

Memorandum

DATE: January 25, 2017

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SUBJECT: **Projected Nutrient Load Reductions to the Sacramento-San Joaquin Delta
Associated with Changes at Four POTWs**

INTRODUCTION

Ambient nutrient (nitrogen and phosphorus) concentrations in the Delta are the result of the mixture of nutrient loadings from a variety of internal and external sources, as modified by internal processes (nutrient transformations, sinks and sources) in the Delta. As described in Novick, et al 2015¹, major nutrient sources to the Delta include treated wastewater effluent from publicly owned treatment works (POTWs) and agricultural runoff. Natural land cover, urban runoff and boundary inflows are minor sources of nutrients.

This memorandum describes changes in nutrient loadings to the Delta that will occur as a result of either planned and permitted treatment facility upgrades or planned and permitted effluent diversion projects at four major POTWs:

- Sacramento Regional County Sanitation District's (Regional San's) Regional Wastewater Treatment Plant (WWTP),
- Stockton Regional Wastewater Control Facility (RWCF),
- Modesto Water Quality Control Facility (WQCF),
- Turlock Regional Water Quality Control Facility (RWQCF).

Resultant changes in Delta ambient water quality conditions (i.e. nutrient concentrations) will occur in proportion to the change in contribution of these four POTWs to the current nutrient mass balance in the Delta. The permitted discharge from the four POTWs in question represents approximately 59% of the current total POTW contribution to the Delta (on a volume basis). Total

¹ Novick, E., R. Holleman, T. Jabusch, J. Sun, P. Trowbridge, D. Senn, M. Guerin, C. Kendall, M. Young, and S. Peek, 2015, *Characterizing and Quantifying Nutrient Sources, Sinks and Transformations in the Delta: Synthesis, Modeling and Recommendations for Monitoring*, December 2015

POTW loadings of total nitrogen and total phosphorus to the Delta have been estimated to be one half or less of the total nutrient loadings from other sources (LWA, 2015).

Aggregate POTW nutrient loads to the Delta are expected to decrease in the future due to planned treatment plant improvements and/or change of discharge location at Regional San, Stockton, Modesto and Turlock POTWs. These four POTWs currently discharge treated wastewater effluent into either the Sacramento River or San Joaquin River, major tributaries to and elements of the Sacramento-San Joaquin River Delta, as shown in Figure 1. These facilities are planning the following changes in operation:

- Within three years, the Modesto Water Quality Control Facility plans to remove discharge from the San Joaquin River and send treated tertiary effluent to the Delta Mendota Canal. Tertiary discharge to the San Joaquin River will be available as an emergency option.
- Within three years, the Turlock Regional Water Quality Control Facility plans to divert most of its tertiary discharge (up to 14.2 mgd) from the San Joaquin River to the Delta Mendota Canal (Order No. R5-2016-0010).
- The Regional San treatment plant will be converted to biological nutrient removal (BNR) tertiary treatment (EchoWater project) by May 2021 (Order No. R5-2010-0114-03 page F-6).
- The City of Stockton tertiary treatment plant will be upgraded to include denitrification (or another preferred treatment option) by June 2024 (Order No. R5-2014-0070-02 page 23).

A comparison of the current conditions to planned future conditions resulting from these changes are presented in this memorandum as a percent decrease in nitrogen and phosphorus loads to the Delta from these four POTWs.

