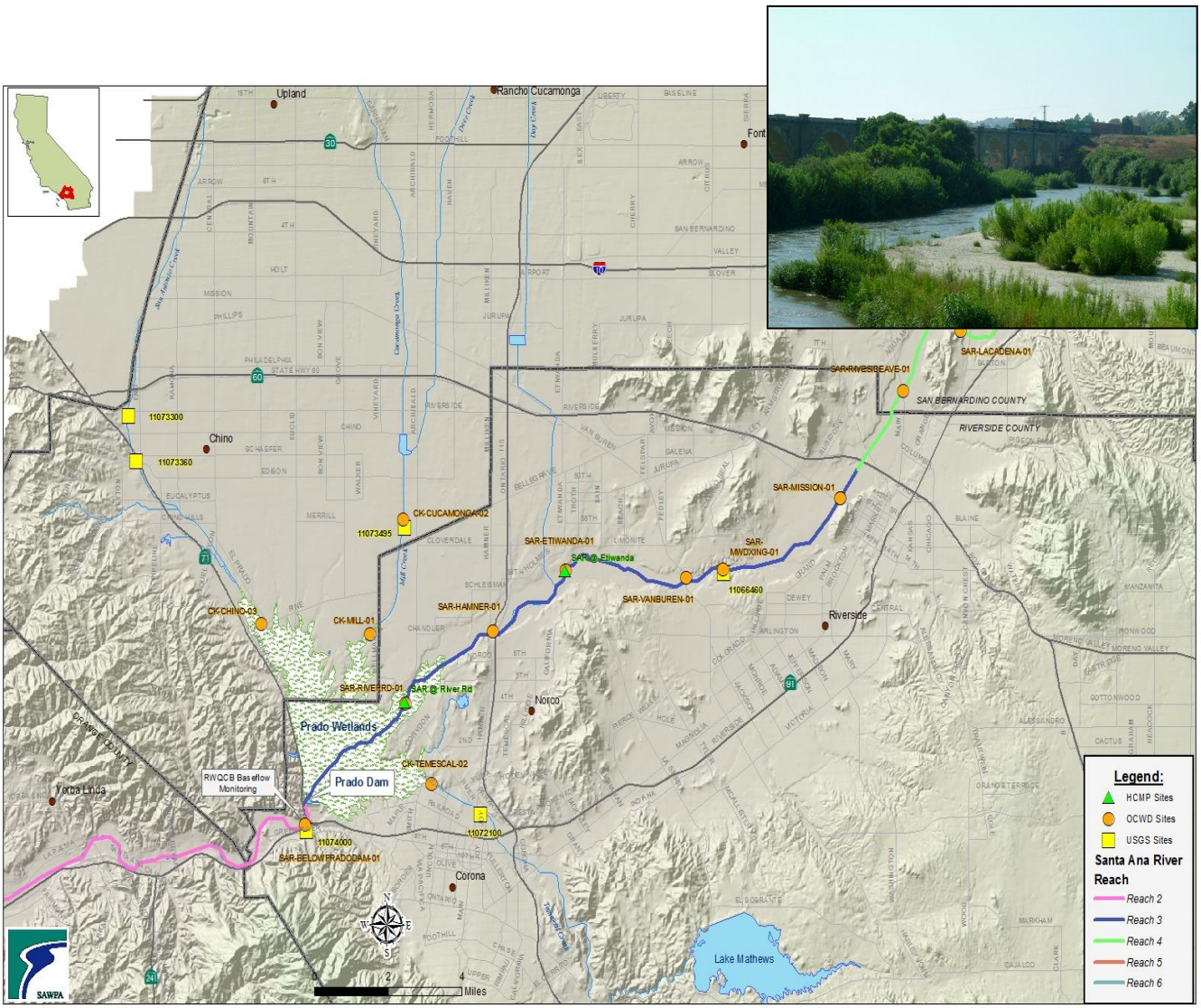
2018 Annual Report

of Santa Ana River Water Quality

Final Report



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Prepared by:

SANTA ANA WATERSHED PROJECT AUTHORITY

June 2019

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Acronym and Abbreviations List

AFY	acre-feet per year
COD	chemical oxygen demand
EC	electrical conductivity
HCMP	Hydraulic Control Monitoring Program
mg/L	milligrams per liter
umho/cm	micromhos per centimeter
MWD	Metropolitan Water District of Southern California
NTU	nephelometric turbidity units
OCWD	Orange County Water District
RIX	Regional Tertiary Treatment Rapid Infiltration and Extraction Facility
RWQCB	Regional Water Quality Control Board, Santa Ana Region
SAR	Santa Ana River
SAWPA	Santa Ana Watershed Project Authority
TDS	total dissolved solids
TIN	total inorganic nitrogen
TN	total nitrogen
USGS	United States Geological Survey

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1 Introduction

In 1996, the Nitrogen and Total Dissolved Solids (N/TDS) Task Force was formed to conduct scientific investigations regarding the then existing nitrogen and TDS water quality objectives of the 1995 Water Quality Control Plan for the Santa Ana River (SAR) Basin (Region 8). This Task Force, administered by the Santa Ana Watershed Project Authority (SAWPA) was comprised of 22 water supply and wastewater agencies. The work performed by the Task Force was broken out into a number of phases. In 2003, the Final Technical Memorandum was completed, which reported the results of this scientific investigation, *The TIN/TDS Study – Phase 2B of the Santa Ana Watershed Wasteload Allocation Investigation*.

As a result of this work, the Regional Water Quality Control Board (Regional Board) staff amended the Santa Ana River Watershed Water Quality Control Plan (Basin Plan). The Basin Plan Amendment (hereafter the 2004 Basin Plan Amendment) was adopted by the Regional Board in January 2004, approved by the State Water Resources Control Board in September 2004, and approved by the Office of Administrative Law in December 2004.

Pursuant to the 2004 Basin Plan Amendment, certain participants in the N/TDS Task Force are required to conduct the following investigations:

- Re-computation of the triennial Ambient Water Quality over a 20 year period; and
- Preparation of an Annual Report of Santa Ana River Water Quality.

This report fulfills the second requirement listed above – *Preparation of an Annual Report of Santa Ana River Water Quality*[1]. Contained within this report are water quality data required to implement the surface water monitoring program necessary to determine compliance with the nitrogen and TDS objectives of the SAR and, thereby, the effectiveness of the wasteload allocations.

In Chapter 4 of the Basin Plan, the baseflow TDS and total nitrogen objectives for Reach 3 of the River are specified. For Reach 2, a TDS objective based on a five-year, volume-weighted, moving average of the annual TDS concentration is also defined. The use of this moving average allows the effects of wet and dry years to be integrated over the five-year period and reflects the long-term quality of water recharged by Orange County Water District (OCWD) downstream of Prado Dam.

The Basin Plan specifies a monitoring program to determine compliance with the Reach 3 baseflow objectives at Prado Dam (see Chapter 4 of the Basin Plan), whereas baseflow is defined by the Basin Plan as composed of wastewater discharges, rising groundwater, and nonpoint source discharges. Regional Board staff conducts this program on an annual basis. The measurement of baseflow quality, rather than the quality of flows in Reach 2, has long been used to indicate the effects of recharge of SAR flows on Orange County groundwater. The efficacy of this approach was evaluated as part of the 2004 Basin Plan Amendment for the TDS/nitrogen management plan in the Basin Plan. As discussed in the 2004 Basin Plan Amendment, Reach 3 baseflow objectives are considered protective of the Orange County Groundwater Basin and the existing monitoring program designed to measure compliance is sufficient.

In addition to the baseflow sampling program and the surface water monitoring commitments associated with certain agencies' "maximum benefit" programs, the comprehensive monitoring program implemented by the Task Force members must include an evaluation of compliance with the TDS and nitrogen objectives for Reaches 2, 4, and 5 of the SAR. Compliance with the Reach 2 TDS objective can be determined by the evaluation of data collected by OCWD, the United States Geological Survey

[1] The 2018 Annual Report was prepared in accordance with the Santa Ana River Water Quality Work Plan approved by the Regional Board in Res. No. R8-2005-0063.

(USGS), and others. Compliance with Basin Plan objectives for Reach 4 and 5 of the SAR can be determined in the same manner.

A description of the data collected for this report is discussed in Section 2. Section 3 presents the analysis of the monitoring data collected. Results are presented by Reach of the SAR. Section 4 provides Conclusions and Recommendations of the report. Section 5 presents the Response to Comments. The complete set of 2018 surface water quality data is included as Appendix B on the enclosed CD.

2 Data Collection

Water quality and discharge data used to prepare the 2018 Annual Report of Santa Ana River Water Quality, were collected from a number of regional efforts to monitor surface water quality along the SAR and its tributaries, including in-stream gauges employed by USGS, shown in Figure 2-1.

A detailed description of each of these monitoring efforts, representing the 2018 calendar year follows:

Regional Board staff typically conducts annual water quality monitoring of baseflow in the SAR exiting Reach 3, below Prado Dam. Monitoring typically extends over a five-week period during the months of August and September and is used to determine compliance with Reach 3 baseflow objectives. In 2018 baseflow monitoring consisted of six sampling events from August 20 through September 24, as shown in Table 3-3. The complete set of 2018 baseflow water quality data collected exiting Reach 3 below Prado Dam by the Regional Board is included in Appendix B on the enclosed CD.

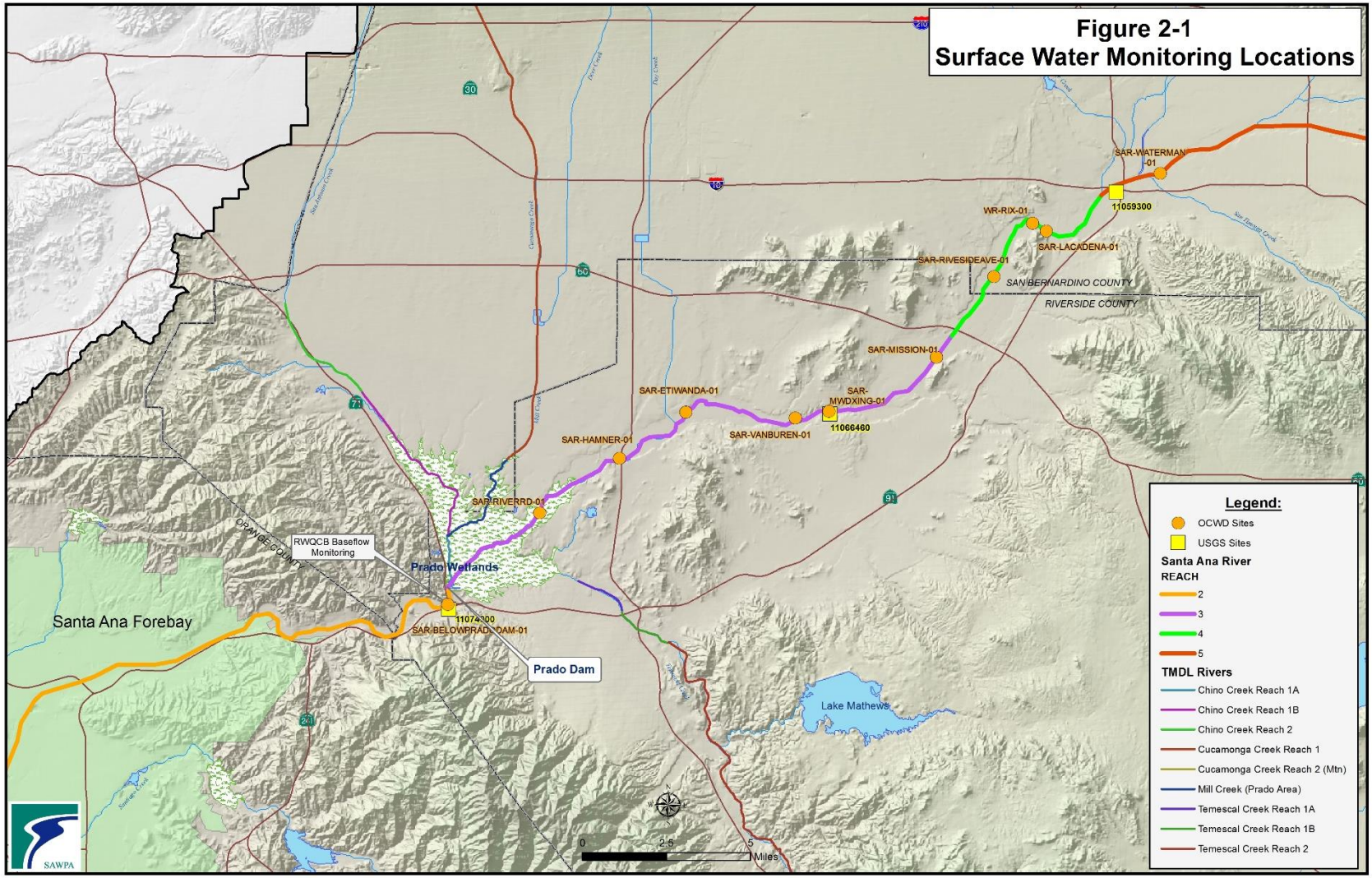
OCWD conducts a monitoring program for the SAR to assess the quality of the SAR water recharged into the Orange County Groundwater Basin. OCWD collects monthly and quarterly samples from the SAR at Imperial Highway in Anaheim and other locations along the SAR below Prado Dam and its tributaries. During the month of August, monitoring is performed with a greater sampling frequency to capture base flow conditions within the Watershed. At sites Above Prado Dam, OCWD collects samples from a single monitoring event in August (event took place on 08/14/2018). These data are used in this report to evaluate water quality for Reaches 2, 3, 4, and 5 of the SAR during low flow conditions. OCWD monitoring locations used in this report are presented in Table 2-1. In later tables and figures, OCWD stations are referred to by their map location. The complete set of 2018 SAR water quality data collected by OCWD and used in this report is included in Appendix B on the enclosed CD.

Table 2-1. OCWD's Santa Ana River Water Quality Monitoring Locations

Station ID	Station Name	Tributary	X Coordinate	Y Coordinate
8105	SAR-BELOWDAM-01	Santa Ana River Reach 2	- 117.644996	33.883665
8096	SAR-RIVERRD-01	Santa Ana River Reach 3	- 117.666485	33.948989
8111	SAR-HAMNER-01	Santa Ana River Reach 3	- 117.556597	33.947337
9672	SAR-ETIWANDA-01	Santa Ana River Reach 3	- 117.52223	33.967365
8112	SAR-VANBUREN-01	Santa Ana River Reach 3	- 117.465465	33.965049
8113	SAR-MWDXING-01	Santa Ana River Reach 3	- 117.448032	33.968027
8114	SAR-MISSION-01	Santa Ana River Reach 4	- 117.392523	33.991576
8115	SAR-RIVERSIDEAVE-01	Santa Ana River Reach 4	- 117.362809	34.02648
14655	WR-RIX-01	Santa Ana River Reach 4	- 117.342839	34.049706
8116	SAR-LACADENA-01 *	Santa Ana River Reach 4	- 117.33571	34.046335
8117	SAR-WATERMAN-01 *	Santa Ana River Reach 5	- 117.276721	34.071365

**No flow at these sites in 2018.*

Figure 2-1. Surface Water Monitoring Locations



The USGS maintains three active gauging stations to monitor flow and water quality along the SAR. Long-term stream flow and water quality data are available for gauging stations 11074000, *located at Below Prado Dam*, and 11066460, *located at MWD Crossing*. Additionally, stream flow data is available for gauging station11059300, located at *SAR at E St near San Bernardino*. The list of USGS gauging stations used in this report is presented in Table 2-2. The complete set of 2018 flow and water quality data available from these USGS gauging stations is included in Appendix B on the enclosed CD.

