WATER RESOURCES AGENCY

M E M O R A N D U M

Monterey County

August 6, 2021

2021 Salinas River Discharge Measurements Series Results

The Salinas River Discharge Measurement Series (River Series) provides valuable information towards understanding the hydrologic conditions under which reservoir releases and flows in the Salinas River are managed. The 2021 River Series occurred during July 19-21, 2021. Ten streamflow measurements were performed by Monterey County Water Resources Agency (Agency) and US Geological Survey (USGS) staff. Overall, the 2021 River Series documented an entirely losing system with 624 cfs, or 1,236 acre-feet per day, lost across the ninety-one sampled river miles. The 2021 River Series recorded more flow lost than in the 2020 River Series, reversing a decreasing trend seen in the River Series since the 2012-16 drought. Further analysis into the reach-to-reach variations in flow loss rates, comparison to historical and recent River Series, and discussion on factors that may have influenced the 2021 River Series are discussed below.

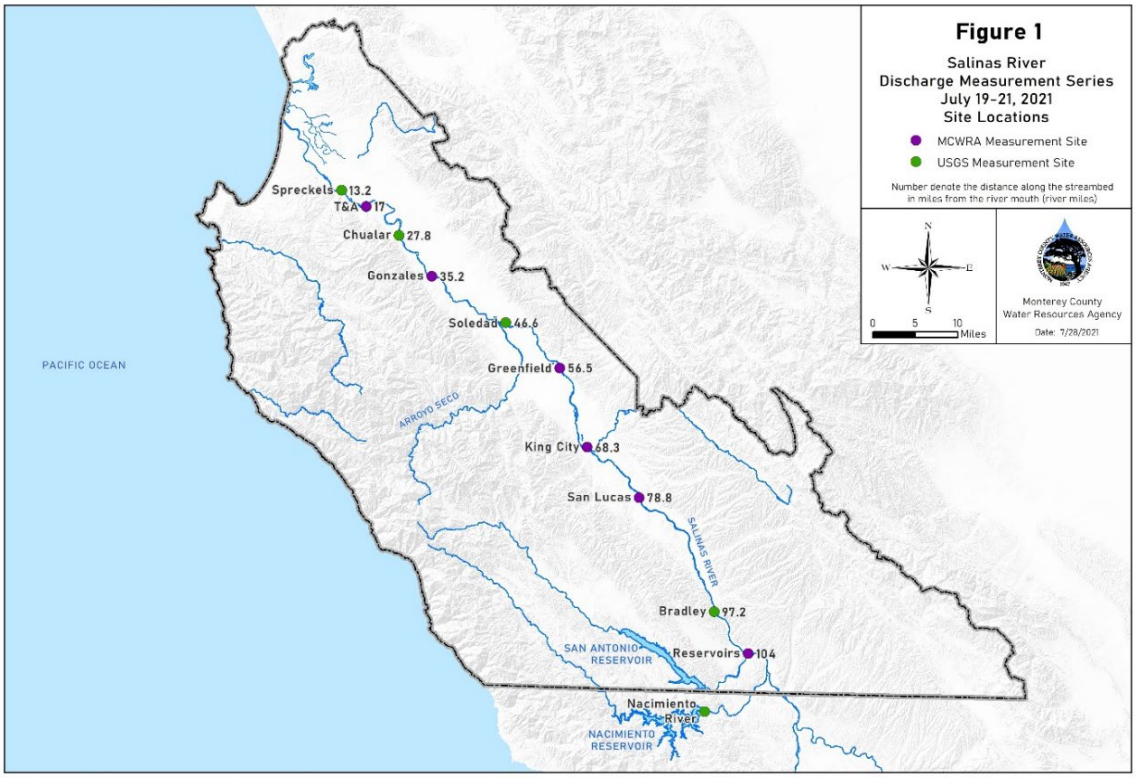

Figure 1. Salinas River Discharge Measurement Series Site Locations

Sample sites were located downstream of Nacimiento and San Antonio Reservoirs, within the lower one hundred miles of the Salinas River watershed (Figure 1). Combined reservoir releases were held around 650 cubic feet per second (cfs) for five days prior to the River Series (Figure 2). This allowed for any variations in flow to move through the system prior to sampling so that changes in flow would not be an artifact of changes in reservoir releases.

