CAP Drought Impact Analysis

June 2007

DRAFT

Introduction

The Colorado River provides more than one-third of all water used in Arizona. More than half of the State's Colorado River water is delivered to central Arizona through the Central Arizona Project. The CAP provides more than half of the annual water supply and approximately 75% of the renewable water supply to the more than 4 million residents of Maricopa, Pinal, and Pima Counties. The CAP also provides irrigation water for more than 300,000 acres of farmland in central Arizona.

Over the past seven years the Colorado River basin has experienced its worst drought since recordkeeping began in 1906. This has led to much speculation as to whether and when Arizona might experience a shortage of Colorado River water and how such a shortage might impact Arizona water users. Shortage is of particular concern to Arizona because of the CAP's junior priority on the River. (The 1968 federal law that authorized the CAP gave priority to California water users.)

To date, there has never been a shortage declared in the Lower Basin (Arizona, California and Nevada). In light of the extended drought, however, the Secretary of the Interior—who serves as the water master for the Lower Colorado River—announced her intention in 2005 to develop shortage guidelines for the Lower Basin.

Over the past two years, the seven Basin States worked diligently to reach consensus, and on April 30, 2007, they submitted their proposal to the Secretary. The Basin States Proposal includes guidelines for the coordinated operation of Lake Powell and Lake Mead and shortage guidelines for the Lower Basin based on certain trigger elevations in Lake Mead: When the end-of-year elevation in Lake Mead was projected to be below 1075 feet above sea level but above 1050, deliveries to the Lower Basin States would be reduced by 333,000 acre-feet; between 1050 and 1025, the shortage would be 417,000 acre-feet; and below elevation 1025 the shortage would be 500,000 acre-feet. If Lake Mead were projected to decline below elevation 1000, then the Secretary would consult with the Basin States about further reductions.

The Secretary intends to adopt guidelines for management and operation of the Colorado River by the end of 2007. Those guidelines would control releases from Lake Powell and Lake Mead, including during times of shortage, for an interim period through 2026.

This paper evaluates the likelihood of a shortage to Arizona's Colorado River supplies through 2026, assuming implementation of the Basin States Proposal and the shortage guidelines contained therein. It then examines the impact of such shortages on water users in Arizona.

I. Likelihood of Shortage

The probability of a shortage in the Lower Basin depends primarily on hydrology—i.e., the amount of runoff generated by rain and snowfall in the Colorado River watershed each year—and, to a lesser degree, on Colorado River water use in the Upper Basin.

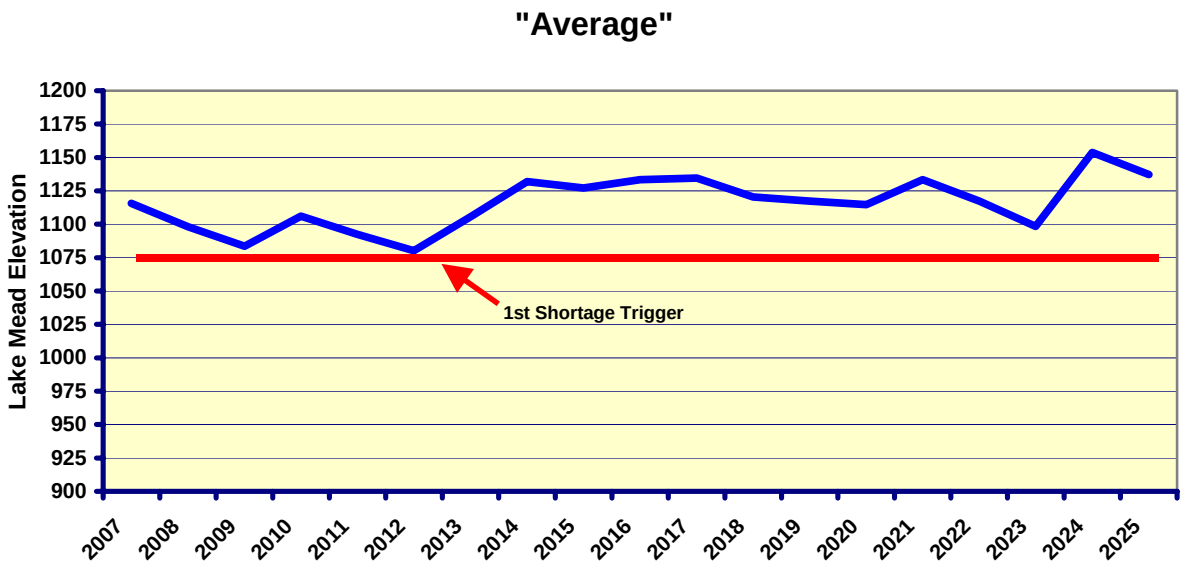
To evaluate the likelihood of a shortage to Arizona during the interim period, CAP looked at the gaged flow record for the Colorado River since 1906. We then compared the average flows for every 18-year period—the duration of the interim period that will be governed by the guidelines the Secretary of the Interior will adopt later this year—and selected three case studies. For ease of reference, we have labeled these three scenarios as Average, Bad and Worst.