Table 2-2. USGS Stream Gauge Stations

USGS ID	Station Name	2018 Flow (AFY)	Tributary	X Coordinate	Y Coordinate
11074000	SAR Below Prado Dam	103,123	SAR Reach 2	- 117.644446	33.881583
11066460	SAR at MWD Crossing	43,827	SAR Reach 3	- 117.447501	33.966858
11059300	SAR at E St near San Bernardino	8,357	SAR Reach 5	- 117.729724	34.016857

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3 Analysis of Monitoring Data

3.1 Santa Ana River Reach 2

Table 4-1 of the Basin Plan specifies only a TDS objective for Reach 2 of the Santa Ana River. . The determination of compliance with the TDS objective for Reach 2 is made by using the mean of the five most recent flow-weighted annual averages as reported by the SAR Watermaster as shown in Table 3-1. In years of normal rainfall, most of the total flow of the river is percolated in the Santa Ana Forebay (see Figure 2-1), and directly affects the quality of the groundwater. For that reason, compliance with the TDS water quality objective for Reach 2 is based on the five-year moving average, which is estimated by computing the arithmetic average of the five most recent annual estimates of flow-weighted TDS for total flow at Below Prado (from Appendix F of the 2017-18 Annual SAR Watermaster Report[2]). Use of this moving average allows the effects of wet and dry years to be smoothed out over the five-year period.

Table 3-1. Yearly Volume-Weighted Moving Average TDS at Below Prado Dam (SAR Watermaster Report)

Water Year Ending *	Yearly Flow-weighted TDS (mg/L)
2014	582
2015	522
2016	560**
2017	408
2018	625
5 Year Average	539

Note: * Santa Ana River Watermaster data reported for FY 2017-18 water year
** FY 2015-16 water year data adjusted from 541 mg/L to remove the influence of non-tributary water transfer flow from OC59.

Alternative Method to Determine Compliance with TDS Objective for Reach 2

Additionally, an alternative methodology was employed using the data collected from OCWD and USGS. These data were plotted and a 60-month volume-weighted moving average[3] was calculated to provide an alternative measure to estimate compliance with this objective.

During the 2018 calendar year, 59 samples were collected for TDS at *Below Prado Dam*. These included grab samples collected by the USGS, OCWD and the Regional Board. From the results of these samples, electrical conductivity (EC) and TDS were graphically plotted. A linear regression of TDS versus EC yielded the following equation:

[2] Determination of flow-weighted TDS for total flow at Below Prado for Water Year 2017-18 is based on records from a continuous monitoring device operated by the USGS for EC of the river flow below Prado Dam. This record is supplemented by grab samples for EC collected by the USGS and analyzed for TDS. Using the daily EC data, flow-weighted average daily concentrations for TDS are calculated using the following best fit correlation equation:

TDS = EC x 0.6068 (where the units of TDS and EC are mg/L and umhos/cm, respectively)

[3]

$$5-Year\ Moving\ Average\ TDS\ (mg/L) = \frac{\left(\sum_{n=first\ month\ of\ 1st\ year}^{last\ month\ of\ 5th\ year} Monthly\ Flow\right) x \left(\sum_{n=first\ month\ of\ 1st\ year}^{last\ month\ of\ 5th\ year} Volume\ Weighted\ Monthy\ Average\ TDS\right)}{\left(\sum_{n=first\ month\ of\ 1st\ year}^{last\ month\ of\ 5th\ year} Monthly\ Flow\right)}$$

$$TDS = (EC \times 0.5756) + 33.713$$

The coefficient of determination (R^2) of the linear regression was 0.88, which indicates a strong correlation between TDS and EC; that is, about 88 percent of the variability in TDS is explained by this equation. Using the above equation and daily EC data from a continuous monitoring device operated by USGS, daily TDS values were calculated for 2018 data. Daily stream flow values at *Below Prado Dam* were multiplied by the computed TDS values and summed for each month. This total was divided by the total monthly flow in order to yield a volume-weighted average for each month. These results are shown in Table 3-2. The 5-year volume-weighted TDS average for the period January 2014 through December 2018 was 515 mg/L. This represents a decrease of 4.0 mg/L from last year's 5-year volume-weighted TDS average of 519 mg/L.

A 60-month , volume-weighted, moving average was calculated using these values in addition to historic flow-weighted TDS averages calculated by the SAR Watermaster. Figure 3-1 shows the time history for TDS observations for 1998 to the present at *Below Prado Dam* as depicted as the mean TDS concentration of five annual flow-weighted averages, and the flow-weighted, 60 month moving average[4] TDS concentration.

The 5-year moving average tends to slightly over-estimate the average TDS concentration likely to percolating from Reach 2 to the Orange County GMZ and the 60-month moving average tends to slightly under-estimate the average TDS concentration likely to percolate to the aquifer thru the streambed. Regardless of which method is used, the five-year, volume-weighted, moving average for TDS is the compliance metric for Reach 2. This statistic has never exceeded the Basin Plan objective of 650 mg/L for the period shown. The five-year, volume weighted moving average TDS concentration has decreased over time from the mid-1980s until about 2000 when TDS concentrations were observed to slightly increase. This upward trend continued until about 2004 when TDS concentrations dropped. Since 2008 there has been an increase in TDS concentrations.

During wet periods, not all of the water flowing from Prado Dam is captured for recharge in Orange County. Therefore, a volume-weighted average may not be representative of the quality of water actually recharged. For comparison, the five-year moving average TDS, based on discrete samples collected by OCWD, Regional Board, USGS, and by CBWM/IEUA for the HCMP through 2012, is plotted on Figure 3-1.

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$$Volume\ Weighted\ Monthy\ Average\ TDS\ (mg/L) = \sum_{n=first\ day\ of\ month}^{last\ day\ of\ month} \frac{Daily\ TDS\ Sample\ \left(\frac{mg}{L}\right) x\ Daily\ Flow\ (cfs)}{\sum_{n=first\ day\ of\ month}^{last\ day\ of\ month} Daily\ Flow\ (cfs)}$$

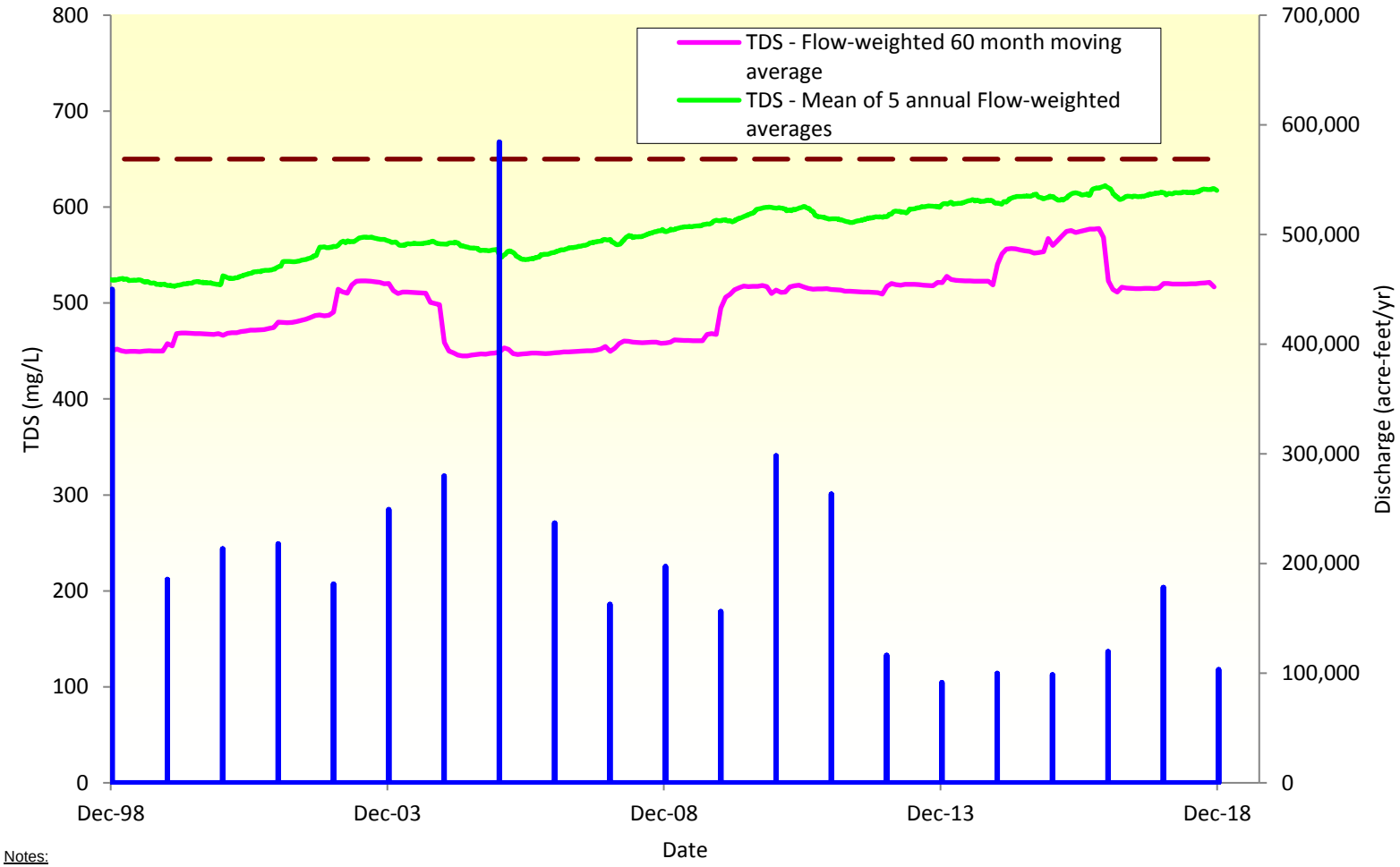
Table 3-2. Monthly Volume-Weighted Moving Average TDS at Below Prado Dam (2018 OCWD, USGS and Regional Board at Below Prado Dam)

Month	Monthly Flow (cfs-days)	Monthly Volume Weighted TDS (mg/L)	Monthly Flow X TDS
Jan-14	3,312	681	2,255,040
Feb-14	3,627	659	2,390,989
Mar-14	10,811	429	4,635,755
Apr-14	4,329	616	2,664,778
May-14	2,160	698	1,507,815
Jun-14	1,857	702	1,304,490
Jul-14	1,698	711	1,206,771
Aug-14	2,452	635	1,557,234
Sep-14	2,043	672	1,373,065
Oct-14	2,057	572	1,175,631
Nov-14	3,541	575	2,171,523
Dec-14	12,331	612	4,029,366
Jan-15*	8,443	558	4,713,608
Feb-15*	4,181	548	2,292,593
Mar-15	5,971	611	3,647,810
Apr-15	3,055	705	2,153,348
May-15	3,917	649	2,540,633
Jun-15*	2,031	658	1,335,858
Jul-15*	3,114	553	1,722,216
Aug-15*	1,975	594	1,173,280
Sep-15*	3,766	451	1,699,702
Oct-15	4,935	631	3,115,713
Nov-15	3,795	659	2,502,562
Dec-15	4,420	586	2,590,772
Jan-16	11,015	355	3,913,599
Feb-16	6,529	610	3,979,901
Mar-16 **	2,454	493	1,209,018
Apr-16	3,753	629	2,362,198
May-16	3,421	614	2,102,066
Jun-16 **	3,792	570	2,162,097
Jul-16 **	903	520	469,962
Aug-16	3,830	499	1,910,346
Sep-16	2,064	683	1,408,987
Oct-16 **	2,907	637	1,851,646
Nov-16	4,082	574	2,344,955
Dec-16	8,304	337	2,795,675
Jan-17	37,876	218	8,255,609
Feb-17	13,557	407	5,515,481
Mar-17	10,781	508	5,473,628
Apr-17 **	7,278	784	5,706,514
May-17	2,958	642	1,899,575
Jun-17 **	1,757	871	1,530,123
Jul-17	2,071	694	1,437,099
Aug-17	2,189	697	1,524,789
Sep-17	2,472	708	1,749,396
Oct-17	2,408	714	1,718,722
Nov-17	3,003	703	2,110,679
Dec-17	2,816	705	1,984,819
Jan-18	8,373	516	4,322,665
Feb-18	3,508	661	2,320,359
Mar-18	7,407	558	4,131,392
Apr-18	3,270	688	2,250,705
May-18	2,855	681	1,943,094
Jun-18	2,346	695	1,629,552
Jul-18	1,840	709	1,304,255
Aug-18	1,681	728	1,223,652
Sep-18 **	1,986	717	1,423,443
Oct-18	3,529	647	2,284,490
Nov-18	3,311	630	2,084,681
Dec-18	11,799	453	5,350,226
Total	**293,946**		**151,445,953**
60 - Month Volume Weighted Average: 515 mg/L			

*Note: *Denotes monthly results with missing EC readings due to instrumentation issues with USGS equipment Monthly Flow weighted results with missing EC used for missing days.*

*** Denotes monthly results with missing EC readings due to instrumentation issues with USGS equipment only available EC data was use.*

Figure 3-1. Total Dissolved Solids (TDS) Below Prado Dam



Notes:
TDS Weighted = Monthly flow weighted TDS calculated from EC. Data prior to October 2003 from Watermaster; October 2003 to December 2004 from WE Inc, 2005 to 2018 from SAWPA.

3.2 Santa Ana River Reach 3

3.2.1 Below Prado Dam

In order to determine whether water quality and quantity objectives for base flow in Reach 3 are being met, the Regional Board typically collects a series of grab and composite samples at *Below Prado Dam* during August and September when the influence of storm flows and nontributary flows is at a minimum. In 2018, there were no non-tributary flows and at this time of year there is usually no water impounded behind Prado Dam, the volumes of storm flows, rising water, and nonpoint sources discharges tend to be low, and the major component of base flow is municipal wastewater. Water quality objectives specified for Reach 3 of the SAR by the Basin Plan include TDS, hardness, sodium, chloride, Total Nitrogen (TN), sulfate, Chemical Oxygen Demand (COD) and boron. In 2018, baseflow monitoring below Prado Dam consisted of six sampling events conducted during the months of August and September. The data collected through this program are presented in Table 3-3.

