Colorado River Basin Reservoir Storage: where do we stand?

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1 June 2025

Overview

We now begin June, when the Colorado River's two largest reservoirs, Lake Mead and Lake Powell, should be swelling with melting snow for use later this year and beyond, but that is not happening. Although Lake Powell is *our* reservoir and Lake Mead is *theirs (*or *vice versa)*, the two reservoirs are effectively one very large facility located downstream from Upper Basin consumptive users and upstream from Lower Basin users. At least 60% of the total storage in 46 reservoirs tracked by Reclamation is in Lake Powell and Lake Mead. The total contents of the two reservoirs have been steadily declining since early July 2024 and continued to decline through at least 31 May 2025. Never in the past 15 years has the decline in total storage of Powell and Mead extended so late into spring. Current reservoir storage data are showing us, in real time, an ominous pattern familiar from past dry years: upstream use of water before it has a chance to get to Lake Powell combined with releases from Lake Mead to users further downstream is outpacing the melting snowpack's ability to replenish the two reservoirs.

While the normal tools we use for measuring and managing use of Colorado River water – the Consumptive Uses and Losses Reports and the Lower Basin decree accounting reports – lag by weeks or even years, reservoir storage, which is the net difference between stream flow into reservoirs and what is released downstream or is lost to evaporation, provides the closest thing we have to an accurate, real-time measure of the Colorado River basin's water budget. Right now, we are not doing well.

- The duration of time during which total storage in Lake Powell and Lake Mead has declined is unprecedented in the past 15 years. In a typical year, the steady decrease in the combined contents of Powell and Mead that begins the preceding summer ends in early May when Rocky Mountain snowmelt becomes significant. However, inflows to Lake Powell this year have yet to exceed releases from Lake Mead[1], and the total contents continue to decline, suggesting that this year's recovery in storage will be minimal.

- Data from other years also suggests that reservoir recovery this year will be relatively small. This year, total unregulated inflow to Lake Powell is predicted to be 55% of normal.[2] Based on past trends, net increase in total reservoir storage of the 46 reservoirs tracked by Reclamation will be ~1.2 million acre feet (af). By July, we are likely to resume draw down the basin's reservoirs until the 2026 snowmelt season begins.[3]
- Presently, storage in the watershed's reservoirs is comparable to conditions in late summer and fall 2021 when water managers expressed significant concern. The very wet conditions of 2023 averted a major crisis, but the system remains depleted. In 2024, total basin reservoir storage climbed by 2.5 million af, but subsequent drawdown of those reservoirs was 3.6 million af during the following 10 months. Although the net difference between reservoir gain and subsequent drawdown of 1.1 million af might be considered "balanced" in the context of the last 15 years, there is no question that we have begun to mine the bounty of 2023, and we are likely to continue to do so until at least spring 2026 unless we greatly reduce consumptive uses.

For too long, we have hoped that big wet years will occur with sufficient frequency to avert true crisis, but there have been too few of those wet years during the 21st century. Only three of the last 15 years have been sufficiently wet to result in a significant increase in reservoir storage given the magnitude of the basin's consumptive uses. We can't continue with a water management policy that hopes for another wet year. The basin's water managers have no choice but to further reduce consumptive uses to sustainably manage the dwindling water supply.

The details …

This year's snowmelt runoff in the middle and southern Rocky Mountains began in earnest in early April, and reservoirs upstream from Lake Powell[4] (hereafter, *upstream reservoirs*) began to fill at

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[1] as well as evaporation from the two reservoirs
[2] Colorado Basin River Forecast Center May 2025 forecast.
[3] Based on correlation between April-July unregulated Lake Powell inflow and basin-wide reservoir storage recovery during the snowmelt inflow season.
[4] There are 42 reservoirs upstream from Lake Powell whose contents are reported by Reclamation at https://www.usbr.gov/uc/water/hydrodata/reservoir_data/site_map.html. This data base also includes Lake

that time. However, total storage in Lake Powell and Lake Mead (hereafter, *Powell+Mead*) continued to decrease until at least 31 May, because inflows to Lake Powell plus inflows to the Colorado River in Grand Canyon were less than releases from Lake Mead plus evaporation losses from the two reservoirs. It is very unusual for Powell+Mead to continue to decrease in total storage so late into spring, and the previous latest date when storage decline reversed and began to increase was 29 May 2021. Because approximately 60% of the basin's stored water is now in Lake Powell and Lake Mead (Fig. 1), conditions in Powell+Mead dominate the watershed's total reservoir storage budget. Even though the upstream reservoirs began to fill in early April, the continued depletion of Powell+Mead was greater than the upstream accumulation and the net, basin-wide storage declined until early May .

