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THE IMPACT OF THE CLOSING OF COAL-FIRED POWER STATIONS ON CONSUMPTIVE USES IN THE UPPER COLORADO RIVER BASIN

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Executive Summary: From the mid-1960s through the early 1980s, ten major coal-fired power stations (also referred to as plants) were constructed in the Upper Colorado River Basin. Each station has one or more individual generating units. The Upper Colorado River system is the source of cooling water for each of the plants. At the peak in the early 2000s, the power stations were collectively consuming about 170,000 acre-feet per year of water, about 4% of the Upper Colorado River Basin's total annual consumptive use. Beginning in 2013 with the closing of three units of the San Juan Generating Station in New Mexico, all these plants, except one, are now scheduled to be shutdown.

By sometime in the 2030s, maybe earlier, the total consumptive use from Upper Basin coal plants will be reduced to nothing. The impact to total consumptive uses in the Upper Basin, while perhaps a small percentage, could be significant. As reported by the Colorado River Basin Consumptive Uses and Losses Report (C, U, & L Report), published by the Bureau of Reclamation, annual consumptive uses in the Upper Basin have been flat since the late 1980s. There is no apparent upward or downward trend. The most likely affect of the closing of the Upper Basins coal-fired power stations will be to offset a major portion of the additional consumptive uses from expected regional growth and the few new export projects now being planned or constructed.

The Power Stations: Prior to the 1960s the Upper Colorado River Basin was home to three small coal-fired power plants; the 100 MW Nucla Power Plant near Nucla, Colorado, the 77 MW Cameo Plant near Grand Junction, Colorado, and the 190 MW Carbon Power Plant near Helper, Utah. These small plants, now all decommissioned, were built primarily to meet local and near-by regional needs. The next generation of large multi-unit plants were built to meet booming electric demands in the entire Southwestern United States. In 1962 construction began on the first units of the Hayden Station near Steamboat Springs, Colorado and the San Juan Station near Farmington, New Mexico. By 1985 ten major power stations were in operation. The total installed capacity was over 14,000 Megawatts (MW). Although, most of the power produced is exported to the West's major urban centers such as Los Angeles, Phoenix, Portland, the Colorado Front Range, and the Wasatch Front, the plants have always had strong local support. Together, with their nearby coal mines, they provide local employment and support the local tax-base.

For several reasons, the shift to renewable power sources to reduce carbon emissions, the high cost of retrofitting the plants with advanced scrubbers, the age of the plants, and high

operating costs when compared to alternatives such natural gas fired plants, the plants are being shut down. The only station that does not now have an announced closing date on the plant website is the Hunter Station in Emory County, Utah.[1] A recent trend is that previously announced closing dates are being accelerated.[2] The following table shows the name plate capacity[3], closing dates, and water source for each station and the total consumptive uses for all power stations in each state with Upper Basin lands.

STATE	STATION	CAPACITY MW	CLOSING DATES	WATER SOURCE	CU by STATE 2006
ARIZONA	NAVAJO	2,250	2019	LAKE POWELL	27000
NEW MEXICO	FOUR CORNERS	2,040	2013, 2031	SAN JUAN RIVER	
NEW MEXICO	SAN JUAN	1,852	2017, 2022	SAN JUAN RIVER	52000
COLORADO	CRAIG	1,283	2025, 28, 30	YAMPA RIVER	
COLORADO	HAYDEN	446	2030, 2036	YAMPA RIVER	19000
UTAH	BONANZA	500	2030	GREEN RIVER	
UTAH	HUNTER	1,577	NOT PUBLISHED	COTTONWOOD CR (GR)	
UTAH	HUNTINGTON	1,037	2036	HUNTINGTON CR (GR)	35000
WYOMING	BRIDGER	2,442	2023, 28, 36	GREEN RIVER	
WYOMING	NAUGHTON	832	2019, 2025	HAMS FORK (GR)	38000
	TOTAL	14,259		TOTAL	172000

[1] In a March 3, 2020 article in the Salt Lake Tribune by Brian Maffly, a PacificCorp spokesman is quoted as saying the closing date for the Hunter Station is 2042, and that the closing dates for both the Hunter (2036) and Huntington Stations may be accelerated when the company issues its 2021 IRP.

[2] This happened for the San Juan Station and the Nixon Plant located in Colorado Springs, CO.

