Summary of CCRS White Paper 3

Strategies for Managing the Colorado River in an Uncertain Future

A white paper by Jian Wang, David E. Rosenberg, Kevin G. Wheeler, and John C. Schmidt

Understanding What We Don't Know

Colorado River stakeholders face many uncertainties—issues like climate change, future water demand, and evolving ecological priorities—and are looking for new tools to help cope with this uncertain future. Managers and stakeholders need new ways to help classify uncertain conditions, manage for uncertain conditions, and create models in the face of a slew of oncoming unknowns.

To help Colorado River stakeholders think about, talk about, and better manage the future river, the Center for Colorado River Studies offers a new white paper that distinguishes four levels of decision-making uncertainty. Future conditions on the Colorado River can be described by point estimates with small ranges (Level 1), probabilities (Level 2), scenarios of alternative possible future conditions (Level 3), or a level encompassing complete unknowns (Level 4).

In the paper, we illustrate each level of uncertainty with examples from the Colorado River. We also show that there is greater uncertainty associated with planning for long time horizons, such as in developing policies that anticipate the increasing possibility of drought, extreme climate events, and unknown patterns of future human use of water. We argue that better public policies will emerge if stakeholders recognize the different levels of uncertainty for future events.

Managing for What We Don't Know

Using defined levels of uncertainty can guide stakeholders to appropriate management and modeling tools (Figure 2), and lead to more precise and effective conversation and negotiation. Tools include defining scenarios for uncertain future hydrology, water demand, and river ecosystem conditions, seeking policies that work robustly across many future states of the world, identifying future conditions for which

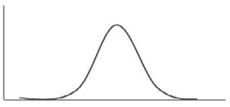
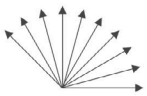
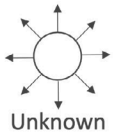
Type	Level 1 Clear Future	Level 2 Probabilities	Level 3 Potential Futures	Level 4 Unknown Future
Future States	 Point estimate or range	 Empirical or expert elicited probabilities	 Multiple scenarios	 Unknown
Colorado River Example	• Prediction of short-term rainfall	• Annual flow & magnitude of next year's snowmelt flood	• Duration & magnitude of mega floods	• Societal response to Glen Canyon Dam failure

Figure 1. Classification of levels of uncertainty, from complete certainty to total ignorance, with examples (adapted from Walker et al., 2013, van Dorsser et al., 2018)

What you'll find in the paper:

- A classification system for uncertainties with Colorado River examples for hydrology, water demand, operations, and ecosystems.
- An explanation of how existing modeling efforts consider uncertainties, and an assessment of alternative tools to model and manage the river.
- Suggestions for new guidelines to better adapt to uncertainties.

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Uncertainty Level	Potential Methods
Level 1 (Clear future)	• Reservoir simulation • Deterministic optimization
Level 2 (Probabilities)	• Mid-term probabilistic operations model • Monte Carlo simulation • Stochastic optimization
Level 3 (Potential Futures)	• Scenario planning • Robust decision making • Decision scaling • Dynamic adaptive policy pathways
Level 4 (Unknown Future)	None Known

Figure 2. Potential methods for planning with different levels of uncertainty.

the system is vulnerable, and adapting policies as conditions change over time. These strategies imply the need to expand the scope of the Interim Guidelines and the Lower Basin Drought Contingency Plan. Expansion might include several practices:

Suggested Practices to Manage for Deeply Uncertain Future Conditions

1. ***Classify uncertainties*** by level.
2. ***Include and track more information*** as it becomes available.
3. ***Define more signposts*** to signal when future water supply and river ecosystem outcomes deteriorate and trigger an alternative policy.
4. ***Identify more alternative policies*** for when circumstances trigger a signpost.
5. ***Construct potential pathways*** that connect signposts and alternative policies over time.
6. ***Match the planning horizon to the uncertainty level***.
7. ***Retain more reservoir storage at the end of the model planning horizon*** to save water for future managers and generations to use.
8. ***Seek better policies*** that improve water supply and river ecosystem outcomes across more future scenarios, rather than best policies.
9. ***Allow users more flexibility*** to respond to changing conditions.
10. ***Visualize adaptive policies*** to show system adaptations over time, identify gaps in policies, and adapt policies to include more information and signposts.

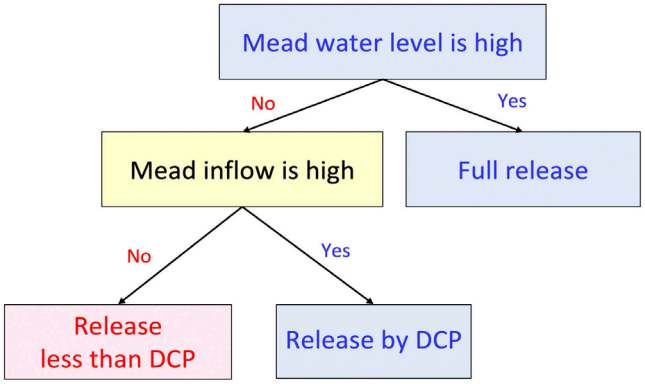

Figure 3. Example decision tree for a Lake Mead release policy that includes emerging information about Mead inflow.

To illustrate the last suggested practice, we show an example decision tree to help visualize complex Lake Mead water releases and show the benefits of including information about Mead inflow (Figure 3). The existing Interim Guidelines and Drought Contingency Plan define releases as schedules of lake water level (blue boxes).

Considering Lake Mead inflow and adding a new signpost for low inflow (yellow box) can help to identify low flow and low storage conditions when a new adaptive action to release less water than specified in the Drought Contingency Plan (red box) may better protect Lake Mead levels. Stakeholders may add more signposts to consider additional upper basin hydrology, demand, and other factors whose uncertainty levels are high.

New guidelines that adapt to uncertain future hydrology, water demand, and river ecosystem conditions might look quite different than the current guidelines. The current guidelines seek to provide managers certainty about the amount of water they can divert. Whereas new guidelines that recognize different levels of uncertainty should be more adaptable, more flexible, and allow managers to better anticipate and respond to a wider range of future Colorado River conditions before a crisis strikes.

See our white paper "Managing the Colorado River for an Uncertain Future" for specifics on how to define levels of uncertainty, examples, what tools can be used for each type of uncertainty, and how to expand existing Interim Guidelines to better adapt policies to emerging information.

Continue the Conversation:

- Read the complete white paper : qcnr.usu.edu/coloradoriver/files/CCRS_White_Paper_3.pdf
- Tell us what you think! Send feedback at https://tinyurl.com/ColoradoUncertaintyFeedback