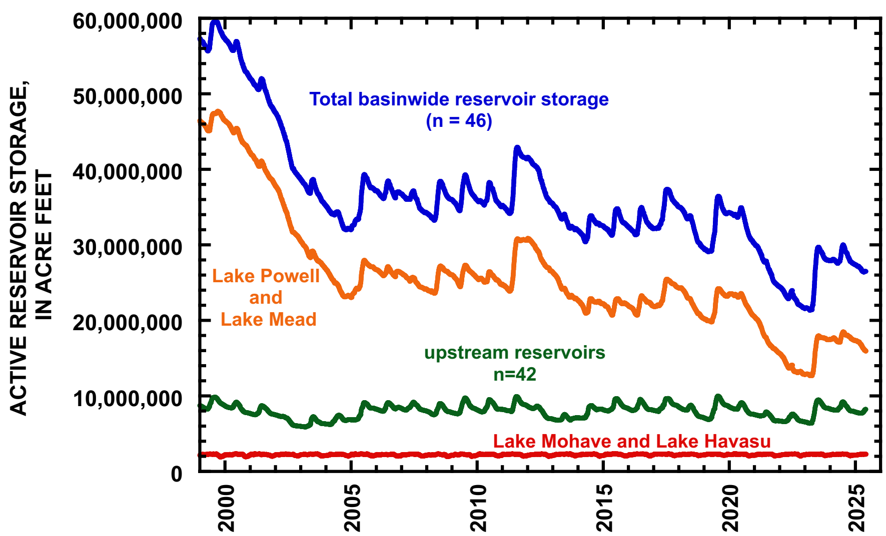

Figure 1. Graph showing total active storage in 46 reservoirs in the Colorado River basin (blue line), total storage in Lake Powell and Lake Mead (orange line), total storage in 42 upstream reservoirs (green line), and total storage in Lake Mohave and Lake Havasu (red line) between 1 January 1999 and the end of May 2025.

Today, total basin reservoir storage is 26.5 million acre feet (af)f[5], of which 15.9 million af is in *Powell+Mead*[6] (Fig. 1). This is similar to conditions in mid-August 2021 and late November 2021, respectively, when Basin water managers described conditions as an unprecedented crisis. The

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Powell, Lake Mead, Lake Mohave, and Lake Havasu. This data base does not include reservoir storage on Lower Basin tributaries.

[5] Total basin storage was 26.48 on 28 May 2025, the most recent data for which data in the 46 reservoirs is available.

[6] On 31 May 2025, storage in Lake Powell was 7.71 million af and storage in Lake Mead was 8.20 million af. Total storage in Powell+Mead was 15.91 million af.

Colorado Basin River Forecast Center's May 2025 forecast is that unregulated April-July inflow to Lake Powell will be 55% of the long-term (i.e., 30-yr) average, though a warm, dry May suggests that the inflow estimate may be even less. As described below, it is likely that there will not be much recovery in reservoir storage this spring. If basin water users want to protect against the risk of a repeat of the crises of 2022-23, they will have to greatly reduce their consumptive uses, lest the 2025-2026 winter is also dry. These present conditions are ominous.

Why bother keeping track of reservoir storage?

To use the well-worn analogy of a checking account, reservoir inflows are the income to the checking account, and reservoir releases plus evaporative losses are the expenses from that account. Reservoir storage is the checking account balance. Although much attention is focused on income (i. e., estimates of natural flow at Lees Ferry and unregulated inflow to Lake Powell) and on expenses (i.e., Upper Basin Consumptive Uses and Losses reports, Lower Basin Annual Accounting and Water Use Reports, and studies of reservoir evaporation), those metrics take weeks to years to emerge into public view. In the meantime, we should make use of the data concerning the balance of the account, which is available in real time. Reservoir storage is the balance from which we draw to support use of the Colorado River by 40 million people, especially during protracted dry years, and there is a significant difference between managing a dry year when there is a large amount of storage and managing a dry year when reservoir storage is small.