[3] The capacity numbers shown are as built. In some cases, plant capacity has been downsized. For example, the as built capacity of Bridger was 2442 MW. It is now listed as 2110 MW.

The Consumptive Uses and Losses Report: Section 601 (b) of the 1968 Colorado River Basin Project Act directs the Secretary of the Interior to "make reports as to the annual consumptive uses and losses of water from the Colorado River system after each consecutive five year period…" beginning with Water Year 1971. Preparation of the *Colorado River System Consumptive Uses and Losses Report* (C U & L Report) has been delegated to the Bureau of Reclamation. The first report, covering 1971-75, was formally issued in 1978. As of October 2020, data for the Upper Colorado River Basin are available through Water Year 2018 (48 years). Data for the most recent thirteen years (2006-18) are considered provisional. As a practical matter, Reclamation has been continually peer reviewing and updating the entire data set. The last C, U, & L report to include data from the Lower Colorado River basin was the 2001-2005 report.

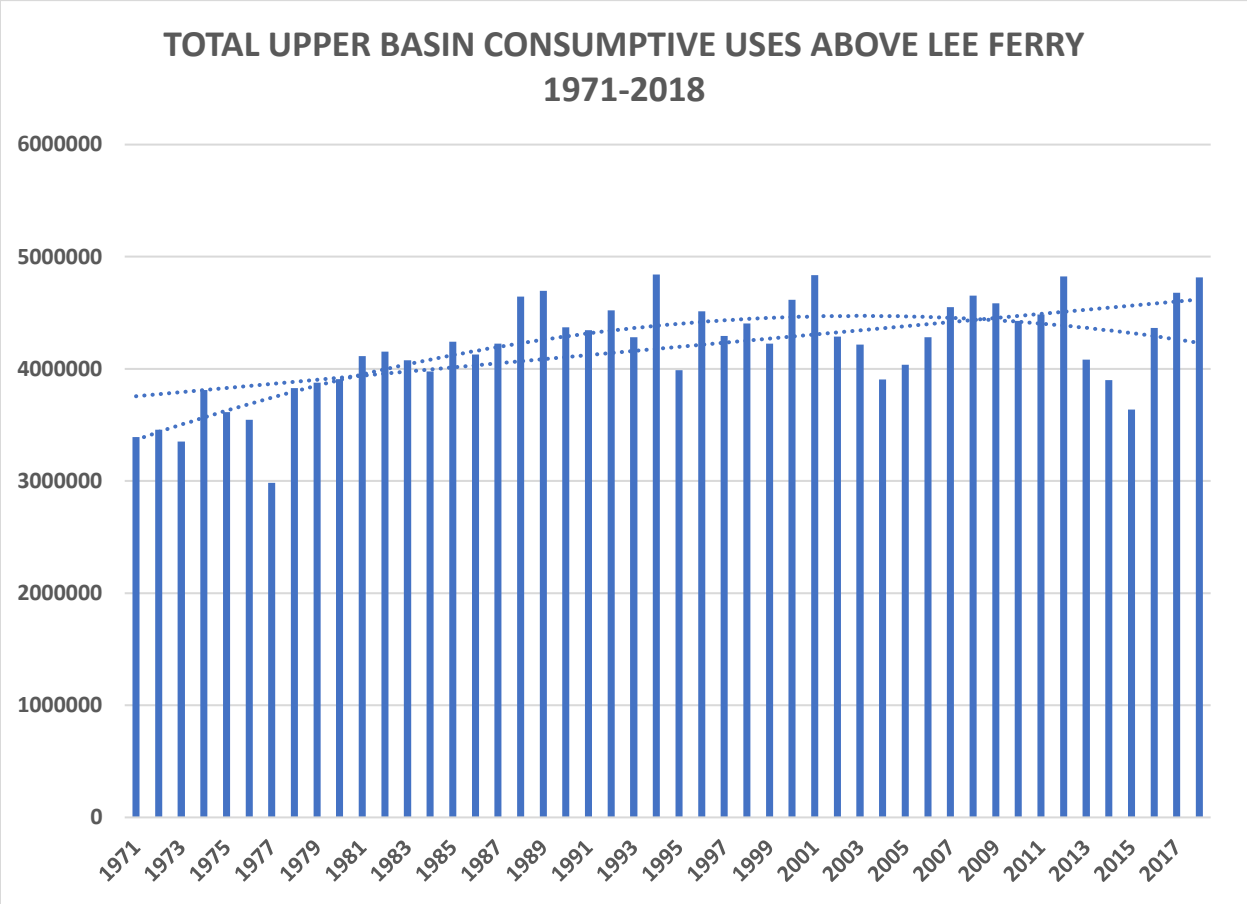
The Upper Basin report shows estimated consumptive uses for Agriculture, Municipal and Industrial, and Exports. The report separately identifies net evaporation for the "joint-use" CRSP Reservoirs; Lake Powell, Flaming Gorge, Blue Mesa, and Morrow Point and evaporation from in-state reservoirs. Net evaporation is the difference between the surface evaporation and the natural losses (from the surface of the stream plus vegetation) that would have occurred had the reservoir not been there. Agriculture is split into irrigation and stock ponds. M & I is split into minerals, thermal power, and other. The "other" includes in-basin municipal uses. The Exports data include both exports out of the Colorado Basin and within the Colorado River Basin from one major drainage basin to another.