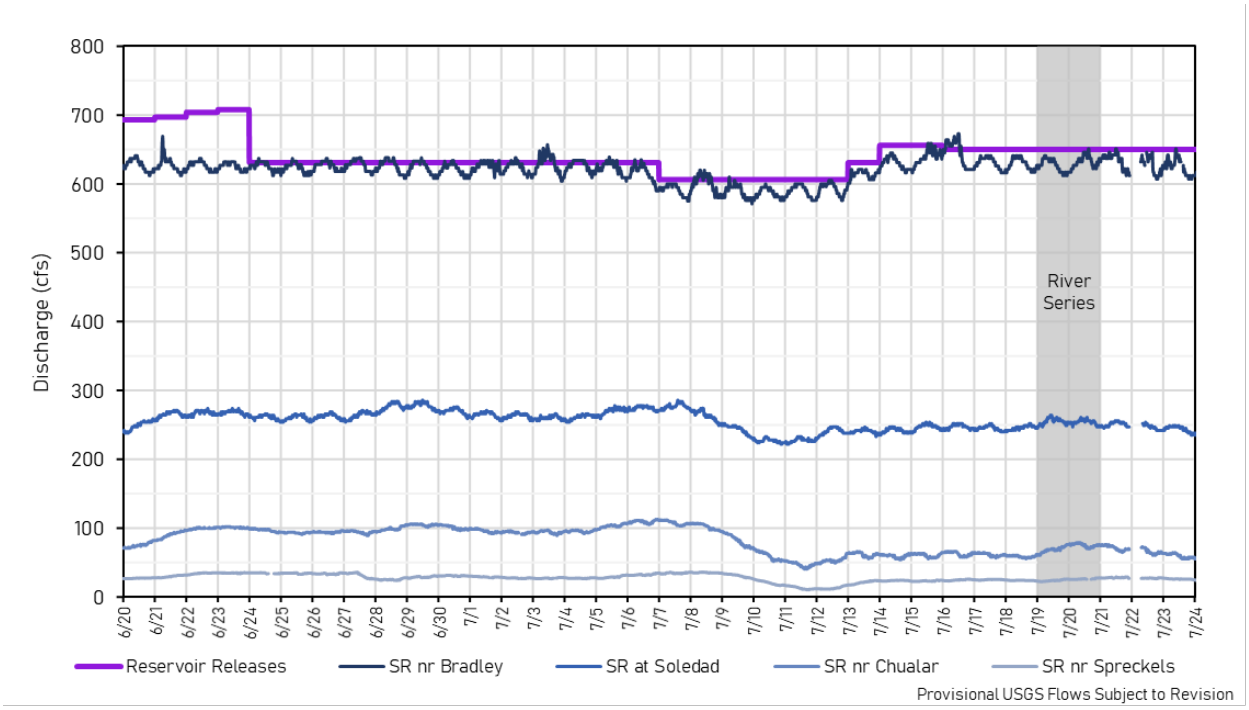

Figure 2. Reservoir Releases and Salinas River Discharge at USGS Gages

River Series measurements were coordinated with USGS staff to coincide with their routine monthly calibration measurements at the five USGS automated gage stations on the Salinas River. USGS staff performed measurements at established USGS gages. Agency staff performed measurements at the San Lucas (river mile 78.8), King City (river mile 68.3), Greenfield (river mile 56.5), Gonzales (river mile 35.2) and T&A, a site approximately two miles south of the town of Spreckels (river mile 17.0) sites. All Agency measurements were collected using an acoustic doppler velocimeter.

The San Lucas site was relocated during the 2018 survey after access issues at the previously established site (river mile 80.6). The relocated site (river mile 78.8) has been utilized for every survey since 2018. The Spreckels site was temporarily relocated to river miles 13.5 and 13.2 during the 2017-2018 and 2019 river surveys, respectively, due to construction but was returned to the original site (river mile 13.0) in 2020. The 2021 River Series occurred slightly earlier in the summer than in recent years, due to the low volume of water in the reservoirs resulting in a shortened conservation season.

