BUREAU OF RECLAMATION

Glen Canyon Monthly Operations Call

Basin Hydrology and Operations

April 22, 2021

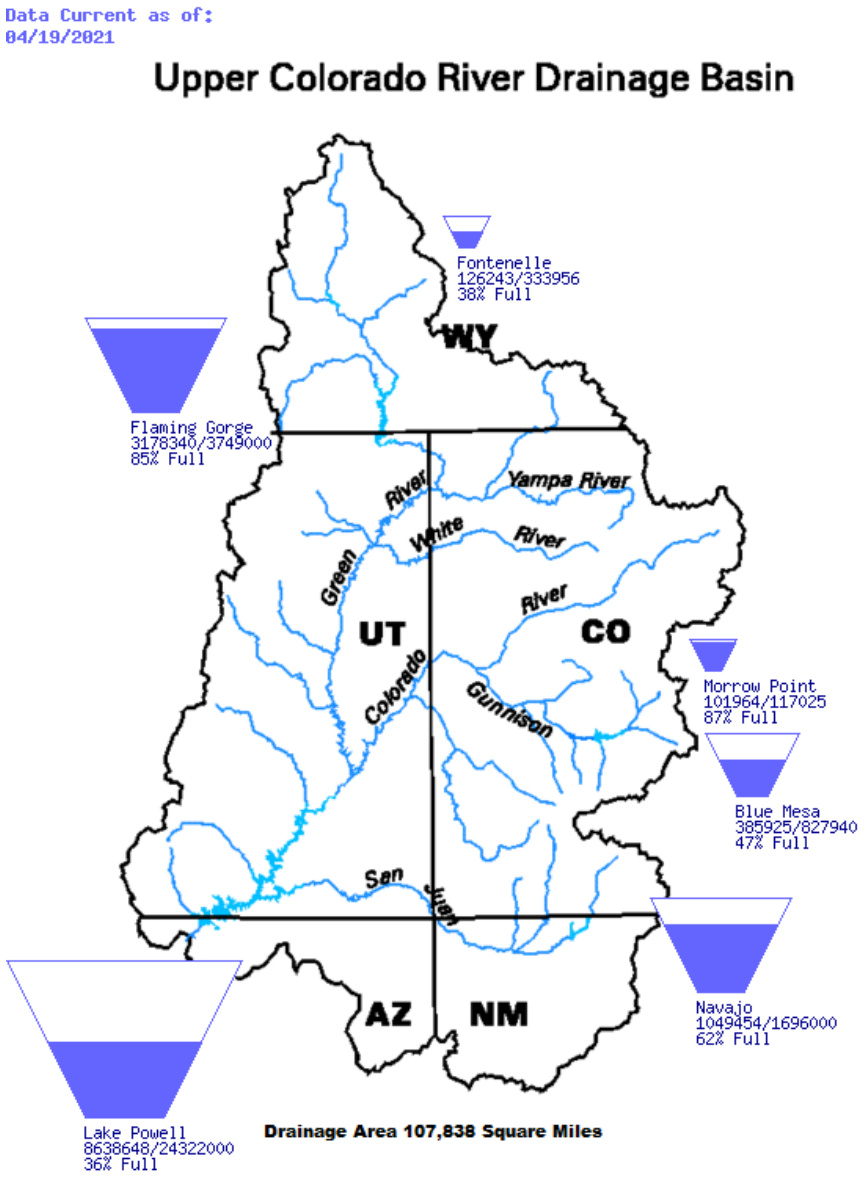
Background

This briefing is being provided consistent with the provision in Section 1.1 of the LTEMP ROD which states:

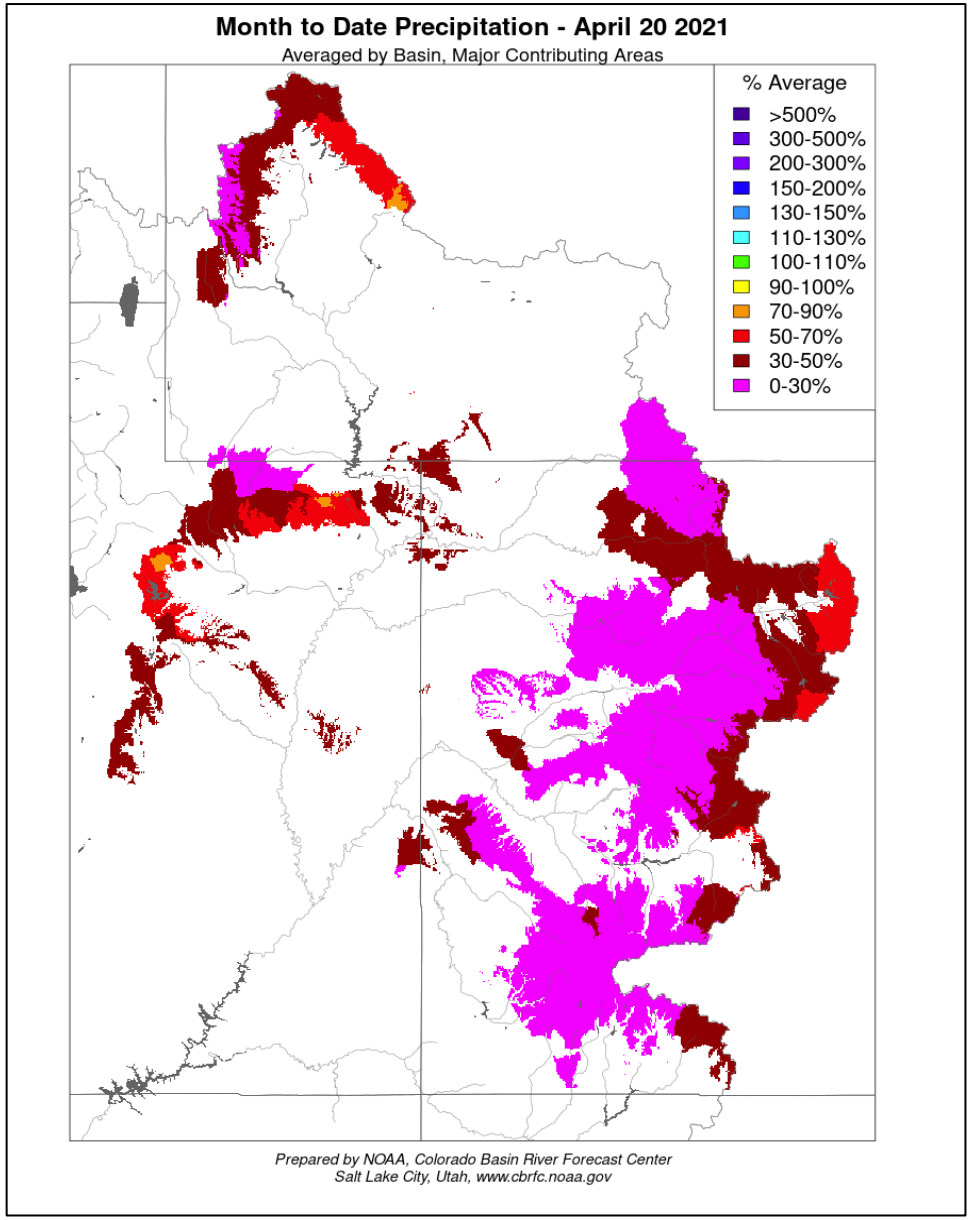
"Annually, Reclamation will develop a hydrograph based on the characteristics above. Reclamation will seek consensus on the annual hydrograph through monthly operational coordination calls with governmental entities, and regular meetings of the GCDAMP Technical Working Group (TWG) and AMWG. Reclamation will conduct monthly Glen Canyon Dam operational coordination meetings or calls with the DOI bureaus (USGS, NPS, FWS, and BIA), WAPA, and representatives from the Basin States and UCRC. The purpose of these meetings or calls is for the participants to share and seek information on Glen Canyon Dam operations. One liaison from each Basin State and from the UCRC may participate in the monthly operational coordination meetings or calls."

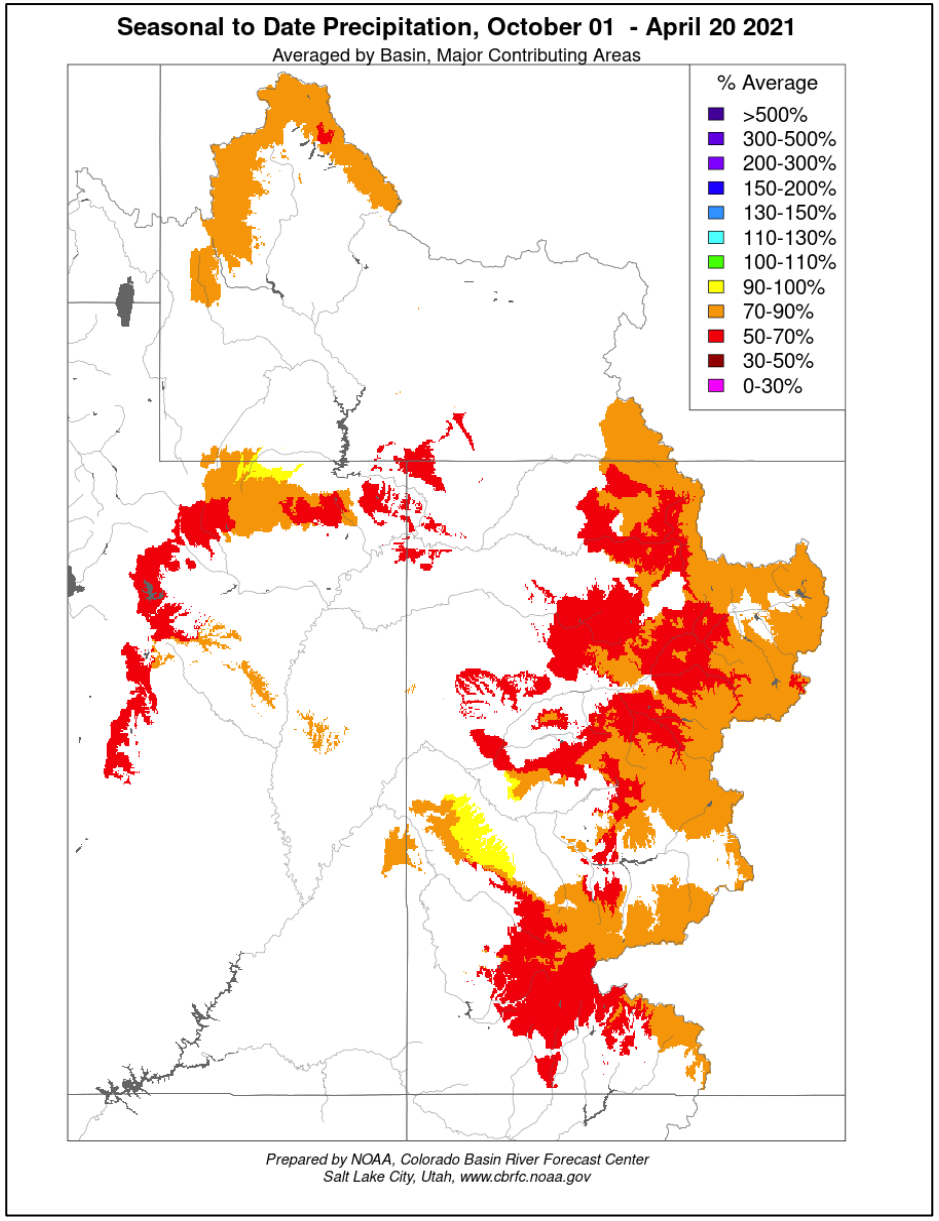
Upper Basin Storage (as of April 19, 2021)

Reservoir	Percent Current Live Storage	Current Live Storage (maf)	Live Storage Capacity (maf)	Elevation (feet)
Fontenelle	38	0.13	.333	6473.27
Flaming Gorge	85	3.18	3.75	6,025.45
Blue Mesa	47	0.39	0.83	7,463.02
Navajo	62	1.05	1.70	6,034.01
Lake Powell	36	8.64	24.32	3,564.10
UC System Storage	43	13.50	31.09	