As we manage the Colorado River system closer to the edge, the timeliness and accuracy of reservoir storage data makes it a vital tool in managing the water supply. Typically, Reclamation reports reservoir content data with only a 1-day lag. Reservoir storage is computed by measuring reservoir elevation and applying an elevation-storage rating relation. Although there is some uncertainty in the long-term application of any elevation-storage rating relation, that uncertainty is small in relation to uncertainties in the estimates of evaporation and consumptive use that are needed to estimate natural flows. Additionally, there is inevitable uncertainty concerning ungaged inflows into some reservoirs, especially Lake Powell.

Decreasing storage in upstream reservoirs does not necessarily represent actual use or evaporative loss in the aggregate system, because releases from upstream reservoirs can be stored downstream. However, aggregated data for the entire watershed does represent the balance between the total supply and the total consumptive use plus evaporative loss, because releases from the most downstream reservoir on the mainstem Colorado River – Lake Havasu -- are entirely consumed, and no water typically makes it to the Gulf of California[7].

As negotiators seek to identify policies that balance use with supply and rebuild basin-wide reservoir storage, it is useful to quantify current rates, magnitude, and timing of change in reservoir storage within the context of previous years. Here, we consider conditions during the past 15 years. What can we learn by summarizing the timely and accurate data concerning reservoir storage?

Conditions today

Average total reservoir storage in the watershed (i.e., the upstream reservoirs as well as Lake Powell, Lake Mead, Lake Mohave, and Lake Havasu) since 2021 has been less than during any other period of the 21st century (Fig. 1). That low amount is due to Upper Basin use that consumes some water that would otherwise flow into Lake Powell as well as releases from *Powell+Mead* to meet the needs of Lower Basin and Mexican users. This year, storage in the 42 *upstream reservoirs* reached its aggregate low on 25 March – 7.72 million af and slowly increased in April and May. In previous years, total storage in the upstream reservoirs varied between 6.38 million af (in March 2023) and 8.23 million af (in late April 2020) (Supplemental Table 1). This year's low point in aggregate upstream reservoir storage is in the middle of those extremes and does not cause alarm.

Storage in *Powell+Mead* has been a different story, however. The combined storage in Powell+Mead decreased to the very end of May. It was 15.9 million af on 31 May 2025, the third lowest springtime minimum of the past 15 years and only surpassed (i.e., even lower) in spring 2022 and spring 2023 (Supplemental Table 1). During the past 15 years, the only year when Powell+Mead storage continued to drop so late in spring was 2021 when storage in Powell+Mead was 2 million af more than today. In 2025, storage in Lake Mead peaked on 24 February, approximately the same time as in 2024, but this year's February peak storage in Mead was 0.65 million af less than last year. Lake Powell has been steadily losing storage since early June 2024. As of late May, 31% of the

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[7] Notably, Reclamation's data do not include information on storage in Lower Basin tributaries, especially in the Gila River watershed. However, little to no flow from the Gila makes it to the Colorado River near Yuma in most years.

watershed's storage is in Lake Mead, 31% is in 42 upstream reservoirs, and 29% is in Lake Powell (fig. 2).