A. "Average" Conditions

The "Average" scenario replicates the natural flow of the Colorado River during the period 1936 through 1953—that is, it assumes that the flow of the River in 2008 is the same as it was in 1936, and that for each successive year the flow matches the respective historical year. The average natural flow for this 18-year period was 14.778 million acre-feet (maf). By comparison, the long-term average natural flow of the Colorado River in the gaged historical record (1906-2004) is 15.024 maf, and recent tree-ring studies suggest that the average over the past 500 years is around 14.5 to 14.7 maf.

As Figure 1 shows, this scenario would not be expected to require a shortage in the Lower Basin during the interim period.

Figure 1



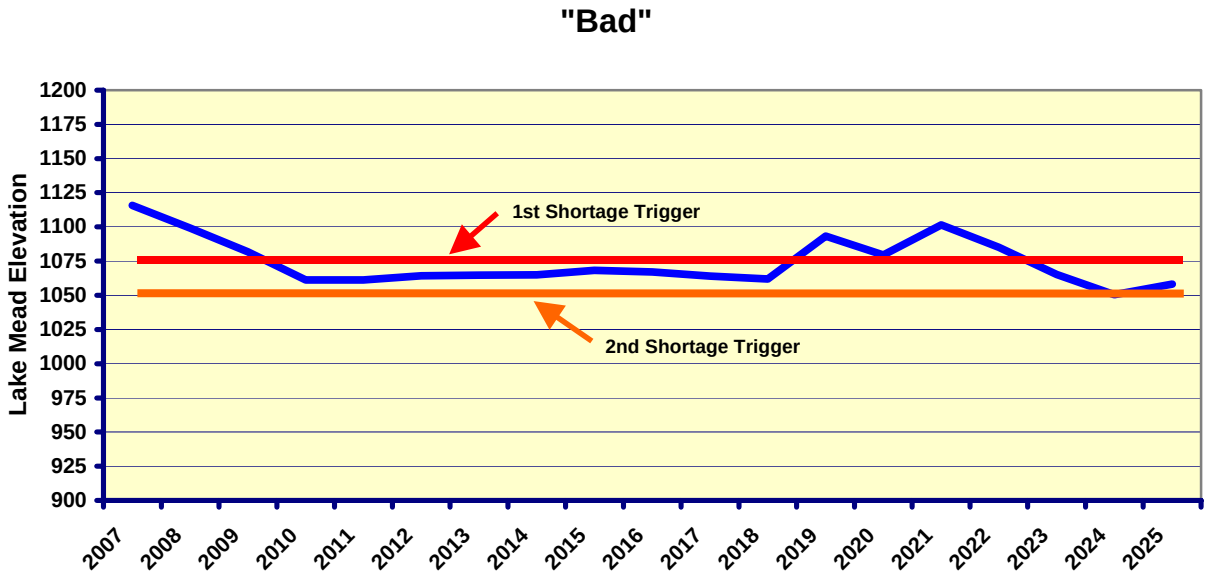
B. "Bad" Conditions

The "Bad" scenario uses the natural flow of the Colorado River during the period 1962 through 1979. The average natural flow for this 18-year period was 13.873 maf, or 92 percent of the historical average. This scenario represents the 25th percentile, meaning

that the 18-year average natural flow since 1906 was greater than 13.873 maf 75 percent of the time.

