Colorado River Risk Study: Executive Summary

Final

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Submitted to the Colorado River District and Project Participants

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Disclaimer

The findings presented herein are for discussion purposes only, and do not represent the official position of any entity with respect to factual or legal matters concerning the Colorado River.

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I. Background

The Colorado River Basin is in the midst of a drought that began in 2000 and continues today. Average naturalized flows at Lee Ferry during this period are approximately 12.6 maf (million acre-feet), or 4.0 maf annually less than would be needed to meet the full compact allotments of the seven basin states and to the Mexican Treaty obligation to Mexico. Recent droughts have significantly reduced storage levels in Lake Powell. If these droughts were to repeat themselves today, the ability of Lake Powell to satisfy its compact-obligation and power-generation purposes would be threatened (Figure 1). Drought Contingency Plans (DCP) are being developed for both the Upper and Lower Basins (See Hydros 2015 report "Summary Report on Contingency Planning in the Colorado River Basin"). While those plans, if implemented, would reduce the risk of a compact deficit or critically low storage levels at Lake Powell, they do not completely eliminate the risk for the Upper Basin States.

Concurrent with the DCP efforts, Colorado completed its Water Plan (https://www.colorado.gov/pacific/cowaterplan/plan), which lays the foundation for a secure water supply for the State. Point #4 of the Plan's Seven Point Framework is to take actions that minimize the risk of a Colorado River Compact curtailment. That objective, plus concerns voiced by the West Slope Basin Round Tables (BRTs) in a joint meeting in December 2014, provided the catalyst for this work.

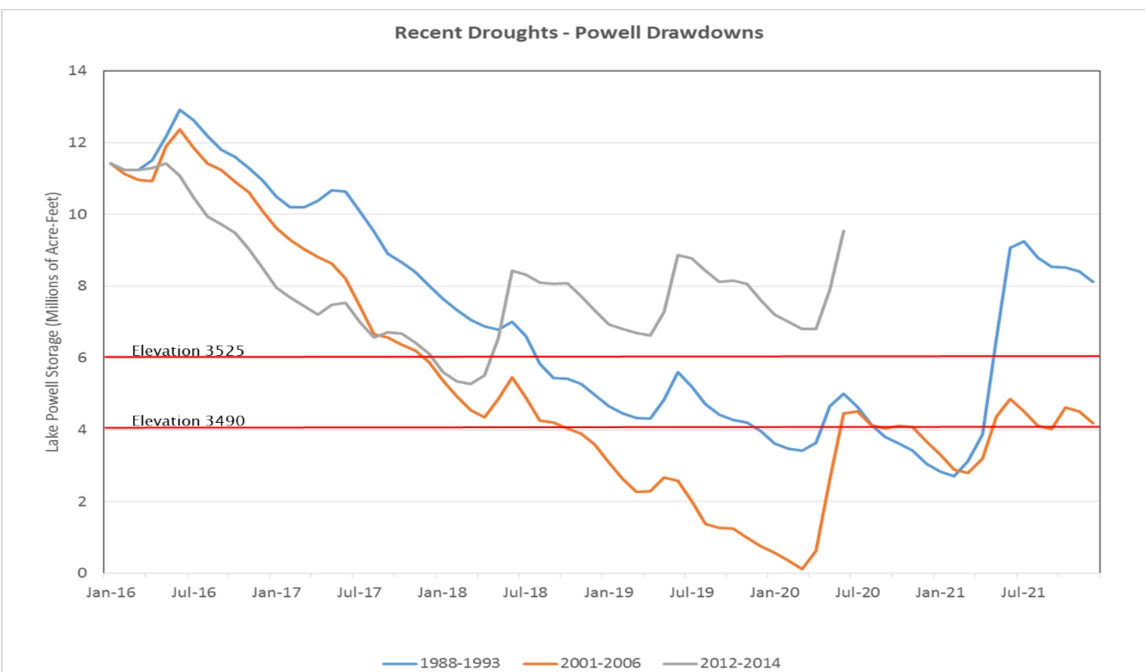

Figure 1. Past Lake Powell drawdowns superimposed on current conditions. A repeat of any of the last three drought events and subsequent drawdown of Powell would threaten the Upper Basin's ability to meet its obligations under the 2007 Interim Guidelines. The Upper Basin States and Reclamation have designed a Contingency Plan to keep Powell's elevation above the 3525' threshold.