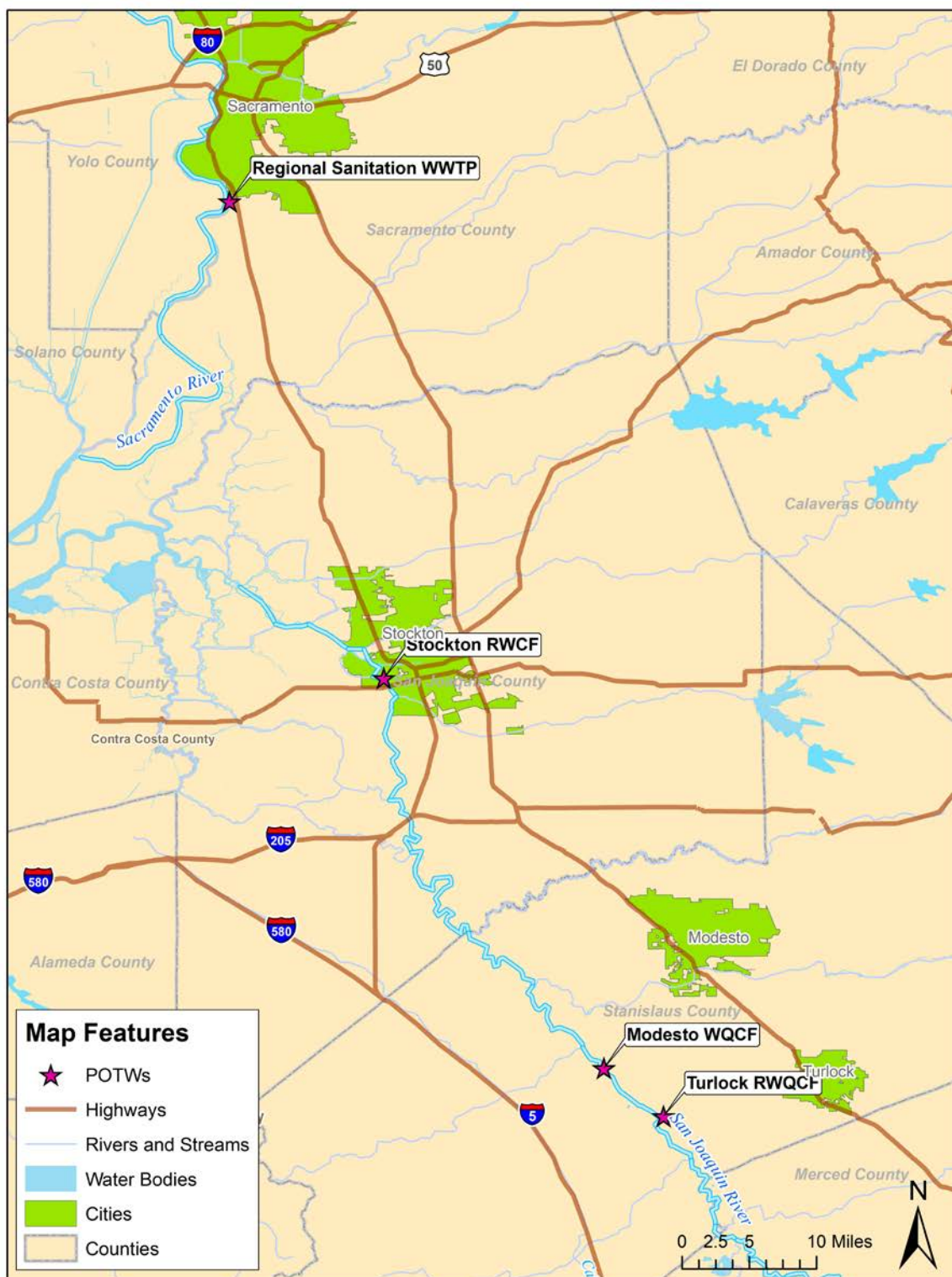


Figure 1. Sacramento and San Joaquin River Delta with POTW Discharge Locations

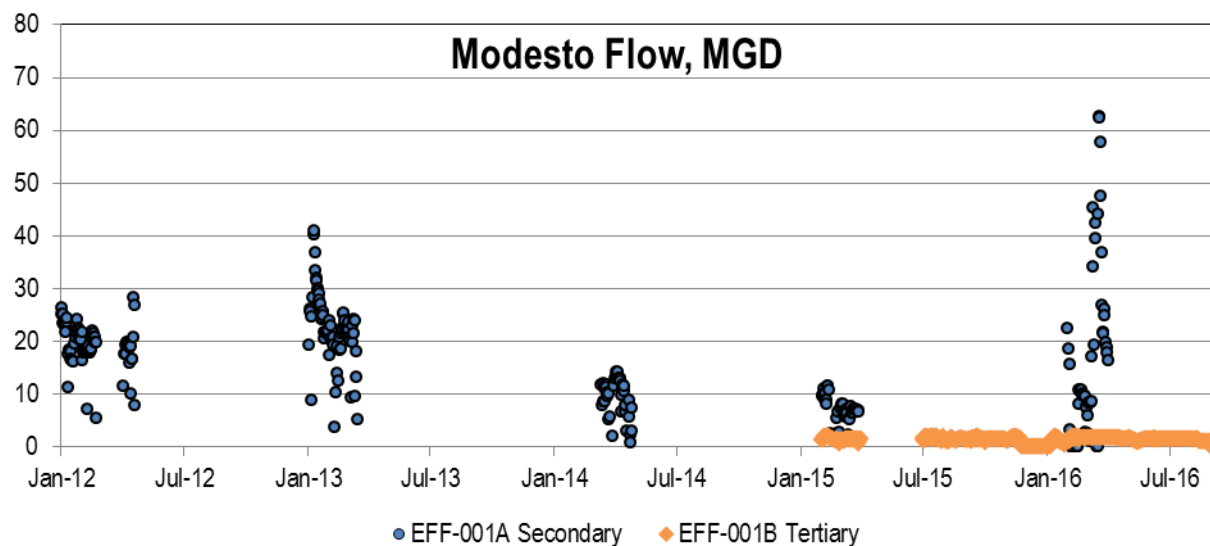
CURRENT CONDITIONS

Current conditions are represented with effluent concentration and flow data from each plant during the period of 2012-2016.

