UPPERMOST VERDE RIVER—PARADISE LOST?

Edward W. Wolfe, Geologist, Ph.D.
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The upper 25 miles of Northern Arizona's Verde River (Figures 1 and 2) is a scenic and largely wild treasure flowing year-round. However, its lowest yearly flows (Figure 3) are being reduced by continuing drought, warming climate, and groundwater pumping. They may be additionally and fatally threatened by demand for additional groundwater from the Big Chino Valley to supply human wants and development or increased agricultural pumping. Thus, this wild river could become "Paradise Lost" owing to insufficient effort to protect it.

Figure 1. Upper Verde River. Photo courtesy of Gary Beverly.

PLANS TO EXPORT BIG CHINO GROUNDWATER TO PRESCOTT AND PRESCOTT VALLEY

The City of Prescott and the Town of Prescott Valley, as well as other users in the Prescott Active Management Area (Figure 2), have no access to water from the Colorado River and are depleting their local groundwater supplies. Hence, in an exception to Arizona law that normally prohibits transportation of groundwater from one groundwater basin to another, the Arizona legislature in 1991 approved importation by Prescott of up to 14,000 acre-feet (nearly 4.6 billion gallons) per year of groundwater from the Big Chino aquifer (Figure 2).

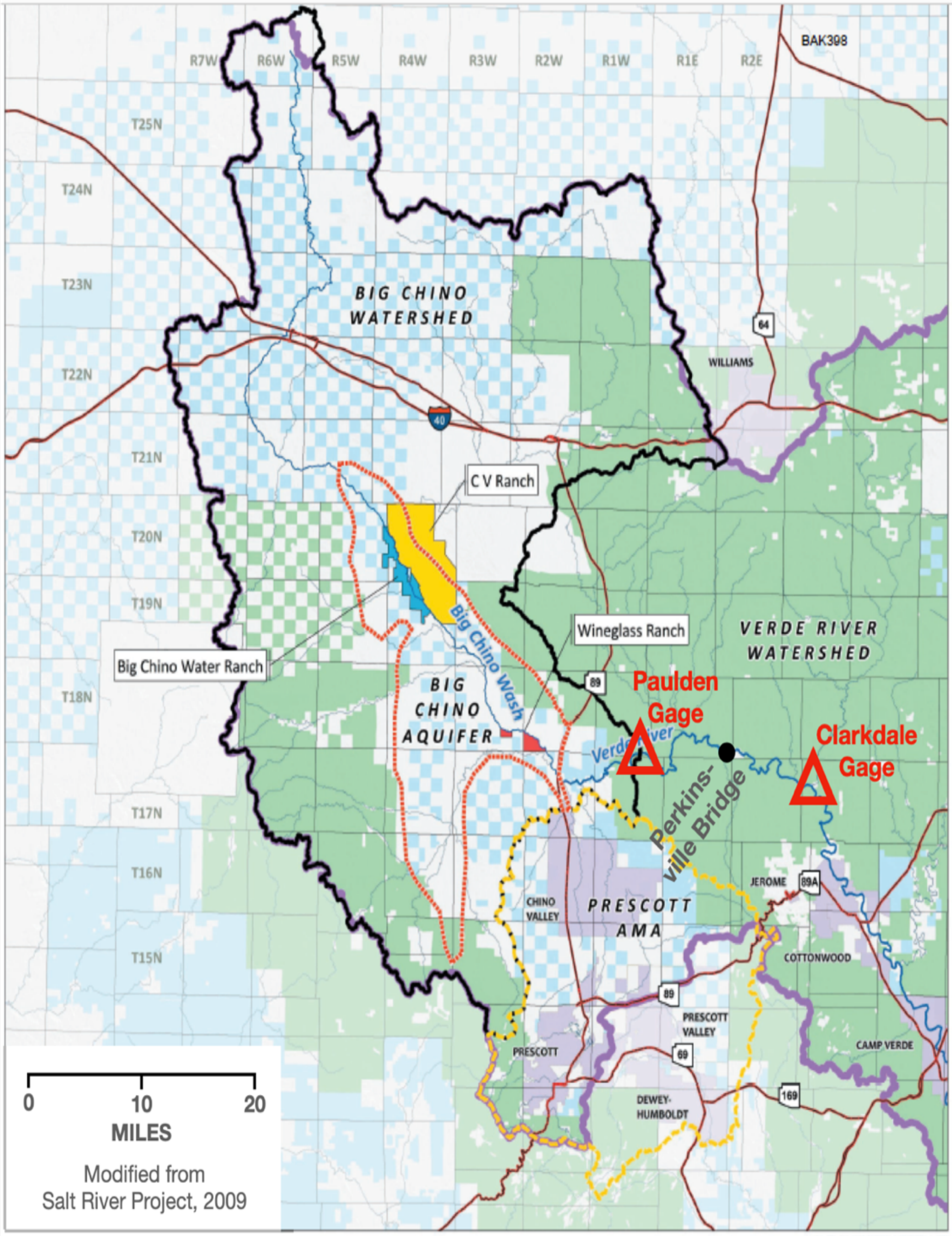

Figure 2. Map showing the upper part of the Verde River, the Big Chino watershed, upper part of the Verde River watershed, the location of the Big Chino aquifer, the Big Chino Water Ranch, the USGS Paulden and Clarkdale streamgages on the Verde River, the Perkinsville bridge, and the Prescott Active Management Area (yellow boundary), which drains northward to the Verde River groundwater system and southward to the Agua Fria River.