II. Project Scope and Objectives

This Executive Summary covers Phases I and II of the Colorado River Risk Study. A third phase is scheduled for the second half of 2018. Phase I built directly upon work conducted for the Upper Colorado River Commission that explored risks to Lake Powell and Upper Basin water users, and the effectiveness of proposed Drought Contingency Plans in reducing or eliminating those risks. Particular emphasis was given to potential deficits at Lake Powell relative to critical target elevations, and Colorado's potential share of those volumes. The Phase I analyses utilized Reclamation's CRSS model.

Phase II further refined the "Big River" analysis from Phase I, and also explored certain aspects of demand management, shepherding, and water banking options within the State of Colorado, using the State's CDSS (StateMod) tools. The purpose of the StateMod investigation was two-fold. One purpose was to better understand how StateMod could be used to model demand management, water banking, and delivery of conserved demand management water to Lake Powell. A second objective was to better understand the variability in yields across the west-slope sub-basins under different hydrologic conditions, levels of demand management, and water shepherding assumptions.

III. Model Assumptions

A. CRSS

Phase I and Phase II Task 1 utilize Reclamation's CRSS model. The model is configured to replicate as closely as possible, with publicly available information, the proposed Drought Contingency Plan for the Lower Basin and the CRSP Drought Operations component of the Upper Basin's Plan. Additional key assumptions in the CRSS modeling include:

- Most simulations utilized the 1988-2012 historical period of hydrology (aka "Stress Test"). This period is also being used by Reclamation and the Basin States in the DCP process. Certain scenarios were also simulated using paleo-hydrology, climate change hydrology, and an extended historical period. These additional datasets are directly from the Colorado River Basin Study database.
- The 2007 Interim Guidelines are assumed to continue unchanged beyond 2026.
- Demand data are directly from or based on Reclamation's Colorado River Basin Study. Demand scenario A is the "current trends" data from the study, while the 90%D1 dataset is a scaled back version of the D1 demand set.
- Water Banking scenarios utilize the non-equalized reservoir construct from the Basin Study.
- Upper Basin demand management volumes are not assumed to come from specific water users or states.

These model simulations evaluated the likelihood of reaching critical elevations at Lake Powell, and were then used to quantify volumes of water that Colorado might need to conserve in order to avoid or reduce that risk.

B. StateMod

Phase II Task 2 primarily utilizes StateMod, Colorado's surface water allocation and operations modeling tool. While this task did produce interesting results, particularly with respect to variability of yield under different demand management programs, its primary purpose was to better understand strengths and weaknesses of the models themselves when simulating demand management, water banking, and shepherding operations. For this task, each of the west-slope StateMod models was run using the baseline data set, which imposes current levels of water demand and use onto the period of historical hydrology (1903-2013). The analysis of results focused on the 1988-2012 stress-test period, to coincide with the CRSS simulation outputs. The analysis explored several aspects of modeling demand management, including:

- How much additional water could be realized at the state line if each basin were to forego 5%, 10%, or 15% of its direct flow consumptive uses?
- How does the ability to shepherd or not shepherd that conserved water impact the yield?
- How do yields change between dry and wet years?
- What mechanisms are available within StateMod, and what additional functionality may be desirable, to simulate demand management and water banking activities?

C. Coupled StateMod / CRSS

In addition to the StateMod-specific simulations, a loosely coupled model of in-state demand management (StateMod) and basin-wide river operations including drought contingency plans and water banking (CRSS) was examined. The objective of this exercise was to evaluate the utility of both models in evaluating questions that are not readily addressed in either model by itself. The coupling involves removing the Colorado portion of CRSS and replacing that piece of the basin-wide model with outputs generated by StateMod. This allows a more accurate representation of in-state operations including non-federal reservoir operations, ditch and water-right specific consumptive use data, and more realistic outcomes from demand management activities. By incorporating with CRSS, those in-state actions can be modified based on "big-river" operations, including specifically changing conditions at Lake Powell.