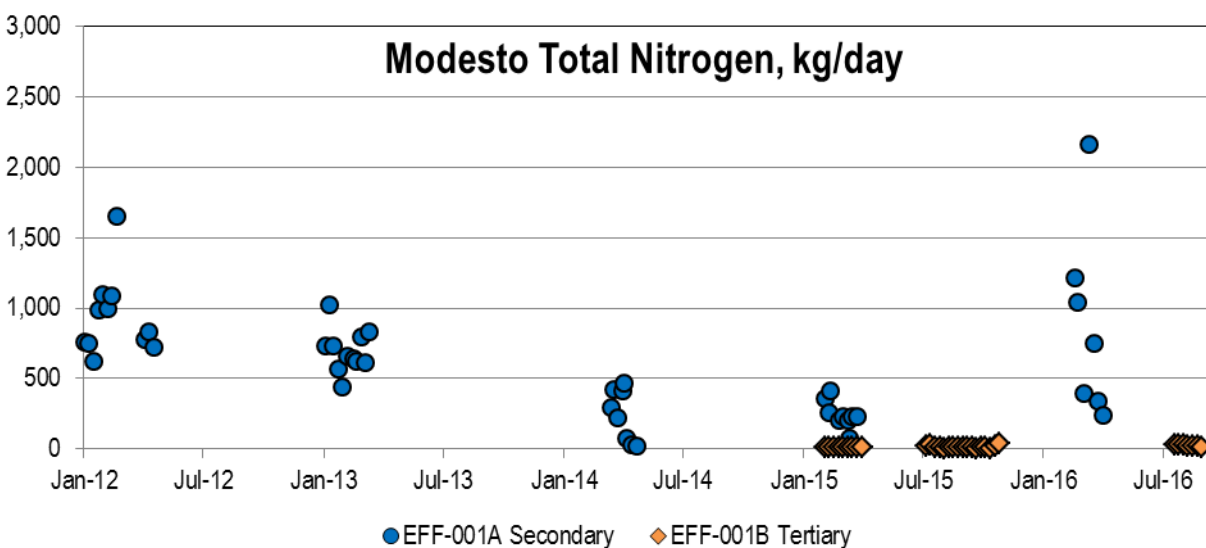
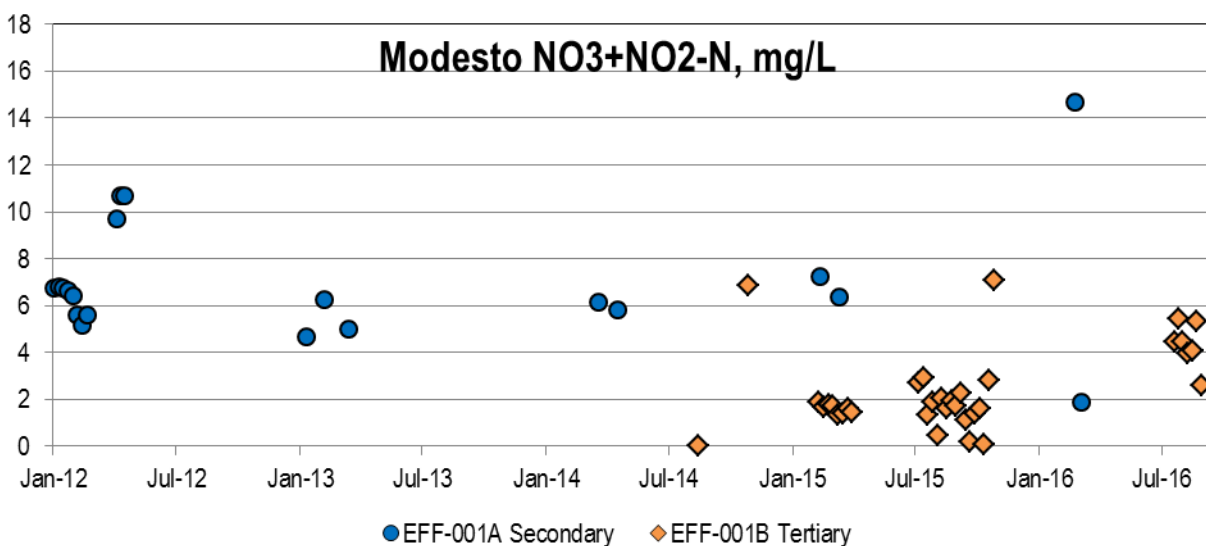
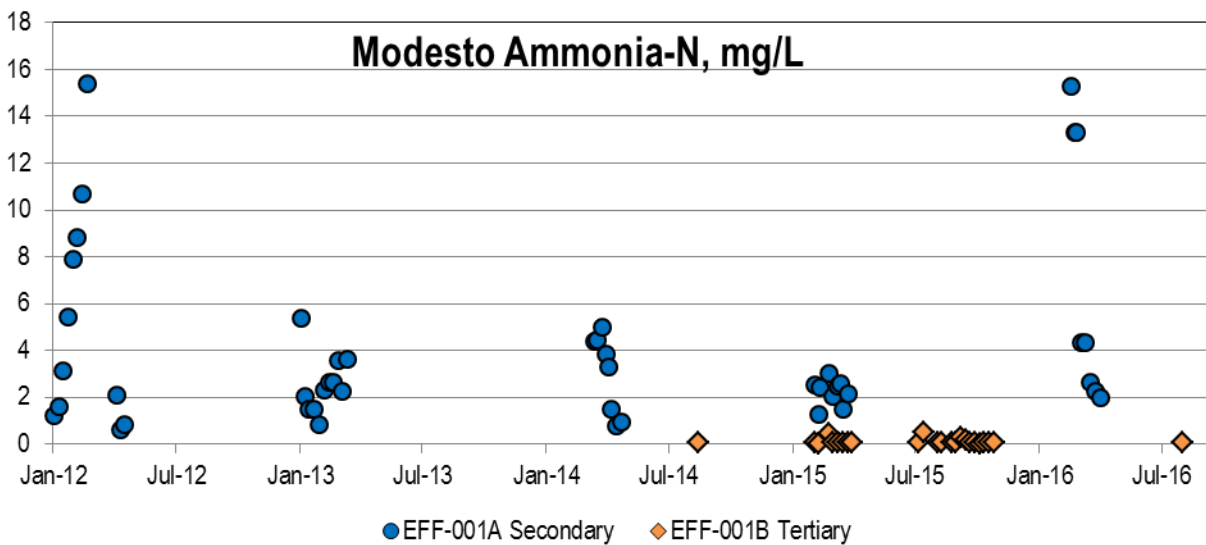
The Modesto and Turlock treatment plants currently discharge tertiary treated effluent to the San Joaquin River, upstream of the Delta. The Modesto treatment plant has also discharged a larger volume of secondary treated effluent to the San Joaquin River at times between October and May. Regional San discharges secondary treated effluent to the Lower Sacramento River below Freeport, within the boundaries of the Delta. The Stockton treatment plant discharges tertiary treated effluent to the San Joaquin River, also within the boundaries of the Delta.