Discharge (Q) results for each site are summarized in Table 1 and graphed by river mile in Figure 3. The changes in flow (ΔQ) between measurement sites, referred to as a 'river reach' and reach-to-reach loss rates (ΔQ/RM) are summarized in Table 2.

Table 1. Discharge Measurement Results for 2021 River Series					
Measurement Site Name	River Mile (RM)	Measurement			Discharge Q (cfs)
		Date	Time	Source	
San Antonio		7/20/2021	7:00	MCWRA	240*
Nacimiento		7/20/2021	8:30	USGS	410
Combined Reservoirs	104	7/20/2021	7:00	MCWRA	650**
Bradley	97.5	7/20/2021	10:46	USGS	637
San Lucas	78.8	7/20/2021	8:01	MCWRA	510
King City	68.3	7/20/2021	12:01	MCWRA	419
Greenfield	56.5	7/21/2021	8:43	MCWRA	329
Soledad	46.7	7/20/2021	13:14	USGS	258
Gonzales	35.2	7/19/2021	11:25	MCWRA	138
Chualar	27.8	7/20/2021	10:57	USGS	74.8
T&A	17	7/19/2021	9:07	MCWRA	28.3
Spreckels	13	7/20/2021	13:29	USGS	26.4

* Reservoir releases as reported by the Agency
**Combined release from San Antonio releases and Nacimiento USGS Station