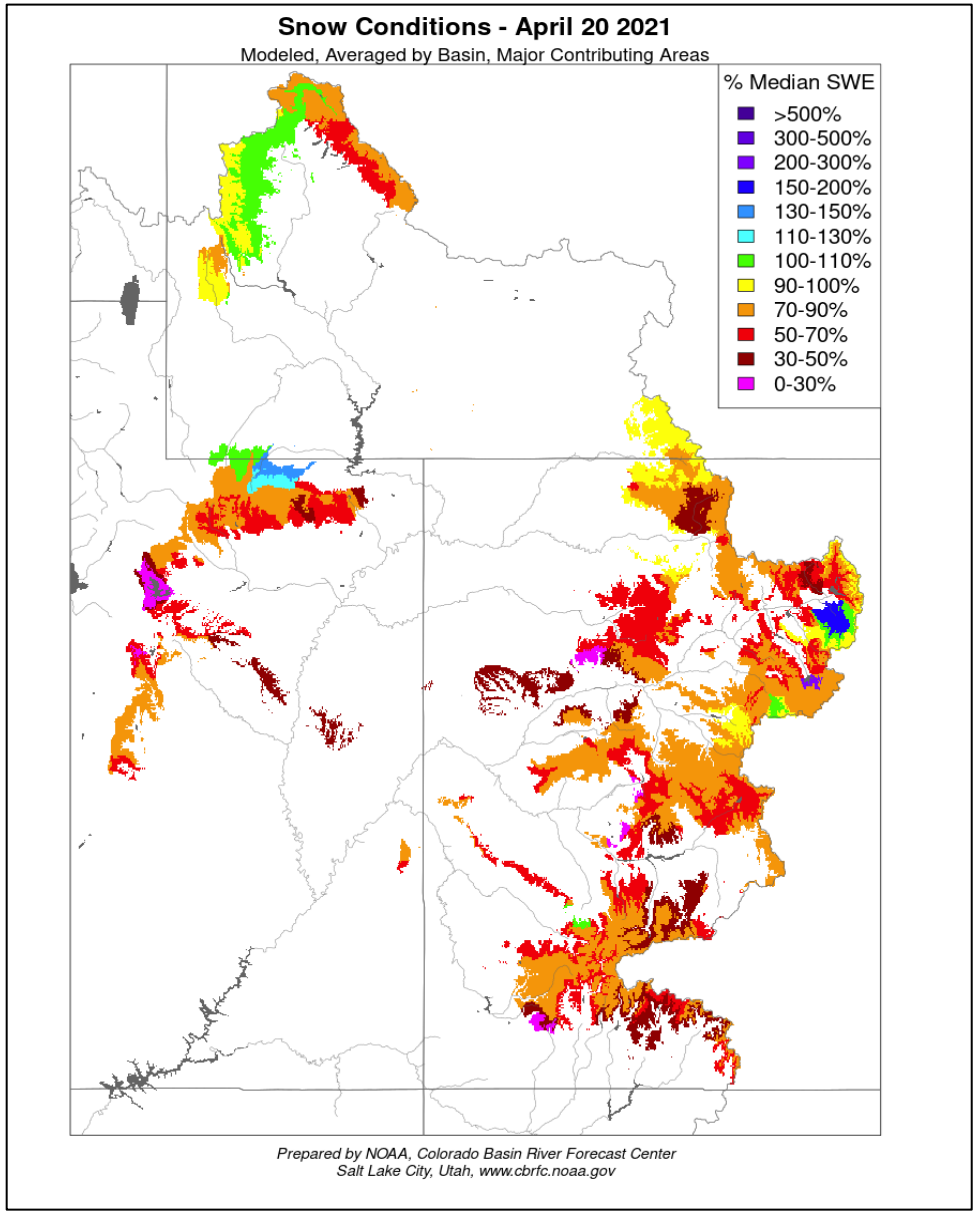


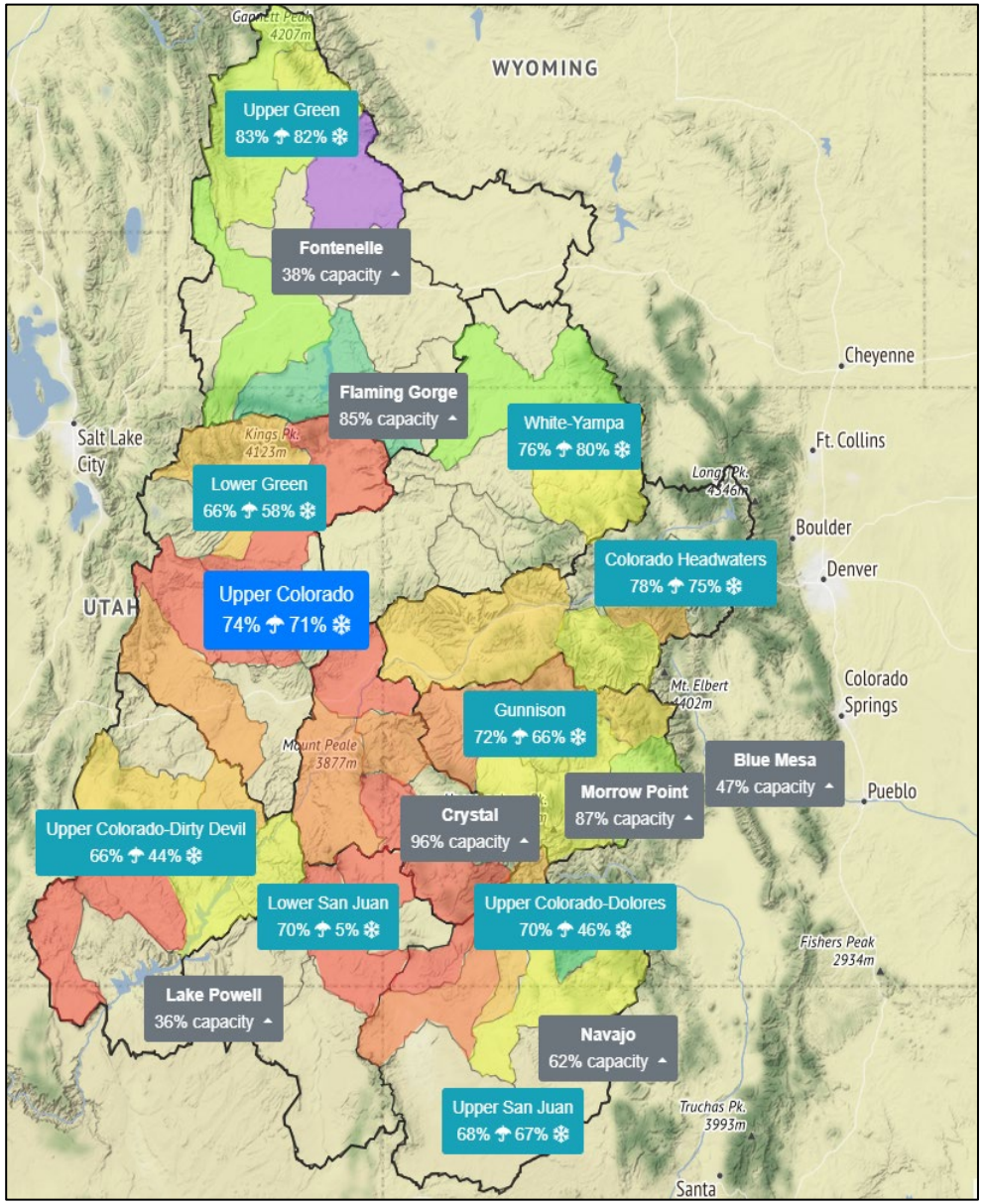
Seasonal and Monthly Precipitation



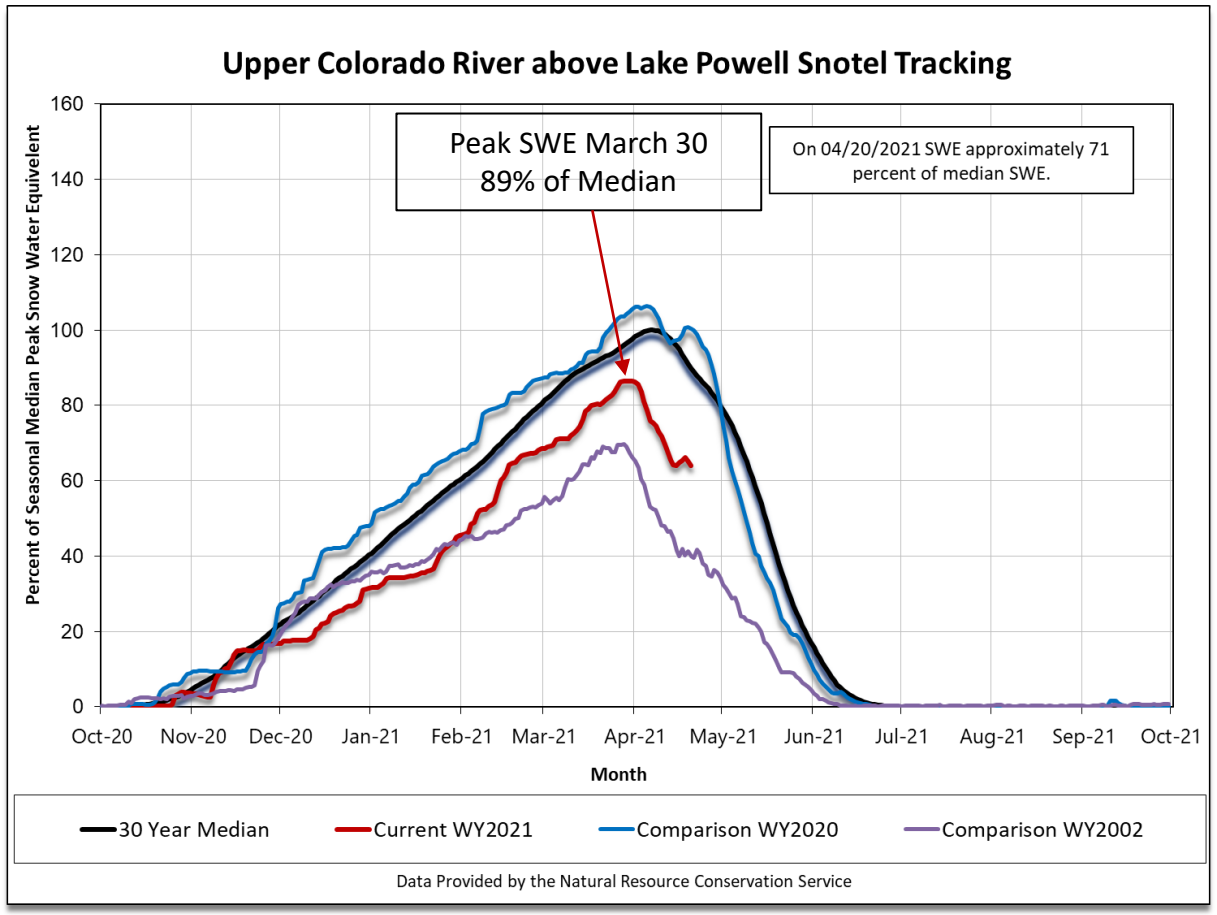


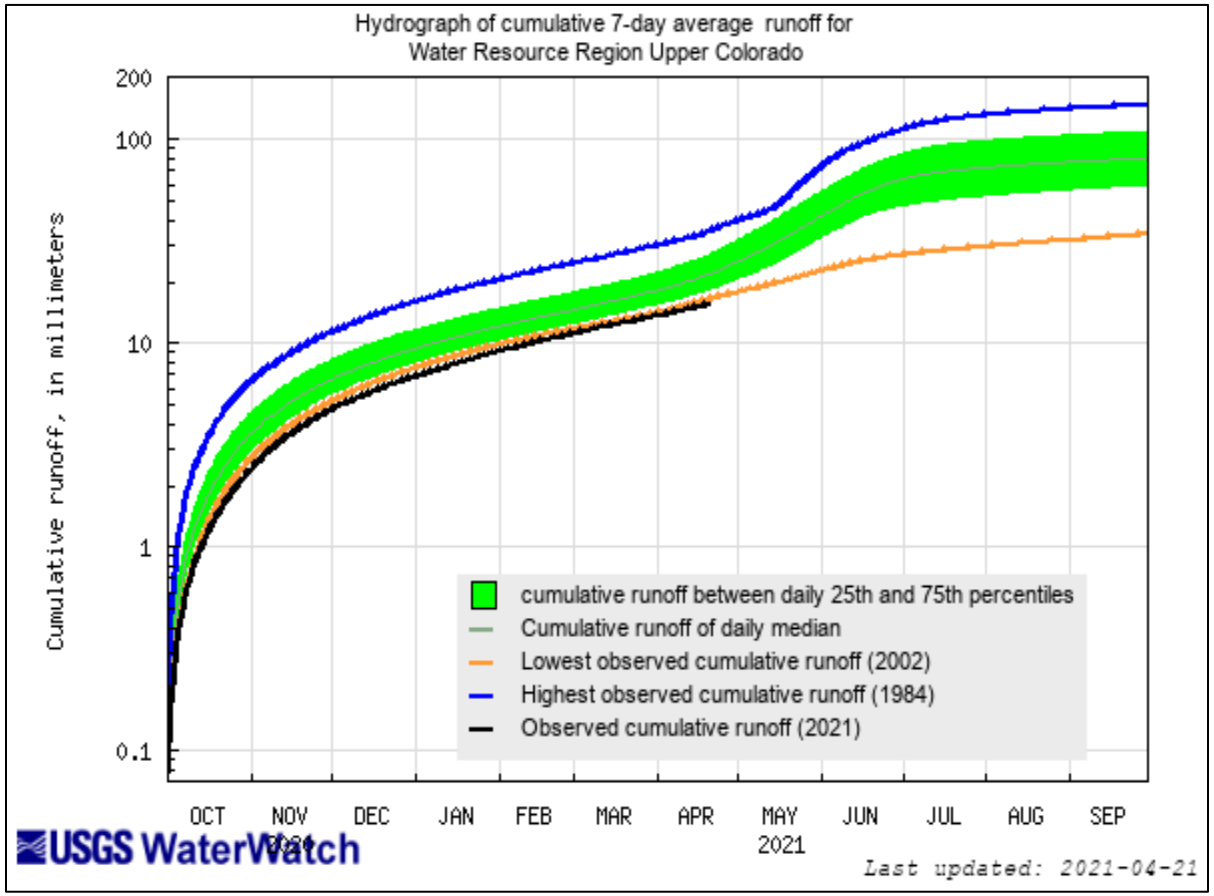
Seasonal Snow Conditions and Basin SWE





Current Snow Water Equivalent (as of April 19, 2021)





Upper Colorado Basin

Projected Operations for Water Year 2021 Based on April 2021 Modeling

Most Probable Spring and WY 2021 Forecast

April – July 2021 Forecasted Unregulated Inflow

as of April 2, 2021

Reservoir	Unregulated Inflow (kaf)	Percent of Average[1]
Fontenelle	430	59
Flaming Gorge	430	54
Blue Mesa	440	65
Navajo	395	54
Powell	3,200	45

Water Year 2021 Forecasted Unregulated Inflow

as of April 5, 2021

Reservoir	Unregulated Inflow (kaf)	Percent of Average[1]
Fontenelle	691	64
Flaming Gorge	833	57
Blue Mesa	645	68
Navajo	538	50
Powell	4,897	45

[1] Percent of average based on the period of record from 1981-2010.