The City of Prescott and Town of Prescott Valley formed a partnership in 2004 to construct a pipeline to convey up to 12,000 acre-feet (nearly 4 billion gallons) per year of Big Chino groundwater to their municipal water systems. Intense litigation ensued concerning the potential loss of perennial upper Verde River streamflow, the wildlife it supports, and its contribution via the Salt River Project (SRP) to the water supply of users far downstream in Maricopa County. Prescott, Prescott Valley, and SRP, as unusual bedfellows but nevertheless collaborating partners, achieved a negotiated settlement in 2010 to abandon litigation and proceed with a plan to import 8,067 acre-feet per year (af/y) of groundwater from the Big Chino Valley for municipal use.

Prescott also has an additional legal right to import up to 3,483 af/y from Big Chino agricultural lands that were irrigated at some time between January 1, 1975 and January 1, 1980, and from which irrigation has been retired. Thus, Prescott and Prescott Valley could legally import up to as much as 11,550 af/y. Accordingly, a pipeline sufficient to supply Prescott and Prescott Valley with up to 12,000 af/y of Big Chino groundwater has been envisioned. The pumping source would be the Big Chino Water Ranch (Figure 2), which Prescott had purchased.

Now, in mid-2022, Prescott has apparently put the Big Chino pipeline on hold. However, Prescott Valley, as stated in its 2035 General Plan, is committed to importing Big Chino groundwater to support new population growth.

PIPE DREAM?

The settlement among Prescott, Prescott Valley, and SRP specified that no depletion of Verde River baseflow as a consequence of this extraction would be tolerated. (Baseflow is the contribution of groundwater inflow to the river). The three partners undertook development of a new groundwater model of the Big Chino Valley. **The model must address how the effect of groundwater extraction at the Big Chino Water Ranch (Figure 2) will be identified and completely ameliorated**. Completion of the model, hidden so far from the public, is expected some time this year (2022).

PUBLISHED SCIENTIFIC CONSENSUS

Published scientific consensus supports the conclusion that groundwater in the upper Big Chino Valley exits to the springs that supply the perennial flow of the Verde River headwaters east of Paulden:

•From the 1994 modeling study of the Bureau of Reclamation: "*groundwater in the Big Chino Basin is hydrologically connected to the upper Verde River…there is no continuous impediment to the flow of water from the northern part of the valley to the upper Verde River*".

•Wirt, 2005, U.S. Geological Survey (USGS) Open File Report, 2004-1411-G, used a complex geochemical analysis to infer that 80-86 percent of the Verde River streamflow measured at the USGS Paulden streamgage (Figure 2) originates from the Big Chino basin-fill aquifer and the underlying much older, approximately 340- to 500-million-year-old, carbonate (limestone and dolomite) formations.
•Plate 3 of Blasch and others, 2006, USGS Scientific Investigations Report 2005-5198, portrays groundwater flow from the northwestern end of the Big Chino Aquifer (Figure 2) to the headwaters of the Verde River.
•Pool and others, 2011, Regional Groundwater Flow Model…Northern and Central Arizona, USGS Scientific Investigations Report 2010-5180 concluded (p.94) "*…groundwater in the Big Chino alluvial aquifer discharges to the Verde River…".*
•Kennedy and others, 2019, USGS Scientific Investigations Report 2019-5060 Aquifer Storage Change and Storage Properties, 2010-2017, in the Big Chino Subbasin…"*The Big Chino Subbasin is a groundwater basin that includes the Verde River headwaters…". "…the (*Big Chino Valley) *is a potential municipal water source for growing communities in Yavapai County, particularly groundwater from the Big Chino Water Ranch….Groundwater in the Big Chino Valley discharges…to the upper Verde River springs, which form the headwaters of the Verde River".*

These reports clearly indicate that groundwater pumpage in the Big Chino Valley will reduce the amount of groundwater reaching the Verde River over time and therefore the base flow of the river. The Prescott, Prescott Valley, and SRP model is expected to show the same conclusion.

DIMINISHED STREAMFLOW

As discussed above, the ongoing decline in the flow of the Verde River reflects the effects of past and present groundwater pumping, the continuing drought, and warming climate.

When or if the river begins to dry, the first occurrence of dry streambed is expected to occur at the time of lowest annual streamflow. For the Verde River that would be when the flow consist flow only of groundwater (base flow) inflow to the river. Lowest annual streamflow in central Arizona generally occurs in late spring or early summer, before the beginning of monsoon summer rains, or in fall or early winter before the first significant winter storm. Since, for much of the year, there is no storm or snowmelt runoff to the river, much of the flow or the Verde River during the year represents only the contribution of groundwater inflow. As shown in Figure 3, streamflow for about 2/3 of water year 1978 is primarily, if not entirely, from groundwater.