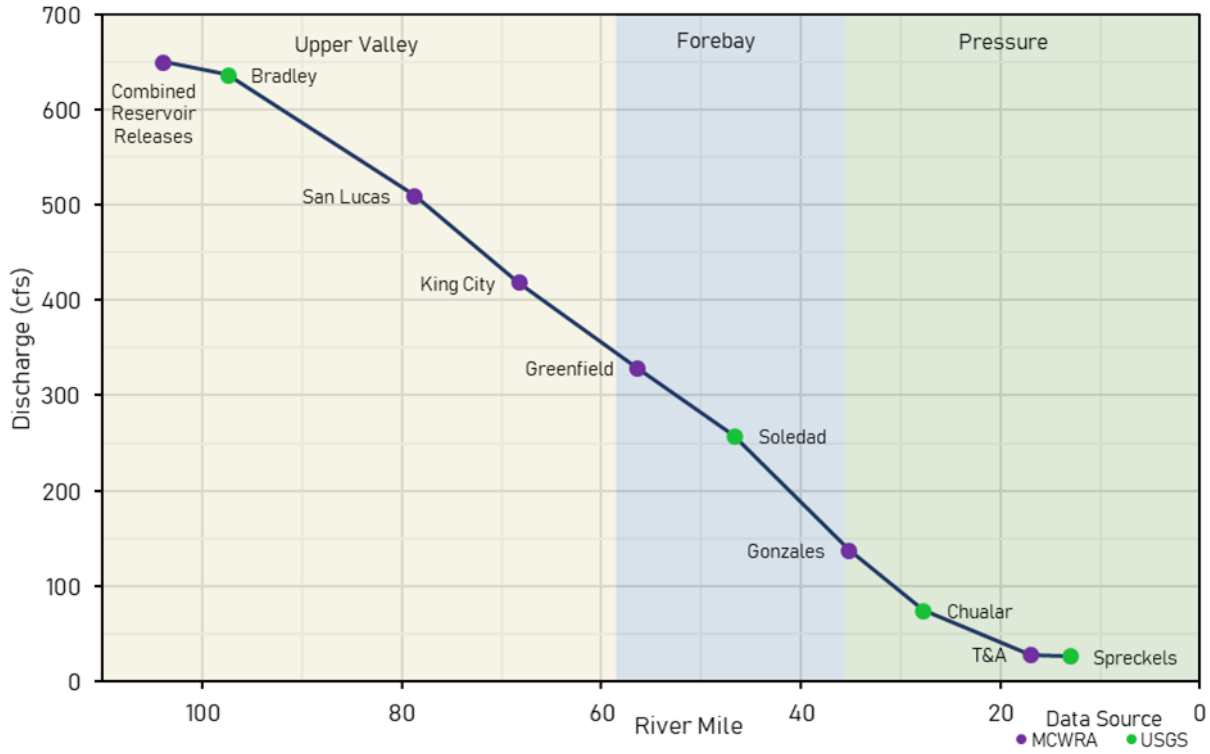

Figure 3. Discharge Measurement Series Results for the 2021 Salinas River Series

Table 2. Flow Loss Rates by River Reach					
River Reach	Upstream River Mile	Downstream River Mile	Length of Reach (miles)	ΔQ (cfs)	ΔQ/RM (cfs/mile)
Reservoirs- Bradley	104	97.5	6.5	13	2.0
Bradley- San Lucas	97.5	78.8	18.7	127	6.8
San Lucas- King City	78.8	68.3	10.5	91	8.6
King City- Greenfield	68.3	56.5	11.8	90	7.6
Greenfield- Soledad	56.5	46.7	9.8	71	7.3
Soledad- Gonzales	46.7	35.2	11.5	120	10.4
Gonzales- Chualar	35.2	27.8	7.4	64	8.6
Chualar- T&A	27.8	17	10.8	47	4.3
T&A- Spreckels	17	13	4	2	0.5
Chualar- Spreckels *	27.8	13	14.8	48	3.3

* Included for comparison of loss rates discussed in text

During the April through October conservation season, Salinas River flows are maintained by the modulated release of accumulated winter and spring flows stored in Nacimiento and San Antonio reservoirs. The Salinas River is predominantly a losing stream, meaning the amount of flow decreases downstream as water from the river recharges the underlying aquifers, or is taken up by riparian vegetation. By contrast, a gaining stream would show an increase in the amount of flow downstream as groundwater was discharged to the surface water system. Table 1 and Figure 3 show that all of the 2021 measurements decreased downstream, indicating an entirely losing stream for the sampled portion of the Salinas River. By taking the difference between the combined reservoir releases and the flow at the most downstream Spreckles station, the total flow lost over the 91 miles of the River Series would be:

$$650 \text{ cfs} - 26 \text{ cfs} = 624 \text{ cfs}$$

Assuming the reservoir releases remained constant over a twenty-four hour period, this loss rate can be converted to a daily volume for comparison to water stored in the reservoirs. Using a conversion factor of 1 cfs to 1.983 acre-feet/day, this loss rate would equate to 1,237 acre-feet per day lost between the two stations.

$$1{,}289 \text{ acre-feet/day} - 52 \text{ acre-feet/day} = 1{,}237 \text{ acre-feet/day}$$

A total flow loss of 624 cfs suggests that on average 6.86 cfs are lost every river mile. However, flow is not lost at the same rate throughout the entire system. Variations in loss rates across the different reaches can be seen in loss rate hydrographs (Figure 4). These hydrographs compare 2021 discharge loss rates per river mile (ΔQ/RM) to the mean loss rates for each reach. Mean loss rates are calculated from the reference period of 1995-2011, the most recent extended period of consecutive years in which River Series surveys were conducted. This period immediately preceded the recent five-year drought (2012-2016), during which conservation releases were curtailed due to lack of available water and no River Series measurements were performed.

