

# Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead & Efforts Addressing Climate Change and Variability

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## Introduction

The Colorado River is a critical resource in the West, but only through careful planning and management by the Bureau of Reclamation (Reclamation) can the River accommodate the multiple needs, including residential, industrial, agricultural, hydropower generation, environmental, and recreational of seven western states and Mexico. The two largest reservoirs on the Colorado River (and in the entire U.S.) are Lake Powell (24.322 million acre-feet) and Lake Mead (26.159 million acre-feet). From 2000 to 2005, the Colorado River region experienced the worst drought conditions in approximately one hundred years of recorded history, and Lakes Powell and Mead dropped from nearly full to approximately 46 percent of capacity. At that time, there were no specific operational guidelines to address the operations of Lake Powell and Lake Mead during drought and low reservoir conditions. In order to provide a greater degree of certainty to Colorado River water users and managers during times of prolonged drought, Reclamation was tasked with developing a management plan for the Colorado River Basin that includes interim guidelines for coordinated operations of Lakes Mead and Powell and Lower Basin shortage.

Through the National Environmental Policy Act (NEPA) process, Reclamation simulated new operations under a variety of hydrologic conditions and evaluated these in an Environmental Impact Statement (EIS). This article describes the NEPA process and the resulting Interim Guidelines. In addition we describe two additional analyses which appear in appendices of the Final EIS: Appendix N is a quantitative sensitivity analysis of the Colorado River Basin hydrology to variability as described by paleo-reconstructions of streamflows; Appendix U assesses the state of knowledge with regard to climate change on the Basin and prioritizes future research and development needs.

## NEPA Process

In May of 2005, the Secretary of the Department of the Interior (Secretary) tasked the Basin States<sup>1</sup> to develop a consensus plan to mitigate drought in the Colorado River Basin (Basin). The Secretary was clear that the Department was committed to developing guidelines with or without the States' consensus. Accordingly, the Secretary directed Reclamation to engage in a process to develop guidelines for Lower Basin shortages and the operation of Lake Powell and Lake Mead, particularly under

drought and low reservoir conditions. Later that year, Reclamation announced the intent to initiate a NEPA process to develop such guidelines.

During the scoping phase of the NEPA process, three important considerations were identified. The first consideration was to encourage conservation of water, particularly during times of drought. The second was to consider reservoir operations at all operational levels, not just when reservoirs are low. The last consideration was to establish operational guidelines for an interim period to gain valuable operational experience to inform future management decisions.

A broad range of reasonable alternatives were analyzed in the Final Environmental Impact Statement (Final EIS). These alternatives were developed in coordination with a diverse body of stakeholders, including the Basin States, a consortium of environmental non-governmental organizations (NGOs), Native American tribes, federal agencies, and the general public. The Basin States submitted a consensus alternative in June 2006 signifying a historical agreement on issues of this magnitude.

The Preferred Alternative (PA), based on the Basin States consensus alternative and an alternative submitted by the environmental NGOs called "Conservation Before Shortage," was comprised of four key operational elements. These emerged from the three considerations identified during the scoping phase.

1. *Shortage strategy for Lake Mead and the Lower Division states:* The PA proposed discrete levels of shortage volumes associated with Lake Mead elevations to conserve reservoir storage and provide water users and managers in the Lower Basin with greater certainty to know when, and by how much, water deliveries will be reduced during low reservoir conditions.
2. *Coordinated operations of Lake Powell and Lake Mead:* The PA proposed a fully coordinated operation of the reservoirs to minimize shortages in the Lower Basin and to avoid risk of curtailments of water use in the Upper Basin.
3. *Mechanism for the storage and delivery of conserved system and non-system water in Lake Mead:* The PA proposed the Intentionally Created Surplus (ICS) mechanism to provide for the creation, accounting, and delivery of conserved system and non-system water thereby promoting water conservation in the Lower Basin.
4. *Modifying and extending elements of the existing Interim*

<sup>1</sup> The Basin States are comprised of Arizona, California, and Nevada in the Lower Basin and Colorado, New Mexico, Utah, and Wyoming in the Upper Basin.