Table 3-3. Results for 2018 Annual Baseflow Monitoring Program for the Santa Ana River at Below Prado Dam (Regional Board Data Only)

Parameter	Units	Basin Plan Objectives SAR Reach 3	8/20/2018	8/27/2018	9/4/2018	9/10/2018	9/17/2018	9/24/2018
Ammonia-Nitrogen	mg/L	***	0.27	0.23	0.28	0.19	0.28	0.19
Bicarbonate (as CaCO3)	mg/L		206	220	220	210	220	220
Boron	mg/L	**0.75**	0.42	0.34	0.37	0.34	0.35	0.31
Calcium	mg/L		70	97	94	91	84	87
Carbonate (as CaCO3)	mg/L		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chemical Oxygen Demand	mg/L	**30**	12	28	38	32	24	23
Chloride	mg/L	**140**	165	164	154	137	144	138
Electrical Conductivity	umhos/cm		1170	1170	1120	1090	1100	1000
Magnesium	mg/L		24	23	22	21	20	20
Nitrate-Nitrogen	mg/L		3.9	3.7	3.5	3.7	3.4	3.2
Nitrite-Nitrogen	mg/L		< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Organic Nitrogen	mg/L		0.61	0.57	0.49	0.41	0.37	0.29
Potassium	mg/L		17.2	15.4	15.6	15.6	16.1	17.8
Sodium	mg/L	**110**	135	136	125	129	127	126
Sulfate	mg/L	**150**	118	114	110	97	95	100
Total Alkalinity (as CaCO3)	mg/L		206	220	220	210	220	220
Total Dissolved Solids	mg/L	**700**	784	786	742	742	736	680
Total Hardness (as CaCO3)	mg/L	**350**	****	320	312	292	272	280
Total Inorganic Nitrogen	mg/L	**10**	4.2	4.0	3.7	3.9	3.7	3.4
Total Kjeldahl Nitrogen	mg/L		0.88	0.80	0.77	0.60	0.65	0.48
Total Nitrogen	mg/L		4.8	4.8	4.2	4.3	4.1	3.7
Total Organic Carbon (total)	mg/L		6.0	7.3	7.1	5.6	7.9	8.0

Notes: All nitrogen species filtered

*** *Santa Ana River Basin Plan specifies an un-ionized ammonia objectives for WARM designated surface water bodies including site specific objectives for the Santa Ana River and certain tributaries including the middle Santa Ana River, Chino Creek, Mill Creek (Prado Area), Temescal Creek, and San Timoteo Creek. Site specific objectives must be computed based upon temperature and pH.*

**** *8/20/19 Hardness value was deemed to be a laboratory error and disqualified from the dataset. See Section 5-Response to Comments for a detailed explanation.*

A summary of all baseflow monitoring data collected by the USGS, OCWD and the Regional Board at *Below Prado Dam* during 2018 along with Basin Plan objectives for baseflow conditions for SAR Reach 3 water quality are presented in Table 3-4. This includes six monitoring events conducted by the Regional Board for their annual water quality monitoring of baseflow in the SAR during August and September of 2018. OCWD conducted six baseflow monitoring events at Below Prado Dam in 2018. However, as the nitrogen species data collected by OCWD was not filtered, it was not used to evaluate the water quality objective for TIN. The USGS conducted monthly baseflow sampling events at Below Prado Dam in August and September 2018. Table 3-4 presents the results of this monitoring.

Table 3-4. Summary of Baseflow Water Quality Observations for the Santa Ana River at Below Prado Dam

Constituent	Units	Basin Plan Objectives SAR Reach 3	Baseflow Average	# of Samples
Ammonia-Nitrogen	mg/L	***	0.19	8
Ammonia-Nitrogen (unfiltered)	mg/L		0.26	6
Bicarbonate (as CaCO3)	mg/L		235	14
Boron	mg/L	**0.75**	0.34	11
Calcium	mg/L		91	11
Carbonate (as CaCO3)	mg/L		1.2	14
Chemical Oxygen Demand (unfiltered)	mg/L	**30**	22	10
Chloride	mg/L	**140**	154	14
Electrical Conductivity	umhos/cm		1188	77
Electrical Conductivity (field)	umhos/cm		1182	6
Fluoride	mg/L		0.37	8
Hydroxide (as CaCO3)	mg/L		<1.0	12
Magnesium	mg/L		21	11
Nitrate-Nitrogen	mg/L		3.5	8
Nitrate-Nitrogen (unfiltered)			3.0	6
Nitrite-Nitrogen	mg/L		0.08	8
Nitrite-Nitrogen (unfiltered)			0.05	6
Organic Nitrogen	mg/L		0.48	8
Organic Nitrogen (unfiltered)			0.80	6
Potassium	mg/L		15.5	11
Sodium	mg/L	**110**	125	11
Sulfate	mg/L	**150**	113	14
Total Alkalinity (as CaCO3)	mg/L		228	14
Total Dissolved Solids	mg/L	**700**	720	18
Total Hardness (as CaCO3)	mg/L	**350**	300	10
Total Inorganic Nitrogen	mg/L	**10****	3.7	8
Total Inorganic Nitrogen (unfiltered)			3.3	6
Total Kjeldahl Nitrogen	mg/L		0.70	6
Total Kjeldahl Nitrogen (unfiltered)			1.03	6
Total Nitrogen	mg/L		4.2	8
Total Nitrogen (unfiltered)			4.1	6
Total Organic Carbon (total)	mg/L		5.9	14
Turbidity	NTU		25.0	8

Notes: Table presents average concentration data

Table summarizes baseflow monitoring data collected by USGS, OCWD and the Regional Board at Below Prado Dam during 2018

*** - *Santa Ana River Basin Plan specifies an un-ionized ammonia objectives for WARM designated surface water bodies including site specific objectives for the Santa Ana River and certain tributaries including the middle Santa Ana River, Chino Creek, Mill Creek (Prado Area), Temescal Creek, and San Timoteo Creek. Site specific objectives must be computed based upon temperature and pH.*

**** - *Santa Ana River Basin Plan specifies that Total Nitrogen Samples are to be filtered*

The USGS also maintains a gauging station, 11074000, located on the SAR below Prado Dam, shown in Figure 2-1. In 2018, this station recorded flows totaling 103,123 AFY.

A long time-history of water quality data has been collected by USGS along with data collected by OCWD, Regional Board baseflow monitoring program, and by CBWM/IEUA at *Below Prado Dam* and *MWD Crossing*. These data were plotted for each constituent that has a Basin Plan objective for January 1998 through to current and are included in Appendix A, to show the longer-term trends in baseflow data, and non-baseflow water quality samples, as well as non-volume-weighted five-year moving averages.

3.2.2 Santa Ana River Mainstem between Riverside Narrows and Prado Wetlands

Monitoring of Reach 3, above Prado Dam is performed by OCWD for their SAR Water Quality Monitoring Program and the USGS at MWD Crossing. This included monitoring of the following locations: *MWD Crossing, Van Buren Blvd., Etiwanda Avenue, Hamner Road, and River Road*, as shown in Figure 2-1. OCWD conducted a single monitoring event for each of the locations on August 14, 2018. However, as the nitrogen species data collected by OCWD was not filtered it was not used to evaluate the water quality objective for TIN. Additionally, the USGS collects electrical conductivity and TDS at their gauge located *Santa Ana River at MWD Xing*. Table 3-5 presents a summary of the results of these monitoring efforts for base flow conditions.

An assessment of Baseflow conditions, represented by water quality data collected in August and September of 2018, showed no exceedances of water quality objectives specified in the Basin Plan. The USGS maintains a gauging station, 11066460, located along Reach 3 of the SAR at the MWD Crossing, shown in Figure 2-1. In 2018, this station recorded flows totaling 43,827 AFY.

Table 3-5. Summary of Baseflow Water Quality Observations for the Santa Ana River Reach 3 (Between Riverside Narrows and Prado Wetlands)

Constituent	Units	Basin Plan Objectives SAR Reach 3	Baseflow Average	# of Samples
Ammonia-Nitrogen (unfiltered)	mg/L	***	0.12	5
Bicarbonate (as CaCO3)	mg/L		220	5
Carbonate (as CaCO3)	mg/L		2.52	5
Chemical Oxygen Demand (unfiltered)	mg/L	**30**	5	5
Chloride	mg/L	**140**	124	5
Electrical Conductivity	umhos/cm		1053	9
Electrical Conductivity (field)	umhos/cm		1008	5
Hydroxide (as CaCO3)	mg/L		< 1.0	5
Nitrate-Nitrogen (unfiltered)	mg/L		5.9	5
Nitrite-Nitrogen (unfiltered)	mg/L		0.013	5
Organic Nitrogen (unfiltered)	mg/L		< 0.1	5
Sulfate	mg/L	**150**	109	5
Total Alkalinity (as CaCO3)	mg/L		222	5
Total Dissolved Solids	mg/L	**700**	626	9
Total Inorganic Nitrogen (unfiltered)	mg/L	**10****	6.0	5
Total Kjeldahl Nitrogen (unfiltered)	mg/L		< 0.2	5
Total Nitrogen (unfiltered)	mg/L		6.0	5
Total Organic Carbon	mg/L		2.8	5
Turbidity	NTU		2.1	5

Note: Table presents average concentration data

**** - Santa Ana River Basin Plan specifies an un-ionized ammonia objectives for WARM designated surface water bodies including site specific objectives for the Santa Ana River and certain tributaries including the middle Santa Ana River, Chino Creek, Mill Creek (Prado Area), Temescal Creek, and San Timoteo Creek. Site specific objectives must be computed based upon temperature and pH.*

***** - Santa Ana River Basin Plan specifies that Total Nitrogen Samples are to be filtered*
Site SAR River Road includes data collected by OCWD at "SAR-RIVERRD-01"
Site SAR Hamner includes only data collected by OCWD at "SAR-HAMNER-01"
- Site SAR Etiwanda includes data collected by OCWD at "SAR-ETIWANDA-01"
- Site SAR Van Buren includes only data collected by OCWD at "SAR-VANBUREN-01"
- Site SAR MWD includes data collected by USGS at "Santa Ana River at MWD Xing" and OCWD at "SAR-MWDXING-01"

3.3 Santa Ana River Reach 4

The Basin Plan has specified water quality objectives for SAR Reach 4 for TDS, TIN, and COD. Along SAR Reach 4, OCWD monitors sites, *SAR-MISSION-01*, *SAR-RIVERSIDEAVE-01*, *and SAR-LACADENA-01*, shown in Figure 2-1. The site designated WR-RIX-01 is located directly in the RIX Outfall pool and is not considered representative of the mainstem of the Santa Ana River.

In 2018, the *SAR-MISSION* and *SAR-RIVERSIDEAVE* sites were monitored once by OCWD in August, but no data was collected at *SAR-LACADENA-01*.

A review of this data showed an insufficient amount of available surface water quality monitoring data to evaluate water quality objective specified in the Basin Plan. Table 3-6 presents a summary of the results of this monitoring.

Table 3-6. Summary of Water Quality Observations for Santa Ana River Reach 4

Constituent	Units	Basin Plan Objective SAR Reach 4	SAR Reach 4 Average	# of Samples
Ammonia-Nitrogen	mg/L	***	< 0.1	3
Bicarbonate (as CaCO3)	mg/L		176	3
Carbonate (as CaCO3)	mg/L		< 1	3
Chemical Oxygen Demand (unfiltered)	mg/L	**30**	6	3
Chloride	mg/L		91	3
Electrical Conductivity	umhos/cm		865	3
Hydroxide (as CaCO3)	mg/L		< 1	3
Nitrate-Nitrogen	mg/L		7.1	3
Nitrite-Nitrogen	mg/L		0.042	3
Organic Nitrogen	mg/L		< 0.1	3
Sulfate	mg/L		75	3
Total Alkalinity (as CaCO3)	mg/L		176	3
Total Dissolved Solids	mg/L	**550**	501	3
Total Inorganic Nitrogen	mg/L	**10**	7.2	3
Total Kjeldahl Nitrogen	mg/L		< 0.2	3
Total Nitrogen	mg/L		7.3	3
Total Organic Carbon	mg/L		2.4	3
Turbidity	NTU		0.9	3

Note: Table presents average concentration data

**** - Santa Ana River Basin Plan specifies un-ionized ammonia objectives for WARM designated surface water bodies including site specific objectives for the Santa Ana River and certain tributaries including the Middle Santa Ana River, Chino Creek, Mill Creek (Prado Area), Temescal Creek, and San Timoteo Creek. Site specific objectives must be computed based upon temperature and pH.*

3.4 Santa Ana River Reach 5

The Basin Plan has specified water quality objectives for the SAR Reach 5 for TDS, hardness, sodium, chloride, TIN, sulfate, and COD. Along the SAR Reach 5, OCWD monitors a single site, *SAR-WATERMAN-01*, shown in Figure 2-1. In 2018, no data was collected at *SAR- WATERMAN -01*, as during the time scheduled for sampling there was no stream flow.

The USGS maintains a gauging station, 11059300, located along the SAR at E Street near San Bernardino, shown in Figure 2-1. In 2018, this station recorded flows totaling 8,357 AFY.

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4 Conclusions and Recommendations

4.1 Conclusions

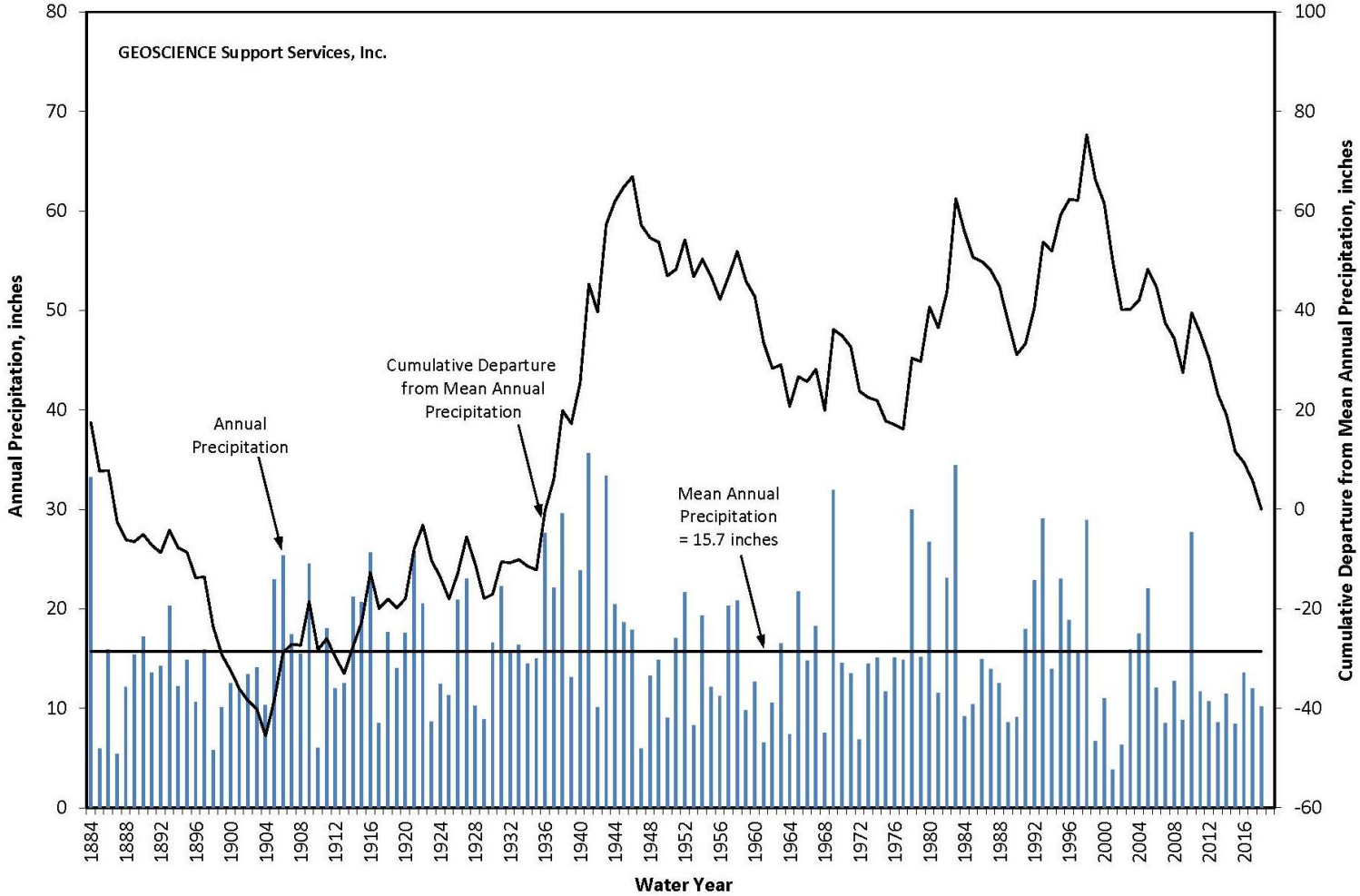
The five-year running average TDS concentration, for samples collected immediately below Prado Dam, continues to comply with the water quality objectives established for Reach 2 of the Santa Ana River and the underlying Orange Country Groundwater Management Zone (650 mg/L and 580 mg/, respectively). However, the average TDS concentration of the 18 samples collected at the same location in August and September of 2018 exceeded the water quality objective established for Reach 3 during baseflow conditions (720 mg/L vs. 700 mg/L, respectively).