Figure 2 shows that under this scenario the Lower Basin States would experience shortages in 11 of the 18 years, although none would require a reduction of more than 333,000 acre-feet. (The projected elevation of Lake Mead at the end of 2024 is 1050.49, thus narrowly avoiding the second level shortage trigger in that year.)

Figure 2



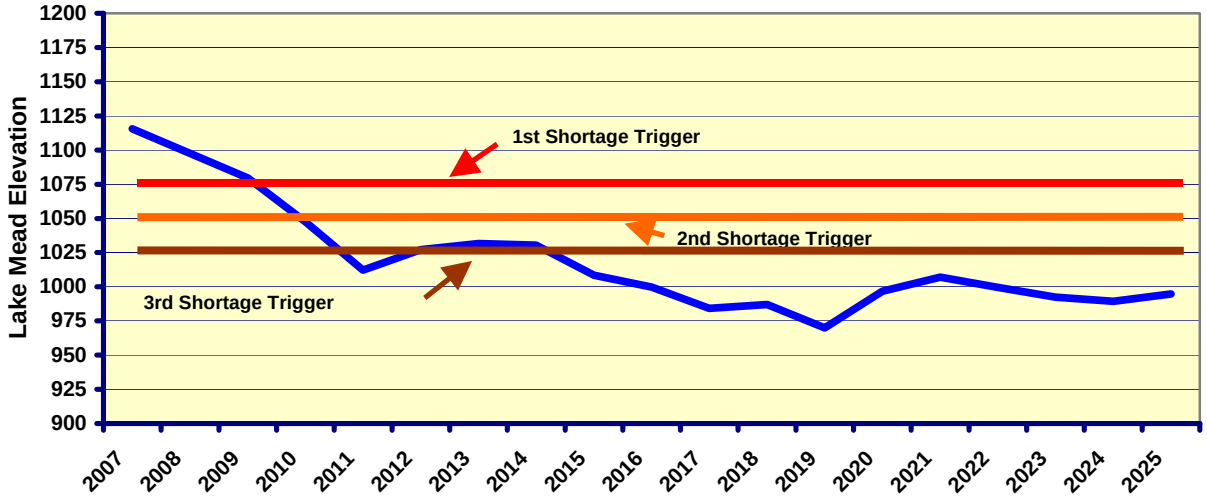
C. "Worst" Conditions

The "Worst" scenario mimics the natural flow of the Colorado River from 1953 through 1970. This is the driest 18-year period in the gaged record, with an average natural flow of only 12.926 maf—about 2 maf per year below the long-term average. Thus, our "Worst" case assumes that the 7 years of drought experienced in the Colorado River Basin since 2000 are followed by the worst prolonged drought in the historical record. The resulting 25-year drought would be comparable to the type of extended drought that some tree-ring studies suggest occurred in the past.

Not surprisingly, under this "Worst" case scenario the Lower Basin would experience shortages virtually throughout the interim period. Moreover, as shown in Figure 3, Lake Mead would be expected to fall below elevation 1000 for half of the 18-year period, necessitating further consultation with the Secretary. (At present, if Lake Mead were below elevation 1000, the Southern Nevada Water Authority would not be able to divert water for the Las Vegas area, as the water level in Lake Mead would be below SNWA's lowest intakes. However, Nevada is already working on extending its intakes to below 900 feet above sea level.)

Figure 3

"Worst"



To keep Lake Mead at or above elevation 1000, the Lower Basin would have to take shortages greater than those described in the Basin States Proposal, as shown in Table 1.