The reports include a section on "Methodology and Data Adequacy." In general, the exports data are considered good because 99%+ are measured. Data for thermal power uses are also considered good. All other data are only considered adequate. Irrigation consumptive uses are estimated using the Modified Blaney-Criddle method. In recent years, individual Upper Division states have begun using different methods to determine irrigation consumptive uses. The States of the Upper Division and the Bureau of Reclamation are currently engaged in a project to study changing to a common and more "modern" method such as Penman-Monteith. When and if this happens the C U & L Report will require a major updating (as will the Natural Flow Data Base).

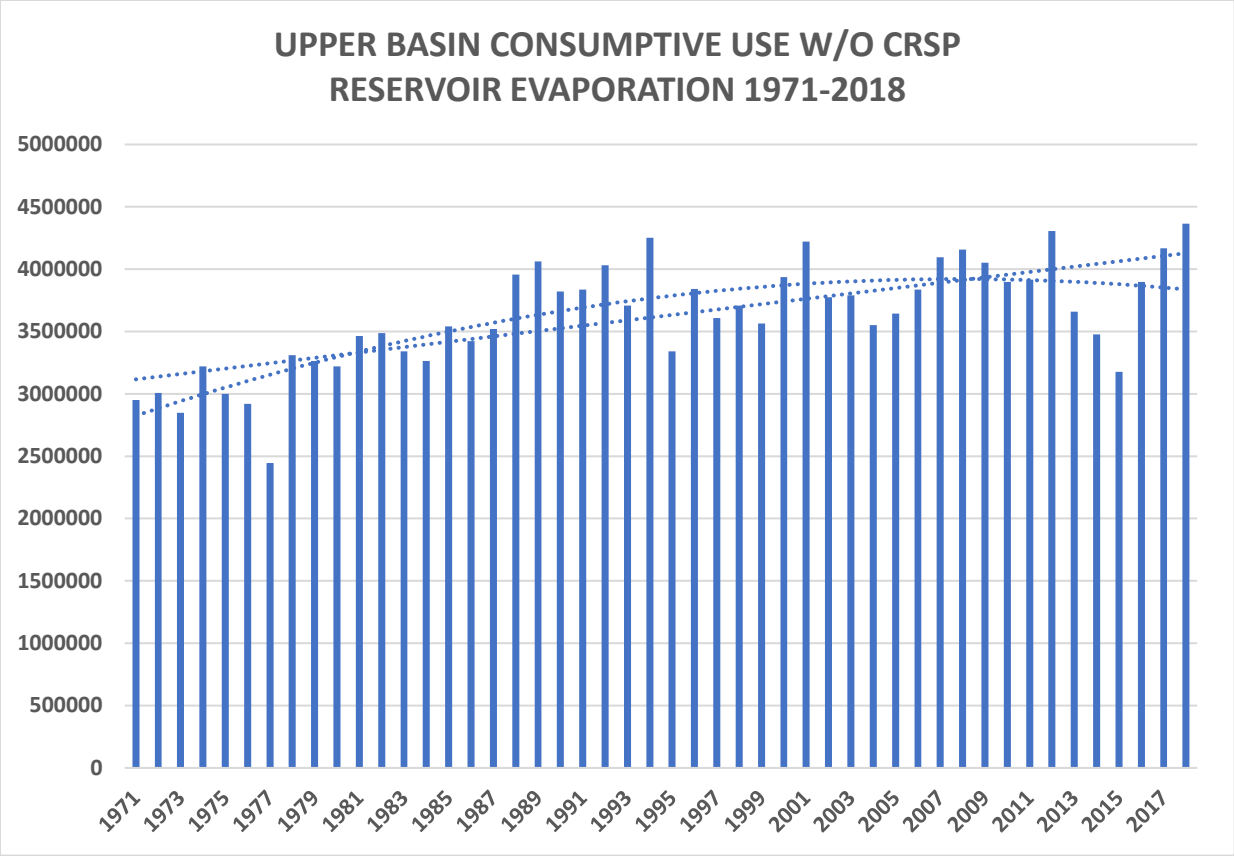
Upper Basin Consumptive Uses Based on the C U & L Report: The following graph shows total annual Upper Basin consumptive uses.[4] It includes the net evaporation on the CRSP reservoirs and Arizona's consumptive uses from its small portion of the Upper Colorado River Basin. The graph includes both linear and polynomial trendlines. The net evaporation from CRSP reservoirs is based on the surface area of the reservoirs which varies based on the storage level. Because storage in the largest reservoir, Lake Powell, was being filled in the 1970s and since 2000 has