Average TDS concentrations measured during summer baseflow conditions have been slowly increasing at Prado Dam for the last 10-12 years. In 2015, the Basin Monitoring Program Task Force commissioned an investigation to determine what was causing this trend. The study found that average TDS concentrations were increasing because the POTWs, while still meeting their discharge obligations were discharging less treated wastewater to the Santa Ana River system.[5] Additionally, the watershed is in a long term dry period[7], which makes the interpretation of trend data more difficult, as shown in Figure 4-1. During the late summer months of August and September, the combined volume-weighted average TDS concentration for the nine municipal effluents that eventually converge at Prado Dam ranges between 535-570 mg/L.[6] High quality (low TDS) municipal effluent tends to dilute low quality (high TDS) discharges from other sources (e.g. dry weather urban runoff, rising groundwater, etc.) that also contribute flows to Reach 3. In the period from 2005 to 2014, POTWs reduced the total volume of treated wastewater discharged to Reach 3 of the Santa Ana River (and its major tributaries) by 45%; from 145 mgd down to 79 mgd. Additional modeling revealed that, if the total volume of municipal effluent discharge had remained unchanged, average TDS concentrations at Prado Dam would also have remained stable. The reduction in wastewater flows, and the subsequent loss of dilution, also appears to be a correlation to the long-term rising trend in the average concentration of various individual salt ions (i.e. chloride, sodium and sulfate) during baseflow conditions.

In 2018, the average baseflow concentration of Total Nitrogen at Prado Dam was 4.2 mg/L, well below the water quality objective established for Reach 3. Long-term water quality monitoring data confirms that average nitrogen concentrations are continuing to slowly decline over time (see Figure 3-2). This is also the result of discharging less treated wastewater into the river system because the average nitrogen concentration in municipal effluent ranges from 8-10 mg/L.

[5] Wildermuth Environmental, Inc. Investigation and Characterization of the Cause(s) of Recent Exceedances of the TDS Concentration Objective for Reach 3 of the Santa Ana River. Feb. 11, 2015.
[6] Wildermuth Environmental, Inc. Volume-Weighted TDS Concentration of POTW Discharges above Prado Dam during August-September. June 15, 2015.
[7] Long term Dry Period as shown by the Mean Annual Precipitation as reported by San Bernardino County Flood Control District. http://www.sbcounty.gov/dpw/pwg/Precip_Data/Zone_2_Precip_Stations.htm

Figure 4-1. Cumulative Departure from Mean Annual Precipitation San Bernardino County Hospital Station (1884-2018)



In addition, some of the observed trend toward lower average nitrogen concentrations is likely due to the operation of OCWD's treatment wetlands immediately above Prado Dam.

Baseflow samples are also collected further upstream where the MWD pipeline crosses the Santa Ana River in Riverside. The average TDS concentration of these samples was 626 mg/L and the average TIN concentration was 6 mg/L. Both values were in compliance with the water quality objectives for Reach 3 of the river.

The average TDS concentration for the two samples collected in Reach 4 of the Santa Ana River was 501 mg/L which complies with the applicable water quality objective of 550 mg/L. The average TIN concentration in these same two samples was 7.2 mg/L which complies with the applicable water quality objective of 10 mg/L.

4.2 Recommendations

The Task Force has now been implementing the approved monitoring plan for more than ten years. Recently numerous issues have arisen regarding the proper way to collect, analyze, interpret and report the resulting data. Therefore, the Task Force would like to initiate comprehensive discussions at upcoming meetings to address these concerns.

1) The monitoring plan should be formally reviewed to ensure that we are collecting all the data necessary to assess compliance with relevant water quality objectives and the overall effectiveness of the new wasteload allocation (anticipated adoption in late 2019). In particular, should the program be expanded to include the major tributaries to the Santa Ana River (e.g. Chino Cr., Mill-Cucamonga Cr., Temescal Cr., Hole Lake Cr., San Timoteo Cr., etc.)?

2) The monitoring plan should include a list of parameters to be analyzed, identify the sites to be sampled, and specify the sampling schedule. A Quality Assurance Project Plan (QAPP) should also be prepared to support the monitoring program. Some decision must also be made as to whether the monitoring data must be uploaded to CEDEN or other state database.

3) The Basin Plan should be revised to include a clear definition of what constitutes "baseflow" with respect to the water quality objectives for Reach 3. Should data influenced by summer precipitation in August and September be included? Can we use data from other months to characterize baseflow conditions provided that no recent precipitation has occurred? Should data influenced by state water project transfers be excluded?

4) In order to assure more consistent application of water quality standards, the question of when and where to use filtered vs. unfiltered samples should be re-visited. If it is appropriate to evaluate compliance with TIN objectives by measuring TN using a filtered sample (as is

done in Reach 3), then it may also be appropriate to use this same procedure elsewhere in the watershed.

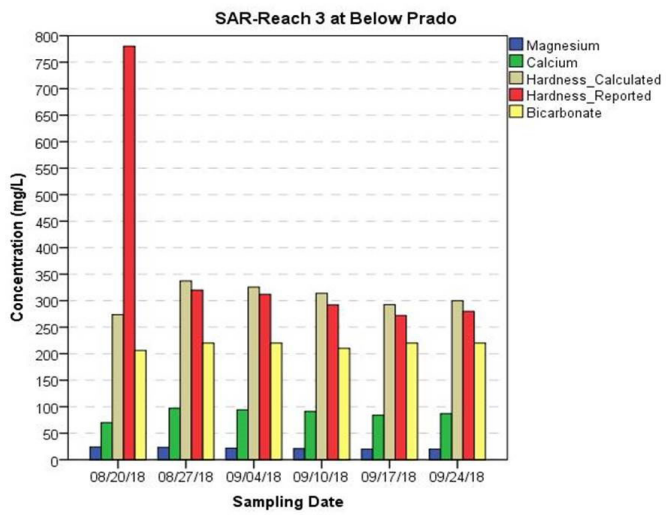
5) The existing water quality objectives for various salt ions may no longer be necessary. Most were established based on very limited sampling data collected in the early 1980's. All were intended to represent antidegradation targets not use impairment thresholds. The Nitrogen/TDS Task Force recommended that these objectives for individual salt ions be eliminated because it was more efficient and effective to implement the state Antidegradation Policy (Res. 68-16) using TDS instead. This would be consistent with the State Board's decision in the Chino Basin MWD permitting case (WQO 82-5) which provides the Regional Board with such discretion.

6) Should the monitoring program be expanded to integrate other discharges governed by NPDES permits (e.g. MS4 permits, deminimus discharge permits, CAFO permits, etc.)?

5 Response to Comments

Comments and Responses to 2018 Draft Annual Report of Santa Ana River Water Quality

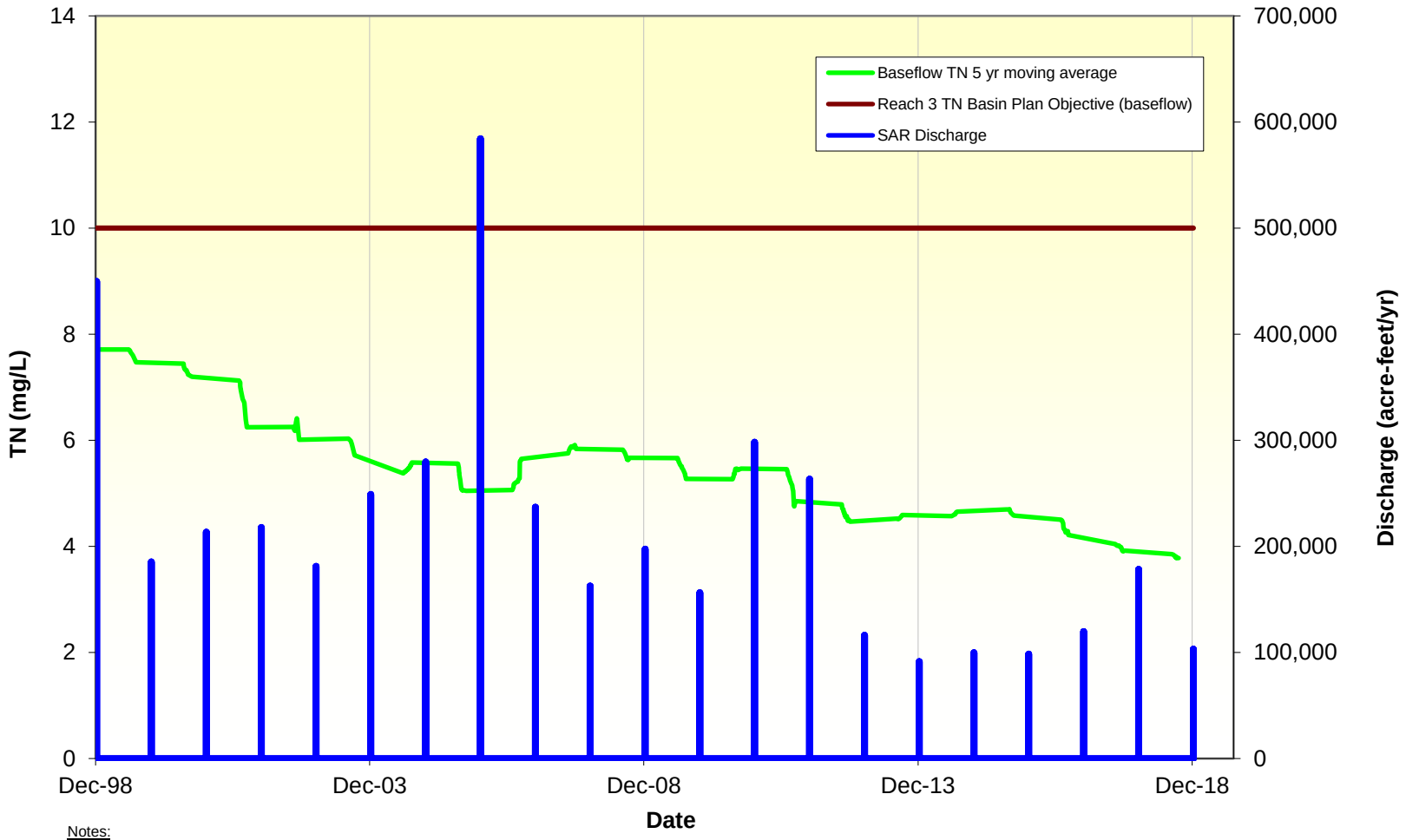
Comments Received	Agency	Page/Table/Section	Detail	Response to Comments
Joshua Aguilar	IEUA	General	Report should mention drought has an impact on quality/flow.	Staff will add material to indicate that the recent long-term drought is also influencing the TDS and TIN trends at Prado. Add GeoSciences graphic
		Table of Contents	Include the titles of the appendices in the Table of Contents	Staff will make appropriate revisions
		Figure 2-1	The scale for the map is overlapping a label in the map. Adjust the label or scale so that both are visible.	Staff will make appropriate revisions
		Page 3-1	The TDS objective for Reach 2 is 650 mg/L, not 700 mg/L.	Staff will make appropriate revisions
		Page 3-1	Footnote 2 is missing part of a unit for EC.	Staff will make appropriate revisions
		Page 3-2	The last sentence of the second paragraph is confusing. Please clarify what is shown on Figure 3-1.	Figure 3-1 shows the time history for TDS observations for 1997 to the present at Below Prado Dam as depicted as the five-year moving average TDS concentration. Staff will revise Figure 3-1 to show the two different methods for computing the 5-year moving average as separate lines on the same graph.
		Figure 3-1	We understand that the metric the Regional Board uses to determine compliance with the TDS concentration objective of 650 mg/l for Reach 2 of the Santa Ana River is the five-year moving average of the annual flow-weighted TDS concentration of the Santa Ana River at Prado Dam as estimated by the Santa Ana River Watermaster. Why isn't this metric plotted on Figure 3-1?	Staff will revise Figure 3-1 to show the two different methods for computing the 5-year moving average as separate lines on the same graph.
		Page 3-4	Figure 3-1 does not appear to be a running average, which typically have a smoother curve.	the 5-year moving average curve in Figure 3-1 is not as smooth as expected because El Nino winters have a disproportionate influence on a 60-month moving average. When we add the Regional Board's computation method to Figure 3-1, the new line will be much smoother because wet years and dry years have the same weight.
		4-1, 2nd para.,mid para.	When referring to reduced volume from the POTWs, please clarify that the POTWs are meeting their discharge obligations.	Staff will revise text
		4-1, 2nd para., 2nd to last sentence	"*responsible for" should be replaced with "appears to be a correlation to* "	Staff will revise text
		4.1, 3rd para.,	Please verify statement: "Average of 8-10 mg/L seems high for SAR dischargers"	Average TIN of POTWs discharging to Reach 3 does range between 8-10 mg/L. IEUA's permit requires the volume-weighted average TIN of their combined treatment facilities to be below 8 mg/L. Consequently, their discharges to Chino Creek and Cucamonga Creek tend to be in the range of 6-8 mg/L. That's why the 8-10 values "seems high" to IEUA staff.
		4.2, 2nd para., 1st sentence	Remove the stricken portion from the following statement " *The monitoring plan should be formally reviewed ~~and revised~~ to ensure that we are collecting all the data necessary to assess compliance* ..." Recommending a review of the monitoring plan is sufficient until the evaluation determines a need to revise the plan.	Staff will revise text
		4.2, 1)	Replace "*…Scheduled for adoption in early 2019.* ." with "*…Anticipated adoption in late 2019* …"	Staff will revise text
		Page 3-7	The text states that "Basin Plan objectives for water quality are based on discrete samples" yet the charts in Appendix A do not show discrete sample results. The charts only show 5-year moving averages of various constituents with concentration objectives.	Staff will remove text from the report. Actually, in the vast majority of cases, the Basin Plan does not specify an averaging period. The only exceptions are the 5-year moving average for Reach 2 and the "baseflow" average for Reach 3. It is NOT true that compliance with other objectives in the Basin Plan is determined using "discrete values." In fact, we strongly objected when State Board staff tried to use that approach during the most recent 303(d) listing cycle.
		Table 3-4	Table 3-4 is confusing. Are the data displayed on Table 3-4 from "baseflow" samples collected during August/September or from "annual" samples collected over the entire year? The table indicates 17 sample results for TDS, yet the text discusses only 13 samples (five by Regional Board, six by OCWD, and two by USGS). Please clarify.	Staff will revise text. Note: USGS collects additional TDS samples at Below Prado, in addition to their regular monthly monitoring.
		Page 4-1	In the first paragraph, what does 530 mg/L reference?	The reference to 530 mg/L should be deleted from the report. The Reach 3 objectives is 650 mg/L (as a 5 year moving average) and the objective for OC GMZ is 580 mg/L. There are no other relevant objectives and the 530 mg/L value shown in the draft report is probably just a type from a previous revision cycle.
		Page 4-1	Paragraph 2 states: "Average TDS concentrations measured during summer baseflow conditions have been slowly increasing at Prado Dam for the last 10-12 years (see Figure 3-1)." However, Figure 3-1 does not show these data.	It is true that average TDS concentrations measured during summer baseflow conditions have been slowly increasing at Prado Dam for the last 10-12 years but Figure 3-1 does not show baseflow concentrations. It shows the 60-month flow-weighted average. Best thing to do , for now, is simply to remove the reference to Figure 3-1 from the end of this sentence. Eventually, we will need to create a new figure showing the long-term trend in TDS in baseflow data. But we cannot do that until we go back and correct all the old computations to remove any outliers caused by OC-59 deliveries or by summer thunderstorms.
		Appendix A	Figures in this appendix should start be titled "Figure A-1, Figure A-2, Figure A-3" and so on.	Staff will make appropriate revisions