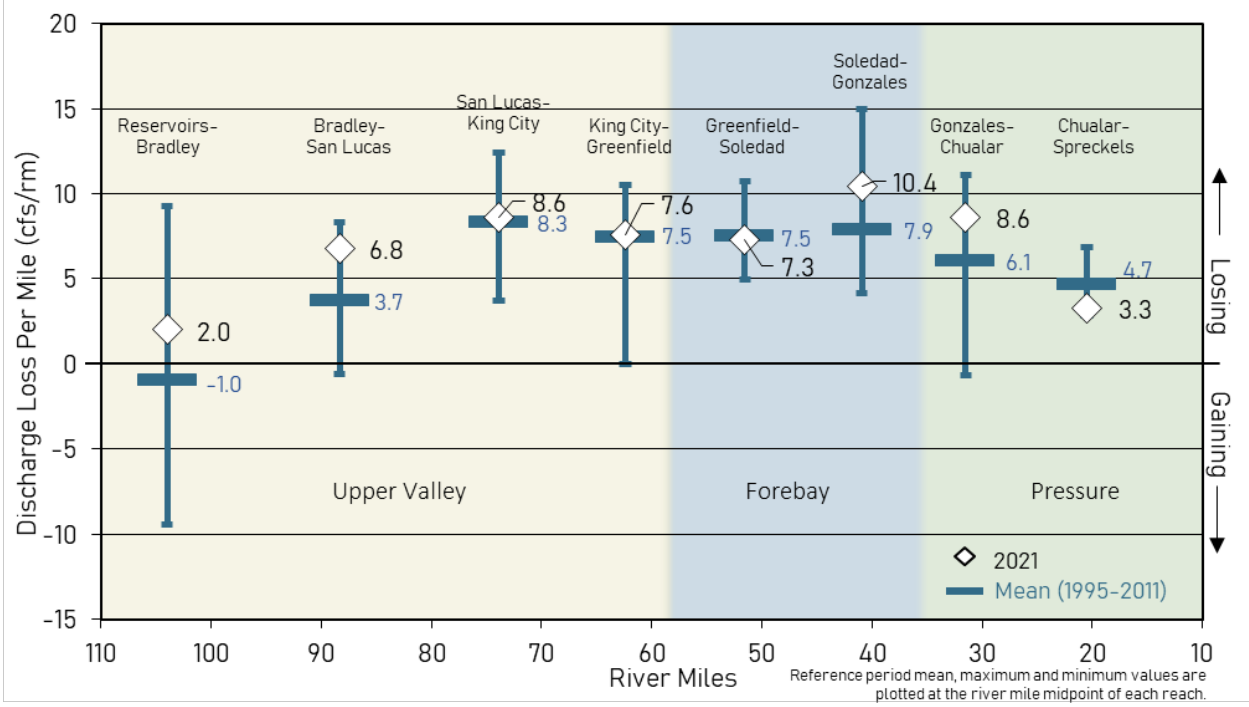

Figure 4. Comparison of 2021 Reach-to-Reach Discharge Loss Rates to 1995-2011 Loss Rate Ranges

Historically, the only section of the Salinas River considered a gaining reach, or having a loss rate less than zero, is the stretch between the confluence of the reservoirs and Bradley in the Upper Valley (-1.0 cfs/rm on average). River Series data collected since end of the recent drought has showed this reach has shifted to a losing reach, including a loss of 2.0 cfs/rm recorded during the 2021 series. This reach remained the lowest loss rate observed during the 2021 series. The San Lucas-to-King City reach, which historically has the highest loss rates in the system (8.3 cfs/rm on average) saw a smaller reach loss rate in 2021 (8.6 cfs/rm) compared to recent years (10.6 cfs/rm in 2020, 12.7 cfs/rm in 2019). This reach is characterized by galleries of production wells in direct hydraulic communication with the Salinas River. Continuing downstream, 2021 loss rates remained similar to reference period averages through the King City-to-Greenfield and Greenfield-to-Soledad reaches. The Soledad-to-Gonzales reach saw the highest loss rate in the 2021 River Series (10.4 cfs). This reach and the Gonzales-to-Chualar reach saw above average loss rates in water year 2021, while the furthest downstream reach, Chualar-to-Spreckels, saw a below average loss rate.

The lowest loss rate observed during the 2021 River Series was 2.0 cfs/rm at the furthest upstream Reservoirs-to-Bradley reach. The next lowest loss rate was in the furthest downstream reach, Chualar-to-Spreckels (3.3 cfs/rm), over strata dominated by low permeability clay layers of the 180/400-Ft Aquifer Subbasin, followed by the Bradley-to-San Lucas reach (6.8 cfs/rm), located within the hydrogeologically constricted portion of the Upper Valley. Overall, half of the reaches showed 2021 loss rates exceeding reference period averages, and three reaches remaining similar to their reference period averages (within +/- 4% difference).