[4] The Consumptive Uses and Losses report are available on the Bureau of Reclamation, Upper Colorado Region website, https://www.usbr.gov/uc/water/index.html

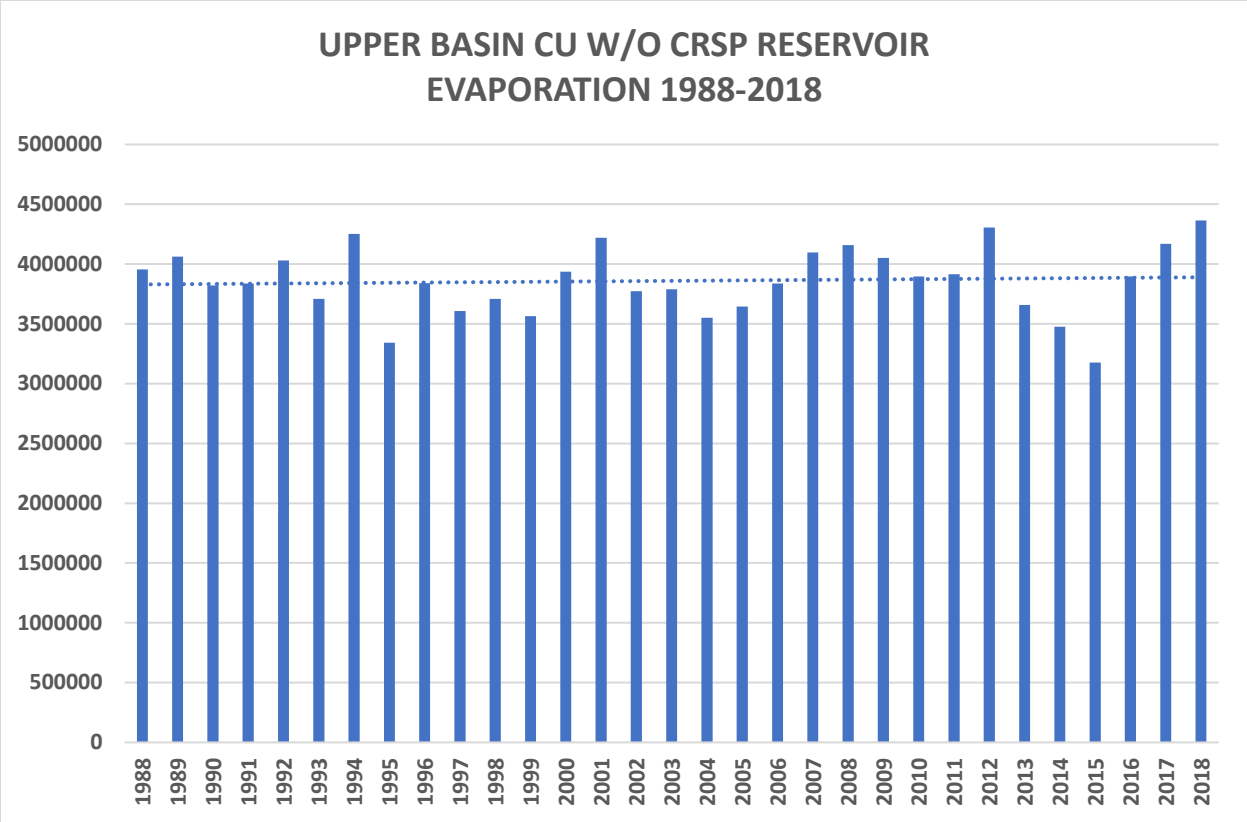
been declining in response to post-2000 drought, removing CRSP reservoir evaporation gives a better picture of actual consumptive use trends.