Midmonth Most Probable Spring and WY 2021 Forecast

April – July 2021 Forecasted Unregulated Inflow

as of April 16, 2021

Reservoir	Unregulated Inflow (kaf)	Percent of Average[1]
Fontenelle	400	55
Flaming Gorge	470	48
Blue Mesa	420	62
Navajo	370	50
Powell	2,700	38

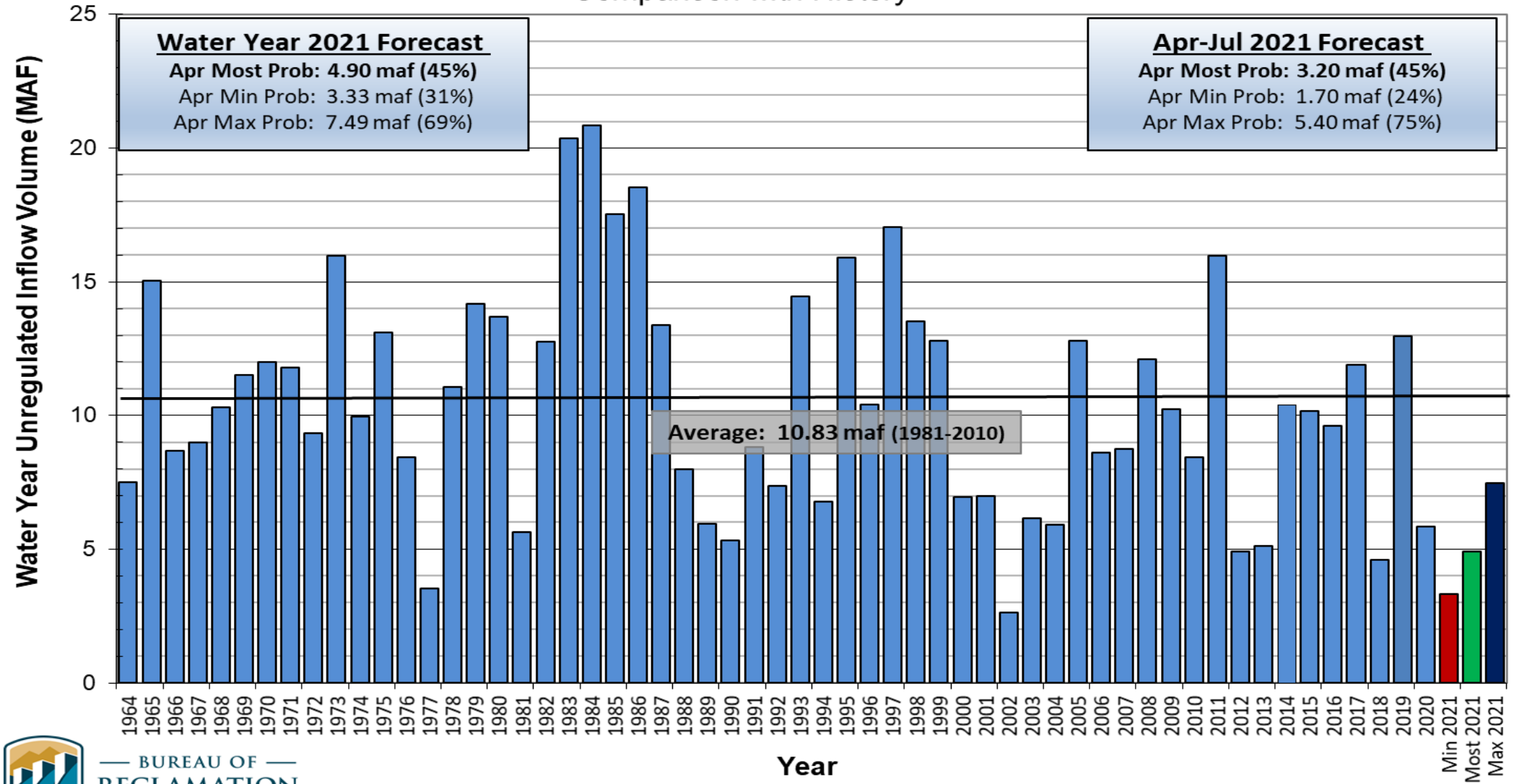
Water Year 2021 Forecasted Unregulated Inflow

as of April 16, 2021

Reservoir	Unregulated Inflow (kaf)	Percent of Average[1]
Fontenelle	661	61
Flaming Gorge	783	54
Blue Mesa	625	65
Navajo	518	48
Powell	4,400	41

[1] Percent of average based on the period of record from 1981-2010.

Lake Powell Unregulated Inflow
Water Year 2021 Forecast *(issued April 2)*
Comparison with History



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Drought Response Operations Agreement (DROA)

- Formal notification that the January 2021 Minimum Probable 24 Month Study (24-MS) run projected Powell to fall below 3,525 feet in 2022 was provided pursuant to the DROA.
  - February through April Minimum Probable 24-MS continued to indicate elevations below 3,525 feet in 2022.
- These minimum projections *do not* initiate immediate operational changes to Reclamation facilities.
- These minimum projections *do* initiate enhanced monitoring and coordination under the DROA.
- These minimum projections *do* initiate monthly analysis of min/most/max with the parties specified in the DROA.
- The DROA enhanced monitoring and coordination will continue until either:
  - (i) The minimum probable projected elevation remains above 3,525 feet for 24 months; or
  - (ii) the process moves to the next step when the Most Probable 24-MS projects Powell elevations below 3,525 feet and a specific Drought Response Operations Plan is developed.

Lake Powell & Lake Mead Operational Table

Operational Tiers for Water/Calendar Year 2021[1]

Lake Powell		
Elevation (feet)	**Operation According to the Interim Guidelines**	**Live Storage (maf)[1]**
3,700	**Equalization Tier** Equalize, avoid spills or release 8.23 maf	24.3
3,636 - 3,666 (2008-2026)	**Upper Elevation Balancing Tier**[3] Release 8.23 maf; if Lake Mead < 1,075 feet, balance contents with a min/max release of 7.0 and 9.0 maf	15.5 - 19.3 (2008-2026)
3,591.60 ft Jan 1, 2021 projection		
3,575	**Mid-Elevation Release Tier** Release 7.48 maf; if Lake Mead < 1,025 feet, release 8.23 maf	9.5
3,525		5.9
3,490	**Lower Elevation Balancing Tier** Balance contents with a min/max release of 7.0 and 9.5 maf	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** Deliver > 7.5 maf	25.9
1,200 (approx.)[2]	**Domestic Surplus or ICS Surplus Condition** Deliver > 7.5 maf	22.9 (approx.)[2]
1,145		15.9
1,105	**Normal or ICS Surplus Condition** Deliver ≥ 7.5 maf	11.9
1,085.28 ft Jan 1, 2021 projection		
1,075	**Shortage Condition** Deliver 7.167[4] maf	9.4
1,050	**Shortage Condition** Deliver 7.083[5] maf	7.5
1,025	**Shortage Condition** Deliver 7.0[6] maf Further measures may be undertaken[7]	5.8
1,000		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 operational tier determinations were based on August 2020 24-Month Study projections and are documented in the 2021 AOP.

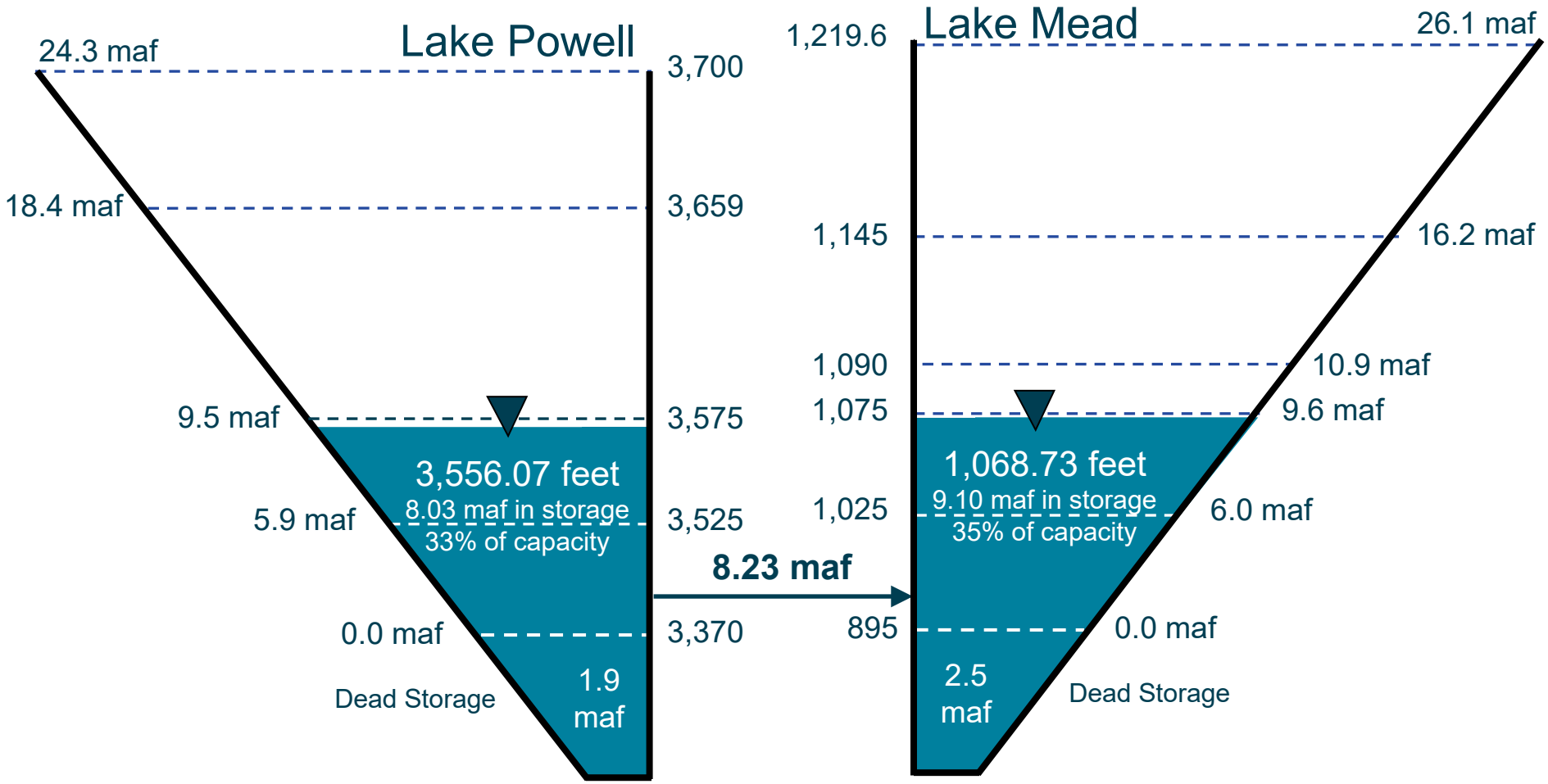
Timing of Operational Decisions

- August 24-Month Study projections of January 1 elevations sets the operating tiers for Lake Powell and Lake Mead
- When Lake Powell is in Upper Elevation Balancing Tier, April 24-Month Study projections of September 30 elevations may result in an adjustment to Powell's operations

End of Water Year 2021 Projections

April 2021 24-Month Study Most Probable Inflow Scenario[1]

Based on a Lake Powell Unregulated Inflow Forecast of 4.90 maf (45% of average)

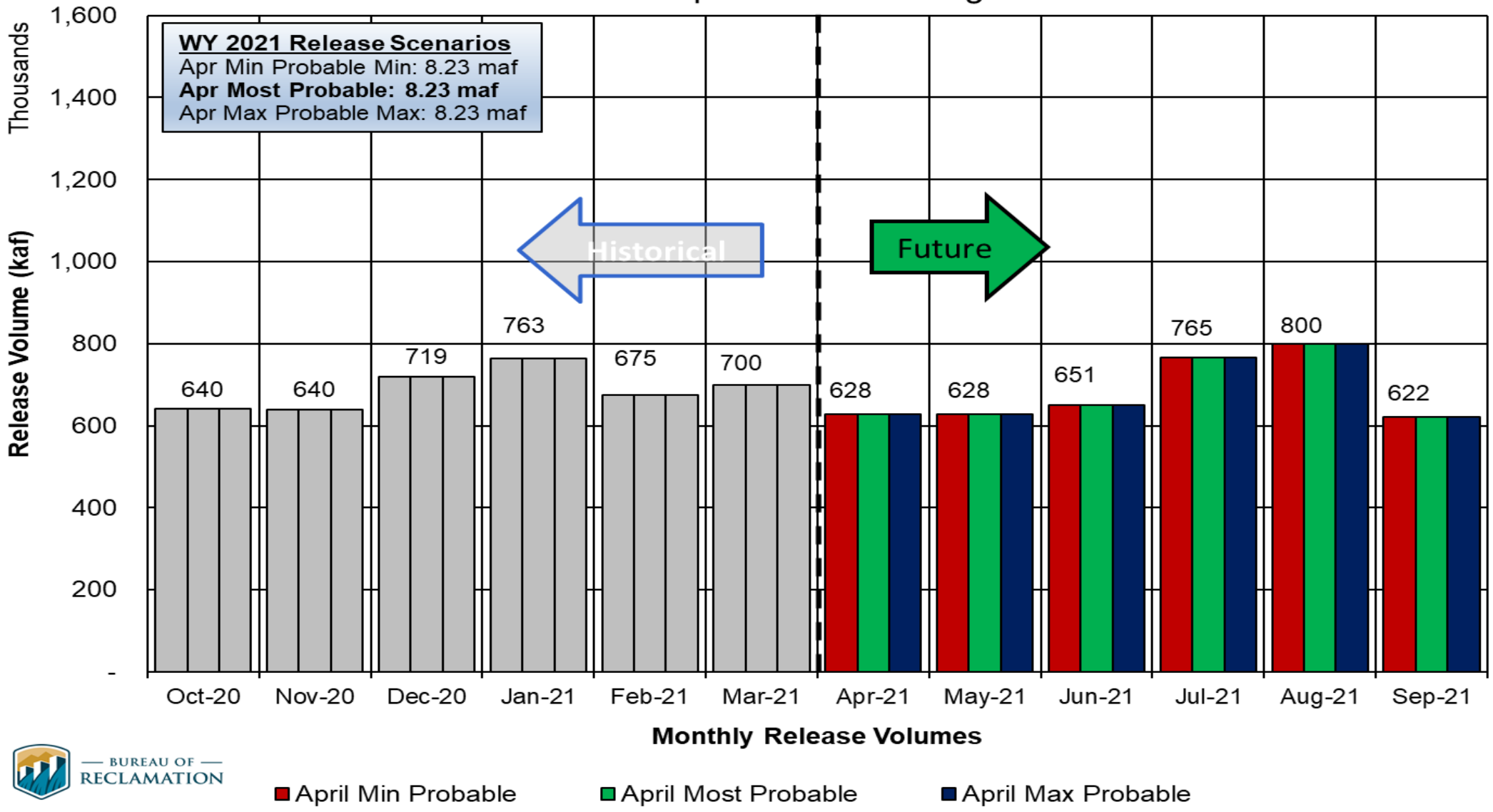


Not to Scale

[1] *WY 2021 unregulated inflow into Lake Powell is based on the CBRFC forecast dated 4/2/21.*