The flow lost during the 2021 River Series can also be compared with the River Series since the 2012-2016 drought. Figure 5 shows the variability in hydrologic conditions and water year types under which reservoir releases and Salinas River flows have been managed in order to deliver similar downstream flows to Spreckels. For example, water year 2017 was a wet year, followed by a dry-normal year in 2018, a wet year in 2019, a dry-normal year in 2020 and a dry year in 2021. Overall, there has been a decreasing trend in the amount of total flow lost between the reservoirs and Spreckels since the end of the drought. However, water year 2021 was the first year this trend reversed, with more flow being lost to the system than in the previous year. Several factors can impact flows and flow losses in the Salinas River including weather, riparian vegetation, groundwater extractions, surface diversions, the degree of aquifer depletion and antecedent moisture conditions which reflect the degree of saturation in the subsurface.

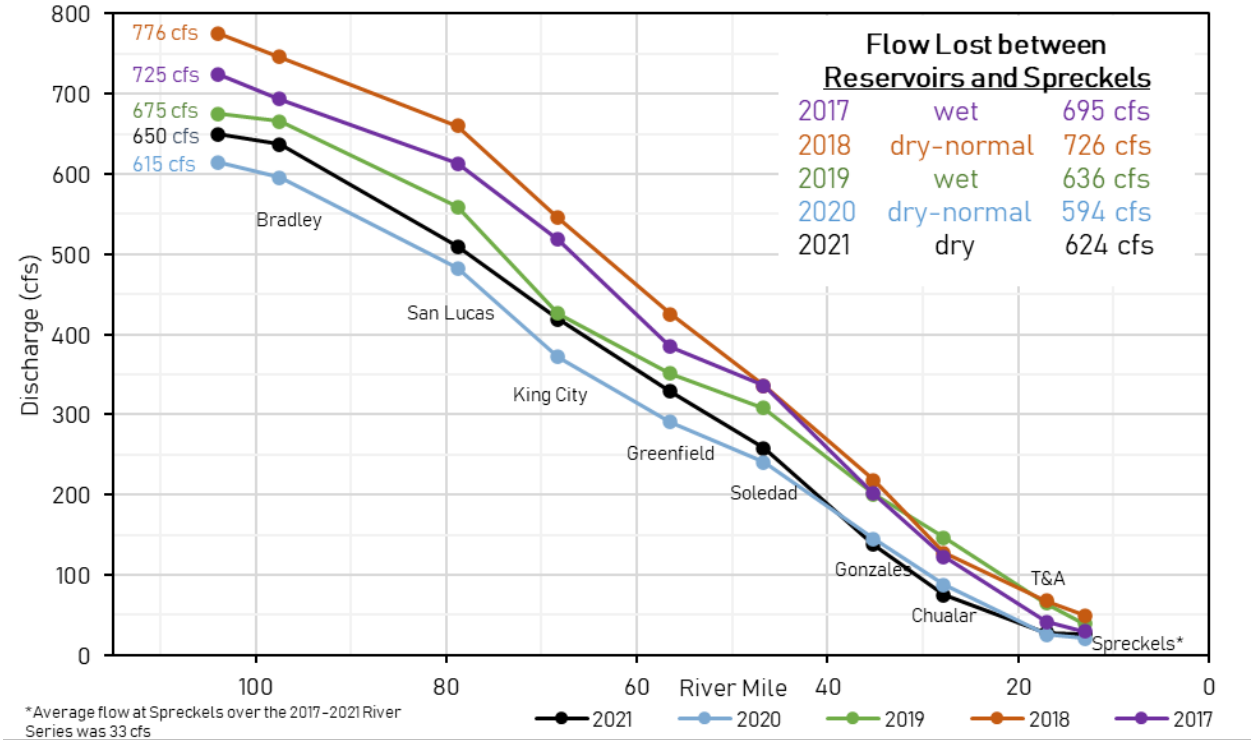

Figure 5. 2021 Discharge Measurements Compared to 2017-2020 River Series

One way to evaluate antecedent groundwater conditions is by looking at the water year type and timing of natural flows in the system. While the River Series occurs in late summer, usually after several months of conservation releases, natural flows can indicate the amount of groundwater recharge that occurred during the winter and spring recharge period. For example, frequent rainfall over an extended period of time allows for the subsurface to become saturated, which promotes groundwater recharge, while times with episodic storms may only penetrate the top portion of the subsurface and potentially dry out before recharging the aquifers. There has been a range in the frequency and intensity of natural flows in the years since the drought, as illustrated by the mean daily discharge at the USGS Arroyo Seco near Reliz streamgage (Figure 6). This gage is often used to represent unimpaired, natural flows in the Salinas Valley watershed. Some years saw