The following graph shows Upper Basin consumptive uses without CRSP reservoir evaporation. It clearly shows that from 1971 to about 1987 annual consumptive uses were increasing. Since 1988, however, it appears that there has been no overall growth in annual consumptive uses. The flattening of consumptive uses after 1988 makes sense based on what was happening on the ground. Several large projects were completed and began diverting water during the 1971-1988 period. Examples are the Windy Gap, San Juan-Chama, Fryingpan-Arkansas, Navajo Indian irrigation, Dolores and Dallas-Creek projects. The last of the coal-fired power stations, Bonanza, was completed in 1985. Since 1988 several projects have been completed, but the consumptive uses associated with these projects have been small, Lake Nighthorse or Wolford Mountain for example.



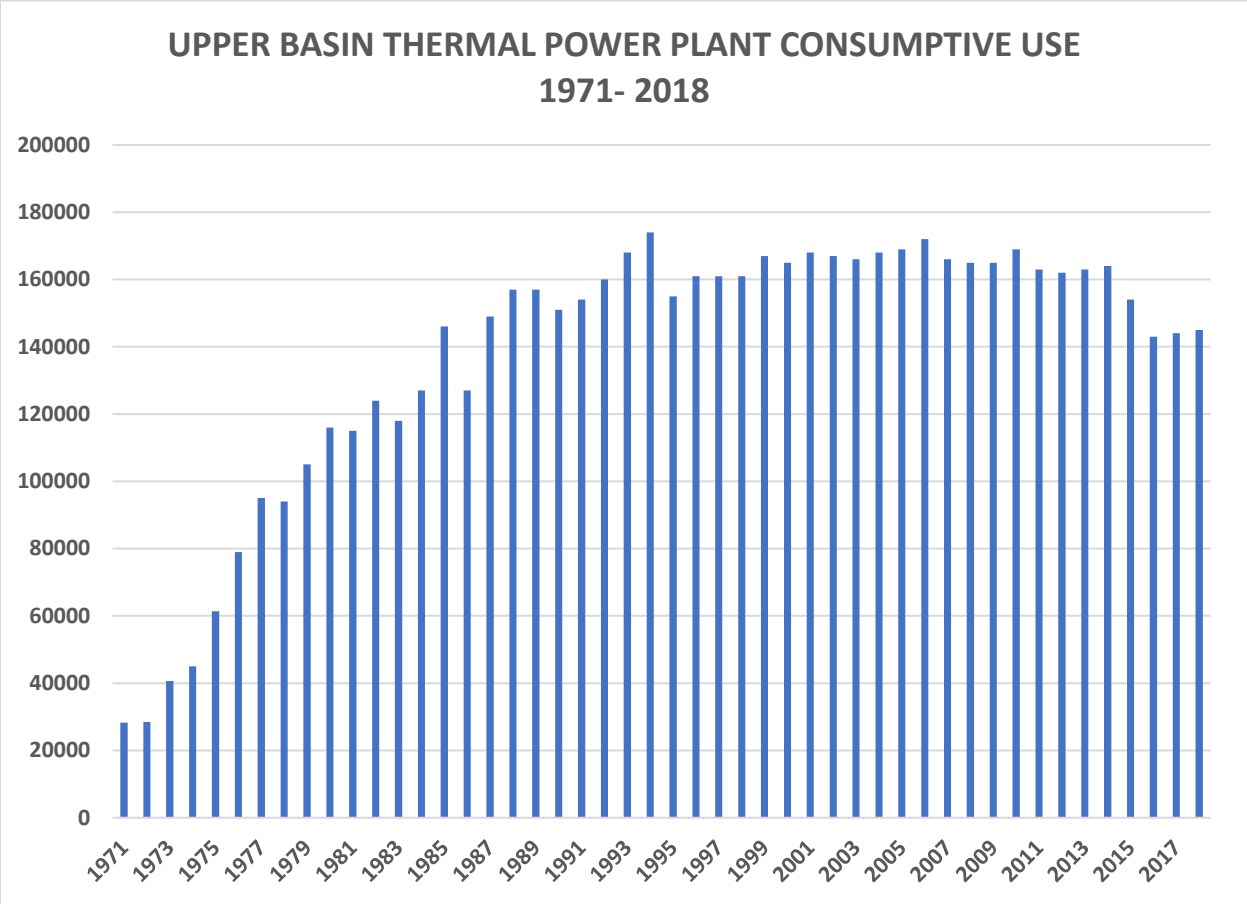
The following graph shows Upper Basin consumptive uses without CRSP reservoir evaporation over the period of 1988-2018. The flat trend line is clearly apparent. Over this period consumptive uses averaged 3,860,000 acrefeet per year. During that same period, cosumptive uses from the basin's coal-fired power plants averaged 160,000 acre-feet pere year, about 4.15%. By comparison, the two largest uses, in-basin agriculture and exports out of the basin, are at 60% and 17% respectivefully.



