WATER RESOURCES AGENCY

M E M O R A N D U M

Monterey County

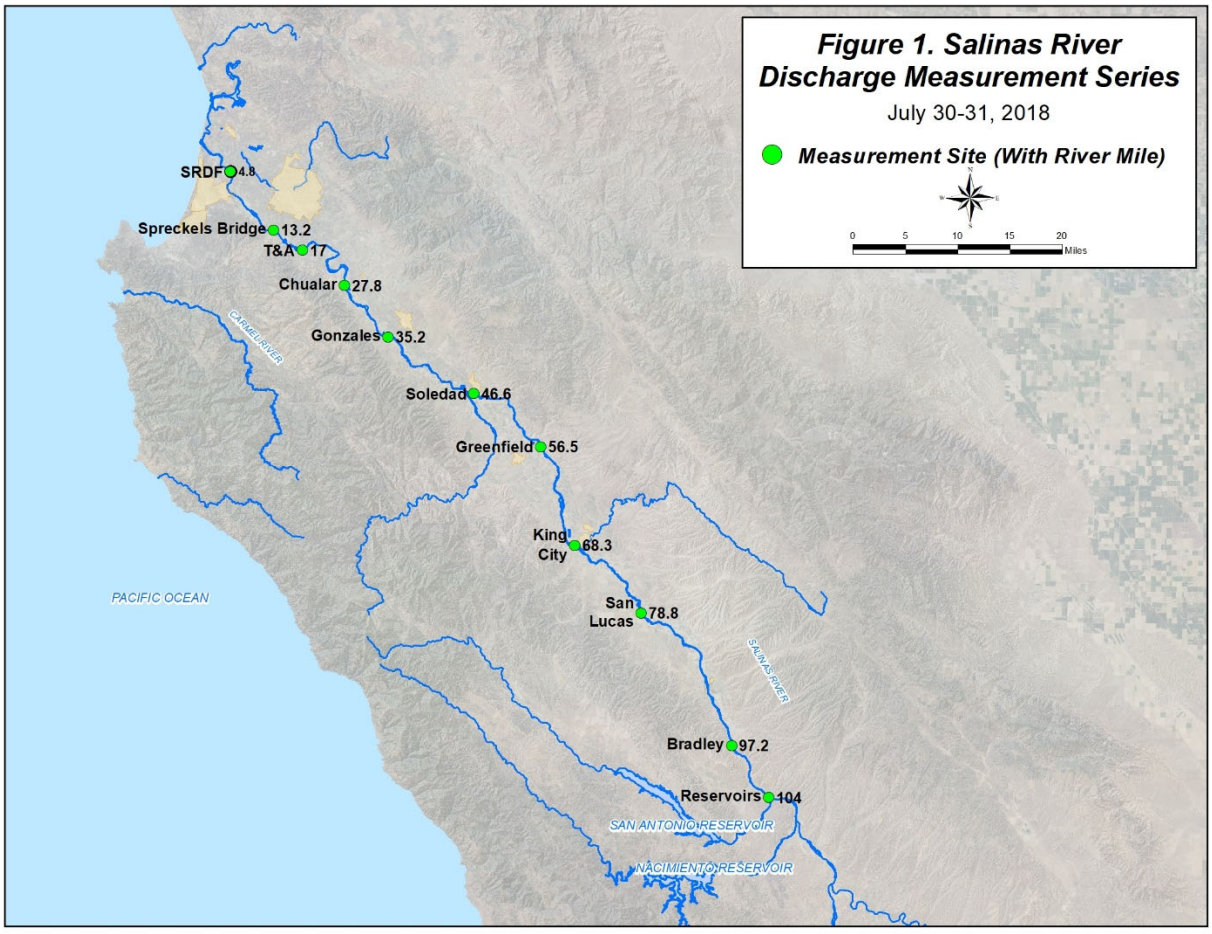
DATE: 12/12/2018

TO: File

FROM: Peter Kwiek

SUBJECT: 2018 Salinas River Discharge Measurement Series Results

Direct streamflow discharge measurements were performed over a twenty-four-hour period (7/30/2018-7/31/2018), by Agency and US Geological Survey staff at Salinas River sites within Monterey County located downstream of flows released from Nacimiento and San Antonio Reservoirs within a larger five-



day window during which engineered combined reservoir releases were held at steady rate of approximately 776 cubic feet per second (cfs) (see location map, Figure 1).