continuous flow in the Arroyo Seco throughout the winter and spring, while others only saw a few rain events that resulted in short periodic flows. Even though each of the 2017-2021 annual River Series events all documented an entirely losing system, the frequency, duration, or intensity of natural flows was not strongly correlated to the amount of flow lost during the River Series. It should be noted that other variables besides natural flows may need to be considered to better represent antecedent groundwater conditions and their impact on flow in the Salinas River.

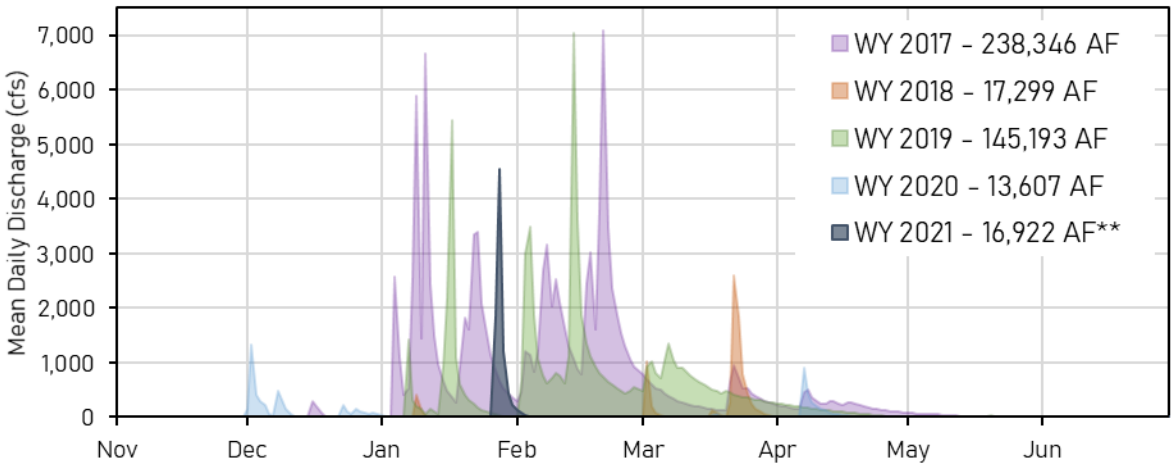

Figure 6. Mean Daily Discharge by Water Year at the USGS Arroyo Seco near Reliz Gage

Another factor that can influence flow losses in the river is the degree of aquifer depletion, which can be thought of as the long-term decline in groundwater levels and groundwater in storage due to pumping. If groundwater levels are lower than average, there is more aquifer storage available to accept recharge from the river system, compared to when groundwater levels are higher. Figure 7 shows the average groundwater elevations in the Forebay subarea over the last decade. The first year of the drought had little impact on groundwater levels, but 2013-2016 saw a steep basin-wide decline in groundwater levels. In water year 2017, the first wet year following the drought, groundwater levels showed a rapid recovery, followed by a slower but continual recovery through 2019. By water year 2020, groundwater levels started to stabilize or slow in their recovery from drought levels. The return of groundwater levels to pre-drought levels, with the exception of the Deep Aquifers and the East Side Subarea[1], indicated a lessening in the degree of aquifer depletion by water year 2020. However, water year 2021 was the first year since the recent drought where groundwater levels started to decline again. This reversal in the groundwater level trend may explain the higher amount of flow that was lost in the 2021 River Series compared to the previous year.