Potential Lake Powell Monthly Release Volume Distribution

Release Scenarios for Water Year 2021
Based on April 2021 Modeling



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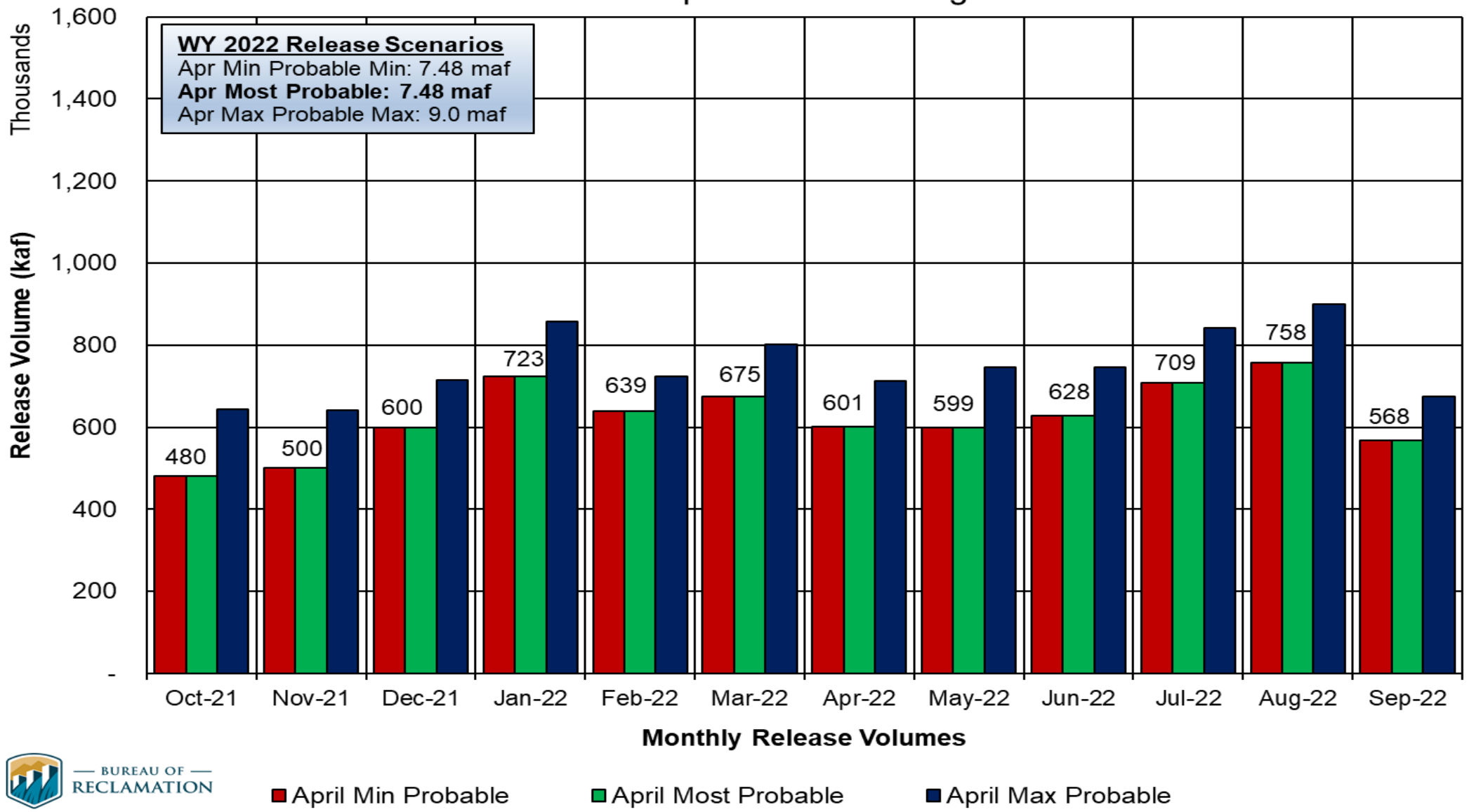
Potential Lake Powell Monthly Release Volume Distribution

Release Scenarios for Water Year 2022
Based on April 2021 Modeling



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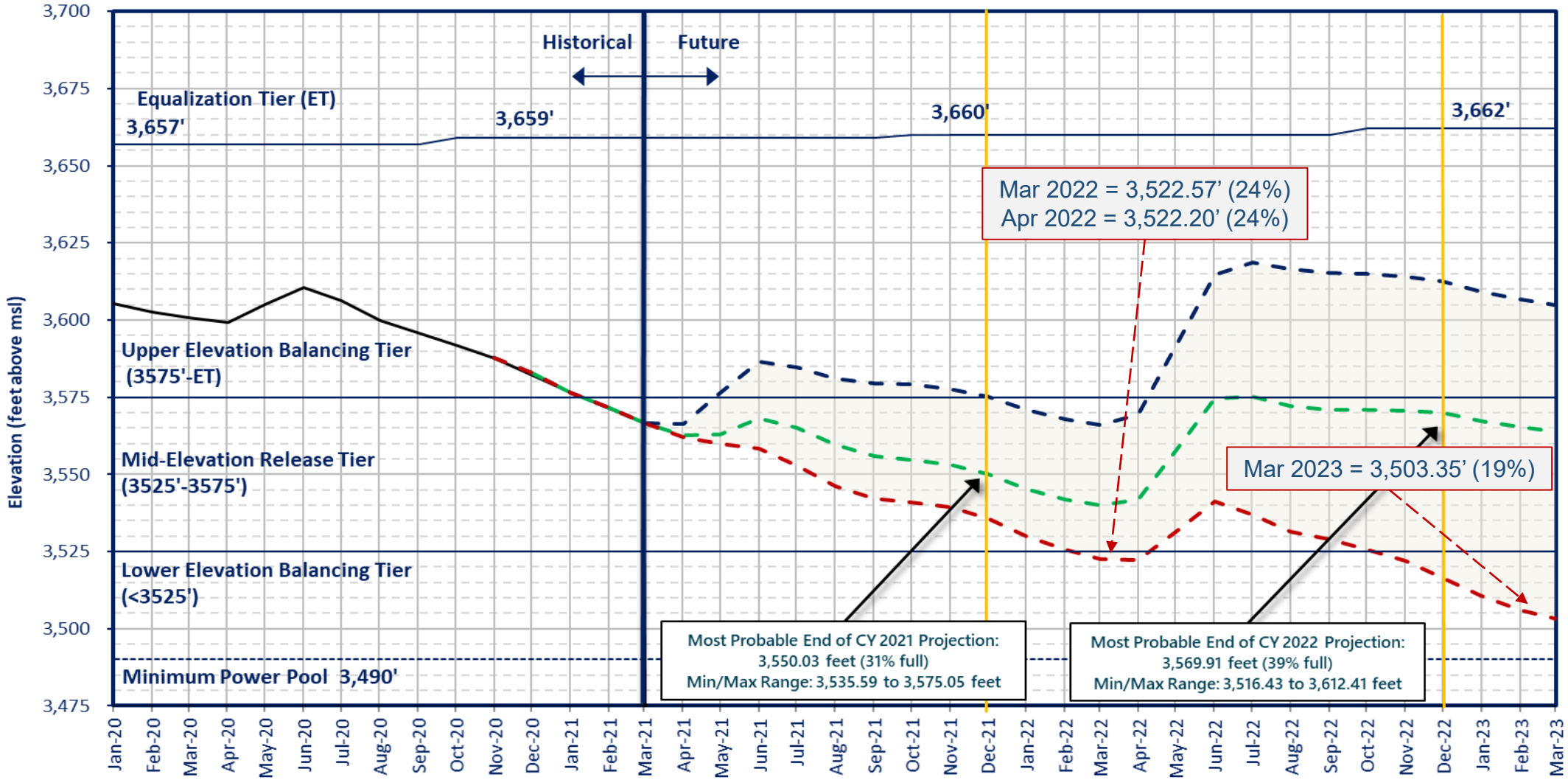
Lake Powell End of Month Elevations

Historical and Projected based on April 2021 24-Month Study Inflow Scenarios



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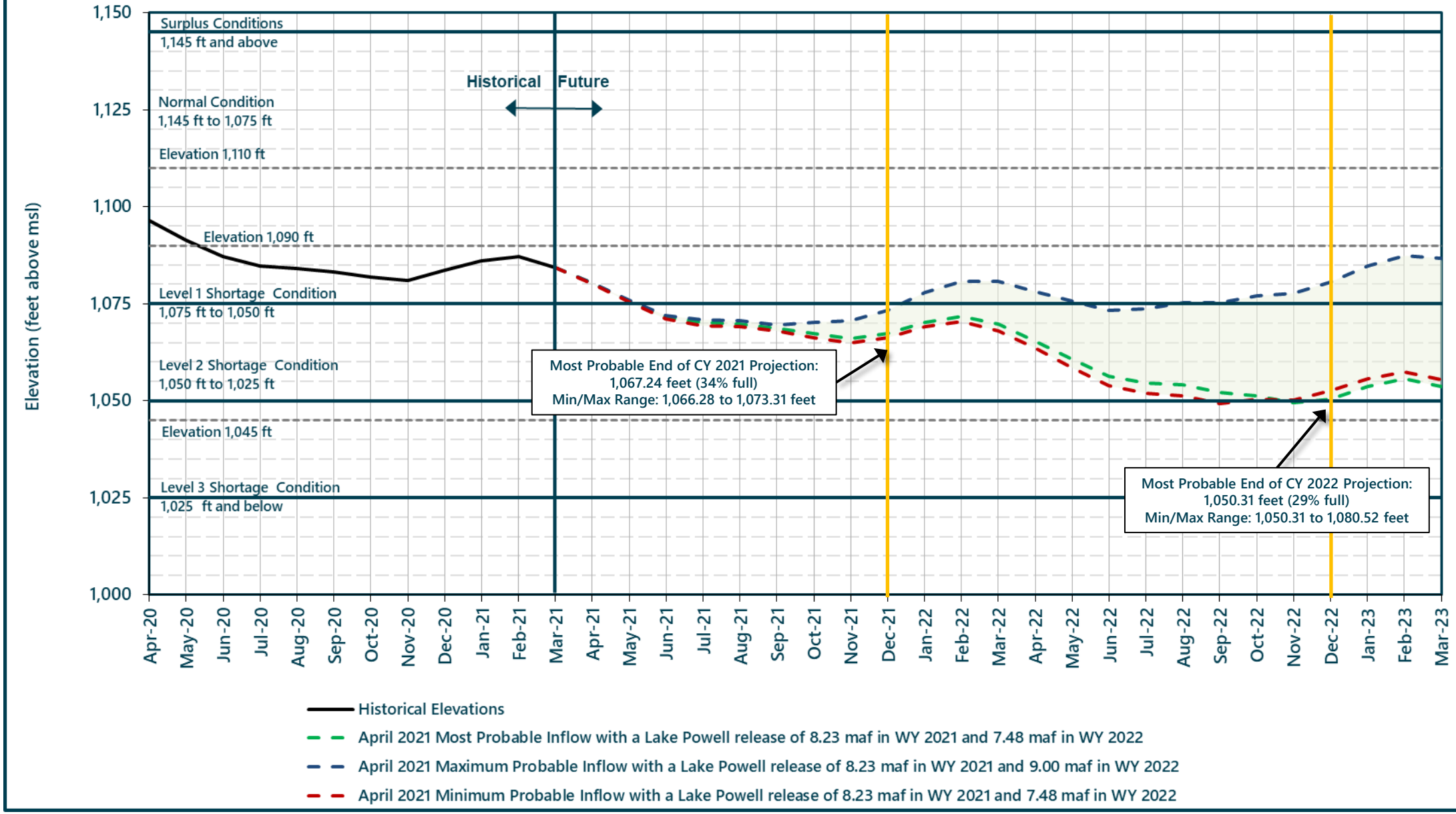
- Historical Elevations
- Apr 2021 Most Probable - Lake Powell release of 8.23 maf in WY2021 and 7.48 maf in WY2022
- Apr 2021 Max Probable - Lake Powell release of 8.23 maf in WY2021 and 9.0 maf in WY2022
- Apr 2021 Min Probable - Lake Powell release of 8.23 maf in WY2021 and 7.48 maf in WY2022

Lake Mead End of Month Elevations

Projections from the April 2021 24-Month Study Inflow Scenarios



Glen Canyon Power Plant Planned Unit Outage Schedule for Water Year 2021

Unit Number	Oct 2020	Nov 2020	Dec 2020	Jan 2021	Feb 2021	Mar 2021	Apr 2021	May 2021	Jun 2021	Jul 2021	Aug 2021	Sep 2021	
1													
2													
3													
4													
5													
6													
7													
8													
Units Available	5	5/4	6	6	6	6/4	4	5	6	6	6	4	
Capacity (cfs)	16,400	16,400/ 12,200	19,800	19,600	19,500	19,400 (20,150)[4]	19,200	15,700	19,400	19,300	19,100	12,000	APR MOST[3]
Capacity (kaf/month)	1,040	1,140	1,250	1,220	1,080	1,540	1,140	1,050	1,150	1,190	1,180	1,010	APR MOST
Max (kaf)[2]	640	640	720	763	675	700	628	628	651	765	800	620	8.23
Most (kaf)[1]	640	640	720	763	675	700	628	628	651	765	800	620	8.23
Min (kaf)[2]	640	640	720	760	680	700	628	628	651	765	800	620	8.23
										(updated 04-22-2021)			

1 Projected release, based on April 2021 Most Probable Inflow Projections and 24-Month Study model runs.
2 Projected release, based on April 2021 Min and Max Probable Inflow Projections and 24-Month Study model runs.
3 Dependent upon availability to shift contingency reserves, which will increase capacity by 30-40MW (3%) at current efficiency.
4 Increased capacity available from shifting contingency reserves for Spring Disturbance Flow.