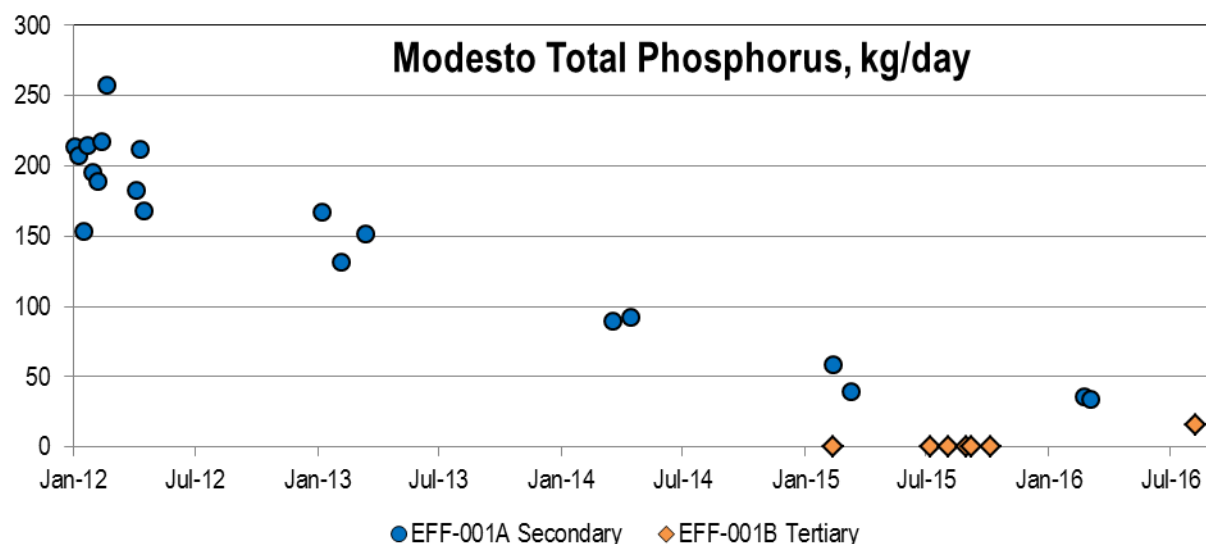
Modesto WQCF

Modesto secondary flow data were available for the period 2012-2016 and tertiary discharge began in February 2015. Detected ammonia concentrations in secondary effluent were reported weekly during that period. During periods of discharge in 2012, nitrate & nitrite and phosphorus were reported weekly. After 2012, nitrate & nitrite and phosphorus were reported monthly during periods of discharge². Organic nitrogen and TKN were not monitored. The total nitrogen load in secondary effluent was calculated weekly using weekly ammonia concentrations and monthly nitrate plus nitrite concentrations. The phosphorus load in secondary effluent was calculated weekly through 2012 and monthly thereafter. Weekly tertiary data for ammonia and nitrate plus nitrite from February 2015, and monthly phosphorus results were available.