		Page iii -Table 3-3	fix Pardo to Prado	Staff will revise text
		Page 3-1	The water quality objective for Reach 2 for TDS is 650 mg/L and not 700 mg/L	Staff will make appropriate revisions
		Table 3-3	Was there an input error for total hardness on 8/20/18 -780 mg/l compared to values of around 300 mg/L for all other dates?	Staff will remove sample from record. A statistical analysis of Regional Board's 2018 sampling data (8/20/18 Hardness). The graph shows there is little variation between the measured magnesium (blue) and measured calcium values (green) across the six samples. So, one would expect little variation in the hardness values as well. That turns out to be true when we calculate hardness (tan) based on the reported magnesium and calcium concentrations. Hardness = (2.5 * Ca) + (4.12 * Mg). But it is not true for the hardness concentration reported by the lab (red). The measured hardness value (red) matches the calculated hardness values (orange) quite well for all but the sample collected on August 20th (r-square >99.9% if August 20th sample is excluded). Based on the reported calcium and magnesium concentrations, the reported hardness value cannot possibly be correct. The actual hardness value for August 20th, computed from the calcium and magnesium concentrations reported for that same sample, should be 274 mg/L not 780 mg/L. In addition because hardness(tan) and bicarbonate (yellow) are both reported as CaCO3 there is always a strong correlation between two (r-square >99.8%). In general, hardness = 1.354 * bicarbonate. Applying that formula to the bicarbonate concentration reported for August 20th, we can predict that the true hardness value for that date should have been about 279 mg/L (very close to the value that we calculated from the calcium and magnesium concentrations using the traditional hardness formula). (continued below)
Heather Boyd	**Santa Ana Regional Water Quality Control Board**			As one final QA/QC check, I compared the reported TDS concentration to the calculated TDS concentration (computed as the sum of the major anions and cations) and found very good agreement between the two (r-square >99.9%). Since the calcium, magnesium, bicarbonate, TDS, calculated hardness, calculated TDS, and bicarbonate predicted hardness all line up as expected, it appears that the measured hardness value reported for August 20th is the only discordant outlier. Based on the above data and analysis, the hardness value reported by the lab for August 20th should be invalidated and replaced with the correctly computed value of 274 mg/L in Table 3-3 of the report. A footnote should be added to document this substitution. In addition, the invalid hardness value should NOT be used to calculate the baseline average shown in Table 3-4 of the report. The mean hardness value should be recalculated using the correctly computed hardness concentration of 274 mg/L for the August 20th sample. P.S.: Since hardness is computed from calcium and magnesium values using a simple formula, it is unclear to me how the lab could simultaneously report a hardness value that was total inconsistent with the reported calcium and magnesium concentrations. This should have failed even the most basic data quality review and calls into question the lab's QA/QC procedures.
		Table 3-3	5/6 samples exceed the TDS objective; 4/6 samples exceed the Chloride objective; 2/6 exceed the COD objective; 6/6 samples exceed the sodium objective. It is apparent that the below Prado Dam monitoring and the language currently in the Basin Plan regarding compliance with SAR R3 objectives needs to be reviewed. These were proposed for review in the upcoming triennial review. The average concentration of TDS immediately below Prado Dam exceeds the water quality objective for SAR R3. Although the TDS objective for R2 continues to be met as do the Orange County Groundwater Management Zone objectives, what effect will the higher TDS values have on the underlying Orange County Groundwater Management Zone if TDS values continue to increase?	Issue to be examined by the Basin monitoring Task Force in the upcoming year.

		Page 3-8	I think a discussion on whether a single monitoring event is adequate to assess water quality objectives for R3 is important and I fully support the recommendations contained within Chapter 4.2 of the Annual Report. The need to revise the monitoring program for Prado is addressed in our triennial review. RB8 staff look forward to working with stakeholders to address the many concerns.	Issue to be examined by the Basin monitoring Task Force in the upcoming year.
			The differences in water quality above Prado Dam for SAR R3 and below Prado Dam that are also used to assess compliance with SAR R3 objectives tell two different stories. Monitoring along SAR R3 shows that objectives are being met while below Prado Dam, objectives are exceeded. Are there current watershed maps/drainage maps that show the additional discharges that SAR-Below Prado Dam receives versus immediately upstream at SAR - River Road? Of interest are the following: COD above the dam (baseflow average of 5 mg/L) vs. Below Prado Dam (baseflow average of 22 mg/L). The BPD COD average is 4 times that of the sites upstream in R3. R4 also has very similar concentrations of COD to R3. So, what is discharged to the BPD site that isn't discharged to the SAR, R3 or SAR,R4? Other observations: TKN below the dam is higher than in R3 or R4. Total organic carbon is higher below Prado Dam than in R3 or R4. Turbidity values below the dam are extremely high compared to values in R3 and R4. The wetlands appear to be reducing N based on the values observed in below Prado Dam versus R3 and R4. Although not in the purview of this report, It would be great to see some data about the effectiveness of the wetlands in removing nitrogen.	Issue to be examined by the Basin monitoring Task Force in the upcoming year.
		Section 3.4	mentions that there were no samples collected in SAR R5 due to no stream flow. How will this situation be rectified for 2019 sampling? Will sampling occur earlier than August? Lack of flow is important to address in revisions to the monitoring program.	Issue to be examined by the Basin monitoring Task Force in the upcoming year.
		Section 4-1	Treated wastewater discharged to Reach 3 decreased 45% from 2005-2014 and this decrease in effluent has affected the TDS values. Will the effluent amounts continue to decline? What actions are being taken to address these issues (i.e., increased TDS due to decreases in effluent discharges)?	Issue to be examined by the Basin monitoring Task Force in the upcoming year.

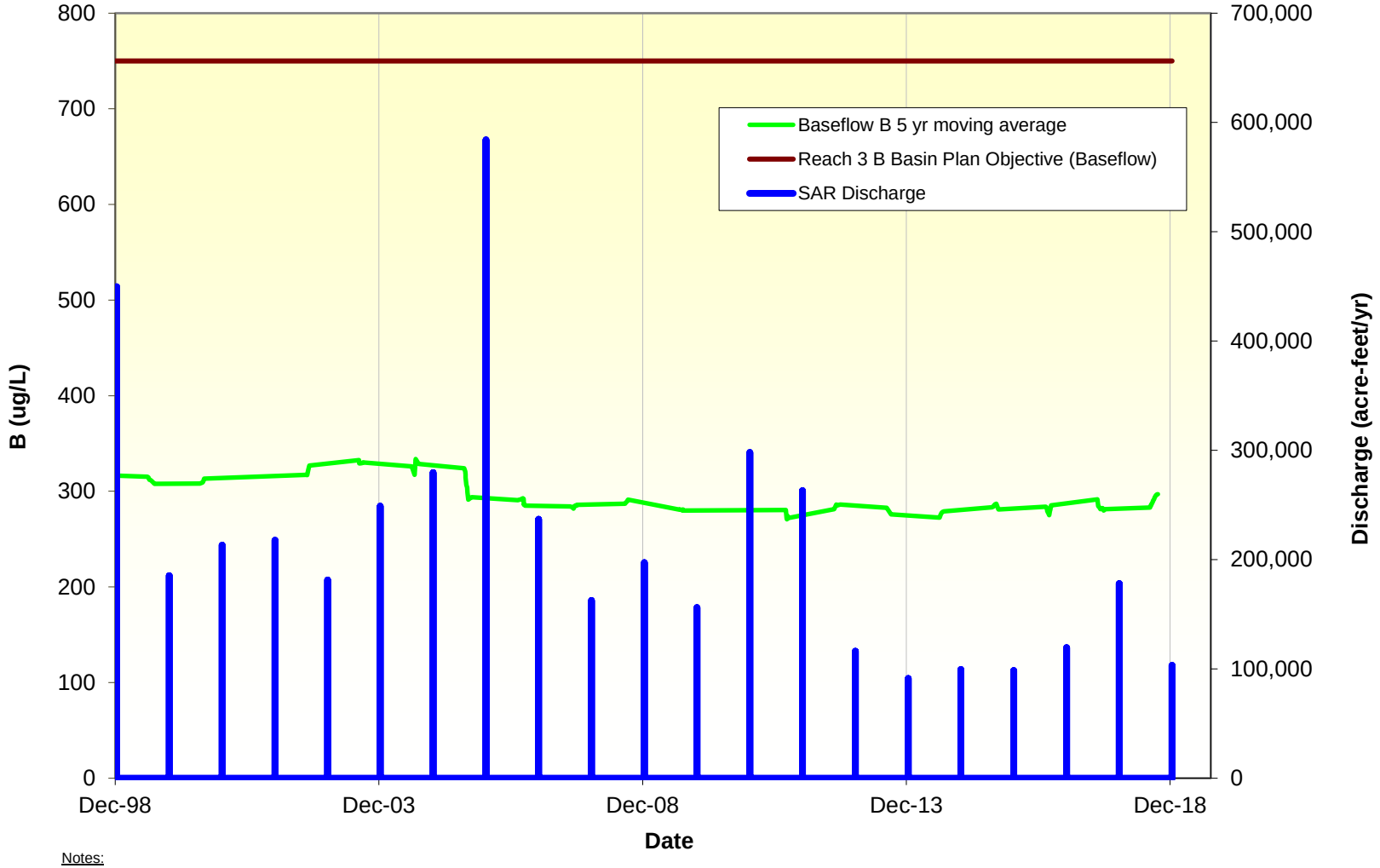
Appendix A
Water Quality Trends
at Below Prado Dam and MWD Crossing
1998 to Current

Figure A-1. Total Nitrogen (TN) Below Prado Dam



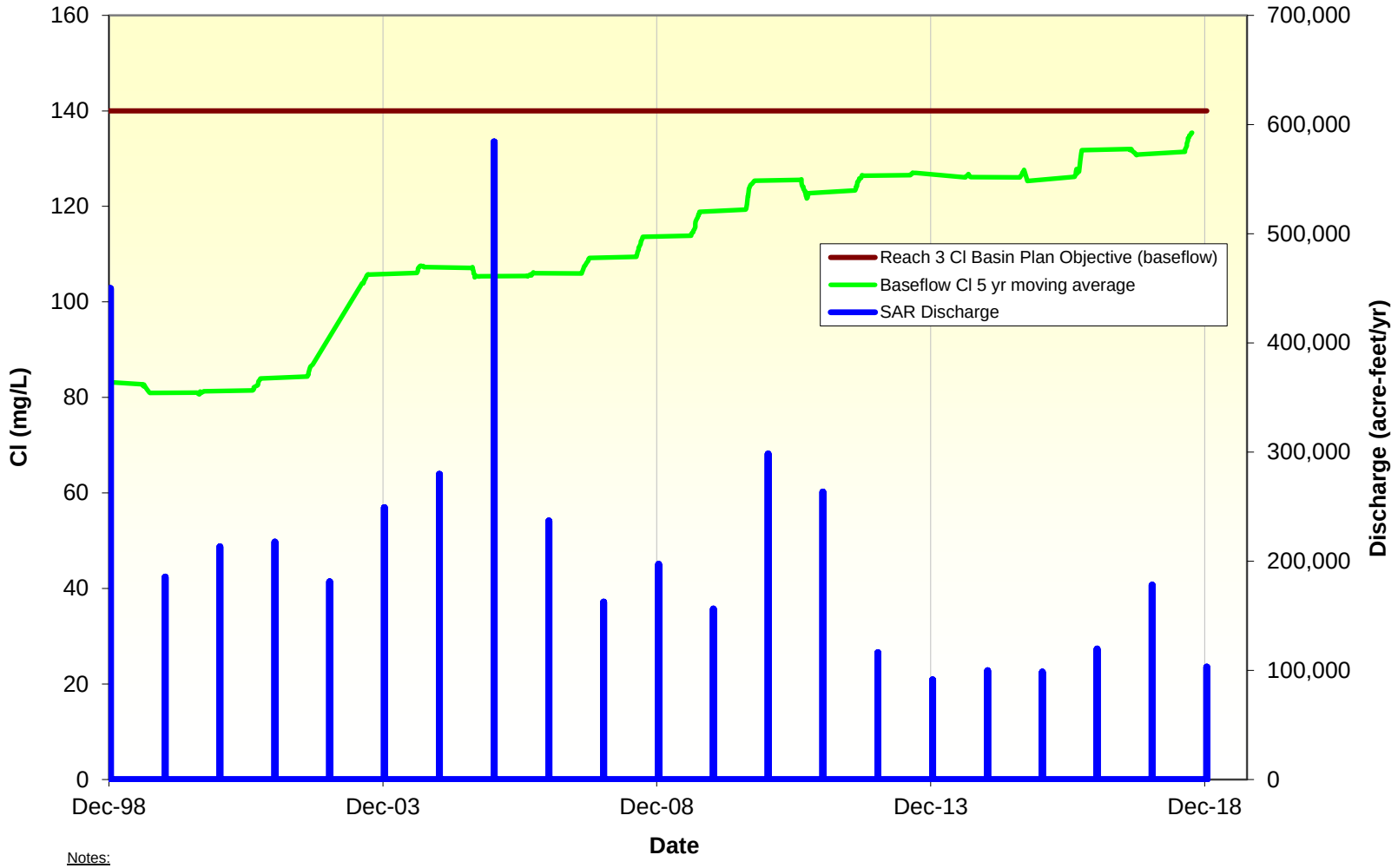
Notes:
Baseflow = TN samples from RWQCB, USGS, HCMP, OCWD for August and September.

