**Lake Mead Water Conservation Accounts: Successes, Challenges, and Suggestions to Improve for Post-2026**

September 4, 2021

|  |
| --- |
|  |
| **Key Points** |

# Introduction

This piece has the purpose to explain and improve the Lake Mead water conservation accounting program because in my view the program is the most innovative, successful, and adaptive component of present Colorado River operations. In one sentence—the program allows Lower Basin users to voluntarily reduce use from their historical allocation, keep the conserved water in Lake Mead, and withdraw the conserved water at a future point in time subject to some constraints. The program was created as part of the 2007 Interim Guidelines {USBR, 2007 #2736}. The Guidelines and Colorado River experts refer to the program as Intentionally Created Surplus (ICS). Minutes 317 and 323 to the 1944 United States - Mexico treaty set up a similar water conservation program for Mexico {IBWC, 2021 #2808}. The program was set up and operates with the assumption that annual reservoir inflow minus evaporation—the available water—exceed historical allocations. The next section describes the program in more readily understandable language of water conservation account credits and debits with examples. Subsequent sections share XX program successes, YY challenges, and ZZ suggestions to addresses challenges as part of new operations post 2026. These suggestions seek to include more of the factors—reservoir inflow, evaporation, and current storage—that determine the water available to release and conserve. The suggestions also seek to give users more autonomy to independently manage More autonomy means fewer negotiations now, in the future, and less stress for basin partners.

# Explanation and Examples

This section describes the program in more readily understood language of reservoir withdraws below and above historical allocations (Box 1). I provide examples of program operations -- credit, debit, flexibility, and system effects (Boxes 2 to 5). I also list program constraints and show activity from 2008 to 2023.

Water

**Box 1. Definitions**

**Historical allocations** - The 4.4, 2.7, 0.3, and 1.5 million acre-feet per year volumes of water allocated to California, Arizona, Nevada, and Mexico under current Colorado River operations.

**Water conservation** - The voluntary and temporary reduction in water use from a historical allocation at one place and at one point in time coupled with a corresponding increase in water use at the same place at a future point in time (or another location at the same or future point in time).

**Water conservation account credit** - The volume of water conserved and left in Lake Mead.

**Water conservation account debit** - The volume of water withdrawn, diverted, and consumed above a historical allocation.

**Water conservation account balance** - The sum of all credits minus all debits from 2007 to present.

**Available water** - The volume of water in a reservoir available for withdraw. Available water is reservoir active storage plus annual inflow minus evaporation. Between 1990 and 2023, *reservoir inflow* has varied from 8 to 16 million acre-feet per year. The volume also depends on the method used to estimate. This work uses the largest inflow estimate which is the sum of gaged flow (Wang and Schmidt). *Reservoir evaporation* - the volume of water that transfers from the liquid state to gas state over the same period of time. Reservoir evaporation is difficult to measure or forecast because the volume is influenced by the reservoir surface area, air temperature, wind, surface water temperature, inflow volume, inflow temperature, reservoir mixing, and other chaotic climate variables. In 2018, Reclamation reported Lake Mead Evapiration for 2010 to 2015. In 2023, Reclamation reported Lake Mead evporation for 2016 to 2020. The reported values varied from. GGG to HHH million acre-feet per year.

**Reservoir protection level** - The reservoir active storage volume (or elevation) set to provide a buffer against reservoir drawdown to the minimum power pool. The Lake Mead protection elevation is 1,020 feet which is 5.9 million acre-feet of active storage above the minimum power pool elevation of 955 feet.

**Prohibition on program debits** -The reservoir volume or elevation trigger below which water conservation program debits are prohibited. This trigger elevation has the purpose to prevent reservoir drawdown below the protection elevation. Presently, the trigger elevation is 1,025 feet

Example 1. Water conservation account credit. At the beginning of 2018, Arizona had a conservation account balance of KKK million acre-feet. In 2018, Arizona withdrew, diverted, and consumed 2.5 million acre-feet -- 200,000 acre-feet \*less\* than its 2.7 million acre-foot historical allocation. Arizona's water conservation account was credited 200,000 acre-feet. At the end of 2018, Arizona's conservation account balance was KKK + 200,000 acre-feet. This water conservation action raised Lake Mead's volume 200,000 acre-feet above the anticipated volume -- the surplus in "Intentionally Created Surplus" -- had Arizona withdrawn, diverted and consumed its historical allocation.