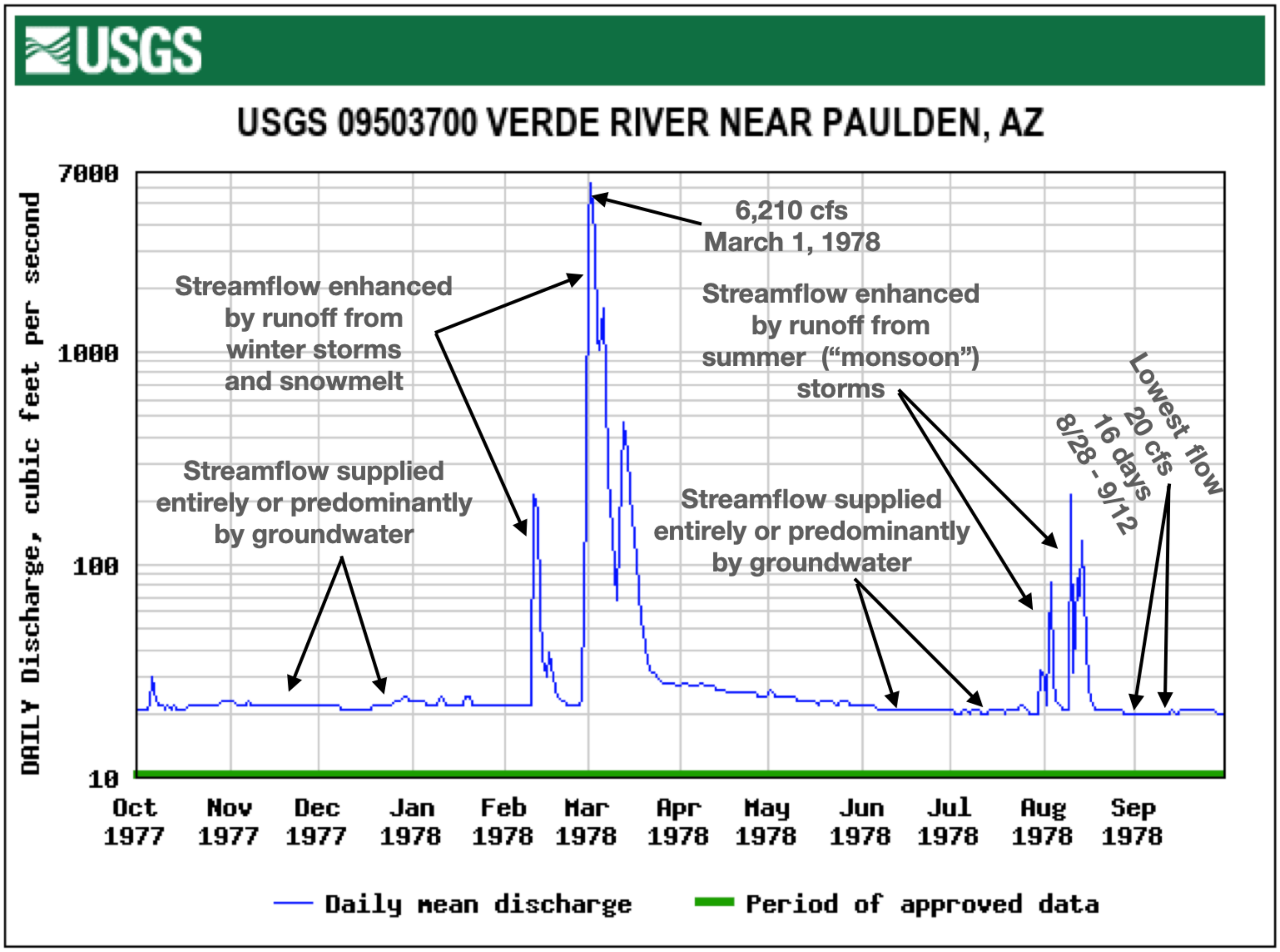

Figure 3. Record of USGS Paulden streamgage, water year 1978 (October 1977 through September 1978). In this case, the average lowest 7-day annual flow is within a 16-day period with constant mean daily flows of 20 cfs.

The USGS Paulden streamgage, located at Verde River mile 10, has recorded streamflow data since mid-1964. The streamflow originates from runoff as well as from three groundwater sources: the Big Chino aquifer, the northern part of the Prescott Active Management Area, and the upper Verde River valley (Figure 2). Figure 4 portrays the average daily measured flow for the seven consecutive days of lowest annual flow per water year (October 1 through September 30), presumably groundwater, at the Paulden streamgage. The record shows an average increase in lowest-flow rate of about 0.13 cubic feet per second (cfs) per year from 1965 through 1996 (approximately 2,900 acre-feet over those 32 years).

The trend changed in the mid-1990s. The record of lowest 7-day annual flow at the Paulden streamgage shows a substantially tighter trend with an aggregated decrease in lowest-flow rate of about 0.36 cfs per year from 1997 through 2021 (a decrease of approximately 6,600 acre-feet over those 32 years). If that rate of decrease were to be sustained, we should expect an annual summer dry period at the Paulden gage and through Perkinsville an estimated 42 years from now.