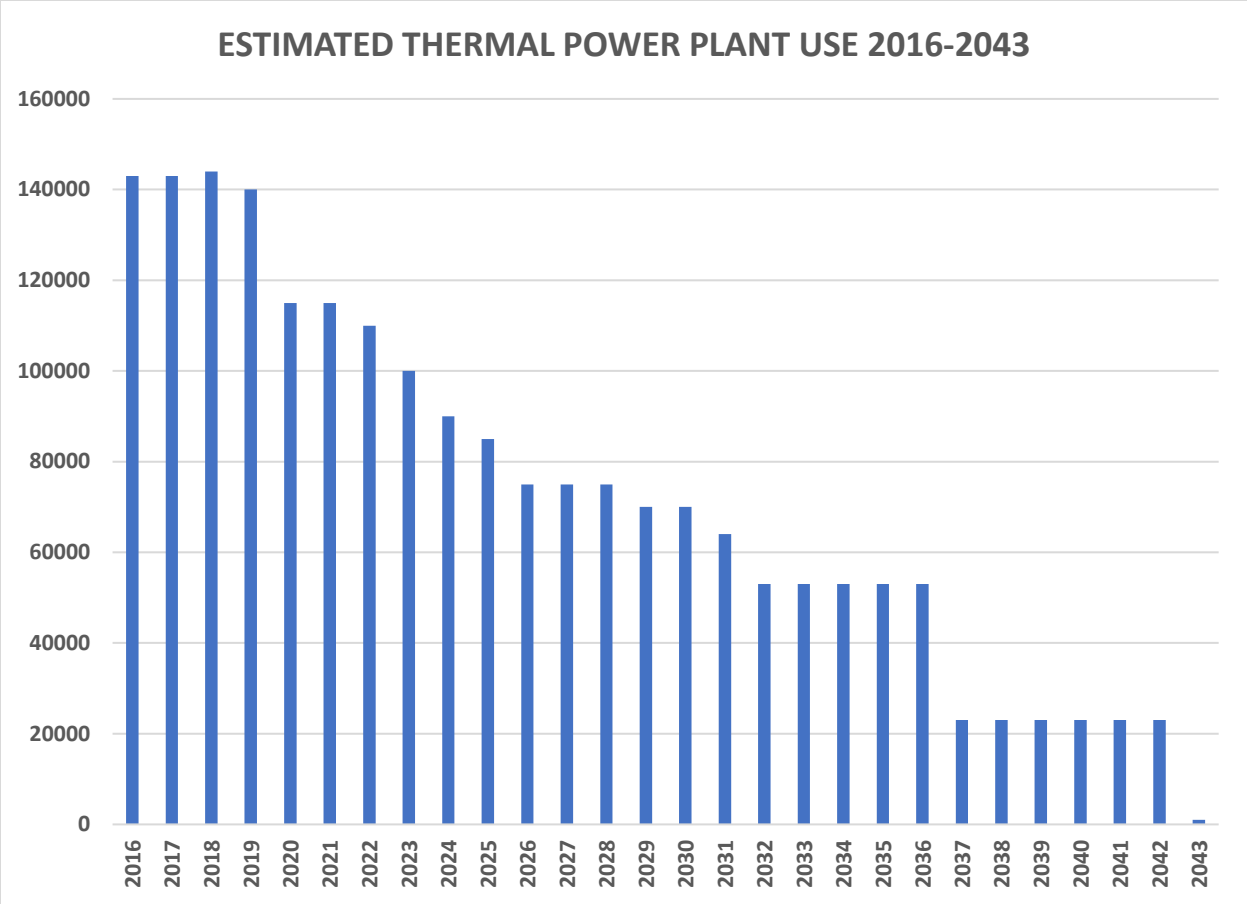
Thermal Power Plant Use: The C, U, & L Report shows the consumptive uses for thermal power plants from 1971-2018. The ten major coal-fired power stations make up about 99% of the consumption.[5] The 2001-2005 C, U, & L Report stated the data were obtained from records obtained from the plant operators and that the "records were complete and judged to be accurate." The data show total uses by state, not by individual plants.