Table 1

	Mead EOY Elevation w/o Additional Shortage	Additional Shortage Required to Protect Elevation 1000 (af)	Resulting Mead EOY Elevation
2008	1097.53	0	1097.53
2009	1079.52	0	1079.52
2010	1047.56	0	1047.56
2011	1012.16	0	1012.16
2012	1027.25	0	1027.25
2013	1031.64	0	1031.64
2014	1030.37	0	1030.37
2015	1008.53	0	1008.53
2016	999.74	14,000	1000.00
2017	984.10	821,000	1000.00
2018	986.91	0	1002.05
2019	969.95	745,000	1000.00
2020	996.73	0	1022.11
2021	1007.12	0	1030.40
2022	999.70	0	1023.08
2023	992.36	0	1015.82
2024	989.42	0	1012.43
2025	994.74	0	1016.34
2026	997.04	0	1017.65

II. Impact of Shortage on Arizona

Arizona and Nevada have entered into an agreement defining how they will share the shortages described in the Basin States Proposal:

Total Shortage	*Arizona Share*	*Nevada Share*
333,000 af	320,000 af	13,000 af
417,000 af	400,000 af	17,000 af
500,000 af	480,000 af	20,000 af

(Shortages of the magnitude described in the Basin States Proposal would not cause reductions in deliveries to California because of its statutory priority.)

Within Arizona, CAP diversions are the first to be reduced, along with mainstem Arizona water users that share the same priority as the CAP—essentially, those with water delivery contracts executed on or after September 30, 1968, sometimes referred to as "P4" water users (for Priority 4 among Arizona's Colorado River uses).

Following an extensive public process, in October 2006 the Director of the Arizona Department of Water Resources recommended a formula for sharing shortages among CAP and the P4 mainstem water users. Under that formula, approximately 10% of any Arizona shortage will be borne by on-river P4 users, with the remainder going to CAP.

As an example, if the end-of-year elevation of Lake Mead were projected to be 1070, then the Secretary would reduce deliveries to the Lower Basin States in the following year by 333,000 af. Arizona would be reduced by 320,000 af, with about 32,000 af of that shortage going to P4 mainstem users and 288,000 af to CAP.

A. Central Arizona Project Water Users

Delivery of water to CAP customers is also based on a priority scheme. In general, water users with long-term CAP delivery contracts have priority over "excess" water users. (Excess water, by definition, is water that is not scheduled for delivery in any year by a long-term contract holder. Excess water contractors have no legal entitlement to receive CAP water in any year.)

There are three categories of long-term CAP contracts: Indian, Municipal & Industrial (M&I) and Non-Indian Agriculture (NIA). M&I and Indian contractors share the highest priority according to a formula developed in the context of the Gila River Indian Community Water Rights Settlement Agreement and approved through the Arizona Water Settlements Act of 2004. NIA is the lowest priority among long-term contracts.

There are three broad categories of excess CAP water: Ag Settlement Pool water, Full-cost excess, and recharge.

CAP non-Indian agricultural users relinquished their long-term entitlements to NIA priority water for reallocation to Indian and M&I users in accordance with the Arizona Water Settlements Act of 2004. In return, CAP agreed to make available to non-Indian agricultural users through 2030 a special category of excess water referred to as the Ag Settlement Pool. By contract, that pool has the highest priority of all excess water. The Ag Settlement Pool is initially sized at 400,000 af per year, declining to 300,000 af in 2017 and to 225,000 af in 2024.

By statute, the Arizona Water Banking Authority (AWBA) has the lowest priority of all excess CAP water users. A.R.S. §45-2427(B). The AWBA recharges, or stores, water underground for future use during shortage. When purchasing water for its replenishment reserve, the Central Arizona Groundwater Replenishment District (CAGRD) shares the same priority as AWBA. A.R.S. §48-3772(E)(8).