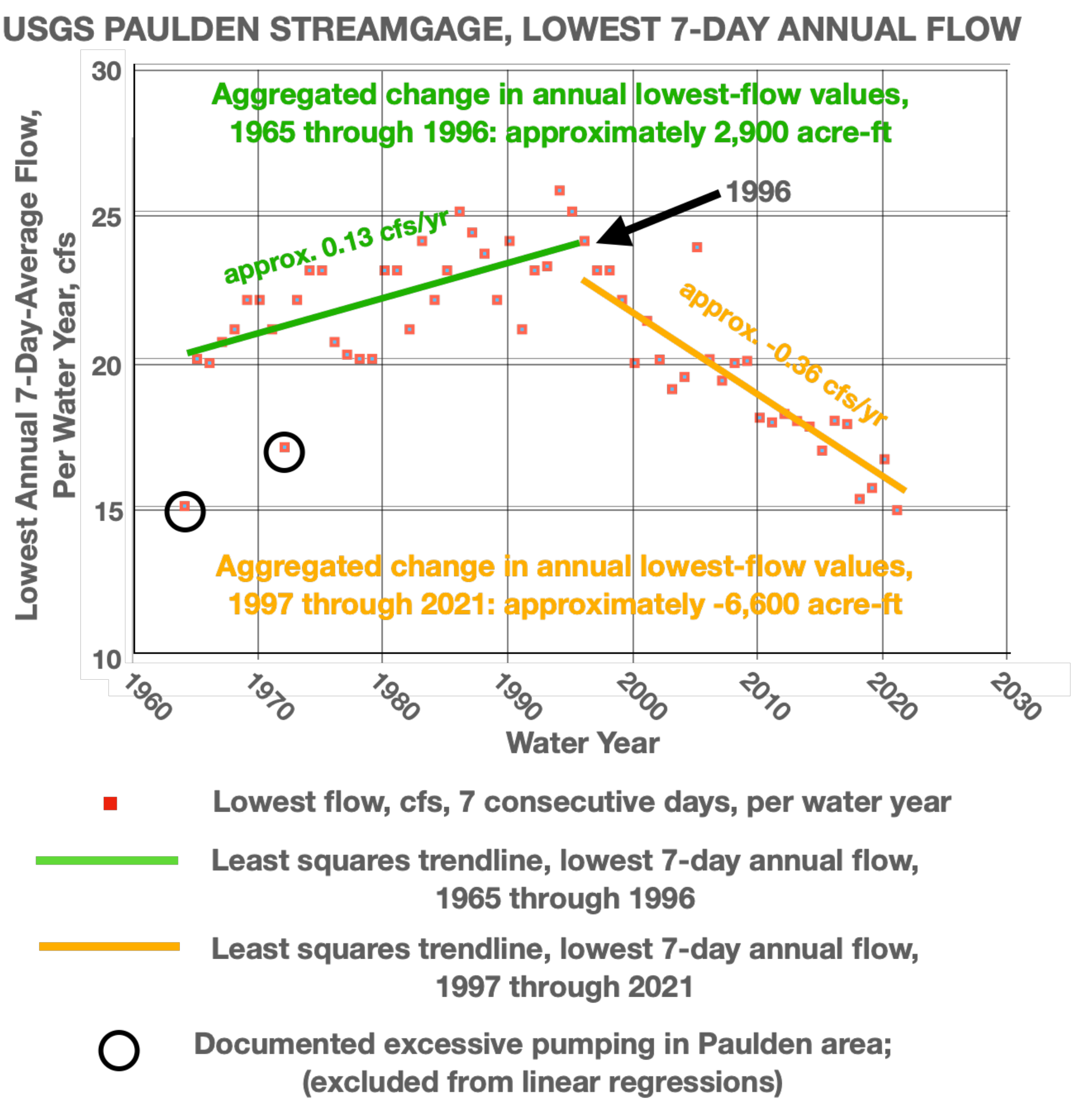

Figure 4. Lowest 7-consecutive-day-average flow per water year (October 1 through September 30) at the USGS Paulden streamgage.

Of course, we do not know whether this rate of decrease will continue for another half century. However, it is important to recognize the potential effect of human consumption.

Prescott and Prescott Valley envisioned exporting 11,550 af/y from the Big Chino Water Ranch for consumption in Prescott and Prescott Valley. That amount of water is nearly 16 cfs, which exceeds the current 15 cfs of lowest 7-day annual flow at the Paulden streamgage.

That would mean an eventual dry river for a part of each year, at least through Perkinsville. At the same time the combined effects of past and current pumping as well as future additional new pumping of Big Chino groundwater will further reduce the contribution of groundwater to the Verde River.

