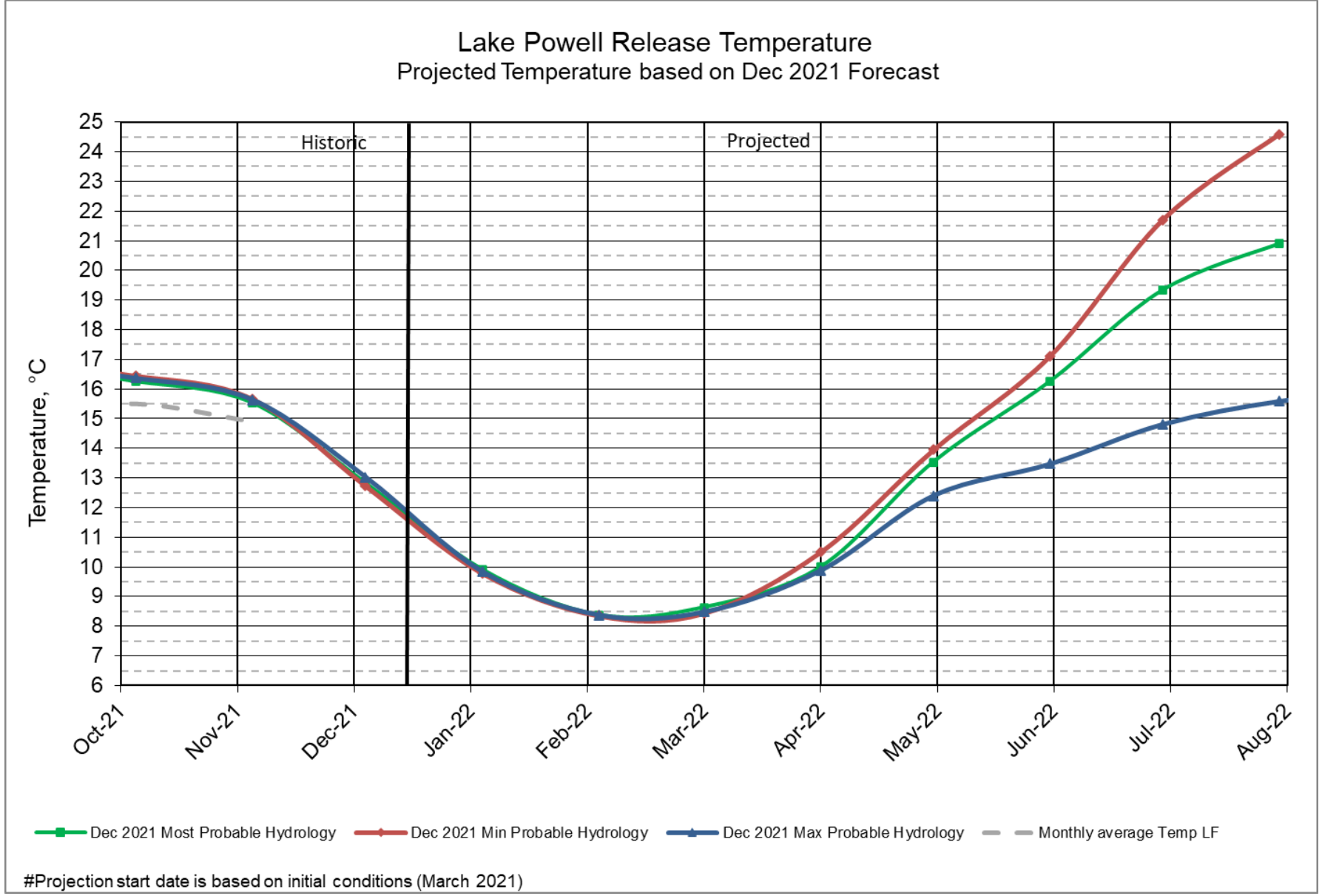
# Water Quality

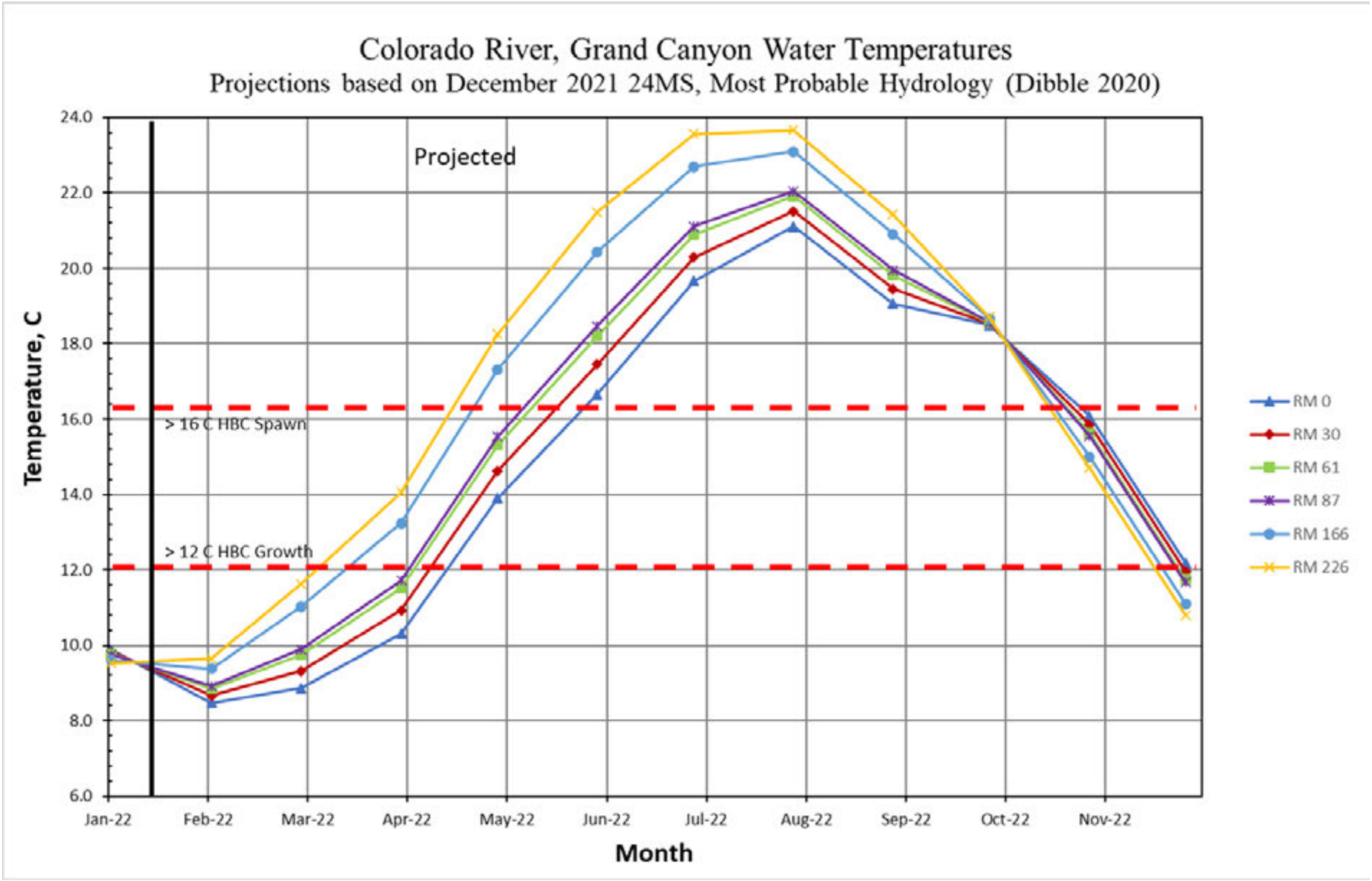
Temperature Profile of Lake Powell near Glen Canyon Dam
1/7/2022