IV. Summary of Findings

Results from Phase I indicate that under certain drought sequences, as seen in the early part of this century, significant volumes of water could be needed to maintain Lake Powell elevations at or above elevation 3525 (Figure 2). These volumes would be required even AFTER taking in to account the release of stored water from other CRSP reservoirs as anticipated by the Upper Basin DCP.

These actions were modeled as single year reductions (with the possibility of consecutive years of conservation during extended drought), for purposes of identifying required volumes. There appears to be broad consensus, based on feedback from various groups including participants in the Colorado River Water Bank Work Group, the System Conservation Pilot Project, and the UCRC, that single-year conservation volumes of the magnitudes shown in Figure 2 are probably not feasible under a voluntary program.

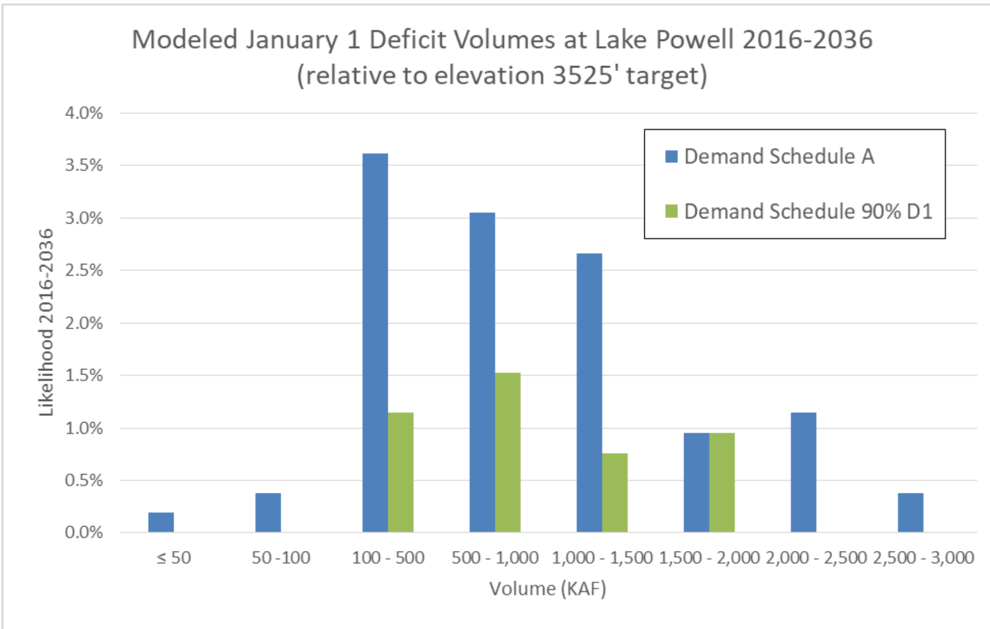

Figure 2. January 1 volumes required AFTER CRSP drought operations to maintain Powell at 3525'. Simulations using Stress Test (1988-2012) hydrology.

An alternate approach to conserving large volumes of water over a short period of time to mitigate the risk to Lake Powell is to create an upper basin water bank or other type of storage account, into which conserved consumptive use water could be deposited pro-actively over a span of many years. A hypothetical proactive demand management program combined with a water bank was simulated in CRSS, using the stress test hydrology (1988-2012) and two demand scenarios (A and 90%D1). Results indicate that the hypothetical bank can reduce the likelihood of Powell dropping below 3525. As demands are reduced, and with the inclusion of the Lower Basin DCP and Upper Basin CRSP Drought Operations, the frequency of bank usage and the total deficit volume at Powell are both decreased. The frequency and magnitude of remaining Powell deficits after bank operation is also significantly reduced.

Phase II analysis focused on the baseline StateMod models, and the ability to quantify state line yields under yields under a hypothetical demand management program. Results for the stress test period (1988-2012) are 2012) are shown in Table 1. Average annual demand management volumes conserved in each of the 5%, 10% and 15% scenarios are shown as "conserved CU". The average annual increase in flow at the state line is for the un-shepherded scenarios (we would expect all the conserved water, minus some loss factor, to make it to

the state line in a shepherded scenario). The yield is a reflection of the expected "loss" incurred in transit for waters conserved but not shepherded (i.e., made available to other water users).