Example 2. Water conservation account debit. At the beginning of 2019, California had a water conservation account balance of 800,000 acre-feet. In 2019, California withdrew, diverted, and consumed 4.55 million acre-feet of water -- 150,000 acre-feet of water \*above\* its historical allocation. At the end of 2019, California had a water account balance of 650,000 acre-feet. Lake Mead's storage reduced 150,000 acre-feet from the anticipated volume had California withdrawn its historical allocation.

Example 3. Flexible management. In 2018 thr Sierra Nevada mountains saw above median snow pack and runoff. The Metropolitan Water District of Southen California (MWD) -- a California contractor -- increased water deliveries from its Owen's Valley and California aquaducts. MWD reduced withdraw from the Colorado River relative to its historical allocation of 1.1 million acre-feet per year.

Example 4. Program Effect. At the end of 2021, the Lake Mead storage volume was 8.4 million acre-feet (elevation Zzz). At thr end of 2023, the sum of the conservation account balances for California, Arizona, and Nevada wad 2.78 million acre-feet. Had the water conservation program not existed -- states continued to withdraw, divert, and consume their historical allocations -- we would anticipate that Lake Mead's storage

Volume would be MMM million acre-feet (elevation NNN feet).

Program constraints. The program setd maximum eatwr conservation account balances for the three Lower Basin states (Table 1). The program also limits maximim credits and debits each year. The program also prohibits debits -- withdraw, diversion, and consumption above historical allocations-- when Lake Mead storage is at or below xxx (elevation 1020 feet). The program asseses a 5% reduction in the first year to cover inceeased reservoir evaporation associated with a higher Lake Mead level and surface area. The program asseses a 3% reduction in subsequent years.

Interaction with mandatory water conservation program. Thr 2007 Interim Guidelines and 2019 Drought contingency plan specify increasing volumes of mandatory reductions in reservoir withdraws as Lake Mead level declines from elevation 1,090 towards 1,020 feet. Thr 2019 DCP allows states and contractors to debit their water conservation account balance to meet their mandatory reductions in water use. This transfer is an administrative action and does not change Lake Mead level. I am unclear whether states and contractors can recover their mandatory conservations -- either from administrative transfers or addition consevstion efforts -- at a future period in time.

The water conservation program functions under thrbassumption that Lake Mead inflow minus evaporation exceeds the sum of the historical alloctions of 9.0 million acre feet per year.

Reclamation reports annually water conservation program account balances, credits, and debits (Figures 1 and 2). The reports show no reductions for evaporation.

A graph with blue bars

Description automatically generated

**Figure 1. Lake Mead Water Conservation Account Annual Credits and Debits.**

A graph of different colored bars

Description automatically generated with medium confidence

**Figure 2. Lake Mead Water Conservation Account Balances**

Successes

1. The Lower Basin states and Mexico have collectively conserved and left in Lake Mead 3.2 million acre-feet of water (Figure 1)!!

2. Each state has participated at levels above or near 1.million acre-feet.

3. For example, Nevada's 2023 water conservation account balance of 1.0 million acre-feet is 5 times it recent consumptive use of 200,000 acre-feet per year. 5 times means Nevada can sustain its operations for 5 years.

4. Program participation has grown in recent years.

5. Participation has exceeded the upper limits for credits (Figure 1). This excess shows the program has grown beyond the expectations of the designers of thr program.

6. The program has conserved more water than other voluntary and compensated water conservation programs (Table 2).

7. States have more autonomy to set their reservoir withdraws independent of other states activity. This autonomy reduces conflict.

8. Today Lake Mead is at elevation 1,055 feet (CCC million acre-feet of active storage). A collective water conservation account balance of 3.2 million acre-feet implies Lake Mead would be at CCC - 3.2 million acre-feet (elevation DDD feet) had Lower Basin states continued withdraws at their historical allocations (Figure 3).

A graph of water and water

Description automatically generated

Figure 3. Lake Mead Storage, Water Conservation Account Balances, and anticipated Lake volume absent the water conservation.

program

9. Program participation jetsioned the principle of "use it or lose it" common to the laws that govern water use in many western states, including California, Arizona, and Nevada. Use it or lose it is a disincentive to conserve water because if a contractor uses less than their historical allocation over a number of years, the state can reclaim thr allocation and assign that right to a different user who can put the water to use.

Challenges

1. Fast reservoir drawdown. States and contractors conserved water with the understanding that they can withdraw that water in thr future. With multiple years of debits,Lake Mead can drawdown close to the protection elevation in a few years. At the basin scale, 3.2 million acre-feet of credits represent an encumberment.