Figure A-2. Boron (B) Below Prado Dam



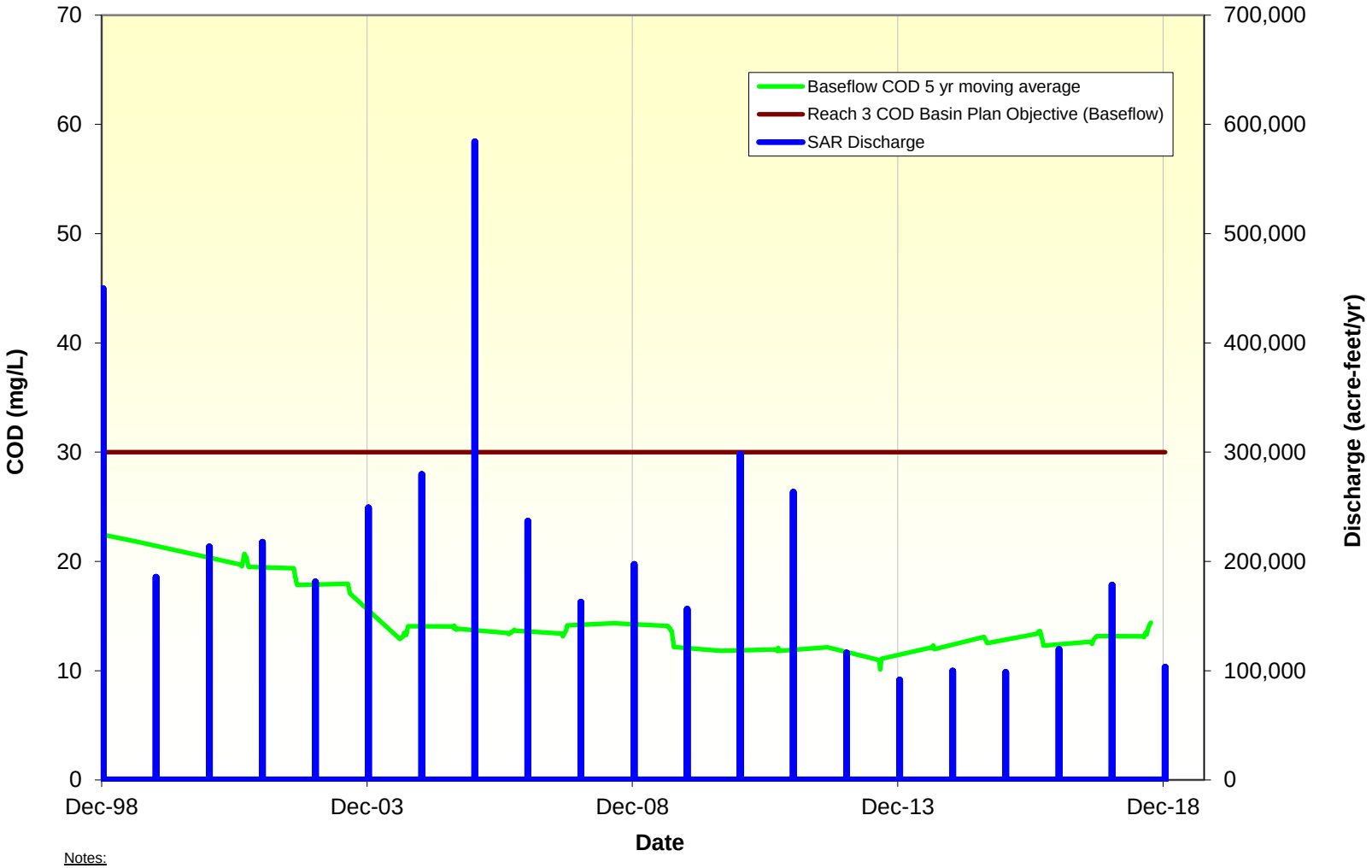
Notes:
Baseflow = B samples from RWQCB, USGS, HCMP, OCWD for August and September.

Figure A-3. Chloride (Cl) Below Prado Dam



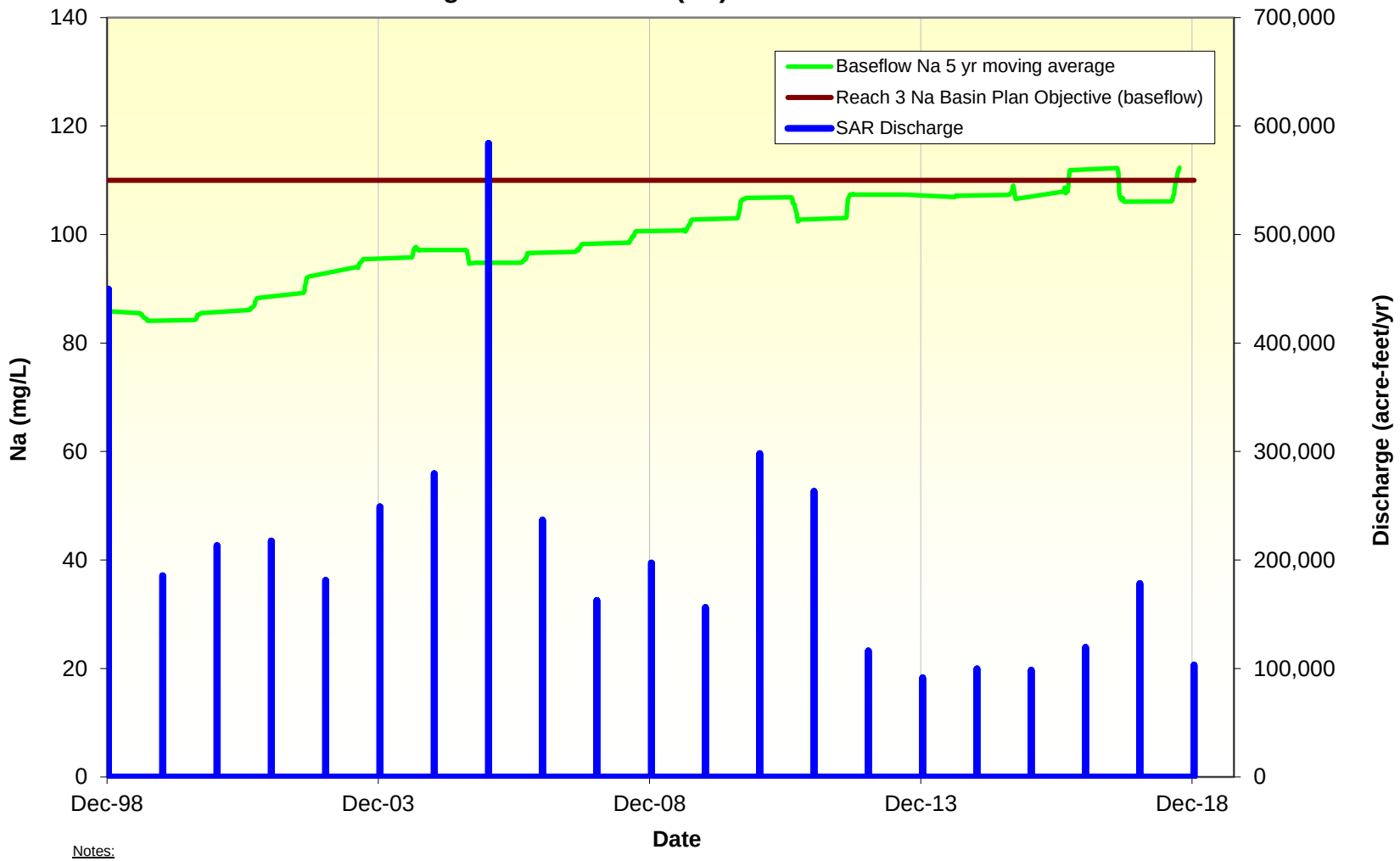
Notes:
Baseflow = Cl samples from RWQCB, USGS, HCMP, OCWD for August and September.

Figure A-4. Chemical Oxygen Demand (COD) Below Prado Dam



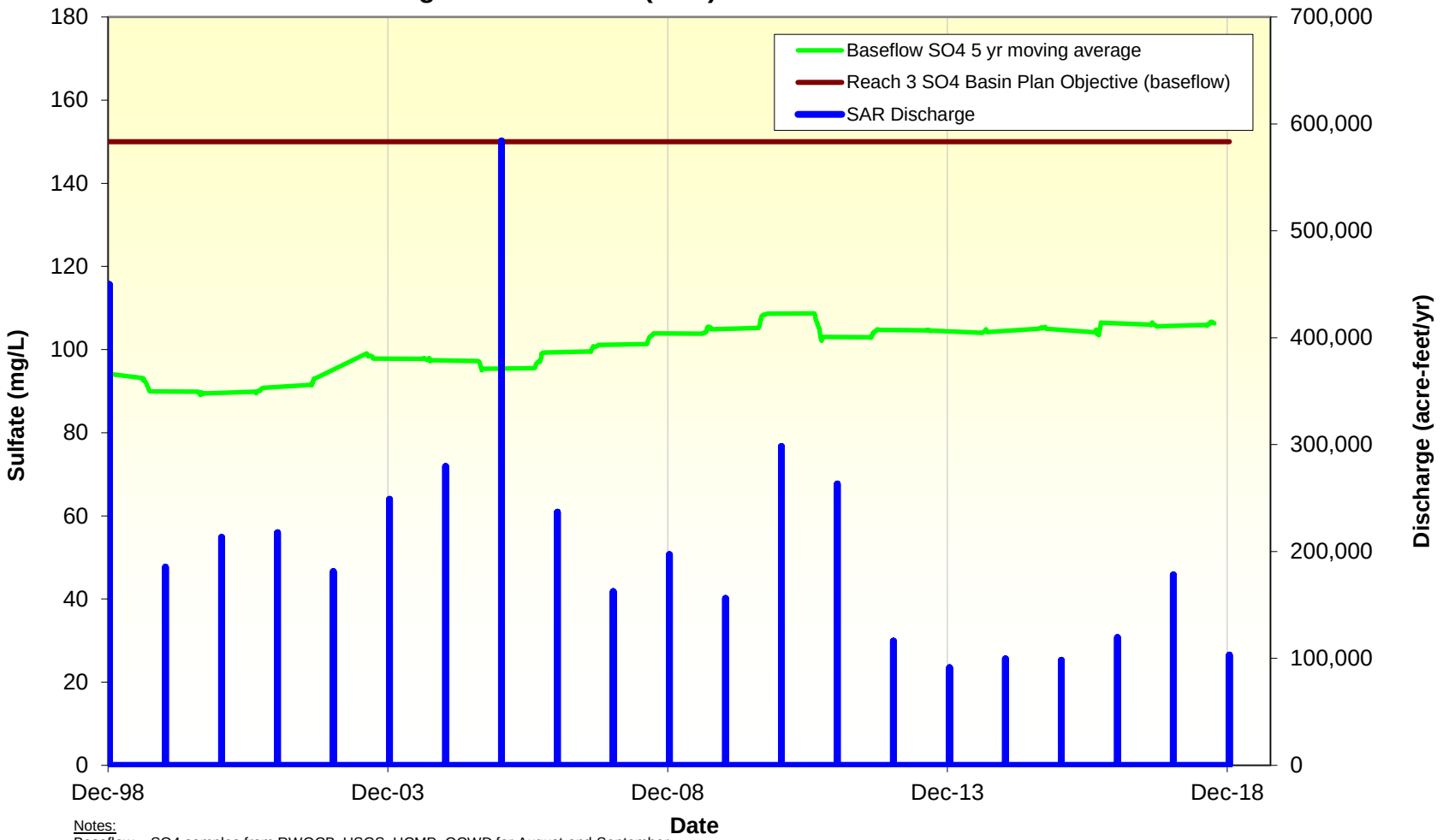
Notes:
Baseflow = COD samples from RWQCB, USGS, HCMP, OCWD for August and September.

Figure A-5. Sodium (Na) Below Prado Dam

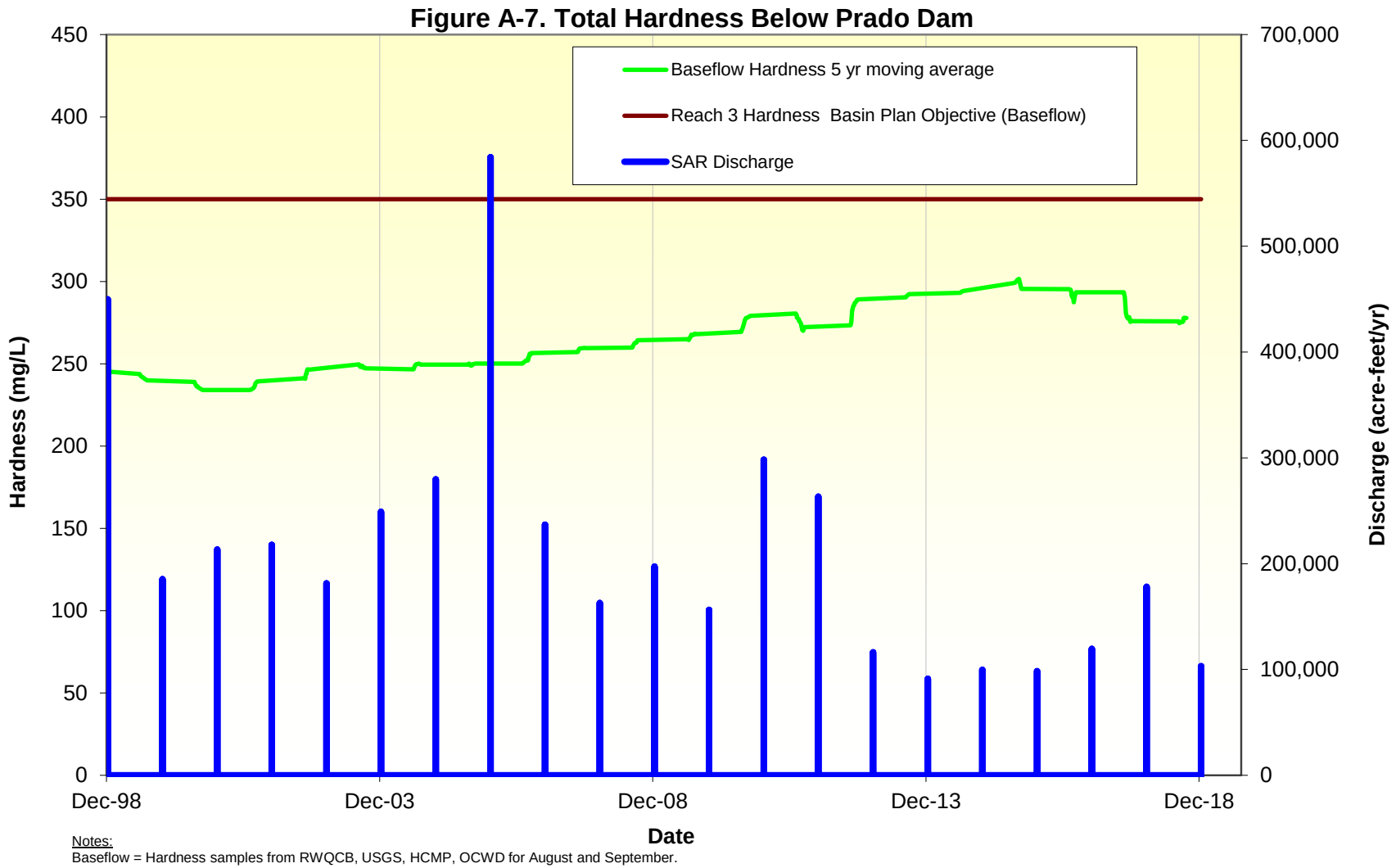


Notes:
Baseflow = Na samples from RWQCB, USGS, HCMP, OCWD for August and September.