The following graph shows thermal plant uses from 1971-2018. The graph shows steady growth from 1971 to the mid-1980s, then flat through about 2015, then a small drop reflecting closure of the first units of the Four Corners station. The closing of the entire Navajo Generation Station and one unit the Naughton Station at the end of 2019 are not yet reflected in the data.

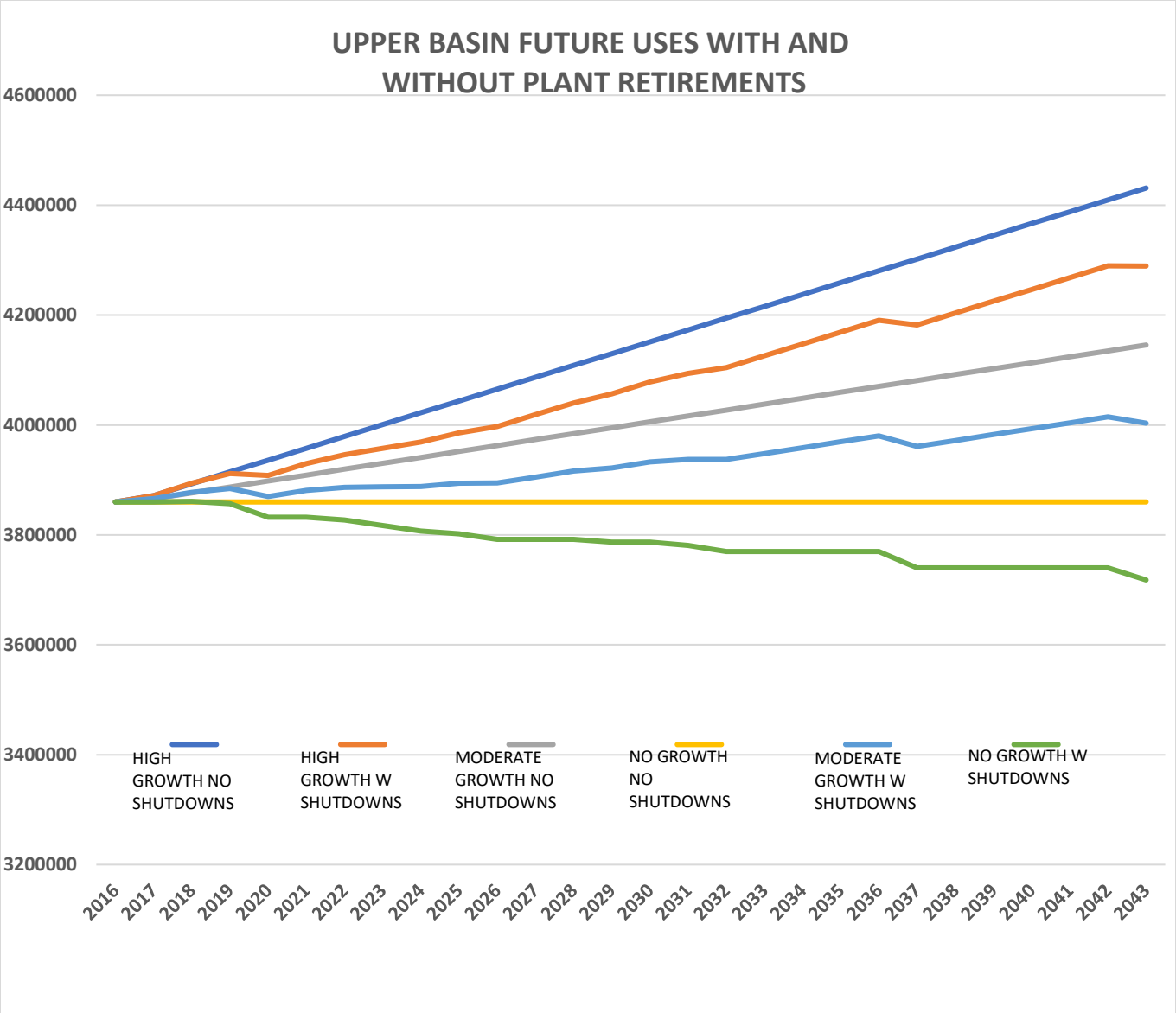
[5] Two of the three smaller plants, Carbon County and Nucla used evaporative cooling. The Cameo plant used pass-through cooling, so its consumptive use was quite small. The Carbon County plant was shut down in 2010. It was only operated sporadically before that. Nucla was shutdown in 2018. The combined capacity of the two was about 1.5% of the combined capacity of the 10 larger power stations.