2.Stranded assets. When Lake Mead is near the trigger elevation that prohibits debits, states can not access their prior conserved water. The asset is unavailable. This situation persists until Lake Mead inflows minus evaporation exceed the historical allocations and/or one or more states withdraw below their historical allocation.

3. Accerbate conflict. There are several scenarios where the voluntary water conservation program will exacerbate conflict. These scenarios occur when Lake Mead elevation is near the protection elevation.

3a. Multiple states desire to debit their accounts so that the total debits will drawdown LakenMead below its protection elevation. The states will need to negotiate lower debits that keep Lake Mead atnor above the protection elevation.

3b. State A debits their account and decreases Lake Mead towards the protection elevation. This activity prevent States B and C in future years to debit their accounts.

3c. State A credits their account to raise Lake Mead level above the protection elevation while in the same year State B debits their account to return Lake Mead Level to the protection elevation. Thr debit prevents State A from debiting its account the next year.

4. Accelerate reservoir drawdown. Scenarios 2, 3a, 3b, and 3c create a situation where states may race to debit their water conservation account balances to access their conserved water once they perceive Lake Mead will drawdown xlose to thenprotection elevation. This situation has the opposite effect of thr program intent. Lake Mead level will stay close to thr protection elevatio until inflow minus evsporation exceeds the historical allocations.

5. Game the voluntary-mandatory conservation program. These scenarios occure when Lake Mead is at an elevation between 1090 and 1020. These scenarios also work counter to thenprogram intent to raise Lake Mead's elevation.

5a. State A makes small (voluntary) credit to raise Lake Mead elevation to a higher tier where the same state is mandated to maka relatively lower mandatory consrvation.

5b. State A makes a small (voluntary) debit to push Lake Mead to a lower tier where States B and C are required to make relatively larger conservations.

6. Similar to challenge #4, games 5a and 5b will likely engender counter measures by other states with the undesired effect to lowr LskenMeads elevation.

7. Lake Mead continues to draw down even as states credit their water conservation accounts. This situation has already hsppened over the past decade! This scenario occurs when Lake Mead inflows minus evaporation are less than historical allocation (Figure 4). Essentially, states got credit for voluntary water conservation activity even though the physical water never entered the reservoir. I estimate that XXX of the current 3.2 million acre-feet of conserved water was credited.

A graph of evaporation and evaporation

Description automatically generated

Figure 4. Lake Mead Inflow, Evaporation, Available Water, and Conservation Credits with and without sufficient available water.

5a.

All of the above challenges reduce to two core challenges and disincentives. It is harder to:

A. Stabilize and recover reservoir storage when key components that define the watercavailable for release -- reservoir inflow, evaporation, protection elevation, and present storage -- are not included in the design of a water conservation program.

B. Motivate voluntaty water conservation -- credits -- as reservoir storage draws down to the protection elevation because states and contractors will face increasing difficulty to access and debit their water conservation account balances.

Suggestions to address challenges

There are numerous ways to combine the key components -- reservoir inflow, evaporation, current storage, protection elevation, trigger elevation -- that define the water available to release and conserve. Thus there are numerous ways to design a voluntary, uncompensated water conservation program to help stabilize and recover reservoir storage. Here I make suggestions to engage more components of the water available to release while reduce the number of required negotiations both presently and in the future. Fewer negotiations means less stress for basin partners.

1. Raise the elevation trigger that prohibits debits to water conservation accounts. This suggestion will create a larger buffer against drawdown to the reservoir protection elevation and thus to the minimum power pool. This suggestion engages two factors -- present reservoir storage and elevation trigger that prohibits debits to water conservation accounts. This suggestion can help address challenge #1 by slowing drawdown to the reservoir protection elevation. This suggestion will accerbate challenge #2 by stranding conserved water earlier. This suggestion will require a new negotiation to set the new trigger elevation. States and contractors maybhave different views on how high to set the new trigger elevation based on their current water conservation account balances and their actual or perceived need to debit their water conservation accounts.