[1] The Quarterly Conditions Report shows groundwater elevations for the major aquifers and subareas in the Salinas Valley, and is updated every quarter of the water year. These reports can be accessed at: https://www.co.monterey.ca.us/government/government-links/water-resources-agency/documents/quarterly-salinas-valley-water-conditions

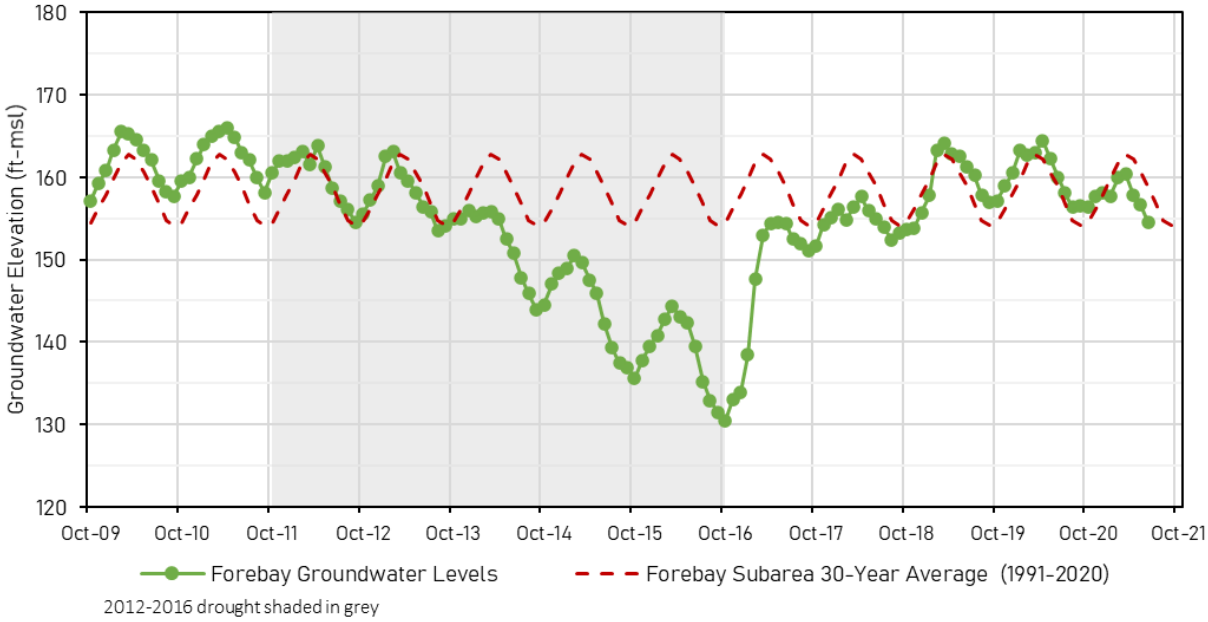

Figure 7. Groundwater Level Trends in the Forebay Subarea

Some of the aforementioned factors may have a larger impact on flows and flow loss rates in some reaches of the river than others. The extent to which these variables may contribute to reach-to-reach loss rates in the Salinas River is beyond the scope of this memorandum but warrants further investigation. These variables may be better quantified in the future using tools such as the Salinas Valley Integrated Hydrologic Model (SVIHM).

Overall, the 2021 River Series documented an entirely losing system with 624 cfs, or 1,237 acre-feet per day, lost across the ninety-one sampled river miles. Half of the reaches saw loss rates exceeding, or losing more water than, their reference period averages, while three reaches saw loss rates similar to their reference period averages. The 2021 River Series recorded more flow lost than in the previous year, reversing a decreasing trend observed in the River Series since the 2012-16 drought. This comes as the Salinas Valley faces its second consecutive water year with dry or dry-normal water conditions, groundwater elevations falling for the first time since their post-drought recovery, a shortened reservoir conservation release season, and the entire county now experiencing extreme drought conditions.