Measurement sites were selected to supplement monthly calibrated automated USGS streamflow gages on the Salinas River near the towns of Bradley, Soledad, Chualar and Spreckels. As was the case for the Agency's 2017 River Series, USGS staff performed supplementary measurements at two Salinas River sites between the automated gages at Bradley (river mile [RM] 97.5) and Soledad (RM46.7), to increase hydrologic resolution: These supplementary sites were located at the pedestrian bridge near King City (RM68.3) and a "San Lucas" site approximately 0.25 miles downstream of the San Lucas Bridge. The San Lucas site (RM78.8) was field-identified and selected during the survey (7/30/2018) due to unexpected access issues which prevented measurement from the previously established San Lucas site (RM80.6). All other sites have pre-existing facility status, with measurement histories dating back at least ten years. All measurements in this survey were performed utilizing an acoustic doppler *FlowTracker*. Compiled discharge measurement results (Q) are summarized along with derived reach-to-reach flow losses (ΔQ) and estimated reach-to-reach loss rates (ΔQ/RM) in Table 1. Discharge measurements are also graphed in Figure 2.

Table 1. 2018 Salinas River Discharge Measurement Series Results

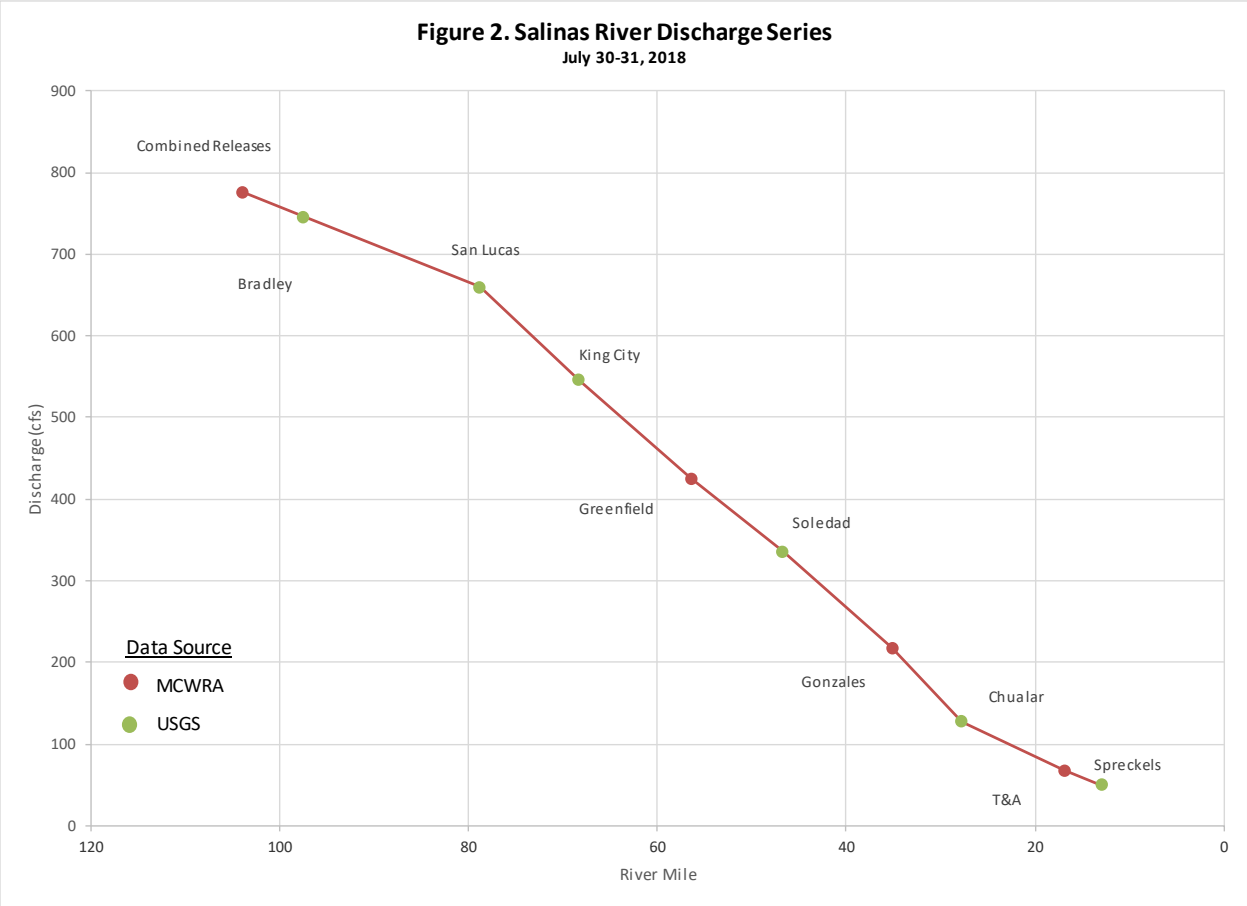
Site Name	River Mile	Measurement Date	Measurement Time	Data Source	Q (cfs)	ΔQ (cfs)	ΔQ/RM (cfs/mi)	River Reach°
Reservoirs*	104	7/30/2018	12:00	MCWRA	776			
Bradley	97.5	7/30/2018	11:10	USGS	746	-30	4.6	Res-Brad
San Lucas	78.8	7/30/2018	9:49	USGS	660	-86	4.6	Brad-SL
King City	68.3	7/30/2018	11:27	USGS	546	-114	10.9	SL-KC
Greenfield	56.5	7/30/2018	9:49	MCWRA	425	-121	10.3	KC-Gf
Soledad	46.7	7/30/2018	13:07	USGS	336	-89	9.1	Gf-Sol
Gonzales	35.2	7/30/2018	13:08	MCWRA	218	-118	10.3	Sol-Gon
Chualar	27.8	7/30/2018	13:24	USGS	128	-90	12.2	Gon-Ch
T&A	17	7/31/2018	9:08	MCWRA	68	-60	5.6	Ch-T&A
Spreckels**	13	7/30/2018	14:42	USGS	50	-18	4.5	T&A-Spr
						-78	5.3	Ch-Spr***