2. Set the Lake Mead elevation criteria that require mandatory water conservation to the anticipated Lake Mead elevation had the voluntary water conservation program not existed. This suggestion engages the factor of current reservoir storage. This suggestion seeks to address Challenges #1 and #5 by requiring larger mandatory conservation earlier and reducing gaming between the voluntary and mandory water conservation programs. Curiously, this suggestion may have unintended consequences to accerbate challenges #1, 2, 3, and 4 -- and the associated conflicts. For example, when the anticipated Lake Mead level absent the voluntary water conservation falls below the reservoir protection elevation, states and contractors may face increasing pressure to access their conserved water sooner (debit their account). The desire to access conserved water sooner will speed drawdown of the actual water level to the protection elevation.

3. Switch from water conservation accounting to water accounting. Water accounting works on the principle of division of each year's available water -- reservoir inflow minus evaporation -- rather than dividing larger shortages tied to declining reservoir storage. Users independently withdraw up to their share of the available water (autonomously manage their vulnerability). Accounts allow users to carry over unused water to the next year. Users can access their prior conserved water at any time in any amount (rollover). The accounting leverages prior shortages sharing agreements without requiring new negotiations. Can also create accounts for communities previously excluded from Colorado River Management such as Tribal Nations and the Colorado River Delta. The accounting works as follows.

1. Set the reservoir protection volume/elevation. Reservoir storage will always stay above this amount. Present conversations suggest setting the Lake Mead protection volume between XXX and YYY million acre-feet of active storage (elevations 1,025 to 1,000 feet).

2. Divide the present active storage above the protection volume among the user accounts. One intuitive division is by user's current water conservation account balances (rollover). Allocate additional active storage (public pool in Figure 3) to accounts for Tribal Nations, the Colorado River Delta, and/or other users.

3. Estimate the year's available water as the reservoir inflow minus evaporation.

4. Divide the year's available water among the water accounts. Here, use recently negotiated divisions of shortages -- AA%, BB%, CC%, and DD% for California, Nevada, Arizona, and Mexico -- by applying a mathematical transformation where a User's share of Available Water = Historical Allocation - Total shortage \* Their percentage (Table Z).

5. Add the share of available water (Step 4) to share of active storage (Step 2). This amount is the water account balance.

6. Each user withdraws, consumes, and conserves within their account balance -- independently manages their vulnerability.

7. Subtract the withdraw amount from the water account balance to specify the new account balance at the beginning of the next year.

8. Return to Step 3.

The water accounting preserves the Lake Mead protection volume because 1) zero account balances for all users represent zero active storage above the protection volume, and 2) each user must maintain a zero or positive water account balance at all times.

The Lake Mead water accounting is agnostic to annual Lake Powell releases and division of water storage between Lake Powell and Lake Mead because all water in Lake Powell is either lost to evaporation or becomes most of the inflow to Lake Mead and water available for consumption and conservation by Lower Basin users. Annual Lake Powell releases rather specify the inter-annual timing of water delivery to and availability in Lake Mead. From the perspective of native warm-water fish in Grand Canyon, water is preferentially stored in Lake Powell to 1) reduce the entrainment of invasive, non-native, warm water fish into the Glen Canyon Dam penstocks, and  2) preserve colder water releases that presently advantage native fish in Grand Canyon. There may be benefit to adjust monthly Lake Powell releases to preserve storage and colder water releases in Summer and Fall months. Such an adjustment will not affect the annual release volume or water available to Lower Basin users.  
  
Lake Mead water accounting is also agnostic to the division of the natural flow above Lake Powell between the states of the Upper and Lower divisions. Such division is a political issue of where and how to consumptively use water and is better left to negotiations.

A graph with blue and red lines

Description automatically generated

# Appendix A. Estimate Share of Reservoir Inflow from Customary Delivery Targets and Mandatory Conservation Volumes.

This appendix estimates Mexico’s and each Lower Basin party’s share of reservoir inflow from their customary delivery target and mandatory conservation volume listed in Minute 323 and the Lower Basin drought contingency plan (IBWC, 2021; USBR, 2019). Converting into a share is desirable and gives Lower Basin parties more flexibility to adapt to changing inflows (Kuhn and Fleck, 2019). Converting into a share also allows the parties to build on their existing agreements (IBWC, 2021; USBR, 2019) rather than negotiate a new agreement. The Upper Basin states split inflow by share in their 1948 Compact (Carson et al., 1948).