The following graph shows my estimate of how the current schedule of plant closings will impact thermal power plant use through 2046. The assumptions are: First, the plants will be shutdown at the end of the year the shutdowns are scheduled. Second, until shutdown, the plants will operate at a similar capacity to 2016-2018. Third, the Hunter Station will shutdown in 2042. Fourth, a small amount of water will be used for a several year period after shutdown for site reclamation.



Impact of Plant Closings on Future Upper Basin Consumptive Uses: The impact of the plant closings on total Upper Basin consumptive uses will vary depending on future growth in other sectors, primarily exports out of the basin and the impact of rising regional temperatures on existing irrigated crops. Shown below are three different scenarios; A high growth scenario based on the actual Upper Basin growth in consumptive use from 1971-2018 (about 17,000 acre-feet per year). A no growth scenario based on a continuation of the 1988-2018 period. The moderate growth scenario is halfway between the high growth and no growth scenarios. The initial conditions are that the annual consumptive use for 2016 was 3.86 million acre-feet per year. This does not include CRSP reservoir evaporation.



Summary: Within 15-20 years all the Upper Basin's coal-fired power plants will be shutdown. These shutdowns, already occurring, will reduce consumptive uses by about 160,000 acre-feet per year from 2014 levels or about 140,000 acre-feet per year from 2019 levels. While the high growth scenario cannot be precluded, a return to the active construction of new projects seen in the 1970s and early 80s seems unlikely. The moderate or no growth scenarios are more likely outcomes. There are several new export projects in the final stages of planning and permitting.[6] Further, the San Juan – Gallup Pipeline is nearing completion. Collectively, however, the expected total new consumptive use from these four projects, about 125,000

[6] The Lake Powell Pipeline, Windy Gap Firming Project, and Moffat System Expansion Project are all either permitted or are in the final stages of permitting.

acre-feet per year, is less than reduction in consumptive use from the retirement of coal plants. The major unknowns are further development of the Upper Basin's Native American rights and the impact that climate change will have on existing irrigated croplands. For these reasons, a moderate growth scenario cannot be discounted.

Supplemental Material: In-basin agriculture makes up the largest component of Upper Basin consumptive uses, about 60%. Yet, the data shown for total irrigation consumptive use is only considered adequate and there is a general consensus that the methodology used to estimate consumptive use, modified Blaney-Criddle, needs to be replaced with a more modern, and presumably more accurate method. When this happens the magnitude of Upper Basin agricultural consumptive use will change. The question is will it change the trend? Shown below is a graph of Upper Basin irrigated acreage from 1971 - 2018. Like total Upper Basin consumptive uses, there was a small increase from 1971 to the mid-1980s, but then flat.