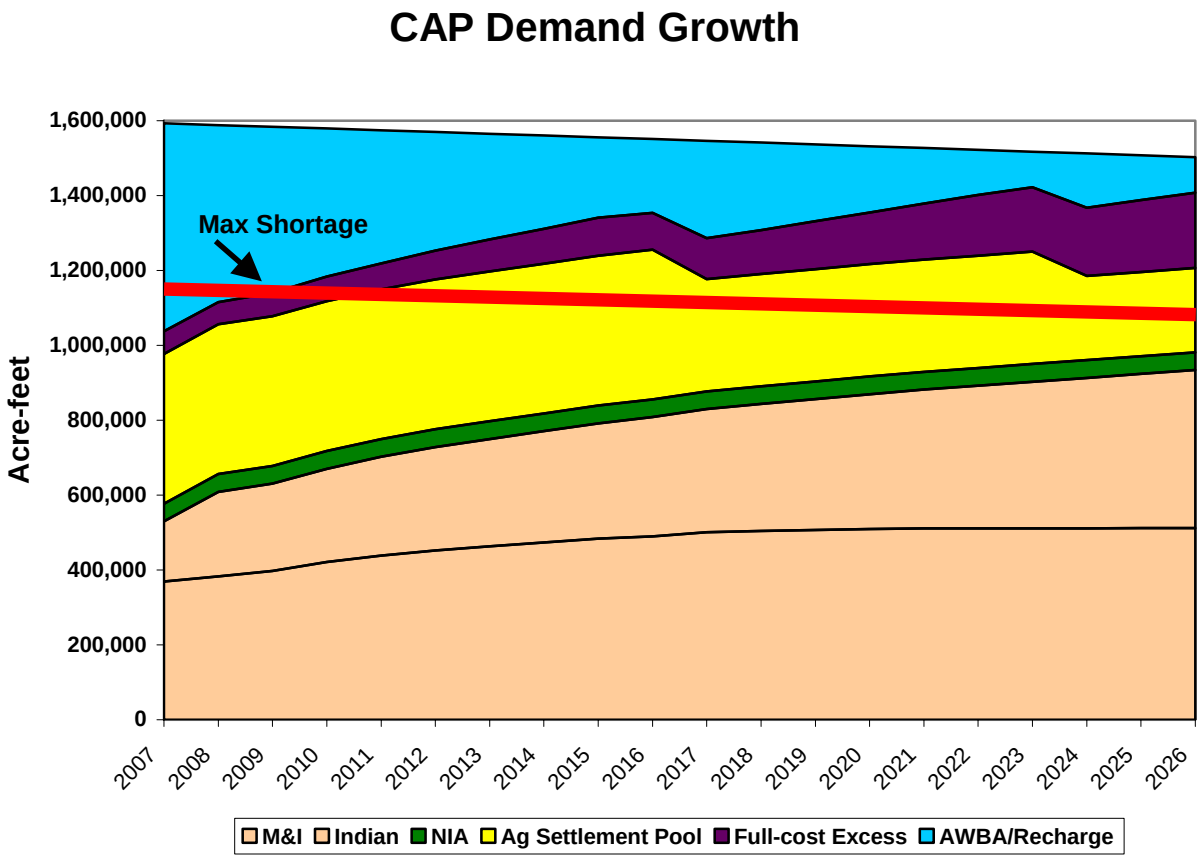
All other excess water uses fall in between the Ag settlement pool's highest priority and the AWBA's lowest priority. This includes full-cost M&I uses, such as the regular replenishment activities of the CAGRD, as well as incentive-priced recharge water offered to those who would develop long-term storage credits. Although there is no formal CAP policy to this effect, for purposes of this study we have assumed that incentive-priced recharge water would be reduced before full-cost excess water uses.

In summary, CAP water uses will be reduced during shortage in the following order:

1) AWBA and CAGRD replenishment reserve
2) Other recharge
3) Full-cost M&I excess water
4) Ag settlement pool
5) NIA long-term contract entitlements
6) M&I and Indian long-term contract entitlements

The extent to which each class of CAP water use will need to be reduced in a shortage is dependent on the total volume of Colorado River water available for diversion through the CAP and the volume scheduled by higher priority uses. This principle is illustrated graphically in Figure 4, which shows the projected demand build-up for each class of use through the interim period. AWBA/recharge demand is assumed to use up all remaining CAP supply each year. The line labeled "Max Shortage" shows what the CAP supply would be reduced to if a 500,000 acre-foot shortage were imposed on the Lower Basin States. As Figure 4 shows, the maximum shortage that would be declared under the Basin States Proposal is not expected to cause a sufficient reduction in the CAP supply to impact M&I, Indian or NIA priority water users at any point during the interim period.