°Reach Name Abbreviations: Res= Nacimiento and San Antonio Reservoirs, as measured at the confluence of the Salinas and San Antonio Rivers; Brad=Bradley; SL = San Lucas; KC = King City = Gf = Greenfield; Sol = Soledad; Gon = Gonzales; Ch = Chualar; T&A = Tanimura & Antle; Spr = Spreckels

*Reservoir total as Reported as Total Release by Agency as of 12:00 PM.

**Gage site temporarily re-located downstream of bridge during bridge construction.

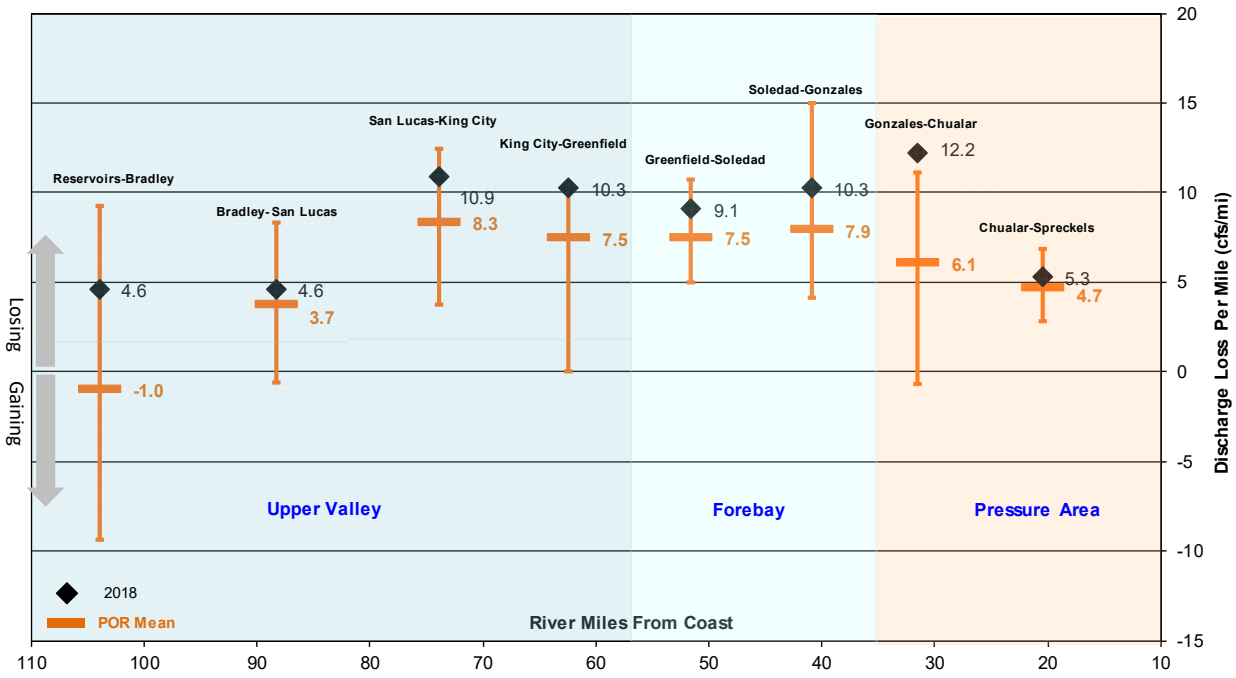
***Included for historical comparison



Historically during the April through October "conservation season," Salinas River flows are maintained not by rainfall runoff or groundwater interflow but by releases from the Nacimiento and San Antonio reservoirs. The Salinas River is normally a "losing stream" during the conservation season, meaning that flow steadily decreases in a downstream direction, as water percolates into the shallow alluvium, ultimately recharging underlying aquifers. An exception is the seven-mile Upper Valley Reservoirs-to-Bradley reach which typically adds surface flow to the river, making it a "gaining" reach. 