Figure A-6. Sulfate (SO4) Below Prado Dam

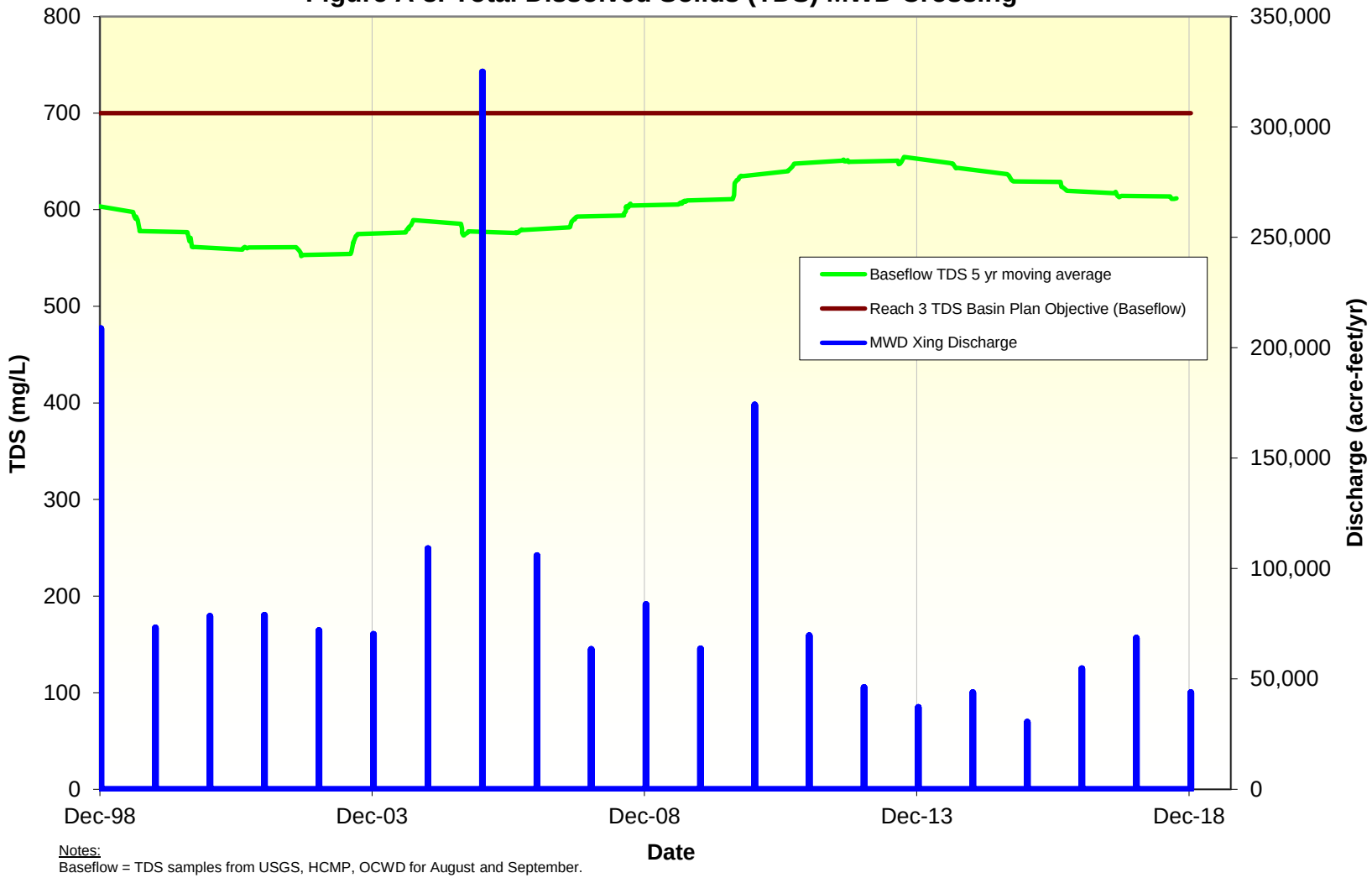


Notes:
Baseflow = SO4 samples from RWQCB, USGS, HCMP, OCWD for August and September.



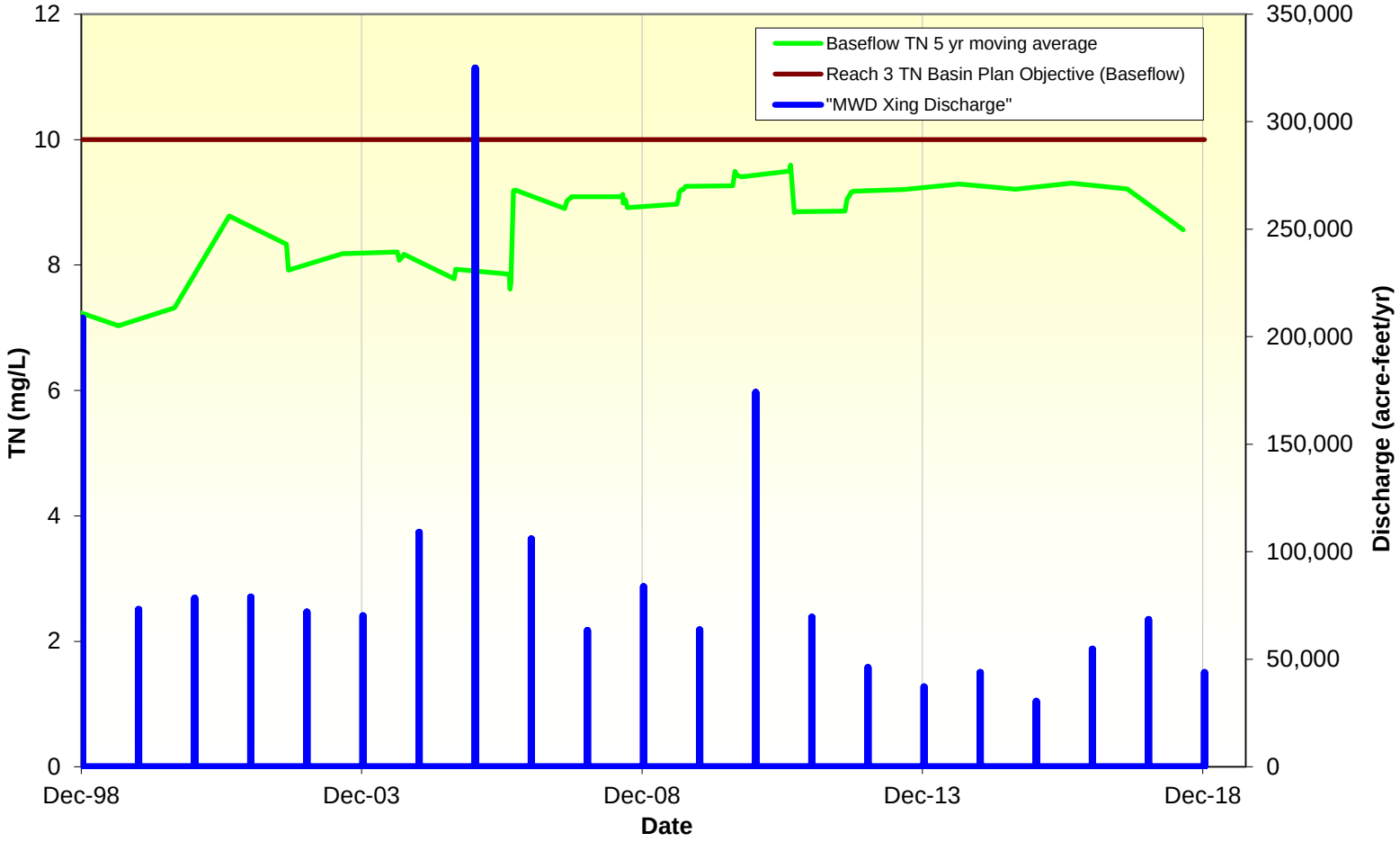
Notes:
Baseflow = Hardness samples from RWQCB, USGS, HCMP, OCWD for August and September.

Figure A-8. Total Dissolved Solids (TDS) MWD Crossing



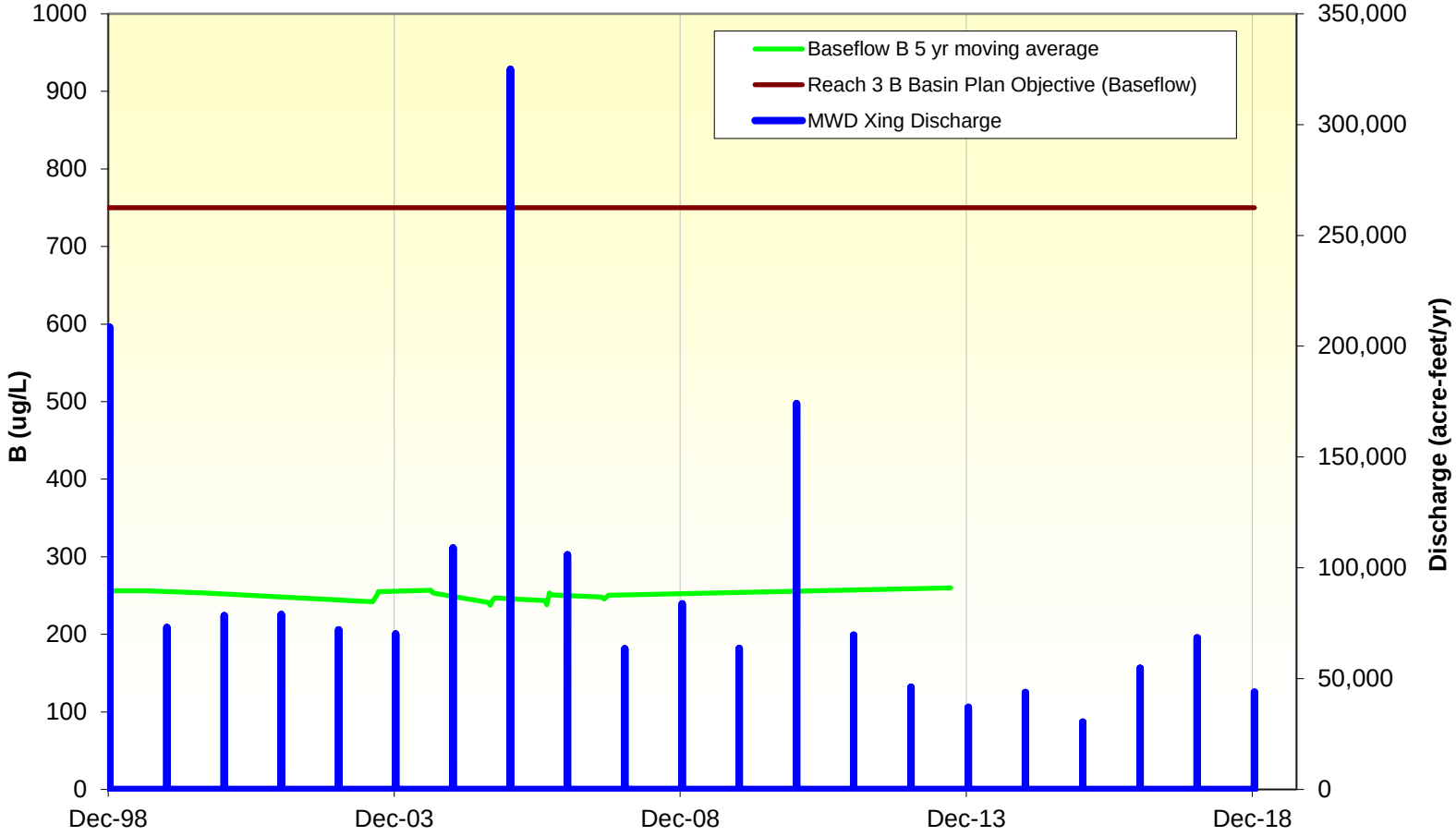
Notes:
Baseflow = TDS samples from USGS, HCMP, OCWD for August and September.

Figure A-9. Total Nitrogen (TN) MWD Crossing



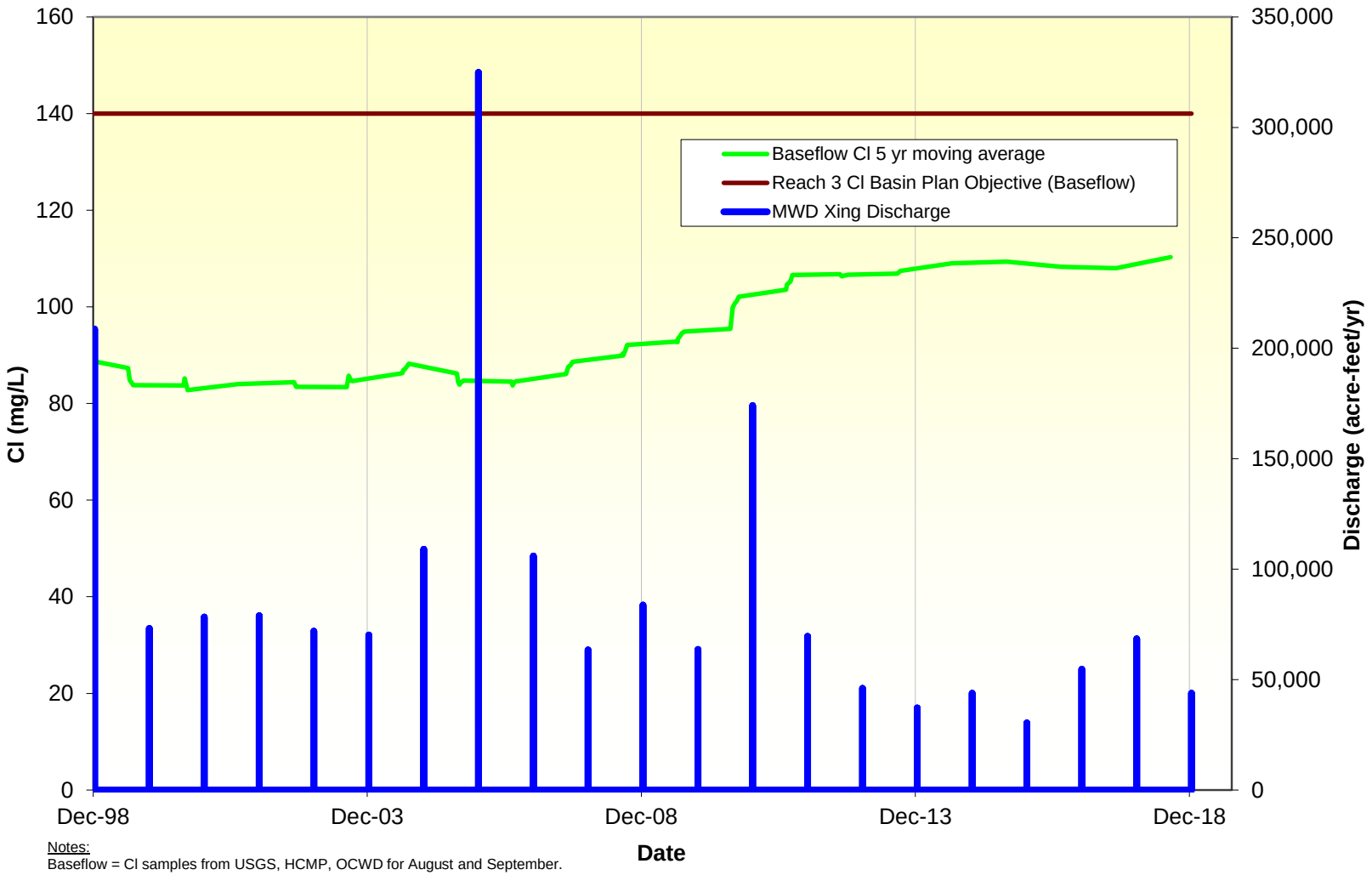
Notes: Baseflow = TN samples from USGS, HCMP, OCWD for August and September.