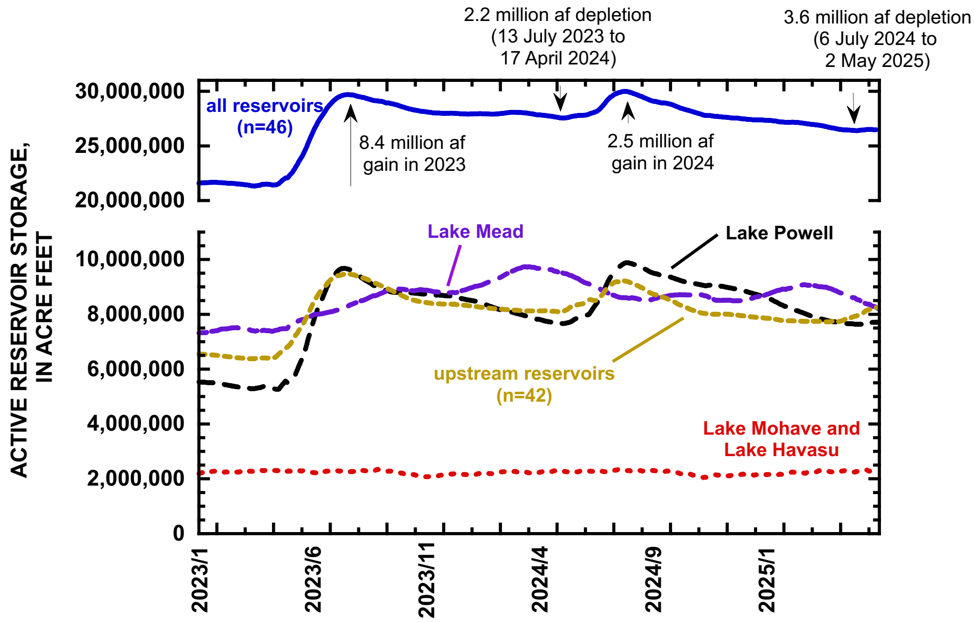

Figure 2. Graph showing reservoir storage in different parts of the Colorado River watershed between 1 January 2023 and late May 2025. Lake Mead (purple line), Lake Powell (black line), and 42 upstream reservoirs (tan line) each store approximately 30% of the total basin storage (blue line). Approximately 9% of the basin's storage is presently in Lake Mohave and Lake Havasu (red line).

This year's snowmelt inflow season is likely to be short. The season of reservoir storage accumulation in past wet years extended from early April to late July[8], but the accumulation season in dry years typically only extends between mid-April and mid-June (Supplemental Table 1). This year's basin-wide reservoir accumulation season began even later, May 3, and basin-wide accumulation of storage will probably end by the third week of June, based on past trends. The accumulation season for *Powell+Mead* has yet to begin.

What holds for reservoir storage caused by this year's runoff? Total basin-wide increase in reservoir storage is well correlated with April to July unregulated inflow to Lake Powell (Fig. 3). The May 2025 forecast for April to July unregulated inflow is 3.5 million af. Based on the last 15 years of data, there is likely to be only a small bump in basin-wide reservoir storage associated with this year's

[8] The latest date of the end of the accumulation period was 4 August 2011, the wettest year of the 21st century.

snowmelt runoff -- approximately 1.2 million af and less than half of last year's increase in storage. By July, reservoir drawdown will resume.