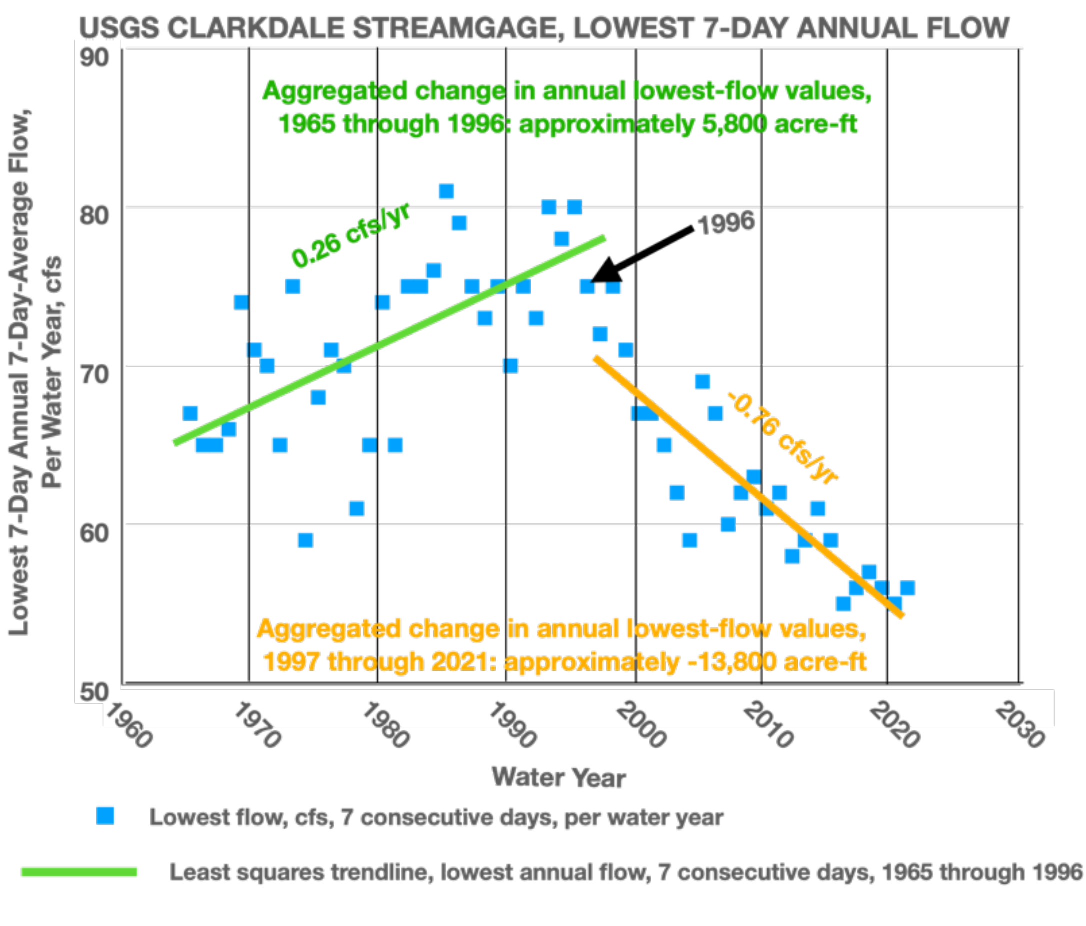

Figure 5. Lowest 7-consecutive-day-average flow per water year (October 1 through September 30) at the USGS Clarkdale streamgage.

Attesting to the regional character of this pattern at the Paulden gage, a similar pattern of change in streamflow has been recorded at the Clarkdale streamgage, mile 39 on the Verde River (Figure 5). As in Figure 4, Figure 5 portrays the average daily measured flow for the seven consecutive days of lowest annual flow per water year (October 1 through September 30), presumably groundwater, at the Clarkdale streamgage. Accordingly, the magnitude of lowest-flow annual data points recorded at the Clarkdale gage (Figure 5) is about 2 to 3 times the magnitude of those recorded at the Paulden gage.

CLIMATE EFFECT

The change from weakly gaining lowest flows to distinctly losing lowest flows from the mid-1990s to the present may relate to increased groundwater pumping but also apparently correlates in time with warming climate (i.e., climate change).

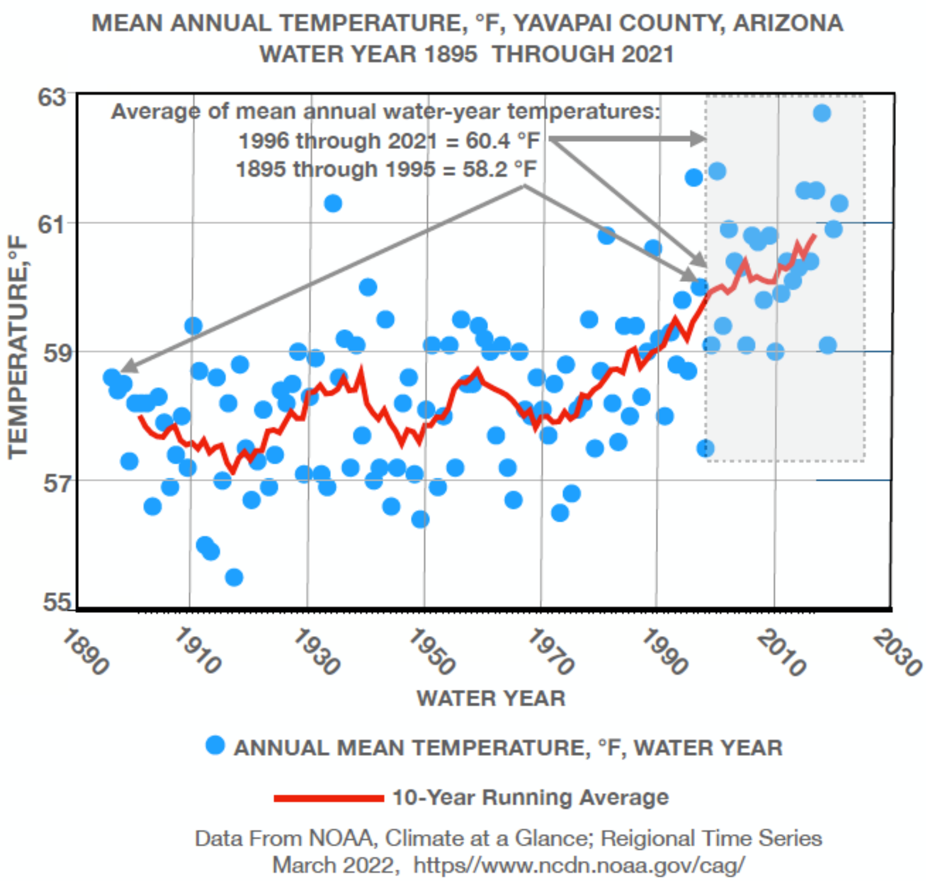

Figure 6. Mean annual temperature, Yavapai County, Arizona, 1895 through water-year 2021. Data From NOAA, Climate at a Glance; Regional Time Series, March 2022.

According to *NOAA Climate at a Glance*, mean annual (water year) temperature for 1996 through 2021 (Figure 6) was 2° F greater than for 1895 through the mid-1990s. Elevated temperature promotes increased evapotranspiration—which refers to evaporation and consumption of water by plants—resulting in reduced infiltration of water to the aquifer system and thus reduced supply of groundwater to streams.

Annual precipitation from the mid-1990s to date was relatively but not uniquely low (Figure 7). Mid-20th century lows in precipitation were similar in magnitude to the current low precipitation but not coincident with notably elevated temperature. Diminution of lowest groundwater discharge to the river beginning in the mid-1990s presumably reflects the combination of groundwater pumping, elevated temperature, and decreased precipitation.