Figure 4



Tables 2 through 4 show the anticipated shortage to each class of CAP customer under each of the three hydrologic scenarios described above.

Table 2 reflects the "Average" case. As discussed previously, no Lower Basin shortages are anticipated under this scenario during the interim period in which the Basin States Proposal would be in effect.

Table 2
Shortage by CAP Water Type -- "Average" Scenario

	AWBA & Recharge	Full-Cost Excess Water	Ag Settlement Pool	NIA	M&I	Indian	Total CAP Shortage
2008	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0

2014	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0
2021	0	0	0	0	0	0	0
2022	0	0	0	0	0	0	0
2023	0	0	0	0	0	0	0
2024	0	0	0	0	0	0	0
2025	0	0	0	0	0	0	0
2026	0	0	0	0	0	0	0

Table 3 shows anticipated shortages under the "Bad" hydrologic scenario. While this scenario predicts frequent shortages to the Lower Basin States, none are anticipated to be greater than 330,000, which means that CAP should not bear more than about 288,000 acre-feet of shortage in any year. As seen in Table 3, a shortage of that magnitude in any year will largely eliminate water banking and recharge activity, and could impact full-cost excess water customers. Significantly, none of these shortages would reduce the supply of water available for the Ag Settlement Pool.

Table 3
Shortage by CAP Water Type -- "Bad" Scenario

	AWBA & Recharge	**Full-Cost Excess Water**	**Ag Settlement Pool**	**NIA**	**M&I**	**Indian**	**Total CAP Shortage**
2008	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0
2011	288,000	0	0	0	0	0	288,000
2012	288,000	0	0	0	0	0	288,000
2013	283,000	5,000	0	0	0	0	288,000
2014	249,000	39,000	0	0	0	0	288,000
2015	215,000	73,000	0	0	0	0	288,000
2016	197,000	91,000	0	0	0	0	288,000
2017	260,000	28,000	0	0	0	0	288,000
2018	234,000	54,000	0	0	0	0	288,000
2019	205,000	83,000	0	0	0	0	288,000
2020	0	0	0	0	0	0	0
2021	0	0	0	0	0	0	0
2022	0	0	0	0	0	0	0
2023	0	0	0	0	0	0	0
2024	145,000	143,000	0	0	0	0	288,000

2025	120,000	168,000	0	0	0	0	288,000
2026	0	0	0	0	0	0	0

Table 4 shows what would happen under the "Worst" scenario. In this case, the CAP would experience shortage every year from 2011 through 2026. From 2016 on, all of the shortages would be the maximum—about a 432,000 acre-foot reduction in the annual CAP supply. As in the "Bad" scenario, these shortages would eliminate all recharge activity. In most years, full-cost excess water would also be unavailable. Unlike the "Bad" case, this scenario would also have a significant impact on the Ag Settlement Pool, reducing it by one-third to one-half in the later years.