Figure A-10. Boron (B) MWD Crossing



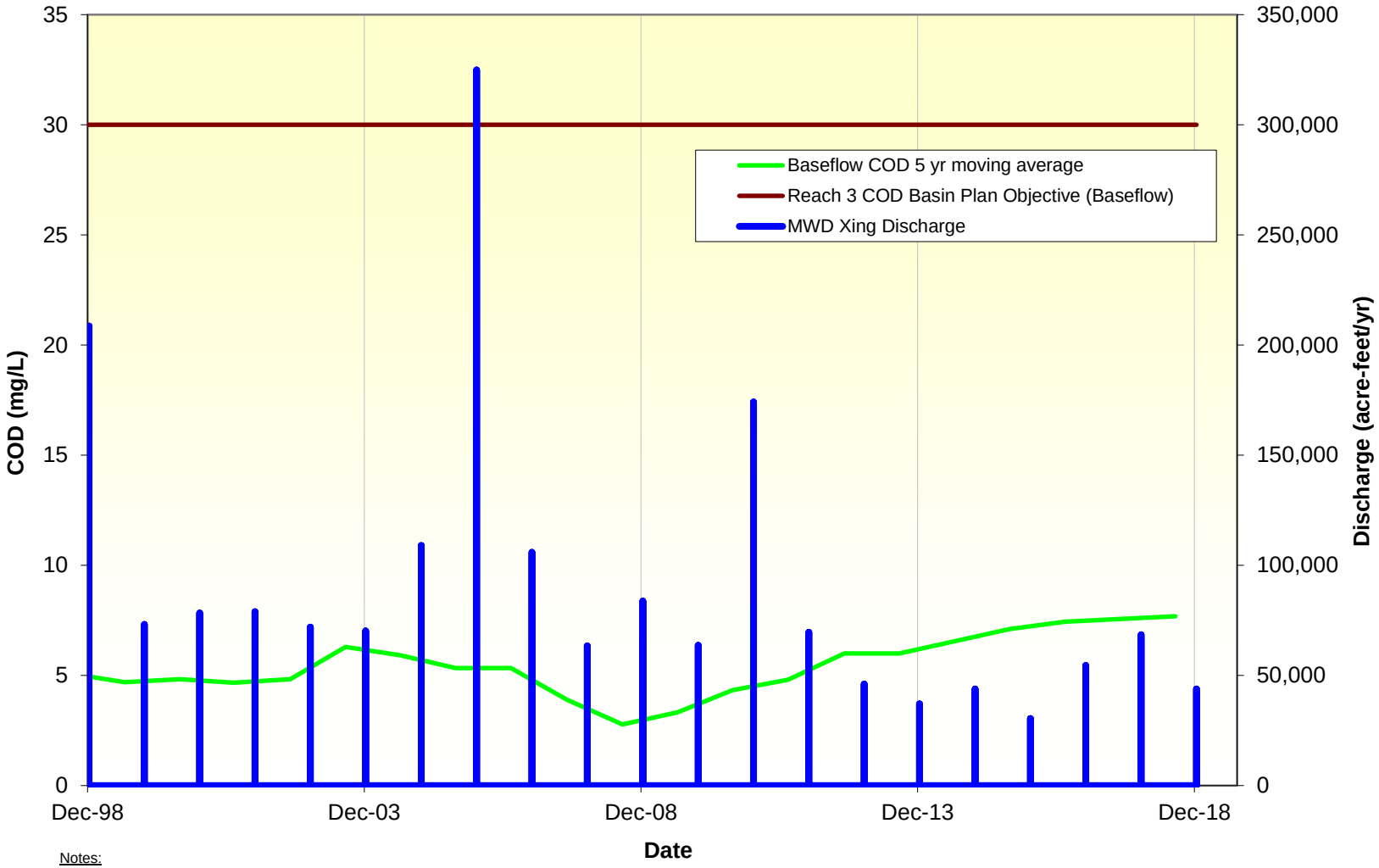
Notes:
No Water Quality data submitted since 2013.

Figure A-11. Chloride (Cl) MWD Crossing



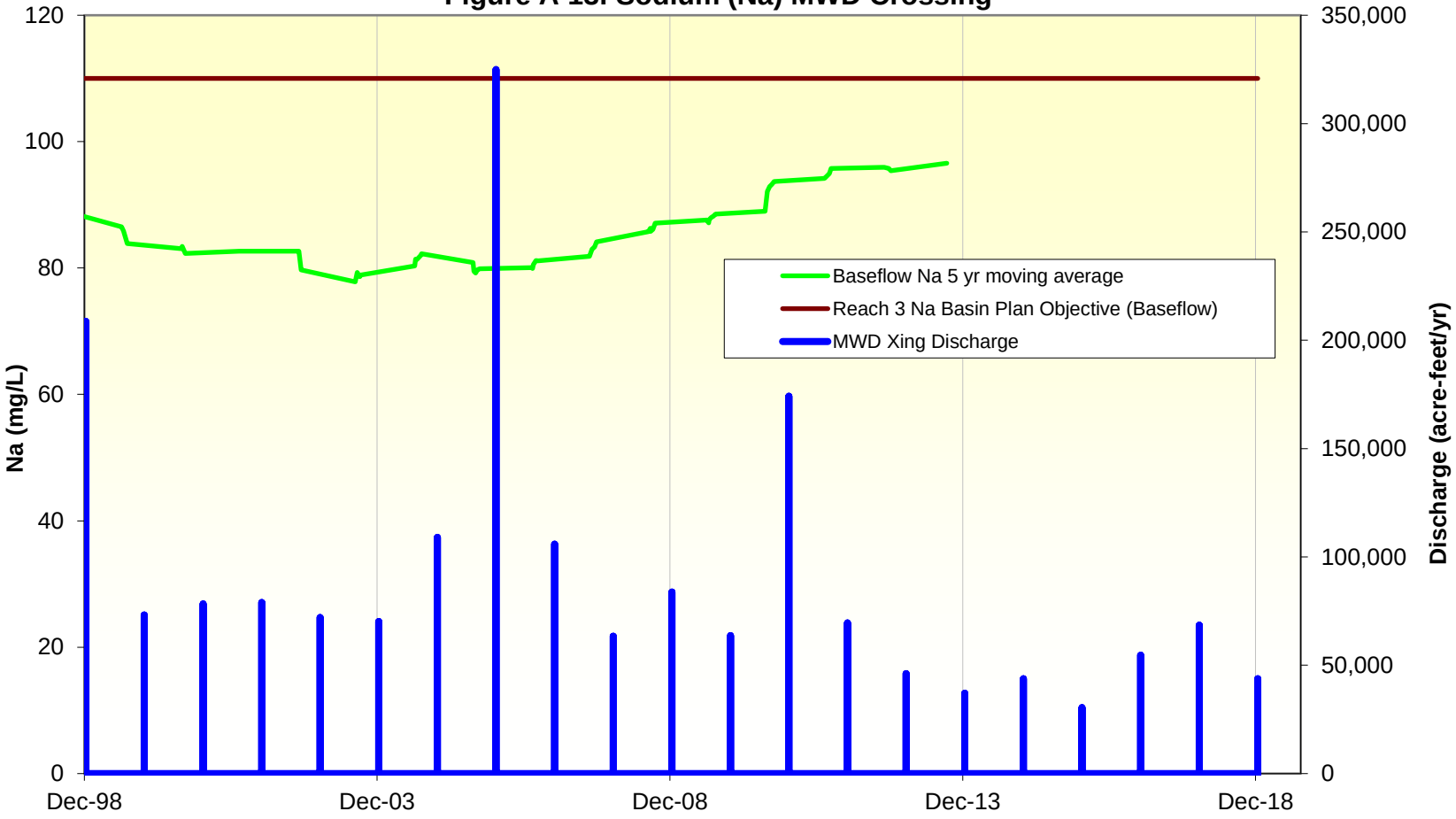
Notes:
Baseflow = Cl samples from USGS, HCMP, OCWD for August and September.

Figure A-12. Chemical Oxygen Demand (COD) MWD Crossing



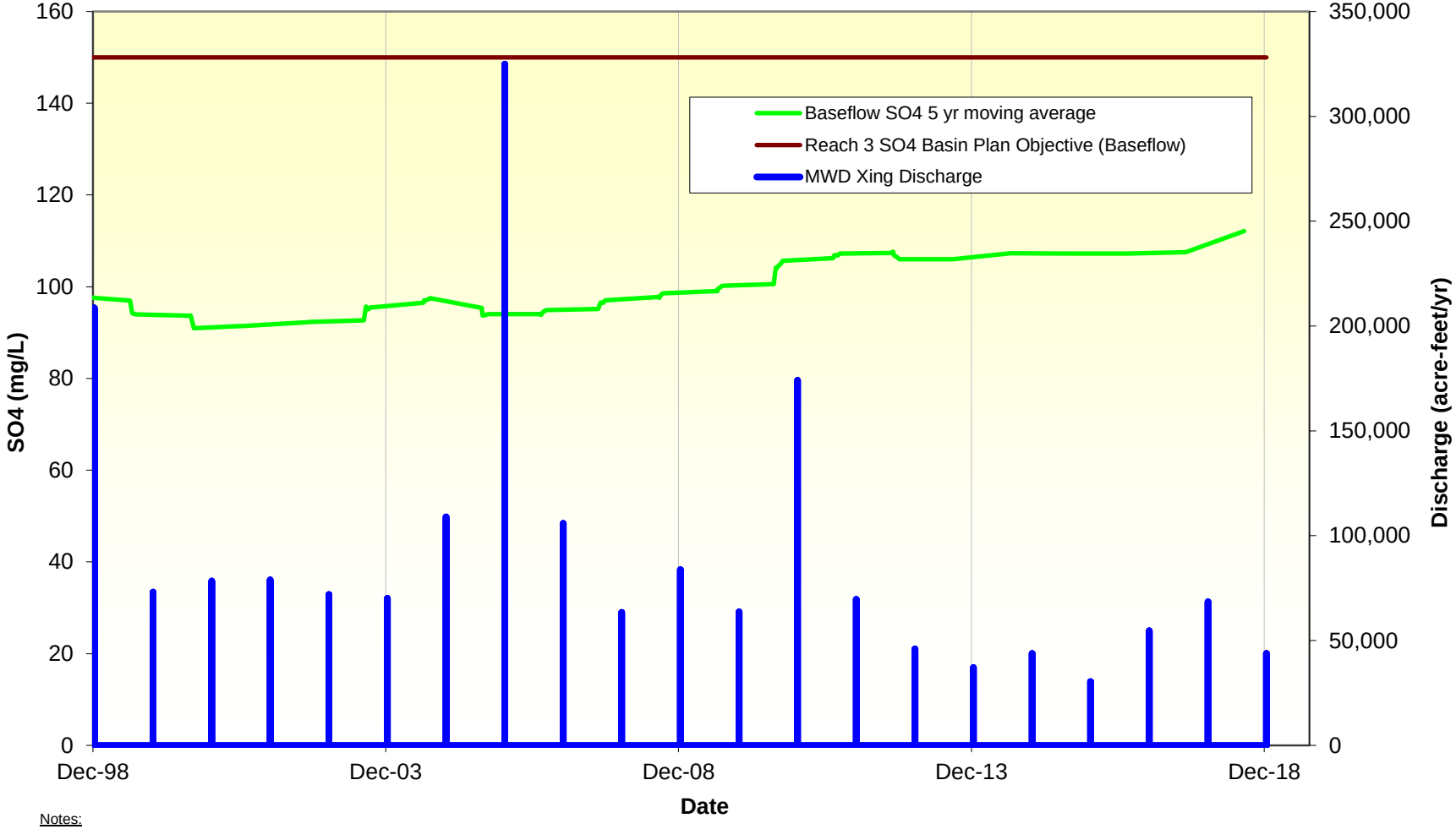
Notes:
Baseflow = COD samples from USGS, HCMP, OCWD for August and September.

Figure A-13. Sodium (Na) MWD Crossing



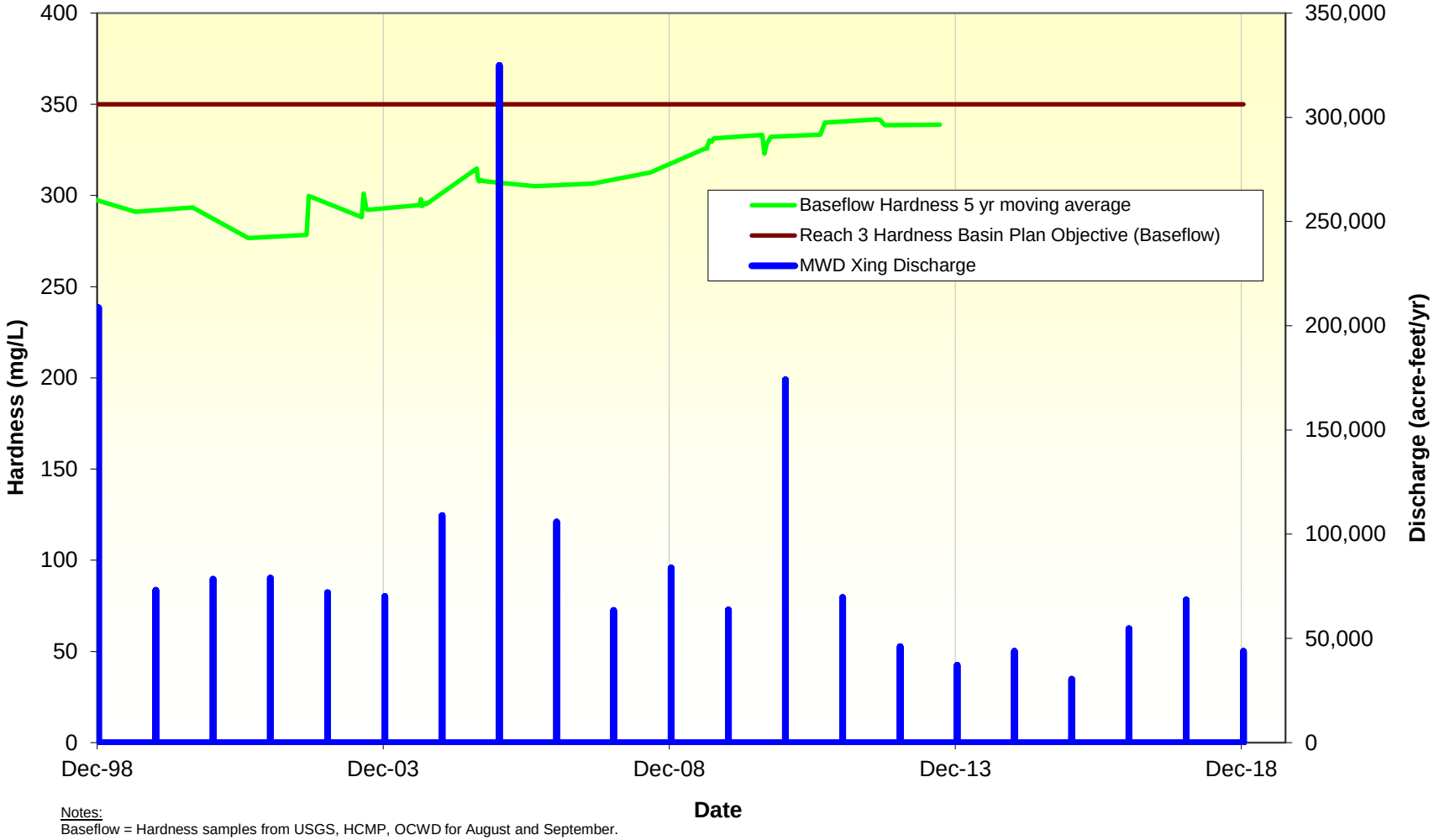
Notes:
Baseflow = Na samples from USGS, HCMP, OCWD for August and September.
No Water Quality data submitted for 2014 - 2018.

Figure A-14. Sulfate (SO4) MWD Crossing



Notes:
Baseflow = SO4 samples from USGS, HCMP, OCWD for August and September.

Figure A-15. Total Hardness MWD Crossing



Notes:
Baseflow = Hardness samples from USGS, HCMP, OCWD for August and September.
No Water Quality data submitted for 2014 - 2018.

Appendix B
All 2018 Water Quality and Flow Data
(Included on Enclosed CD)