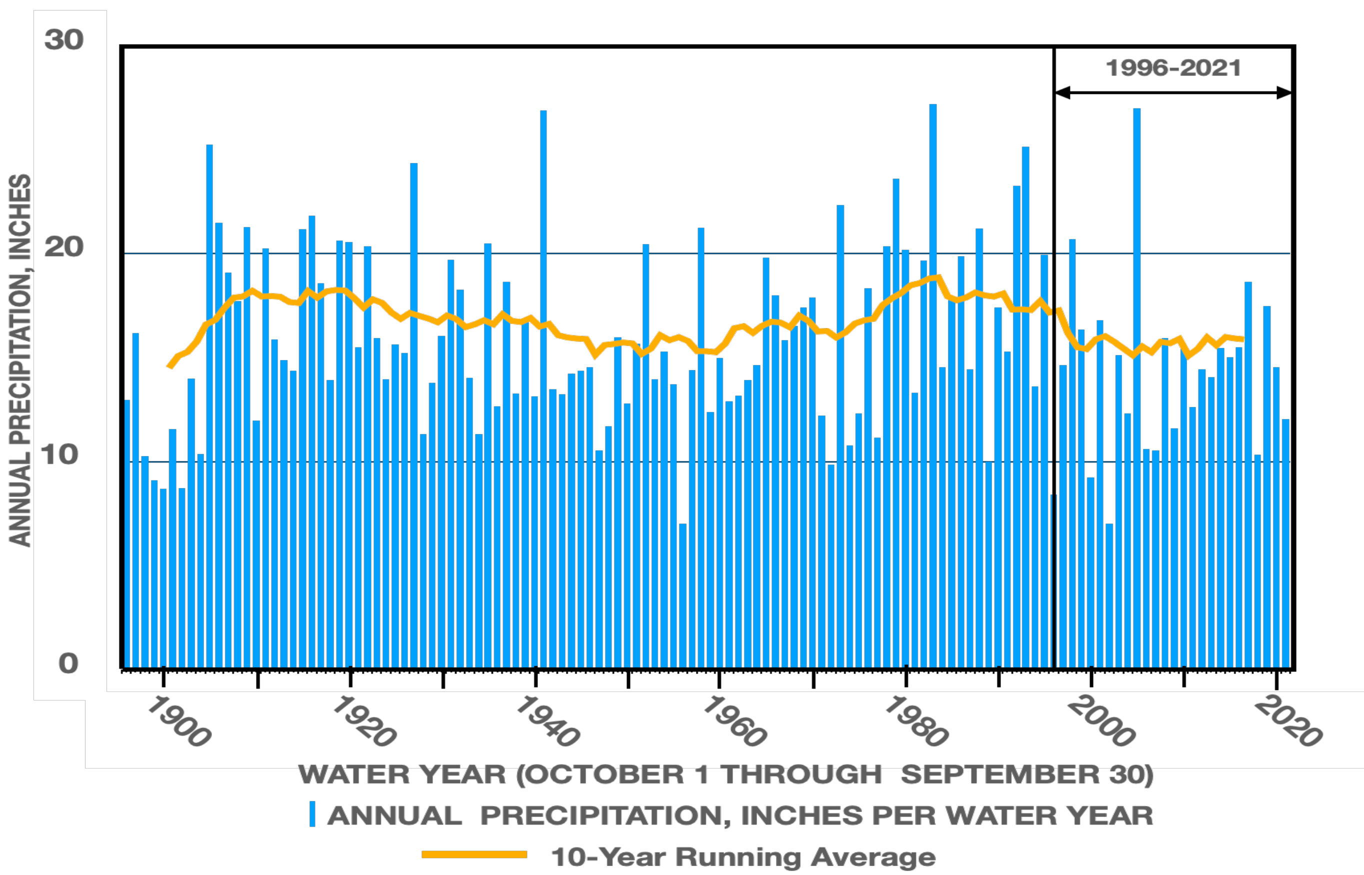

Figure 7. Mean annual temperature, Yavapai County, Arizona, 1895 through water-year 2021. Data From NOAA, Climate at a Glance; Regional Time Series, March 2022.
(https//www.ncdn.noaa.gov/cag)

DIMINISHED FLOW AT PERKINSVILLE

The section of the Verde River from near the Paulden streamgage (approximately river mile 10) through Perkinsville (approximately river mile 25) is identified by the USGS as a predominantly losing reach (Figure 8). A losing reach is one in which streamflow is, gradually in this case, transferred downward from the river into the underlying groundwater system. Streamflow has so far been sustained in the reach through Perkinsville but may eventually be lost for weeks or months in response to human water demand or continuing drought.