Table 4
Shortage by CAP Water Type -- "Worst" Scenario

	AWBA & Recharge	Full-Cost Excess Water	Ag Settlement Pool	NIA	M&I	Indian	Total CAP Shortage
2008	0	0	0		0	0	0
2009	0	0	0		0	0	0
2010	0	0	0		0	0	0
2011	356,000	4,000	0		0	0	360,000
2012	317,000	77,000	38,000	0	0	0	432,000
2013	283,000	77,000	0	0	0	0	360,000
2014	249,000	93,000	18,000	0	0	0	360,000
2015	215,000	101,000	44,000	0	0	0	360,000
2016	197,000	99,000	136,000	0	0	0	432,000
2017	260,000	109,000	63,000	0	0	0	432,000
2018	234,000	117,000	81,000	0	0	0	432,000
2019	205,000	128,000	99,000	0	0	0	432,000
2020	177,000	138,000	117,000	0	0	0	432,000
2021	148,000	150,000	134,000	0	0	0	432,000
2022	121,000	162,000	149,000	0	0	0	432,000
2023	95,000	172,000	165,000	0	0	0	432,000
2024	145,000	182,000	105,000	0	0	0	432,000
2025	120,000	192,000	120,000	0	0	0	432,000
2026	95,000	201,000	136,000	0	0	0	432,000

As noted above, under the "Worst" scenario the elevation of Lake Mead would drop below elevation 1000 for much of the interim period, potentially interfering with Nevada's ability to withdraw water from Lake Mead. Table 1 showed the additional shortages that would be required in the Lower Basin to keep Lake Mead at or above 1000 feet above sea level. Table 5 shows how much of that additional shortage could be expected to fall on Arizona and CAP water users and the total shortage that would result to CAP.

Table 5

	Additional Lower Basin Shortage to Protect Elevation 1000 (af)	Arizona Share of Additional Shortage	CAP Share of Additional Shortage	Total CAP Shortage
2008	0	0	0	0
2009	0	0	0	0
2010	0	0	0	0
2011	0	0	0	360,000
2012	0	0	0	432,000
2013	0	0	0	360,000
2014	0	0	0	360,000
2015	0	0	0	360,000
2016	14,000	11,000	10,000	**442,000**
2017	821,000	657,000	591,000	**1,023,000**
2018	0	0	0	432,000
2019	745,000	596,000	537,000	**969,000**
2020	0	0	0	432,000
2021	0	0	0	432,000
2022	0	0	0	432,000
2023	0	0	0	432,000
2024	0	0	0	432,000
2025	0	0	0	432,000
2026	0	0	0	432,000

Table 6 shows how the increased shortage imposed by protecting elevation 1000 in Lake Mead would impact the various classes of CAP water users. Note that the 2019 shortage under this variation to the "Worst" case scenario would essentially wipe out the entire CAP water supply. Indeed, if higher priority on-river uses in Arizona are greater than projected in this analysis, a shortage of the magnitude shown below for 2019 could even result in shortages to Colorado River users in California.

Table 6
Shortage by CAP Water Type -- "Worst" Scenario (Protect 1000 in Lake Mead)

	AWBA and Recharge	Full-Cost Excess Water	Ag Settlement Pool	NIA	M&I	Indian	Total CAP Shortage
2008	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0
2011	356,000	4,000	0	0	0	0	360,000
2012	317,000	77,000	38,000	0	0	0	432,000
2013	283,000	77,000	0	0	0	0	360,000

2014	249,000	93,000	18,000	0	0	0	360,000
2015	215,000	101,000	44,000	0	0	0	360,000
2016	197,000	99,000	146,000	0	0	0	**442,000**
2017	260,000	109,000	300,000	47,000	169,000	138,000	**1,023,000**
2018	234,000	117,000	81,000	0	0	0	432,000
2019	205,000	128,000	300,000	47,000	146,000	143,000	**969,000**
2020	177,000	138,000	117,000	0	0	0	432,000
2021	148,000	150,000	134,000	0	0	0	432,000
2022	121,000	162,000	149,000	0	0	0	432,000
2023	95,000	172,000	165,000	0	0	0	432,000
2024	145,000	182,000	105,000	0	0	0	432,000
2025	120,000	192,000	120,000	0	0	0	432,000
2026	95,000	201,000	136,000	0	0	0	432,000

B. Arizona On-River P4 Water Users

Unlike most CAP water users, Arizona's 4th priority mainstream water users will be affected immediately by a Colorado River shortage. Also, unlike CAP, the P4 M&I and agricultural users all enjoy the same priority, so on-river P4 M&I users would be subject to reduction as soon as a shortage is declared on the River. In the "Bad" scenario, this would mean that P4 M&I users could face shortages as early as 2011.