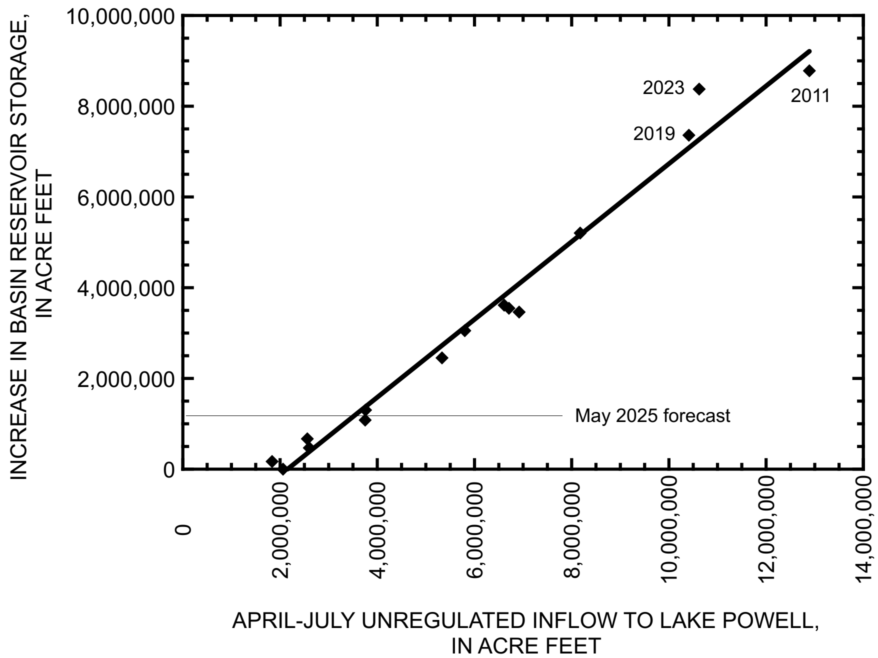

Figure 3. Graph showing aggregated increase in reservoir storage in 46 reservoirs in the watershed correlated with April -July unregulated inflow to Lake Powell, as estimated by the Colorado Basin River Forecast Center and reported by Reclamation in its 24-Month study reports. The May forecast for 2025 is 3.5 million af, which will yield an increase in basin storage of 1.2 million af.

In perspective …

The only way to maintain the checking account balance in years of small inflow is to greatly reduce consumptive uses and losses. In light of the relatively small amount of water now in storage, the need to conserve is even greater. During the past 15 years, there have been three patterns in the balance between income and subsequent expenses (Fig. 4):

- three years when natural supply was large, reservoir storage increased greatly, and subsequent reservoir drawdown was much less than the preceding gain;
- five years when natural supply was low and subsequent reservoir drawdown greatly exceeded the immediately preceding increase in storage; and,
- seven years when the supply and subsequent consumption were approximately in balance.

Since 2010, there have been three years -- 2011, 2019, and 2023 – when the annual increase in reservoir storage greatly exceeded the subsequent decrease (Fig. 4). These three years were the three wettest years of the 21st century, and snowmelt season gains in storage exceeded subsequent reservoir drawdown by approximately 5.5 million af in each year. Although the largest increase in storage was caused by the 2011 snowmelt, the largest annual net increase in storage occurred after the 2023 inflows, because consumptive uses and losses during the following 9 months of 2023 and 2024 were much less than was the case following the 2011 inflows (Supplemental Table 2).

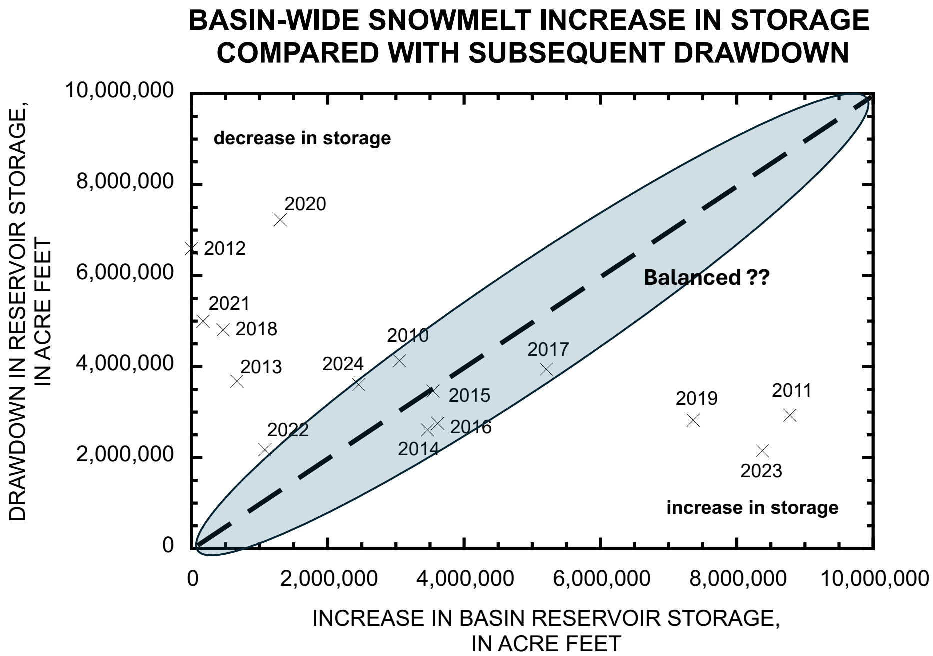

Figure 4. Graph showing annual increase in basin reservoir storage during the snowmelt season and the drawdown in storage that occurred in the subsequent ~9 months. The diagonal line is the 1:1 line of equal increase and drawdown. Years that plot further away from this 1:1 line reflect significant increases (towards the lower right) or significant decreases (towards the upper left) in storage. Data are for 2010 to 2024. A hypothetical zone of sustainability is shown in grey. Years above and to the left of this zone are to be avoided. Significant reservoir recovery has only occurred in years of unusually large snowmelt.