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Glen Canyon Power Plant Planned Unit Outage Schedule for Water Year 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	4/6	6/5	5/6	6/4	4	6	6	5	6	6	8	6	
Capacity (cfs)	12,000	15,500	15,400	11,800	11,800	18,600	18,600	15,600	19,600	19,600	26,700	19,500	APR MOST[3]
Capacity (kaf/month)	960	1,020	1,090	1,140	720	1,140	1,110	990	1,160	1,230	1,640	1,210	APR MOST
Max (kaf)[2]	643	642	715	857	724	801	713	710	745	842	900	708	9.0
Most (kaf)[1]	480	500	600	723	639	675	601	599	628	709	758	568	7.48
Min (kaf)[2]	480	500	600	723	639	675	601	599	628	709	758	548	7.48
										(updated 03-17-2021)			

1 Projected release, based on April 2021 Most Probable Inflow Projections and 24-Month Study model runs.
2 Projected release, based on April 2021 Min and Max Probable Inflow Projections and 24-Month Study model runs.
3 Dependent upon availability to shift contingency reserves, which will increase capacity by 30-40MW (3%) at current efficiency.

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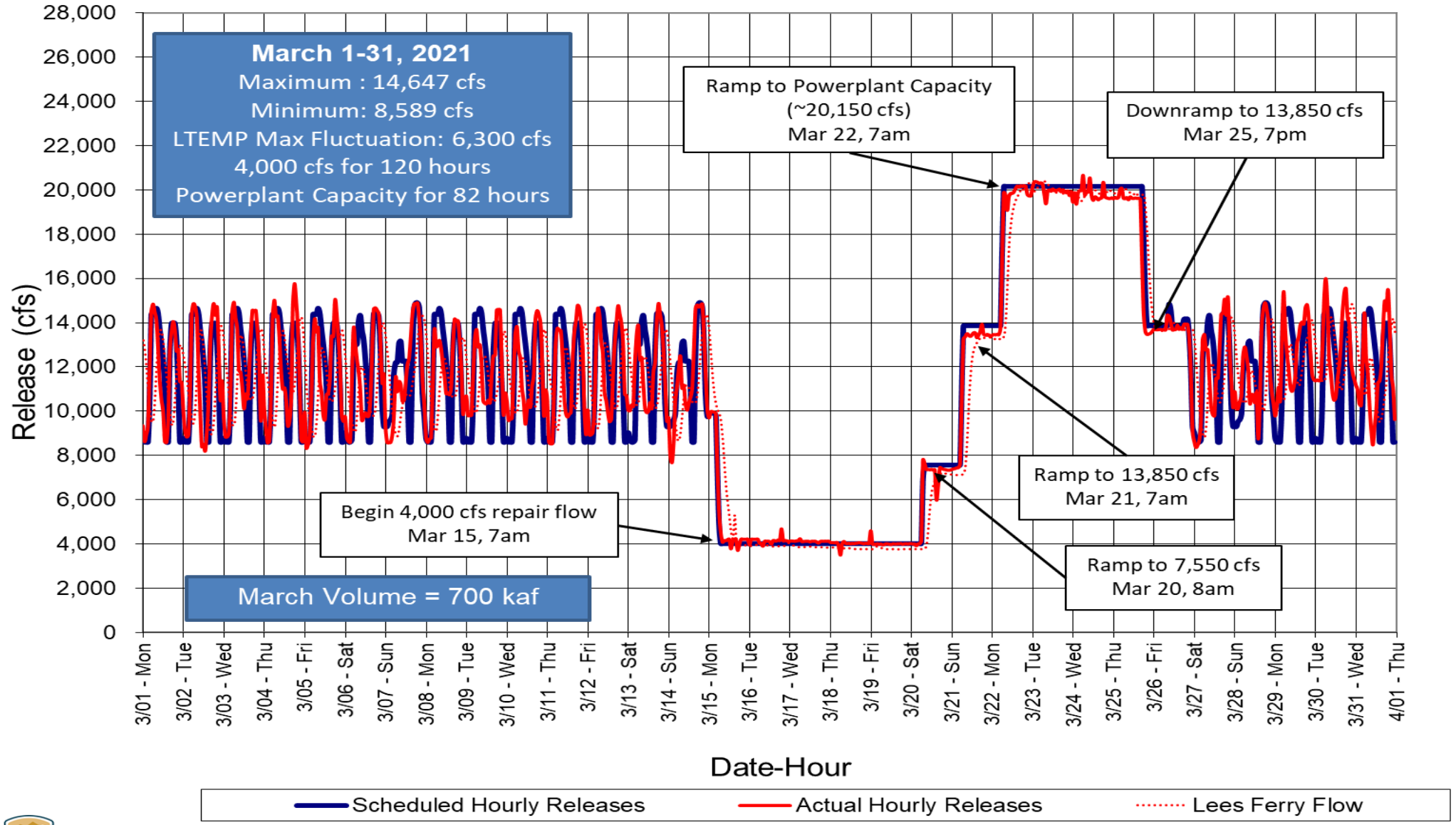
Glen Canyon Dam Hourly Release Pattern March 2021



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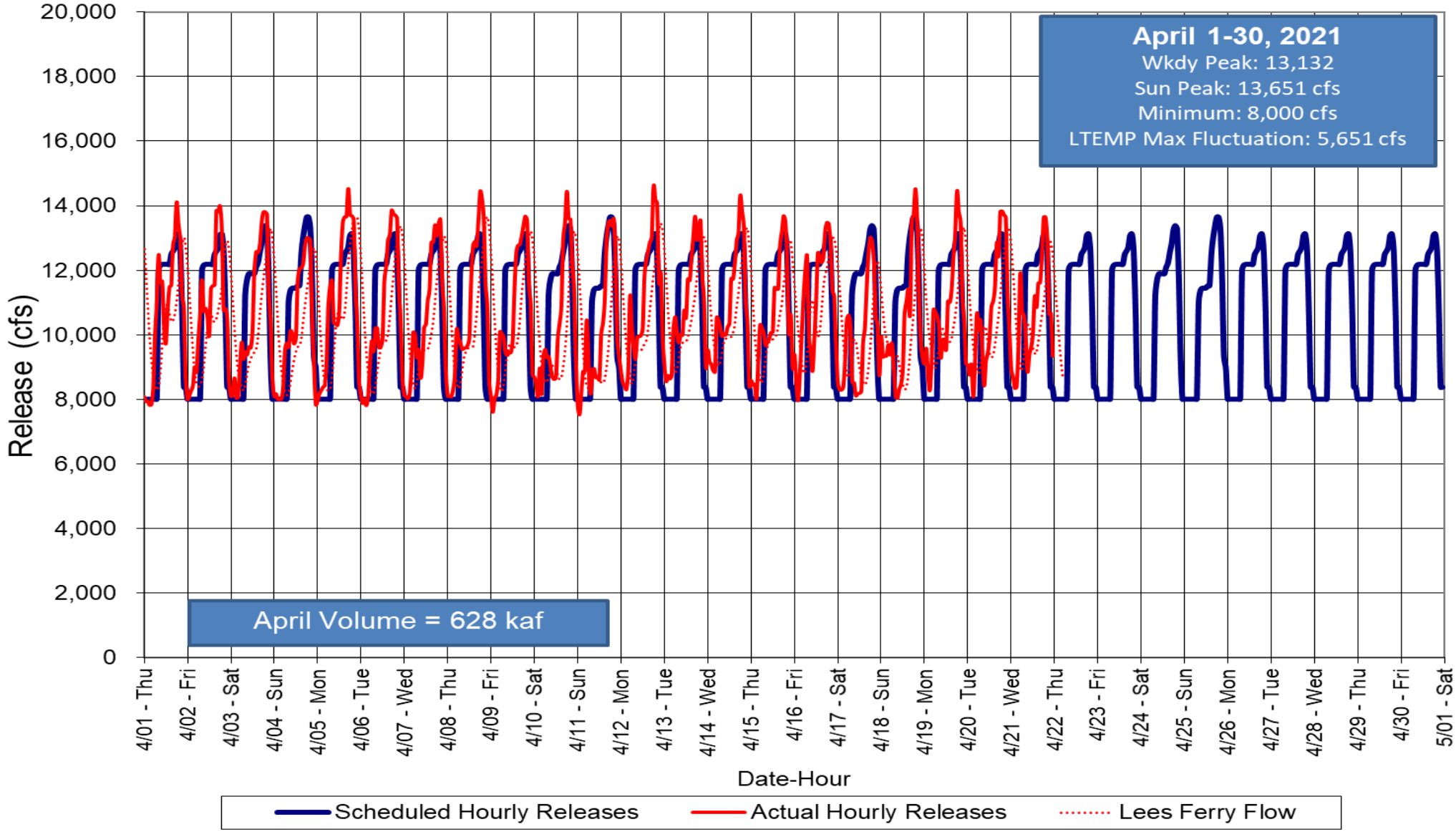
Glen Canyon Dam Hourly Release Pattern April 2021



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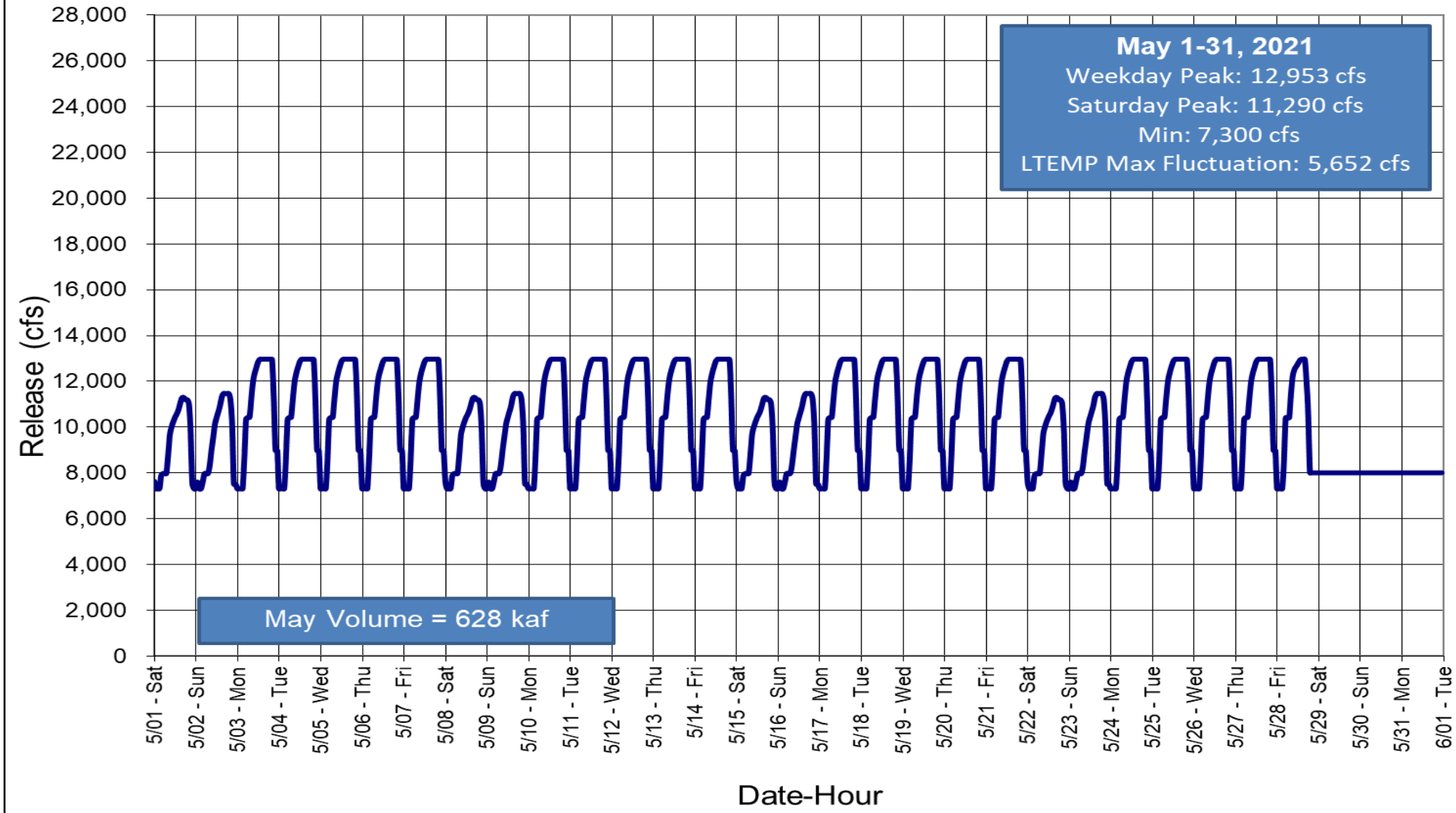
Glen Canyon Dam Hourly Release Pattern May 2021