2018 River Series data presented in Figure 2 and Table 1 illustrate that over the 91-mile reach encompassed within the survey (RM104 to RM13), the Salinas, including the normally gaining Reservoirs-to-Bradley reach, was entirely a losing stream. This results in the entirely downward river series slope of Figure 2 and is also illustrated in Figure 3, which plots calculated 2018 discharge loss rates along with average loss rates for the period 1995-2011, for each reach. Notably, 2018 loss rates exceeded long-term averages for every reach, and Reservoirs-Bradley became a losing reach. As shown in Figure 3, loss rates varied from reach to reach with the highest rates (ranging from 9 to 12 cfs/rm) occurring over a fifty-mile segment from San Lucas to Chualar, a reach which spans all or part of three

hydrologic subareas: the northern portion of the Upper Valley, the entire Forebay and the southern Pressure subarea.

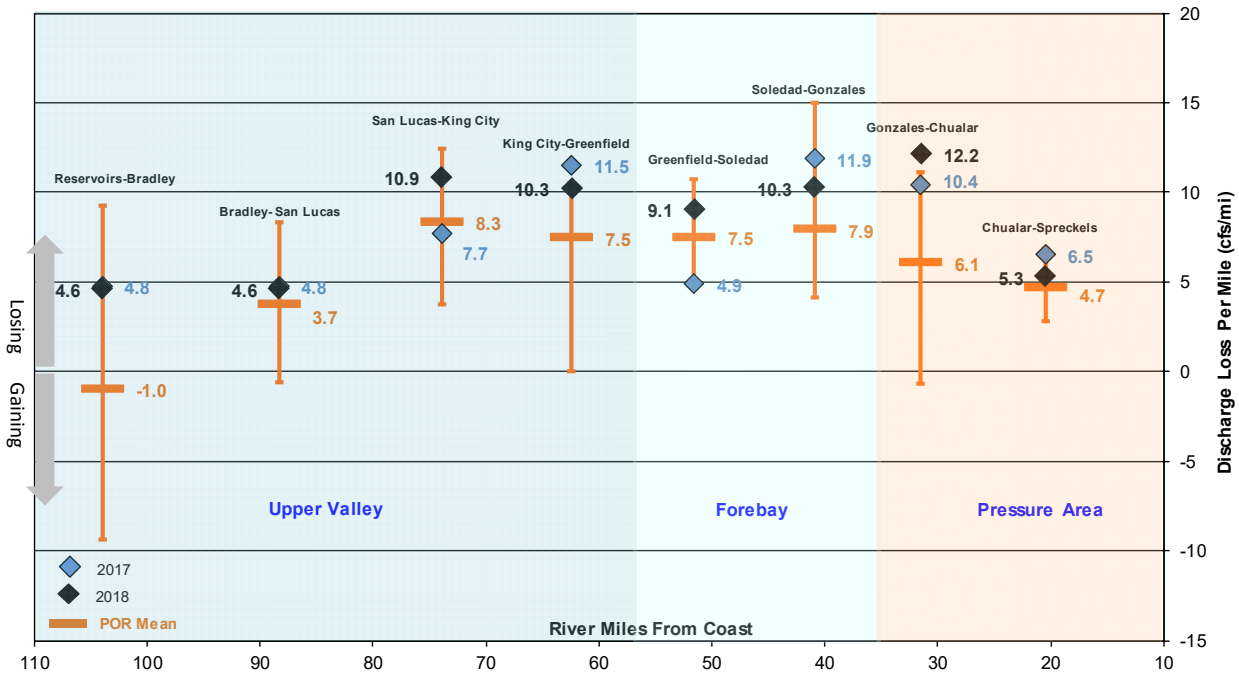
Figure 3: Comparison of 2018 Salinas River Reach-to-Reach Discharge Loss Rates with Loss Rate Ranges, 1995-2011



