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Comments on Proposed Development of Post 2026 Colorado River Operational Strategies

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Dear Ms. Jerla:

Thank you for the opportunity to submit pre-scoping comments on the development of guiding principles and strategies for operating the Colorado River. The Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead (hereafter, Interim Guidelines) will expire in 2026. The unprecedentedly low reservoir storage and the failure (to date) of states to voluntarily distribute the recommended 2-4 MAF water use reductions, reinforce the historic importance of the current deliberations.

The U.S. Bureau of Reclamation and the Colorado River Basins States (hereafter, Basins States) are facing the compound challenge of a long overallocated river, aridification and growth. The resulting supply-demand imbalance is the principle reason reservoir storage in the Colorado River is at a historic low. However, there are other important, albeit subtler factors at play: 1) a system designed for variability is now experiencing change; 2) a focus on lagging indicators of change as policy triggers; 3) prioritization of local flexibility over system stability; and 4) inattention to reservoir recovery. Below I detail each of these factors and present ideas to shape new strategies that address these factors. Then, I conclude with two final recommendations on anticipating the unintended consequences of conservation and planning for the unexpected.

Policy Designed for Change

The Colorado River Basin is in drought; however, the basin is also aridifying. Specifically, one-sixth to one-half of the reduction in streamflow is attributed to rising temperatures and temperatures are highly likely to continue to rise.[1] A sustainable revision to the Colorado River Operating Strategy will require not just reduction in use across the basin consistent with the current supply-demand imbalance, but clear guidelines for equitable sharing of further reductions in use if and when they are needed. A clear process detailed when further reductions are warranted and how they are distributed would further the Interim Guidelines goal of providing greater predictability. The development such a process should

[1] Udall, Bradley and Jonathan Overpeck. 2017. "The Twenty-First Century Colorado River Hot Drought and Implications for the Future." *Water Resources Research* 2404–18.

balance the need for timely adjustment and the risk of overreacting to temporary conditions through the careful selection of an indicator(s). One candidate indicator is the 10-yr naturalized streamflow, but thorough study would be needed to assess how the choice of averaging window impacts tradeoffs.

Even in light of current challenges, the hydraulic infrastructure of the Colorado River, has been highly successful achieving the early twentieth century goals of controlling variability and facilitating development. This infrastructure has insulated the general public and many agricultural water users from the cycles of hydrological variability for decades and is now insulating them from the early signals of climate change. On one hand, this is the system performing as intended. On the other, by working a bit too well, the system has delayed response to changing conditions by reducing the salience of decreasing streamflow. The salience of this information is as important the availability of information because adaptive responses to drought are observed when not only is the system in water stress but information on water stress is highly salient[2]. A similar phenomenon is observed in ecosystems where tight control of variability creates fragility by reducing the information needed for adaptation[3]. In ecological systems increased variability, and the resulting impacts, are needed to facilitate adaptation. However, in engineered systems the salient information required for timely adaption can be retained through careful policy design[4].

The Interim Guidelines used reservoir levels to trigger a shift from one operating mode to another. In a stationary system the use of reservoir levels could effectively achieve the stated goals of balancing "trade-offs between the frequency and magnitude of reductions of water deliveries" and providing predictability.[5] However, in a system with trends in both streamflow and water use, the focus on reservoir levels instead of streamflow, inevitably delays response. Just as reservoir storage delays and dampens the peak of a flood wave, storage delays and dampens the signal of declining streamflow. I recommend that revised operating strategies consider streamflow, or streamflow in conjunction with storage, to trigger a shift from one operating condition to another.

Incentivizing Collaboration while Sustaining the River

A key puzzle is how – beyond the existential threat of system collapse – to incentivize the Basin States to sign on for reduced water allocations and proactively implement measures that reduce water use. The Interim Guidelines created two mechanisms to incentivize proactive implementation: Intentionally Created Surplus (ICS) and Developed Shortage Supply (DSS). These mechanisms encouraged creativity in water conservation, piloting of new ideas and techniques, and resulted in real water savings that helped maintain water levels in Lake Mead. The incentive for participation is the ability of the water user to withdrawal additional water from the system, beyond their allocation. These withdrawals are subject to constraints based on the water level in Lake Mead, though the 2019 Drought Contingency Plan loosened these constraints.[6] The flexibility granted, particularly by the loosening of these constraints, benefits