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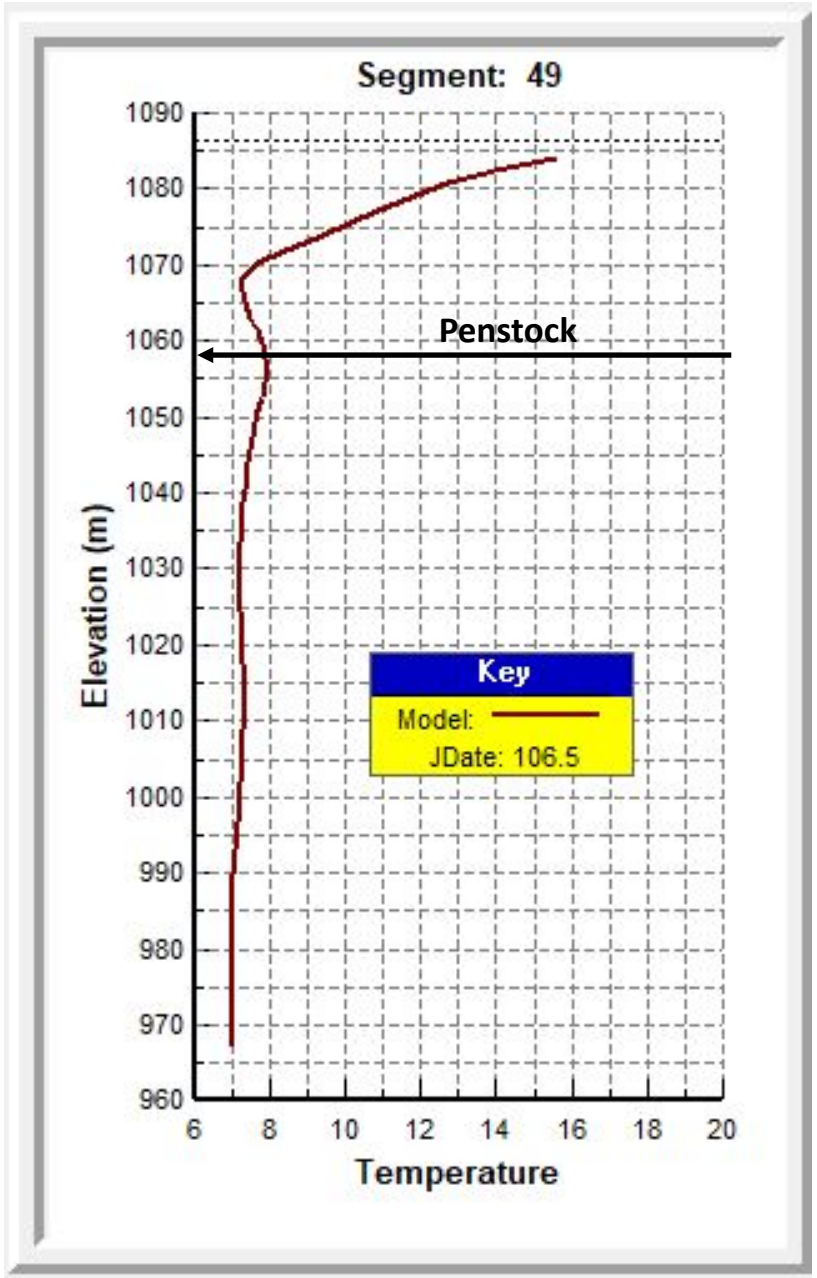
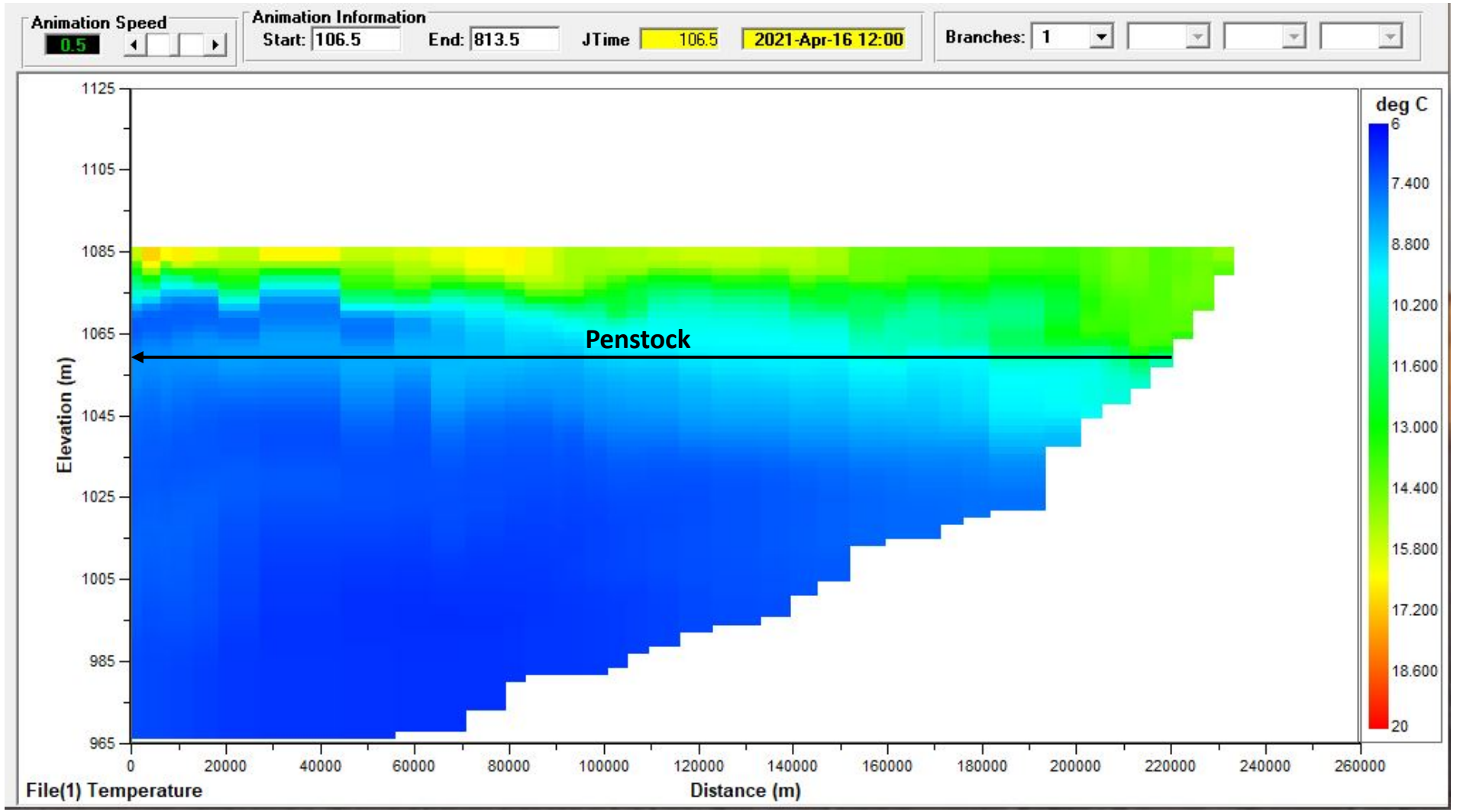
Water Quality

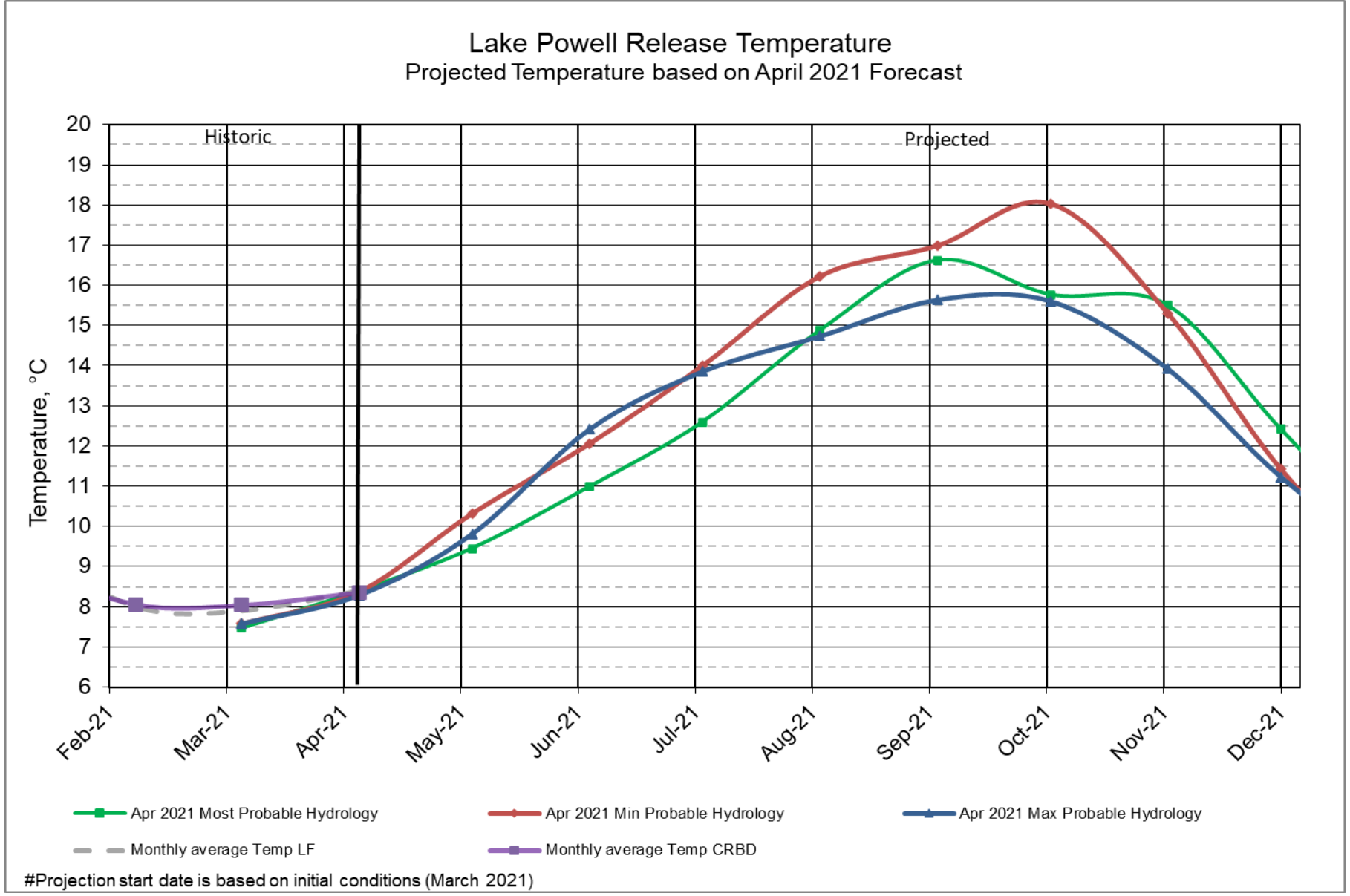
Temperature Profile of Lake Powell near Glen Canyon Dam
4/16/2021



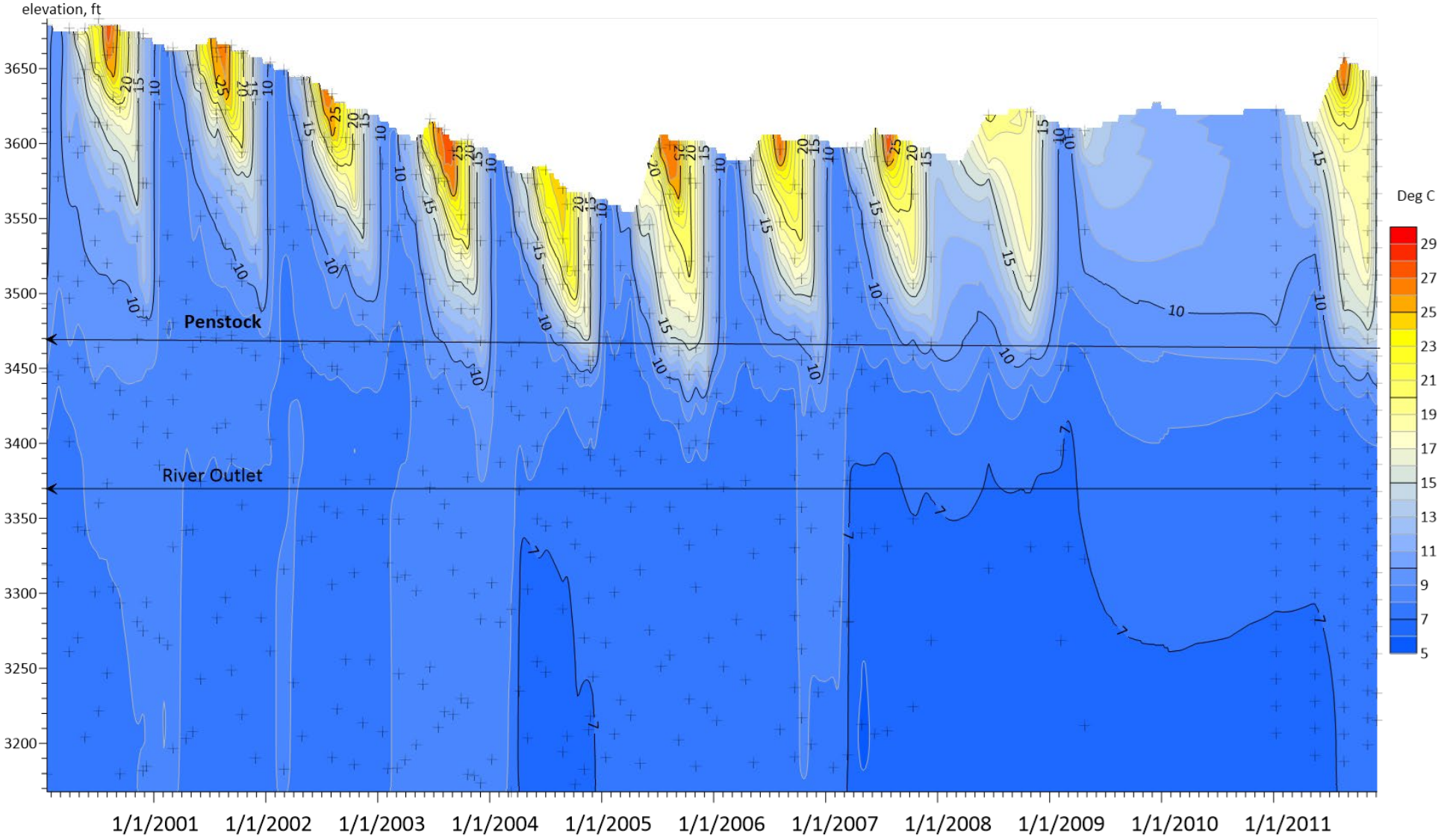
Cross Sectional Temperature Profile of Lake Powell