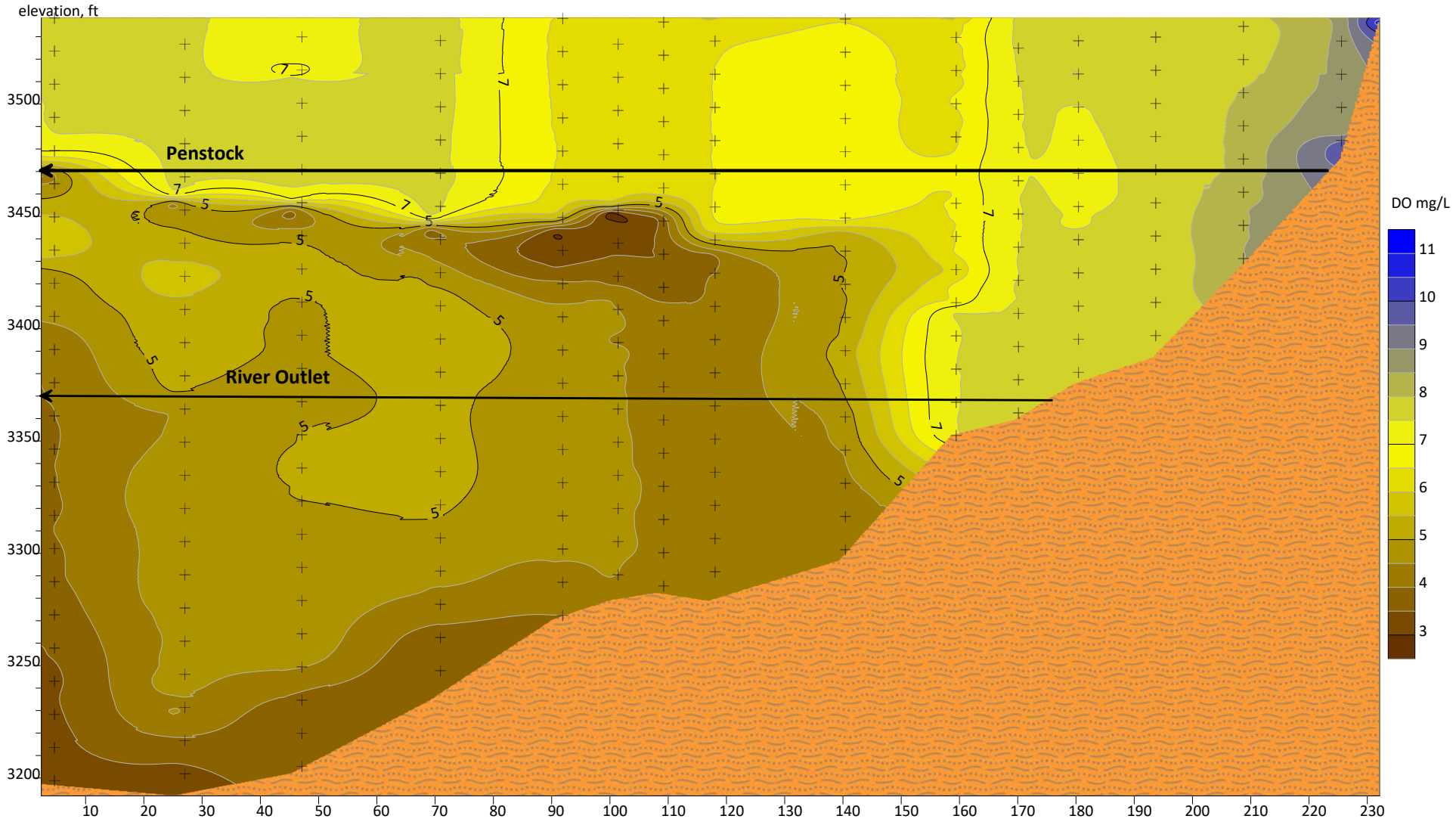
# Cross Sectional Temperature Profile of Lake Powell
1/7/2022




Lake Powell Release Temperature
Projected Temperature based on Dec 2021 Forecast
Historic
Projected
Temperature, °C
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
Oct-21
Nov-21
Dec-21
Jan-22
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Dec 2021 Most Probable Hydrology
Dec 2021 Min Probable Hydrology
Dec 2021 Max Probable Hydrology
Monthly average Temp LF
#Projection start date is based on initial conditions (March 2021)


Colorado River, Grand Canyon Water Temperatures
Projections based on December 2021 24MS, Most Probable Hydrology (Dibble 2020)
Projected
> 16 C HBC Spawn
> 12 C HBC Growth
Temperature, C
Month
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
Jan-22
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
RM 0
RM 30
RM 61
RM 87
RM 166
RM 226

# Lake Powell Dec 2021 Dissolved Oxygen




Questions?
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