Total losses during 2018 measurements: 776 cfs (releases) - 50cfs (Spreckels) = 726cfs.
Measurement period-of-record mean, maximum and minimum values are plotted at the river mile midpoint of each reach.

2017 loss rates are added to the same graph in Figure 4 for further comparison. Both 2018 and 2017 river series show high loss rates in all subareas, relative to long term averages composed of data from past river series.

Figure 4: Comparison of 2018 & 2017 Salinas River Reach-to-Reach Discharge Loss Rates with Loss Rate Ranges, 1995-2011

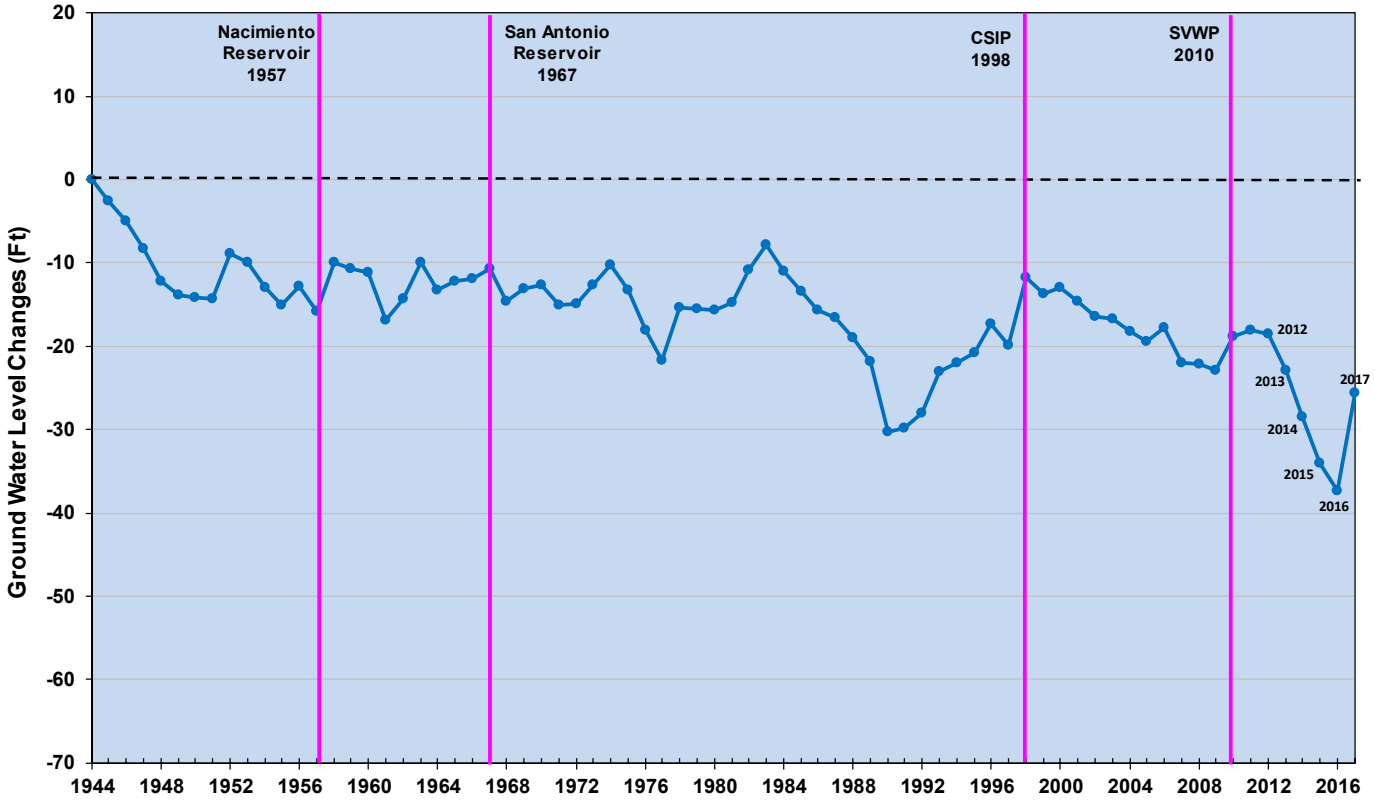


Total losses during 2018 measurements: 776 cfs (releases) - 50cfs (Spreckels) = 726cfs.
Total losses during 2017 measurements: 725 cfs (releases) - 30cfs (Spreckels) = 695 cfs.
Measurement period-of-record mean, maximum and minimum values are plotted at the river mile midpoint of each reach.

Key interrelated variables affecting flow loss rates include groundwater extractions, surface diversions, evaporation, transpiration and regional antecedent shallow groundwater conditions which are affected by natural and operational factors. Antecedent conditions can be thought of as the degree to which the subsurface has been saturated (or dewatered) by infiltration of rainfall-runoff (or lack thereof) on a regional scale, occurring in the recent past over a period spanning weeks to years. Analysis of the extent to which these variables may have played a contributing role in driving recent reach-to-reach loss rates in the Salinas River is beyond the scope of this technical memorandum but warrants further investigation. Although groundwater extraction data for 