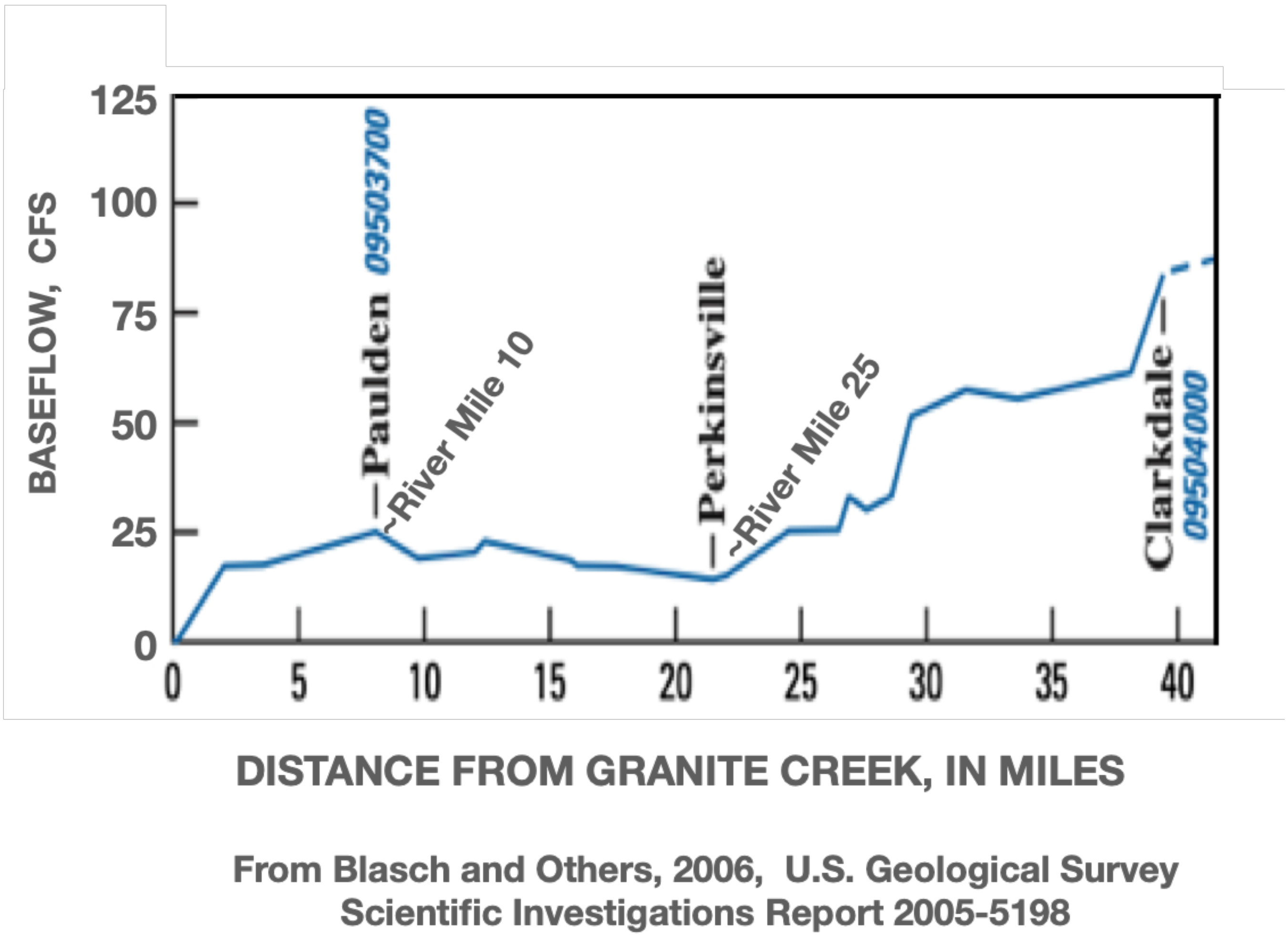

Figure 8. Base flow in the Verde River from the mouth of Granite Creek to the USGS Clarkdale streamgage. Base flow is the water in a stream that comes from groundwater as seepage or spring water. Base flow sustains the stream during periods of no precipitation. (Blasch and others, 2006).

The Water Sentinels, a volunteer group of the Grand Canyon Chapter of the Sierra Club have made once-a-month measurements of Verde River streamflow for nearly 15 years

(Figure 9). Their measurements emulate USGS streamflow-measurement standards and give a valuable streamflow record. Blank spaces in Figure 8 represent missed measurements. The abundant missed measurements in 2020 and 2021 likely reflect the effect of Coronavirus disease.