Table 2 contains the same information, but for the 8 driest years of the stress test period. Note the change in flow at the state line and yield percentages and the variation across the sub-basins. Basin such as the Upper Colorado and San Juan, where depletions are a larger percentage of total supply, exhibit greater differences in state line flows under dry conditions.

Table 1. Conserved consumptive use and state line yields by sub-basin, 1988-2012

	5%			10%			15%		
	Conserved CU (AF/yr)	Flow at State Line (AF/yr)	Yield %	Conserved CU (AF/yr)	Flow at State Line (AF/yr)	Yield %	Conserved CU (AF/yr)	Flow at State Line (AF/yr)	Yield %
Yampa	10,134	8,774	87%	20,269	17,930	88%	30,403	27,189	89%
White	2,982	2,917	98%	5,963	5,894	99%	8,945	8,940	100%
Upper Colorado	52,673	42,873	81%	105,346	87,250	83%	158,019	133,701	85%
Gunnison	28,655	20,631	72%	57,310	42,056	73%	85,964	64,256	75%
San Juan & Dolores	23,439	14,476	62%	46,879	31,387	67%	70,318	49,449	70%

Table 2. Conserved consumptive use and state line yields by sub-basin, 8 driest years, 1988-2012

	5%			10%			15%		
	Conserved CU (AF/yr)	Flow at State Line (AF/yr)	Yield %	Conserved CU (AF/yr)	Flow at State Line (AF/yr)	Yield %	Conserved CU (AF/yr)	Flow at State Line (AF/yr)	Yield %
Yampa	9,809	7,101	72%	19,617	14,852	76%	29,426	22,678	77%
White	2,916	2,720	93%	5,833	5,545	95%	8,749	8,434	96%
Upper Colorado	51,685	21,110	41%	103,370	40,213	39%	155,055	67,529	44%
Gunnison	26,345	8,427	32%	52,689	21,877	42%	79,034	37,658	48%
San Juan & Dolores	20,706	9,541	46%	41,412	19,744	48%	62,118	28,870	46%

The final exercise of Phase II was to test the utility of coupling the CRSS and StateMod models. Each model has strengths, but to have a dynamic model that can simulate Lake Powell and other federal reservoir operations together with specific demand management activities within Colorado, and to understand how each impacts the other, requires use of both. This demonstration showed how StateMod could be used to generate volumes of conserved water through a demand management program, with that water being subsequently stored in hypothetical water bank accounts in a reservoir. That water bank account can then be managed within CRS, with refilling and releases made as required to deliver water into Lake Powell's system pool. The models provide a flexible framework for specifying specific water user participants and for dynamic management of the demand management account.

Takeaway summary:

1. Likelihood of Lake Powell dropping below critical elevations is small, but impact to upper basin water users could be catastrophic.
2. The deficit volumes at Lake Powell, even after proposed Drought Operations of CRSP reservoirs, could be on the order of millions of acre-feet if critical drought periods repeat.
3. It is unlikely that the upper basin could generate that volume of water in a short period of time through a reactive demand management program.
4. A proactive demand management program (voluntary, compensated) combined with a water banking program intended to support Lake Powell elevations could significantly reduce the risks. The size of the bank, its location(s), and operating constraints are important considerations.
5. StateMod is the best tool for modeling in-state demand management activities, non-federal reservoir operations, and yield estimation from participating water rights / water users.
6. CRSS is necessary for understanding Lake Powell operations and other “big river” issues that are the key drivers to demand management requirements.
7. The two models can be combined effectively to simulate complex demand management questions within Colorado as well as the impacts of those actions on Lake Powell, and impacts of basin-wide operations on Colorado water use.

V. Other Reports

The analysis and findings summarized above are further described in three reports:

1. Colorado River Risk Study – Phase I Summary Report
2. Colorado River Risk Study – Phase II Task 1 Report
3. Colorado River Risk Study – Phase II Task 2 Report

These include additional detail on model assumptions, objectives, analysis and results.