Conclusion

The Colorado River is a highly variable system, subject to dramatic change in runoff from year to year. The scenarios described in this report are merely illustrations of the potential impact of shortage under various hydrologic assumptions. It is impossible to predict the future hydrology of the River.

Could the "Worst" case scenario happen? Yes. Is it likely? No.

There is, however, a reasonable chance that CAP will experience some level of shortage during the next 18 years. While we cannot predict the magnitude and duration of any shortage, our analysis suggests that CAP long-term contract holders—those with rights to Indian, M&I and NIA priority water—are not likely to experience a reduction in their supply during this period. But any prolonged shortage will seriously reduce the amount of water available for recharge by the Arizona Water Banking Authority and others in central Arizona, limiting our ability to store water to protect against future shortages that likely will impact CAP long-term contract holders. This makes it imperative that Arizona continue to store as much Colorado River water as physically possible whenever that water is available.

Appendix

Assumptions

Upper Basin Uses: Current Upper Basin use of Colorado River water is just over 4 maf per year. This analysis assumes that Upper Basin use develops at about the same rate as it has historically. This assumption differs from that used by the Bureau of Reclamation in its February 28, 2007 draft EIS on Colorado River operations (DEIS). The projections used by Reclamation—which were provided by the Upper Basin—assume a more accelerated development schedule for the Upper Basin. Reclamation and the Upper Basin have used similar projections showing rapid development for many years, but those projections have far outpaced actual development in the Upper Basin.

This analysis also assumes that Upper Basin uses decline somewhat during times of hydrologic shortage in the basin. Again, that assumption is based on the evidence in the historic record, as documented in past Reclamation reports. However, Reclamation studies typically assume that Upper Basin uses continue unabated, notwithstanding hydrologic shortage.

Reduction in Deliveries to Mexico: This analysis, like Reclamation's DEIS, assumes that deliveries of Colorado River water to Mexico under the 1944 Treaty will be reduced proportionately whenever a shortage is declared for the Lower Basin States. Thus, whenever this analysis indicates a first level shortage of 333,000 af to the Lower Basin States, it assumes that an additional 67,000 af is not delivered to Mexico, making the total reduction in releases from Lake Mead 400,000 af. (For the second level shortage, the total reduction is 500,000 af, and for the third level shortage 600,000 af.) Actual reductions under the 1944 Treaty will be determined by the United States in consultation with Mexico.

Shortages when Lake Mead is Below Elevation 1000: Under the Basin States Proposal, when the end-of-year elevation of Lake Mead is projected to be less than 1000 feet above sea level, the Secretary will consult with the Basin States regarding the magnitude of further shortages. Because it is impossible to predict the outcome of such consultation, this analysis assumes that shortages continue at the third level (500,000 af reduction to the Lower Basin States) when Mead falls below elevation 1000.

Shortage Sharing Between CAP and On-River P4 Users: The Arizona Department of Water Resources' October 2006 recommendation as to how Colorado River shortages should be shared between CAP and on-river P4 water users includes a formula that is based on P4 mainstem water entitlements. The formula yields slightly different results from year to year, depending on the volume of Colorado River water projected to be used by higher priority water users in Arizona. In general, however, approximately 10% of any Arizona shortage will be borne by on-river P4 users, with the remainder going to CAP, so that is the figure used in this analysis.

Indian Demand: Impacts to CAP Indian water users are based on CAP's best estimate of Indian demand build-out, which is less aggressive than projections typically used by the Bureau of Reclamation.

M&I Demand: Impacts to CAP M&I water users are based on CAP's best estimate of M&I demand build-out.

Arizona Mainstream Use: Estimates of the Colorado River supply normally available to CAP each year are based on CAP's best estimate of Arizona's higher priority on-river demands, which are slightly less than those typically used by the Arizona Department of Water Resources. If higher priority on-river uses limited CAP to its nominal long-term contract delivery of 1.415 maf, then shortage impacts would be somewhat greater than described in this report.