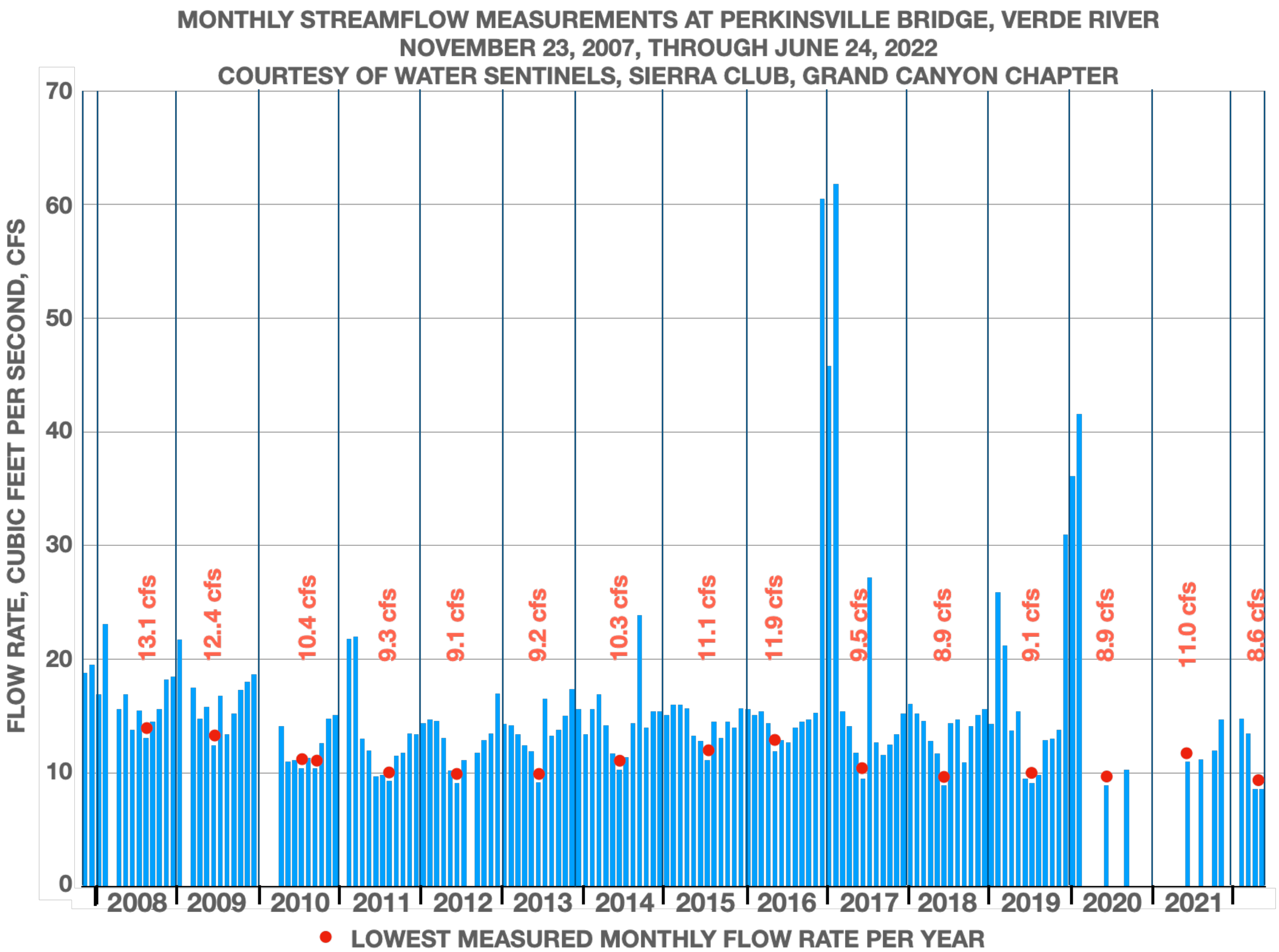

Figure 9. Plot of monthly (weather and health permitting) Verde River streamflow measurements Immediately upstream of the Perkinsville bridge. Measurements include flow in a parallel irrigation ditch nearby on the north side of the river.

The lowest recorded flows occur, as expected, only in the months of May through August. They range from 13.1 cfs in August 2008 to 8.6 cfs in May and June of 2022, but once-a-month measurements are insufficient to determine the record of average lowest 7-day annual flow as shown in figures 4 and 5 at the USGS Paulden and Clarkdale streamgages.

Once-a-month measurements also miss some of the winter storms. However, the effect of winter storms is clear in the winters of 2016-17 and 2019-20. Five of the six storms recorded in Figure 8 were clearly identified by elevated streamflow at the Clarkdale streamgage, but not at the Paulden streamgage. The somewhat elevated flow of January 2017 at Perkinsville was recorded at both the USGS Paulden and Clarkdale streamgages.

The streamflow records of May 29, 2022, and June 24, 2022, at the Perkinsville bridge are identical and are the lowest, 8.6 cfs (6,230 af/y), of the entire record. If the lowest annual streamflow at Perkinsville declines by 8.6 cfs (6,230 af/y), the Verde River will eventually be dry in the summer at the Perkinsville bridge. As there is very little groundwater pumping between the Paulden streamgage and the Perkinsville bridge, it is expected that summer flow will be lost at Perkinsville before summer flow is fully lost at the Paulden streamgage.

THE BOTTOM LINE

The lowest measured flow so far at Perkinsville is 8.6 cfs (6,230 af/y). Over the past quarter century lowest flows at the Paulden gage have decreased at an average rate of 0.36 cfs (260 af/y). At that rate, a loss of 8.6 cfs (6,230 af/y) at the Paulden gage will reduce the flow during the period of lowest flows at Perkinsville to zero in an estimated 24 years.

Current lowest flows measured at the Paulden streamgage are 15 cfs (10,870 af/y). A continuing decline in low flows at the current average rate of decrease of 0.36 cfs (260 af/y) will reduce the period of lowest flows from the upper Verde River springs through the Paulden gage and Perkinsville to zero in an estimated 42 years.

These estimates, of 24 and 42 years, would be substantially smaller if thousands of acre-feet of Big Chino groundwater were being piped into the Prescott region.

The ongoing loss of groundwater going into the Verde River clearly reflects, in part, the ongoing impact of groundwater pumping in the Prescott Active Management Area and the Big Chino Valley. The potential increase of groundwater withdrawal from both will result in further decreases in the inflow of groundwater to the river. These losses result only from a reduction in groundwater stored in the Prescott Active Management Area and the Big Chino Valley. The ongoing drought and warming climate further exacerbate the loss of groundwater in storage.

WHAT CAN WE DO?

The gods help those who help themselves. How many lives in Phoenix or Tucson or Buckeye depend on what happens in Yavapai County? We can't wait for the state legislature to save us; it is understandably focused on Arizona's major population and business centers in Maricopa, Pinal, and Pima Counties. The water supply that we have—our groundwater and, potentially, our stormwater runoff and recycled water—is our sole water source.

Mining groundwater in the Big Chino Valley to expand the number of homes and the population of Prescott Valley exacerbates the problem of overcommitting our water supply and dewatering the uppermost Verde River. We need regional cooperation within Yavapai County, especially among Prescott-region citizens and municipalities and in the Big Chino Valley, to shape our water future. That means requiring maximum water conservation, limiting growth, and optimizing the capture and re-use of stormwater.

We can't wait for the State to save us. Failure to successfully manage our water supply means that the treasure of the uppermost Verde River will be gone, our water supplies will be diminished, and our grandchildren or great grandchildren will have to find somewhere else to live and raise their families.