1. *Surplus Guidelines (ISG)*, which determines those conditions under which surplus water is made available for use within the Lower Division states: The PA extended the term of the ISG and modified those guidelines by eliminating the most liberal surplus conditions, thereby leaving more water in storage to reduce the severity of future shortages.

**Final Decision**

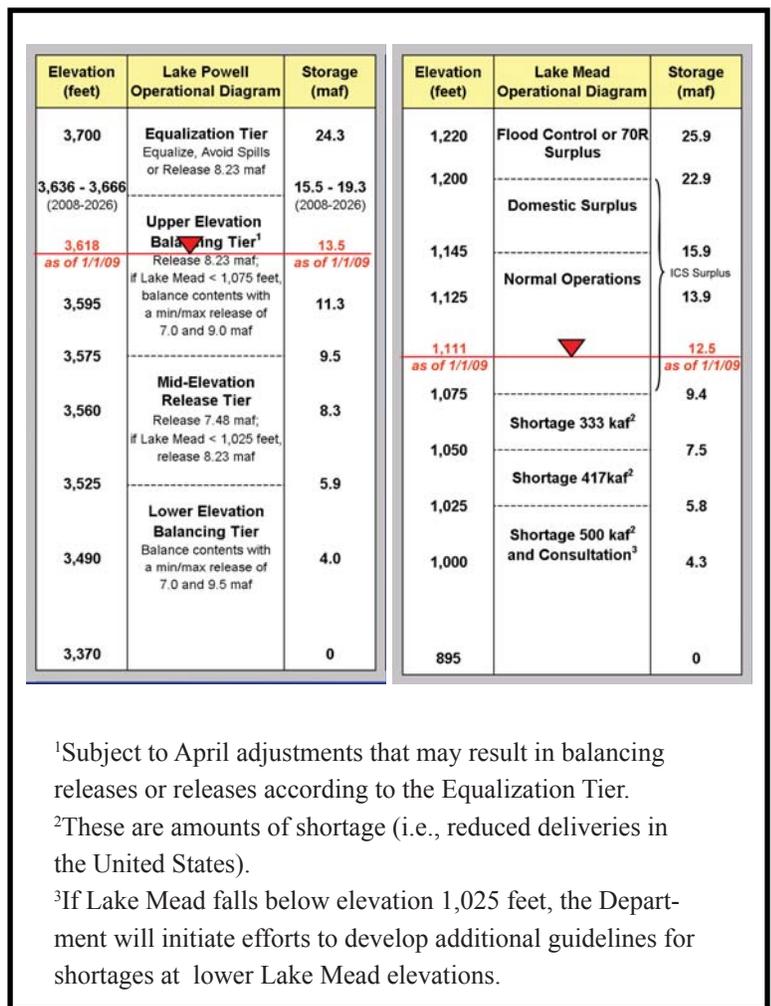
A Record of Decision (ROD) was issued in December 2007 officially adopting the guidelines (Interim Guidelines) set forth in the PA. The ROD implements a robust solution to the unique challenges facing Reclamation in managing the Colorado River. The Interim Guidelines are limited in duration, extending through 2026. This provides an opportunity to gain valuable operating experience for the management of Lake Powell and Lake Mead, and to improve the basis for making additional future operational decisions, whether during the interim period or thereafter. The shortage strategy element for Lake Mead includes a provision for additional shortages to be considered, after appropriate consultation. The coordinated operation element allows for the adjustment of Lake Powell releases to respond to low reservoir storage conditions in either Lake Powell or Lake Mead (Figure 2a). The water conservation element encourages efficient use and management of Colorado River water and enhances conservation opportunities in the Lower Basin and the retention of water in Lake Mead through adoption of the ICS mechanism. Finally, the Basin States have agreed to address future controversies on the Colorado River through consultation and negotiation before resorting to litigation. The Interim Guidelines preserve and provide Reclamation the flexibility to deal with and adapt to further challenges such as climate change and more persistent drought.