2017 and 2018 are not yet available, during the drought (2012-2016), total groundwater extractions throughout the Salinas Valley generally trended upward in all subareas and conservation releases from the reservoirs were halted for three consecutive years (2014-2016) due to a lack of water in storage. Groundwater level data indicate that the first drought year had minimal impact on groundwater levels but that 2013-2016 saw a steep basinwide groundwater drawdown followed by a rapid partial recovery after a wet rainy season in 2017 (Figure 5).

Despite the high rainfall totals of 2017, historically low groundwater levels persisted in the Upper Valley and Forebay beyond the drought period (see Attachments H and I, Quarterly Water Conditions Report, 4th Quarter, 2018) and unprecedented reservoir releases were

Figure 5. Salinas Valley Groundwater Changes Since 1944



Note: Groundwater levels are basin-wide annual averages expressed as a cumulative change since 1944.

required to keep up with normal downstream water demands. This is illustrated in Figure 6, which shows a rapid increase of over 250,000 acre feet in Nacimiento Reservoir storage in the spring of 2017 followed by a steep drawdown, which persisted into the 2018 conservation season.

More recent groundwater levels sampled during the 2018 river series reveal that the basin has yet to fully recover from the drought (see Attachments E through I, Quarterly Water Conditions Report, 4th Quarter, 2018). Specifically, with the exception of the Pressure 400-Foot Aquifer and the Forebay Subarea, groundwater levels remained below their thirty-year averages at the end of water year 2018.