[2] Garcia, Margaret, et al. 2019. "Towards Urban Water Sustainability: Analyzing Management Transitions in Miami, Las Vegas, and Los Angeles." *Global Environmental Change* 58:101967.
[3] Carpenter, Stephen R., et al. 2015. "Allowing Variance May Enlarge the Safe Operating Space for Exploited Ecosystems." *Proceedings of the National Academy of Sciences* 112(46):14384–89.
[4] Garcia, Margaret, Elena Ridolfi, and Giuliano Di Baldassarre. 2020. "The Interplay between Reservoir Storage and Operating Rules under Evolving Conditions." *Journal of Hydrology* 590:125270.
[5] Department of the Interior. 2007. Record of Decision: Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations of Lake Powell and Lake Mead.
[6] US Bureau of Reclamation. 2018. Upper and Lower Basin Drought Contingency Plans.

local reliability. An illustrative example is the Metropolitan Water District of California, which is withdrawing ICS water this year during a Tier 1 Shortage to help the District weather drought on instate water projects. However, this locally beneficial flexibility is contributing to additional drawdown at a time when Lake's Mead and Powell have a real risk of reaching dead pool in the next few years.

Further, the ICS credits issued but not yet called on remain on the books. Similar to gauging your financial health by reading your bank account statement while ignoring your credit card bills, it is now not fully accurate to gauge the health of the river considering only water in storage and not the IUOs created by ICS. Paired with the Interim Guidelines provision for additional allowable water use during surplus operations, the ICS reduces the probability of recovering reservoir storage. The development of guidelines should simultaneously consider the benefits to local water users and what types of actions those benefits will enable or incentivize. Further, new operating strategies should explicitly target reservoir recovery in all but extreme drought years to prevent a repeat of the slow draw down experienced over the last two decades.

Anticipating the Unintended Consequences of Adaptation

Cities and states across the Western U.S. have demonstrated the potential of water conservation during intense drought. However, increased water use following a period of sustained low water use, or rebounding water use, is common[7]. Understanding why this rebound occurs and how policy choices influence the durable amount drought induced water conservation is important to achieve the large scale and long-lasting water use reduction needed in the Colorado River Basin. Reductions in water use can be attributed to behavior change (i.e., choosing to do less with water) and investments in infrastructure efficiency (i.e., changing how much water it takes to achieve a goal). Maintaining behavior change requires attention and effort, and this effort is linked to the salience of water stress; as the salience decreases, rebound begins[8,9]. In contrast, water use reductions attributed to more efficient infrastructure are likely to endure for, at least for municipal water use[10]. This underscores the potential benefits of investing in efficiency, however, there is an important caveat. Where water is a key input to production (e.g., agriculture), increasing efficiency can lead to expanding production or shifting to more water intensive production due the declining costs brought by efficiency. This phenomena, termed Jevon's Paradox, has been documented with agricultural water efficiency investments. For example, Jevon's Paradox frustrated efforts to reduce groundwater pumping in the High Plains Aquifer[11]. In the context of the Colorado River basin this means that while there is great potential for water savings in the agricultural sector, realizing these savings requires careful policy design that anticipates and constraints the use of saved water.

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[7] Beal, C. D., A. Makki, and R. A. Stewart. 2014. "What Does Rebounding Water Use Look like? An Examination of Post-Drought and Post-Flood Water End-Use Demand in Queensland, Australia." *Water Supply* 14(4):561–68.
[8] Gonzales, Patricia and Newsha Ajami. 2017. "Social and Structural Patterns of Drought-Related Water Conservation and Rebound." *Water Resources Research* 1–38.
[9] Quesnel, Kimberly J. and Newsha K. Ajami. 2017. "Changes in Water Consumption Linked to Heavy News Media Coverage of Extreme Climatic Events." *Science Advances* (October):1–10.
[10] Garcia, Margaret and Shafiqul Islam. 2019. "The Role of External and Emergent Drivers of Water Use Change in Las Vegas." *Urban Water Journal* 15(9):888–98.
[11] Pfeiffer, Lisa and C. Y. Cynthia Lin. 2014. "Does Efficient Irrigation Technology Lead to Reduced Groundwater Extraction? Empirical Evidence." *Journal of Environmental Economics and Management* 67(2):189–208.

Planning for the Unexpected

The Colorado River basin is aridifying but that does not preclude future flooding. New operational strategies should retain flood preparedness protocols. Further, new strategies should consider the fact that the current generation of reservoir operators in the basin have little experience with floods. Operational strategies and protocols guide and constrain operators. However, they also allow for professional judgement; in fast paced and high-pressure situations many professionals default to heuristics to guide decisions. These heuristics are shaped by prior experience, and the prior experience of the current generation of operators has been defined by drought which may lead operators to make decisions which are conservative with respect to drought but risky with respect to floods[12]. Strategies and training protocols should seek to minimize this potential.

I thank you again for the opportunity to provide comments. I hope these comments stimulate productive conversation and wish you all luck on the hard work ahead.

Sincerely,

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[12] Garcia, Margaret, et al. 2022. "Weathering Water Extremes and Cognitive Biases in a Changing Climate." *Water Security* (January):100110.