Each Lower Basin and Mexico party share of inflow depends on Lake Mead elevation because the mandatory conservation volumes vary by reservoir elevation. Each party *p*’s share of inflow at reservoir elevation *e* is the ratio of (a) the party’s individual delivery after mandatory conservation to (b) the total delivery to all parties after all mandatory conservation (Eq. 1). Delivery to each party *p* is their Customary Deliveryp [maf per year] minus the Mandatory Conservationp [maf per year]. The Customary Deliveries are 2.8, 0.3, 4.4, and 1.5 maf per year for Arizona, Nevada, California, and Mexico. The calculated shares of inflow are near identical for the 8 reservoir elevation tiers (Table A1).

|  |  |
| --- | --- |
|  | (Eq. 1) |

**Table A1. Share of reservoir inflow calculated from customary deliveries and mandatory conservation volumes.**



# Author

David E. Rosenberg | Utah State University | <http://rosenberg.usu.edu> | [david.rosenberg@usu.edu](mailto:david.rosenberg@usu.edu)

# References

Carson, C. A., Stone, C. H., Wilson, F. E., Watson, E. H., and Bishop, L. C. (1948). "Upper Colorado River Basin Compact." U.S. Bureau of Reclamation. <https://www.usbr.gov/lc/region/g1000/pdfiles/ucbsnact.pdf>. [Accessed on: September 7, 2021].

IBWC. (2021). "Minutes between the United States and Mexican Sections of the IBWC." United States Section. <https://www.ibwc.gov/Treaties_Minutes/Minutes.html>. [Accessed on: July 22, 2021].

Kuhn, E., and Fleck, J. (2019). *Science Be Dammed: How Ignoring Inconvenient Science Drained the Colorado River*, University of Arizona Press.

Moreo, M. T. (2015). "Evaporation data from Lake Mead and Lake Mohave, Nevada and Arizona, March 2010 through April 2015." U.S. Geological Survey Data Release. <http://dx.doi.org/10.5066/F79C6VG3>.

Rosenberg, D. E. (2021a). "Colorado River Coding: Grand Canyon Intervening Flow." GrandCanyonInterveningFlow folder. <https://doi.org/10.5281/zenodo.5501467>.

Rosenberg, D. E. (2021b). "Colorado River Coding: Intentionally Created Surplus for Lake Mead: Current Accounts and Next Steps." ICS folder. <https://doi.org/10.5281/zenodo.5501467>.

Rosenberg, D. E. (2021c). "Colorado River Coding: Lake Mead Steady Inflow Simulations." MeadInflowSimulations folder. <https://doi.org/10.5281/zenodo.5501467>.

Rosenberg, D. E. (2021d). "Colorado River Coding: Pilot flex accounting to encourage more water conservation in a combined Lake Powell-Lake Mead system." ModelMusings folder. <https://doi.org/10.5281/zenodo.5501467>.

Salehabadi, H., and Tarboton, D. (2020). "Sequence-Average and Cumulative Flow Loss Analyses for Colorado River Streamflow at Lees Ferry." Hydroshare. <http://www.hydroshare.org/resource/bbe8dffacb07458783b2e6924aa615bb>. [Accessed on: May 11, 2021].

Salehabadi, H., Tarboton, D., Kuhn, E., Udall, B., Wheeler, K., E.Rosenberg, D., Goeking, S., and Schmidt, J. C. (2020). "Stream flow and Losses of the Colorado River in the Southern Colorado Plateau." Center for Colorado River Studies, Utah State University, Logan, Utah. <https://qcnr.usu.edu/coloradoriver/files/WhitePaper4.pdf>.

USBR. (2019). "Agreement Concerning Colorado River Drought Contingency Management and Operations." U.S. Bureau of Reclamation, Washington, DC. <https://www.usbr.gov/dcp/finaldocs.html>.

Wang, J., Rosenberg, D. E., Schmidt, J. C., and Wheeler, K. G. (2020). "Managing the Colorado River for an Uncertain Future." Center for Colorado River Studies, Utah State University, Logan, Utah. <http://qcnr.usu.edu/coloradoriver/files/CCRS_White_Paper_3.pdf>.

Wang, J., and Schmidt, J. C. (2020). "Stream flow and Losses of the Colorado River in the Southern Colorado Plateau." Center for Colorado River Studies, Utah State University, Logan, Utah. <https://qcnr.usu.edu/coloradoriver/files/WhitePaper5.pdf>.

Wheeler, K. G., Schmidt, J. C., and Rosenberg, D. E. (2019). "Water Resource Modelling of the Colorado River – Present and Future Strategies." Center for Colorado River Studies, Utah State University, Logan, Utah. <https://qcnr.usu.edu/coloradoriver/files/WhitePaper2.pdf>.