**Efforts to Address Climate Change and Variability**

Acknowledging and responding to the potential impacts of climate change and increased hydrologic variability, Reclamation empanelled a group of leading climate experts during the Interim Guidelines development process. The Climate Technical Work Group assessed the state of knowledge regarding climate change in the Basin and prioritized future research and development objectives. Their findings and recommendations were published as an appendix to the Final EIS (Appendix U) and are soon to be re-published, with no change in content, as a stand-alone report. The recommendation of the Work Group was to include a qualitative discussion of climate change and variability accompanied by a quantitative sensitivity analysis using paleoclimate evidence. This became Appendix N of the Final EIS.

**Appendix N of the Final EIS**

Though the Final EIS was primarily based on the re-sampled historical record, Appendix N analyzed the impacts of hydrologies outside the historical range of flows. In particular, the analysis is of the sensitivity of hydrologic resources (e.g. reservoir storage, reservoir releases, and river flows) to alternative hydrologic scenarios methodologies (e.g. derived from stochastic hydrology and tree-ring-based paleo reconstructions). For example, Figure 2b compares the results of two alternative paleo-hydrologic scenarios with the resampled historical record (Direct Natural Flow) for the “No Action Alternative” and the “Preferred Alternative” in terms of the risk of falling below the minimum power pool at Lake Powell. The Direct Paleo scenario directly re-samples the recent Lees Ferry reconstruction completed by Meko



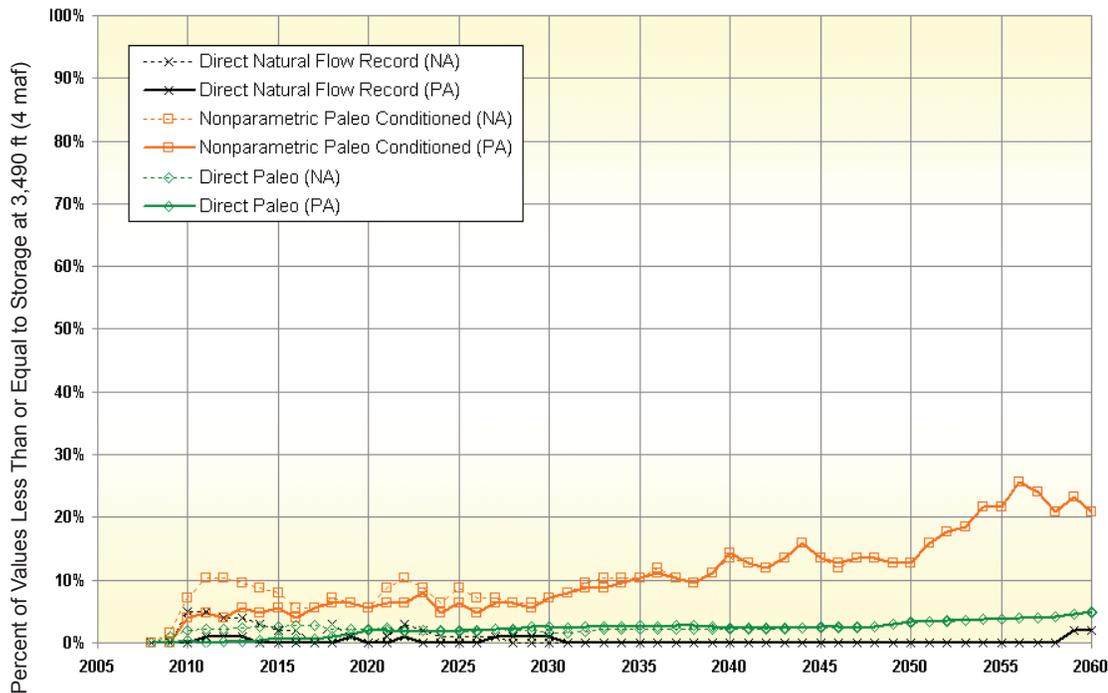
<sup>1</sup>Subject to April adjustments that may result in balancing releases or releases according to the Equalization Tier.