4/16/2021

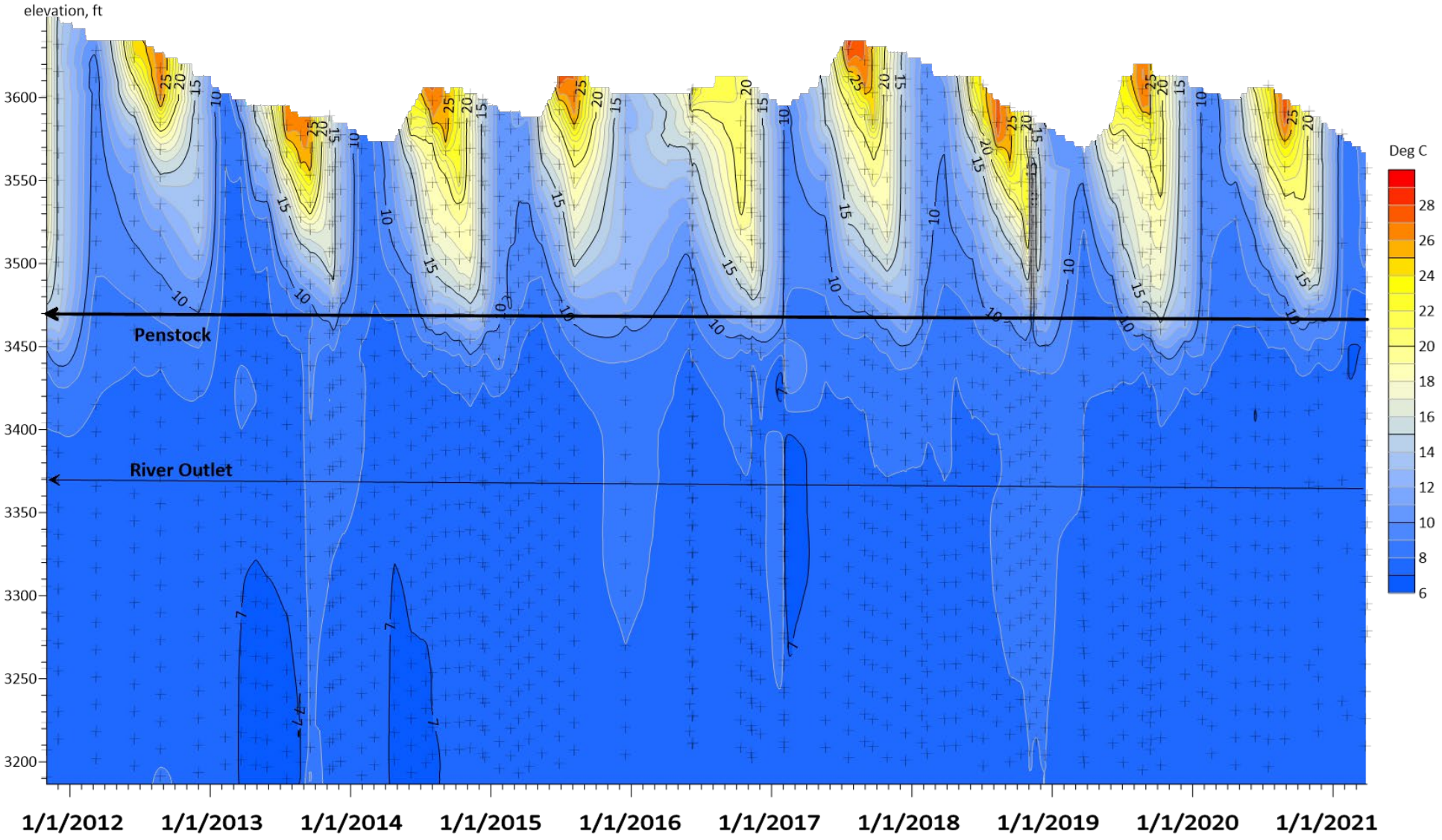


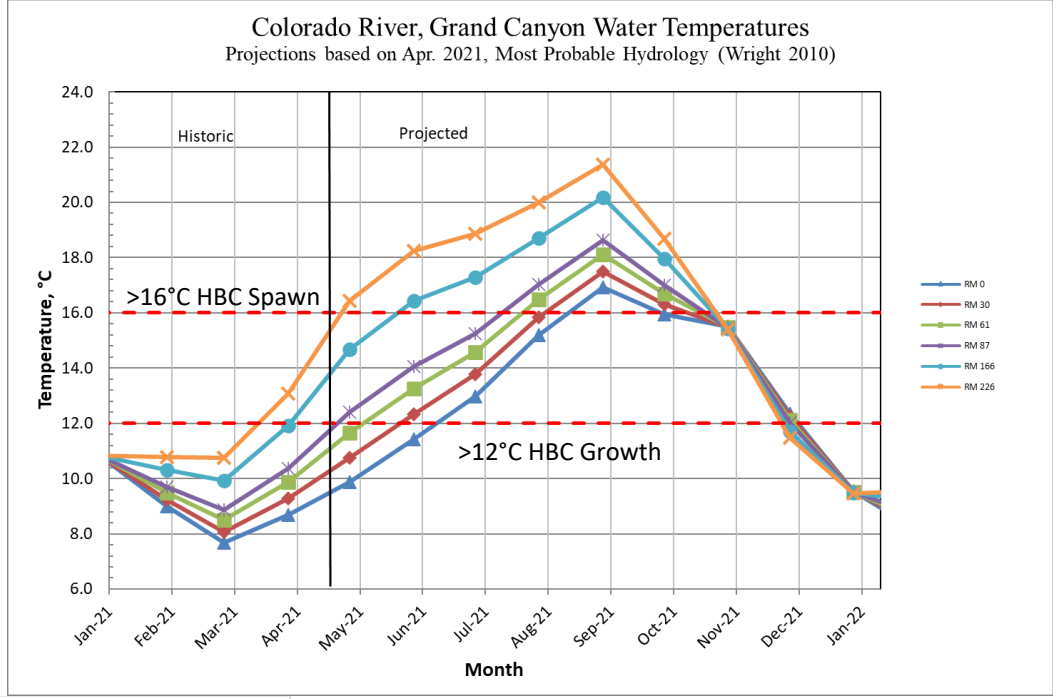

Lake Powell Release Temperature
Projected Temperature based on April 2021 Forecast
Historic
Projected
Temperature, °C
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21
Apr 2021 Most Probable Hydrology
Apr 2021 Min Probable Hydrology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

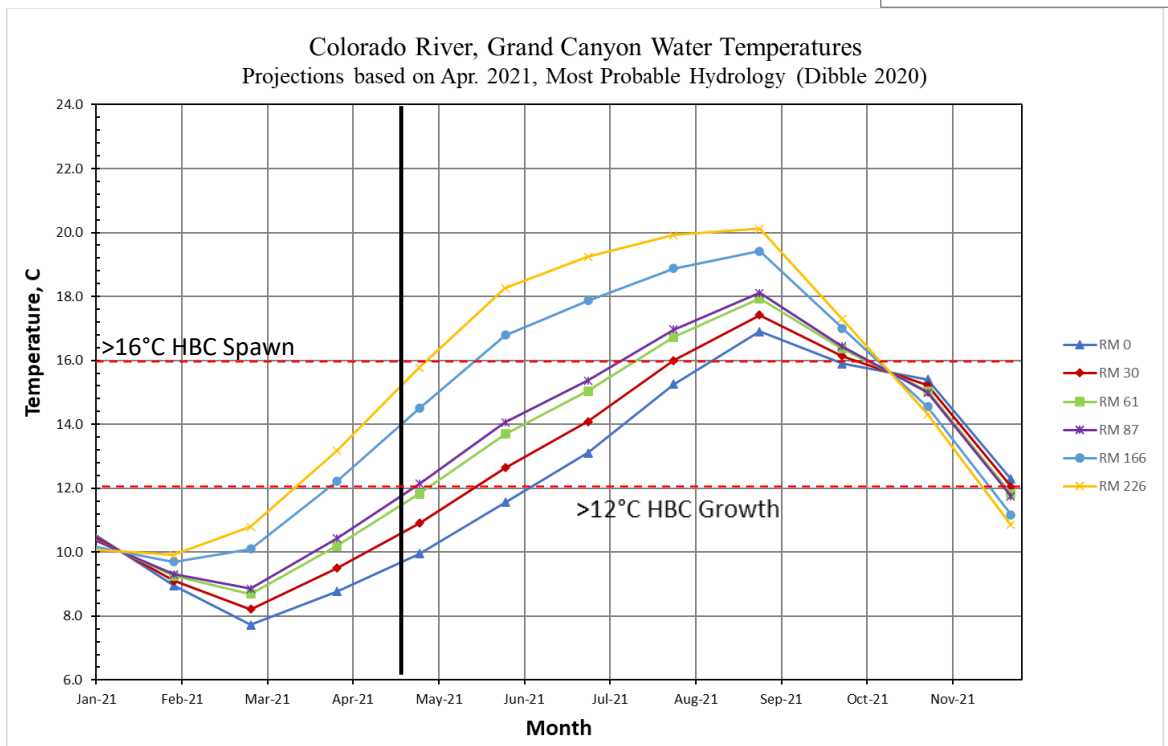
Wahweap Forebay Temperature Jan 2000 - Dec 2011



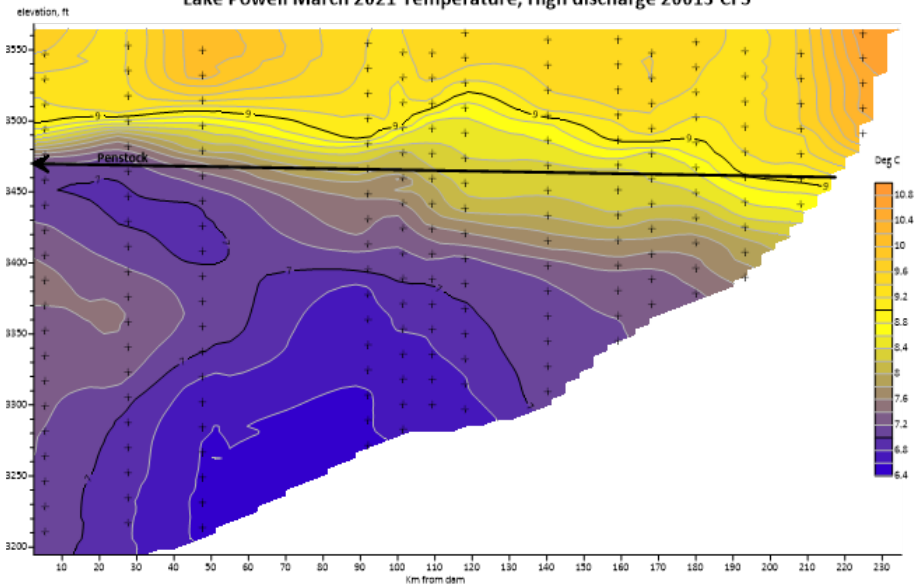
Lake Powell Wahweap Nov 2011 - March 2021