Figure 6. NACIMIENTO RESERVOIR DAILY STORAGE Since Water Year 2014

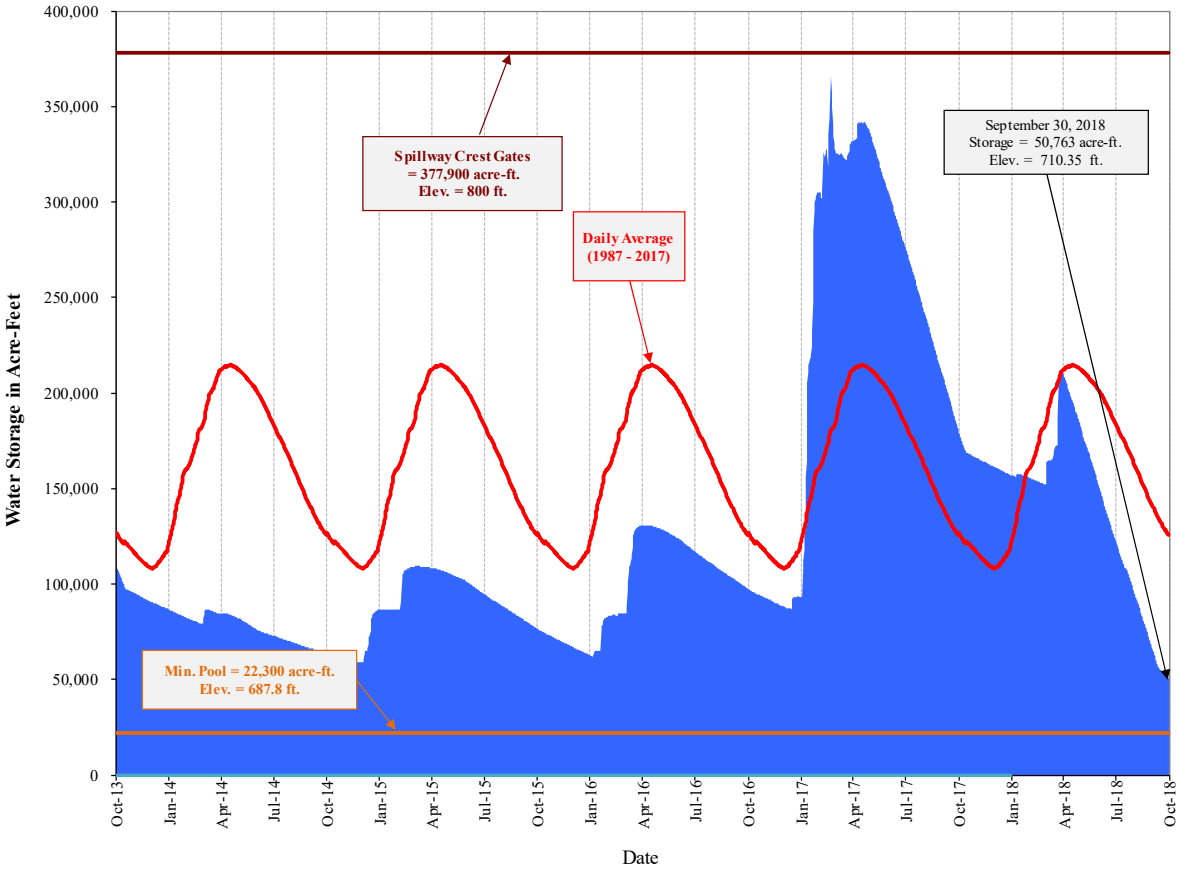


Table 2 summarizes reservoir release totals since 2000 during the months of June through September and total water volume delivered by operation of the Salinas River Diversion Facility (SRDF). A comparison of releases made during this "peak conservation season" illustrates that historically high reservoir releases were required in both 2017 and 2018 to meet water demands that were typical of conservation-season deliveries since operation of the SRDF began in 2010. A similarly high release total in 2013, the second year of the drought, corresponded with the highest SRDF delivery total to date.

Table 2. *Average June-September combined reservoir release rates (in cfs) along with total combined release volumes since 2000, and Salinas River Diversion Facility delivery totals (in acre-feet).*

Year	ADPCR*	TPCR*	SRDF-D*
2000	395	95,564	N/A
2001	426	103,051	N/A
2002	567	137,137	N/A
2003	454	109,904	N/A
2004	426	103,125	N/A
2005	293	71,020	N/A
2006	288	69,600	N/A
2007	447	108,228	N/A
2008	382	92,509	N/A
2009	522	126,298	N/A
2010	511	123,669	3,822
2011	426	102,972‡	3,046
2012	579	140,027	3,801
2013	625	151,313	6,105
2014	36	8,622	0
2015	79	19,178	0
2016	63	15,322	0
2017	776	187,773	4,512
2018	**611**	**147,847**	5,059
21stC*	453	109,601	N/A
SRDFE*	532	142,267	4,391

***Notes:**

ADPCR = Average Daily Peak Period Conservation Release rate (June 1-September 30)
TPCR = Total Peak Period Conservation Release volume (June 1-September 30)
SRDF-D = Water delivered though operation of the Salinas River Diversion Facility
SRDFE =Average SRDF era [2010-2018] values (excluding non-operational years 2014-2016)
21stC = Pre-2017 averages since 2000 (excluding non-operational years 2014-2016), i.e., 2000-2013.
‡ -Releases for SRDFE deliveries were halted in mid-August for SRDF repairs.

In summary, the scale of Salinas Valley Groundwater Basin aquifer depletion during the drought is reflected in the historically high Salinas River discharge loss rates observed in the river series of 2017 and 2018. The resumption in 2017 and 2018 of normal downstream demands (i.e., SRDF deliveries) following a five-year (2012-2016) drought required the largest two-year reservoir release total on record (See Table 2), as over 100 intervening miles of river bed replenished exceptionally thirsty aquifers.