<sup>2</sup>These are amounts of shortage (i.e., reduced deliveries in the United States).

<sup>3</sup>If Lake Mead falls below elevation 1,025 feet, the Department will initiate efforts to develop additional guidelines for shortages at lower Lake Mead elevations.

Figure 2a. Prescribed operations at Lake Powell and Lake Mead in the Interim Guidelines. The Interim Guidelines were implemented for the first time in water year 2008. The current conditions at Lake Powell and Lake Mead are shown below. Current projections for water year 2009 operations show Lake Powell in the Upper Elevation Balancing Tier releasing 8.23 maf, with the potential for increased releases depending on future Powell inflow projections. The ICS surplus condition is the criterion governing operation of Lake Mead for calendar year 2009.





**Figure 2b.** Scenarios of Lake Powell end-of-July water elevations. Percent of values less than or equal to elevation 3,490 feet (4maf). Comparison of Direct Natural Flow Record to Meko et al. reconstructions (Nonparametric and Direct Paleo) No Action Alternative (NA) and Preferred Alternative (PA). (Source: Figure N-4 in Appendix N)

et al. (2007) that extends back to the year 762. The Nonparametric Paleo Conditioned scenario blends the hydrologic state (e.g., wet or dry) from the paleo reconstruction with the flow magnitudes from the historical record. It is evident that the alternative hydrologies increase the range of variability seen in key decision variables, particularly in the extremes.

In addition to the qualitative discussion of climate change included in the Final EIS, the Climate Technical Work Group also recommended the following for future research and development critical to the continued incorporation of climate change information in Reclamation’s long-term planning:

1. Improve availability and temporal resolution of regional climate projections.
2. Improve ability to model runoff under climate change
3. Investigate paradigm for Colorado River Basin precipitation response.
4. Diagnose and improve existing climate models before adding additional features.
5. Investigate changes in modeled climate variability at multiple time scales.
6. Improve understanding of surface water, groundwater and land cover interaction.
7. Improve prediction of interdecadal oscillations
8. Investigate use of paleo record to inform modeled streamflow variability.
9. Interact with Federal Climate Change Science Program and other climate change research initiatives.

A sampling of research presently underway that addresses

select recommendations of the Climate Technical Work Group includes a project lead by NOAA addressing recommendation 2. This project is working to understand and document the different biases resulting from hydrologic models to improve interpretation and comparison of differing runoff projections in the Basin. Along with NOAA members, team members from USGS, NWS, NRCS, University of Washington, and the Scripps Institute of Oceanography are comparing the associated runoff from a collection of dynamic and statistical models maintained by each group given prescribed future climate scenarios.

Addressing recommendations 2 and 8, a pilot study by Reclamation in both the Gunnison River Basin and the Upper Missouri River Basin is comparing runoff generated with a dynamic rainfall runoff model (i.e., NWS River Forecast System), nonparametric statistical techniques, and conditioning both with and without paleo reconstructions to evaluate and document the strengths and weaknesses of each method. Reclamation is also engaged in collaborative research efforts and partnerships through ongoing research at both the University of Arizona and the University of Colorado seeking to improve predictions of interdecadal oscillations and advance understanding of their effects on Basin runoff addressing recommendation 5 and 7.

**Reference**

Meko, D. M, C. A. Woodhouse, C. A. Baisan, T. Knight, J. J. Lukas, M. K. Hughes, and M. W. Salzer. 2007. Medieval Drought in the Upper Colorado River Basin. *Geophysical Research Letters*. 34, L10705.

**On the Web**

- More information relating to the Interim Guidelines, including technical details, development process and environmental effects can be found in either the ROD or Final EIS. Both are available on Reclamation’s website at: <http://www.usbr.gov/lc/region/programs/strategies.html>