In contrast, there was significant net loss in storage of the dry inflow years of 2012, 2013, 2018, 2020, and 2021, followed by large drawdown during the subsequent 9-10 months. Reservoir storage in these five years declined, on average, by 4.9 million af/yr, collectively accounting for a total loss of 24.7 million af. In these years, the estimated calendar year (CY) natural supply ranged between 7.8 and 9.7 million af and the April-July unregulated inflows ranged between 1.8 and 3.8 million af, significantly less than the runoff during wet years. Although these data distinguish between wet and dry periods, Basin consumptive uses and losses data appear to have greater uncertainty and are not much different from use data following the wet years. Consumptive uses and losses following the dry inflow years ranged between 13.3 and 14.4 million af/yr, approximately the same range of losses as occurred during the three wet years (Supplementary Table 2).

There were seven years when reservoir drawdown during the 9-10 months following snowmelt accumulation of storage was in approximate balance, and the balance was less than 1 million af in three of those years. In that sense, the drawdown between July 2024 and today might be considered within the "balanced" envelope of Figure 4, but "balanced" does not result in rebuilding storage, as is evident by examination of Figure 1. In the immediate future, we need to achieve more than "balanced," we need to rebuild storage.

The demise of basin reservoir storage in the 21st century was primarily caused by large drawdown following very dry inflow years, coupled with an insufficient number of very wet years. There are obviously many strategies to reduce reservoir drawdown and rebuild basin reservoir storage, but one strategy has not been successful … hoping and praying for more wet years. Our policies need to be robust to the risk that hopes and prayers have not yet worked in the 21st century. Assuming that the frequency of very wet years does not increase in the future, then a policy focused on reducing reservoir drawdown by reducing consumptive uses during very dry years is critical to rebuilding reservoir storage, because large losses can occur following those very dry years. Another strategy would be to reduce drawdown during years of moderate runoff, between 4 and 7 million af. Further historical policy analysis is needed to identify lessons that can we learn from 2010, 2014, 2015, 2016, 2017, 2022, and 2024, the years when reservoir drawdown hovered around the diagonal 1:1 line of Figure 4.

Closing thoughts

In response to a previously posted mini-white paper on reservoir storage, a supportive friend commented, "Nobody cares." Another friend said, "I don't see how we can get agreement about recovering storage. Let's hope for more wet years." We should care, and we need to try harder.

These mini-white papers seek to demonstrate that reservoir storage data, analyzed in aggregate, provide timely and accurate data relevant to understanding the reliability and security of the Colorado River's water supply. These data are more precise, accurate, and timely than estimates of natural runoff, reservoir inflow, consumptive uses, or evaporation. Reservoir storage data provided by Reclamation are a significant contribution to transparency in water management. However, these data are under-utilized and under-analyzed and are typically reported without long-term context. We can do better.

These data can be used to develop an excellent correlation between April-July unregulated inflow to Lake Powell, forecast by the Colorado Basin River Forecast Center, and anticipated increase in basin-wide storage. Such an analysis strongly indicates that the 2025 snowmelt runoff will yield only a small increase in basin storage and necessitate greater reductions in consumptive use so as to better position the basin's water users should next year also be dry.

Supplemental tables

Supplemental Table 1. Beginning and end dates of the reservoir storage accumulation season for the entire watershed, upstream reservoirs, and Lake Powell plus Lake Mead. The volume in storage for each date and each part of the watershed are indicated. The value at the beginning of the accumulation season is the minimum storage at the end of the preceding 9-10 month period of reservoir drawdown. Tan shading indicates years that were among the five driest of the 21st century. Blue shading were years that were among the five wettest of the 21st century.