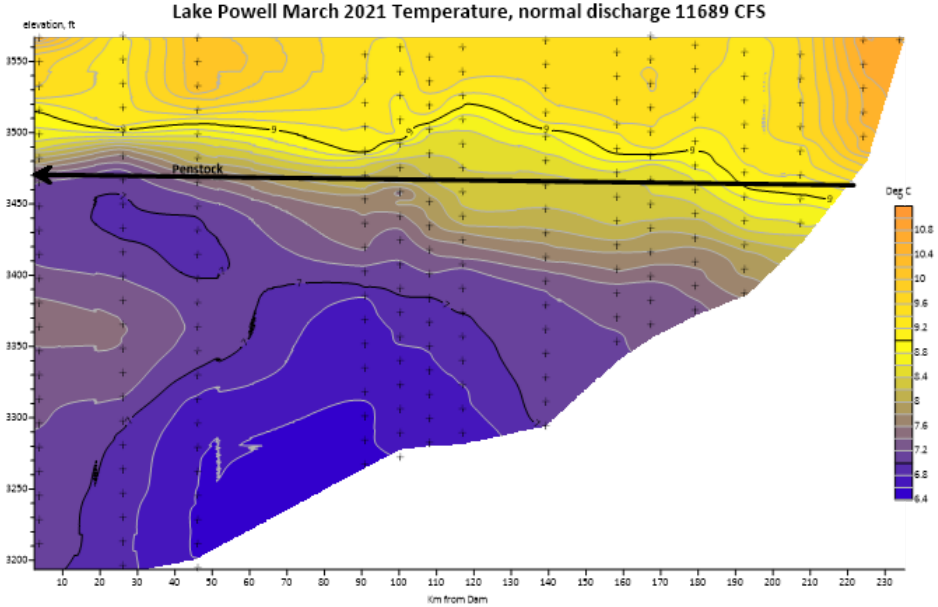

Colorado River, Grand Canyon Water Temperatures
Projections based on Apr. 2021, Most Probable Hydrology (Wright 2010)
Historic
Projected
>16°C HBC Spawn
>12°C HBC Growth
Temperature, °C
Month
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21
Jan-22
RM 0
RM 30
RM 61
RM 87
RM 166
RM 226


Colorado River, Grand Canyon Water Temperatures
Projections based on Apr. 2021, Most Probable Hydrology (Dibble 2020)
>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-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
RM 0
RM 30
RM 61
RM 87
RM 166
RM 226

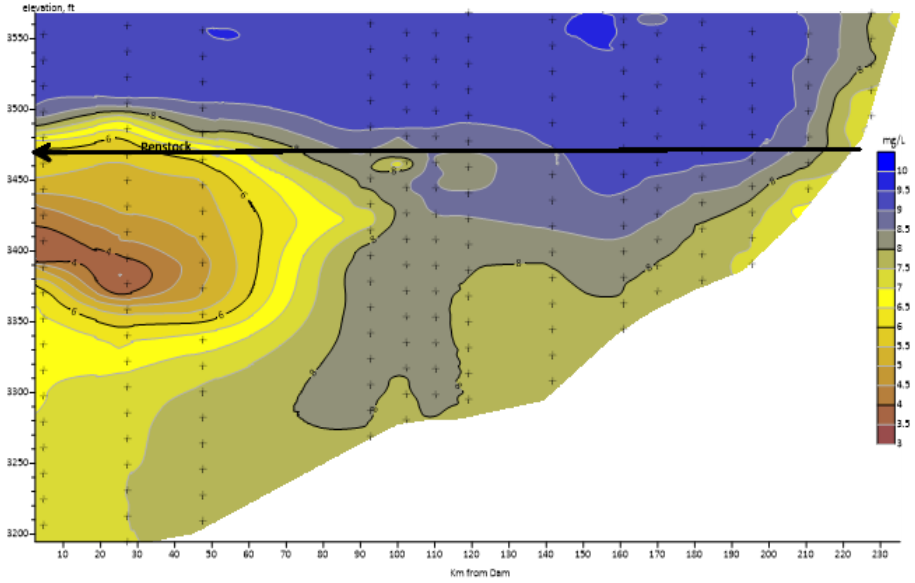
Lake Powell March 2021 Temperature, High discharge 20013 CFS



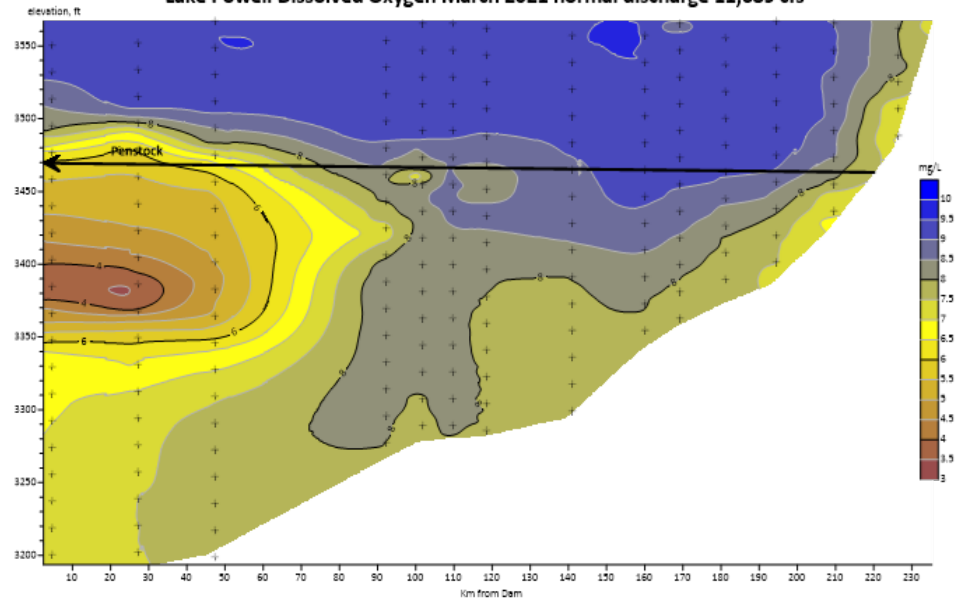
Lake Powell March 2021 Temperature, normal discharge 11689 CFS

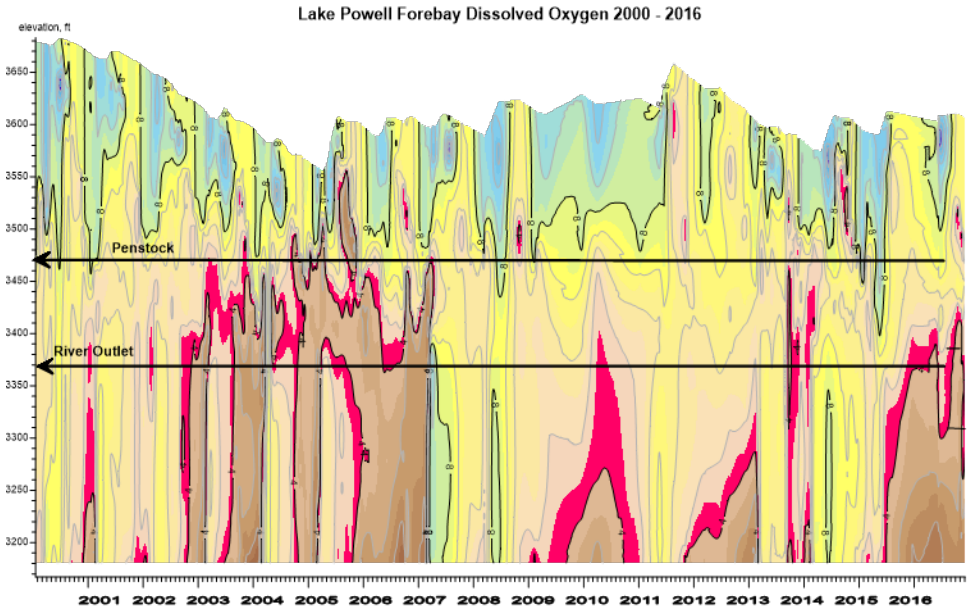


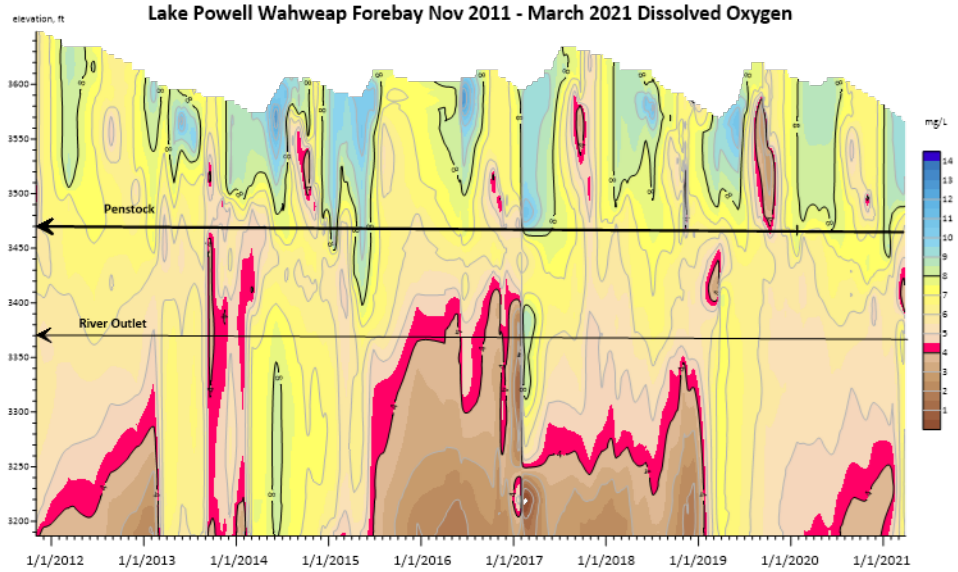
Lake Powell March 2021 Dissolved Oxygen, high discharge 20,013 cfs

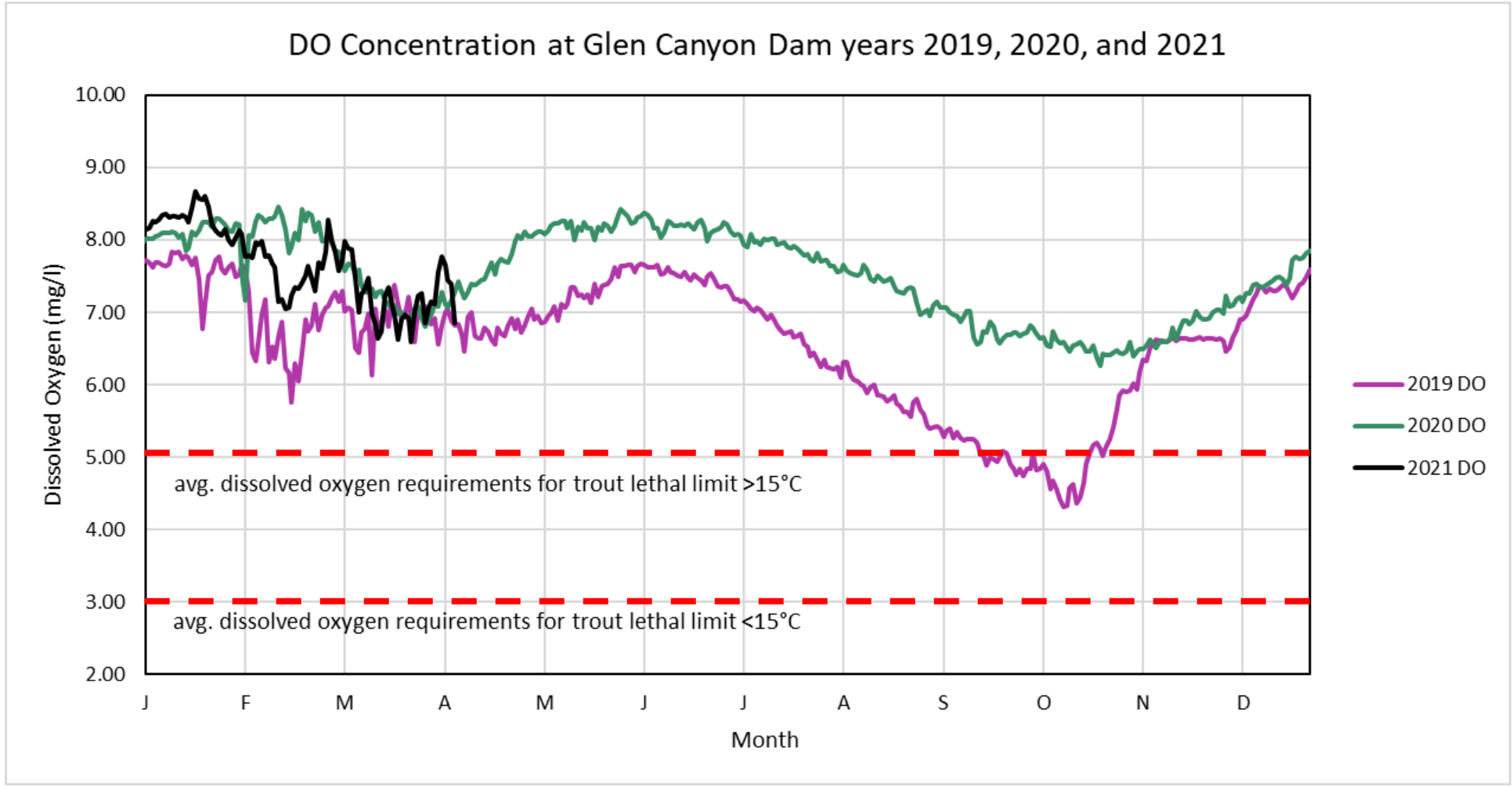


Lake Powell Dissolved Oxygen March 2021 normal discharge 11,689 cfs




Lake Powell Forebay Dissolved Oxygen 2000 - 2016
elevation, ft
Penstock
River Outlet
2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016


Lake Powell Wahweap Forebay Nov 2011 - March 2021 Dissolved Oxygen
elevation, ft
Penstock
River Outlet
mg/L
1/1/2012 1/1/2013 1/1/2014 1/1/2015 1/1/2016 1/1/2017 1/1/2018 1/1/2019 1/1/2020 1/1/2021


DO Concentration at Glen Canyon Dam years 2019, 2020, and 2021
Dissolved Oxygen (mg/l)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
avg. dissolved oxygen requirements for trout lethal limit >15°C
avg. dissolved oxygen requirements for trout lethal limit <15°C
J
F
M
A
M
J
J
A
S
O
N
D
Month
2019 DO
2020 DO
2021 DO

Questions/Discussion

BUREAU OF RECLAMATION