	Beginning and end dates of reservoir storage accumulation season (storage on indicated data, in million acre feet), for indicated part of the Colorado River watershed		
Year	Total watershed	Upstream reservoirs	Powell+Mead
2010	14 April (35.2) – 24 June (38.3)	8 March (7.85) – 24 June (9.54)	16 April (25.0) – 27 June (26.4)
2011	17 April (34.2) – 4 August (42.9)	8 May (7.91) – 21 July (9.92)	15 April (23.9) – 7 August (30.8)
2012	31 May (40.0) [no accumulation]	16 March (8.30) – 9 June (8.54)	26 May (29.2) – 30 May (29.2)
2013	13 May (33.4) – 17 June (34.1)	13 March (6.76) – 19 June (7.56)	17 May (24.1) – 16 June (24.3)
2014	18 April (30.4) – 6 July (33.9)	8 February (7.06) – 13 July (8.73)	23 April (20.9) – 30 June (22.9)
2015	4 May (31.3) – 20 July (34.8)	11 March (8.00) – 13 July (9.64)	8 May (20.7) – 2 August (22.9)
2016	8 April (31.3) – 5 July (35.0)	29 February (8.05) – 21 June (9.54)	6 May (20.7) – 7 July (23.3)
2017	13 January (32.2) – 13 July (37.4)	10 March (7.93) – 26 July (9.65)	12 January (21.8) – 11 July (25.5)
2018	5 May (33.4) – 10 June (33.9)	23 April (8.11) – 22 June (8.77)	25 May (22.9)
2019	2 March (29.1) – 28 July (36.4)	5 March (6.86) – 19 July (9.97)	20 April (19.8) – 28 July (24.2)
2020	29 April (33.6) – 18 June (34.9)	25 April (8.23) – 23 June (9.09)	7 May (23.1) – 15 June (23.6)
2021	28 May (27.7) – 14 June (27.9)	2 April (7.35) – 19 June (7.88)	29 May (17.8) – 30 May (17.8)
2022	2 May (22.9) – 24 June (23.9)	13 March (6.60) – 6 July (7.60)	13 May (13.7) -) – 30 June (14.1)

2023	14 March (21.3) – 13 July (29.7)	9 March (6.38) – 12 July (9.47)	14 March (12.7) – 16 July (18.0)
2024	17 April (27.5) – 6 July (30.0)	12 April (8.09) – 3 July (9.23)	17 May (17.1) – 8 July (18.5)
2025	2 May (26.4) - ??	25 March (7.72) - ??	29 May (15.9) - ??

<u>Supplemental Table 2.</u> *Natural water supply, unregulated inflow to Lake Powell, basin-wide consumptive uses and losses, and changes in reservoir storage during the last fifteen years. All values are in millions of acre feet. Tan shading indicates years that were among the five driest of the 21st century. Blue shading were years that were among the five wettest of the 21st century.*

Year	Natural flow at Lees Ferry (calendar year)	Unregulated April-July inflow to Lake Powell	Basin consumptive uses and losses (calendar year)	Increase in reservoir storage	Reservoir drawdown
Years of large loss in storage (> 4 million af); net change in 5 years = -24.7 million af					
2012	7.89	2.06	14.4	0	6.59
2013	9.73	2.56	13.3	0.667	3.68
2018	8.44	2.60	14.1	0.467	4.81
2020	9.56	3.76	14.0	1.30	7.22
2021	7.82	1.83	13.4	0.170	5.00
Years of large recovery in storage (> 4 million af); net change in 3 years = 16.6 million af					
2011	20.3	12.9	14.2	8.78	2.93
2019	17.7	10.4	13.6	7.36	2.82
2023	17.4	10.6	12.8	8.38	2.15
Years when gain and loss were in approximate balance; net change in 7 years = -0.3 million af					
2010	12.7	5.80	14.1	3.05	4.13
2014	14.2	6.92	14.4	3.46	2.61
2015	13.0	6.71	13.7	3.54	3.46
2016	13.4	6.61	14.0	3.61	2.75
2017	16.3	8.17	13.9	5.21	3.94
2022	10.1	3.75	12.9	1.08	2.18
2024	11.9	5.33	Not available	2.45	3.60
2025 -- Unknown					
2025	??	~3.5		~1.2	??