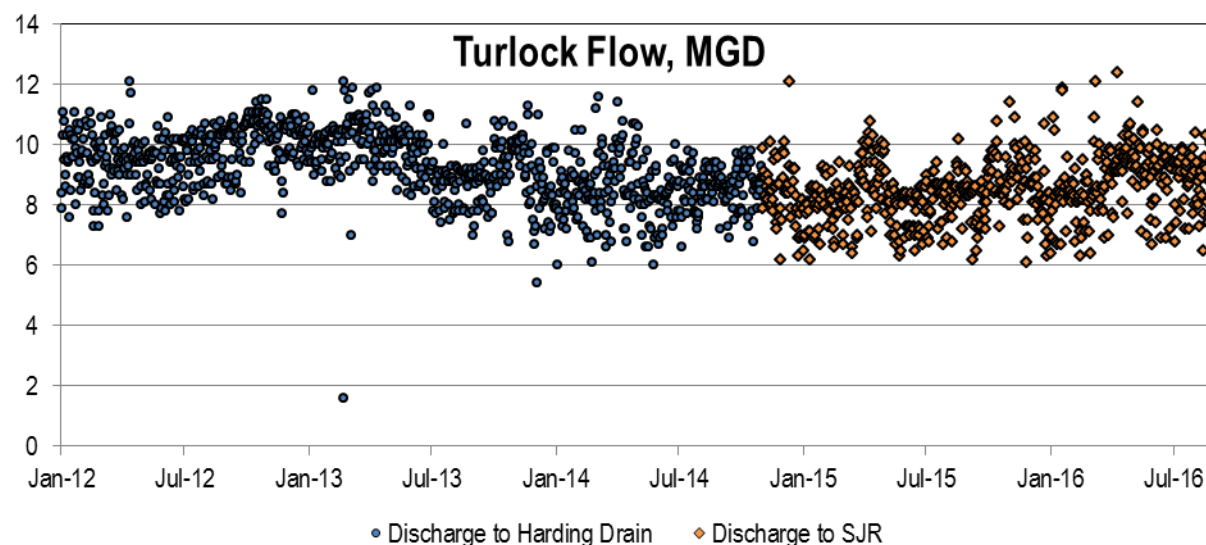
² The Modesto WQCF's 2012 NPDES permit allowed the discharge of secondary effluent to the San Joaquin River only between October 1 and May 31. During the rest of the year, secondary effluent is used for irrigation and does not contribute to river loadings. Tertiary effluent is permitted for discharge year-round.

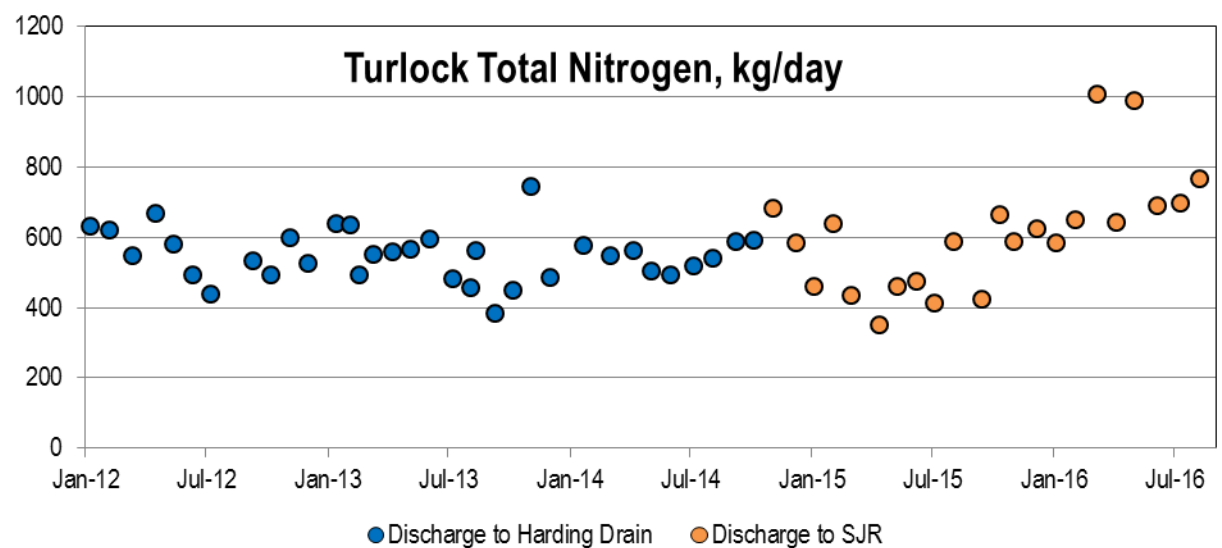
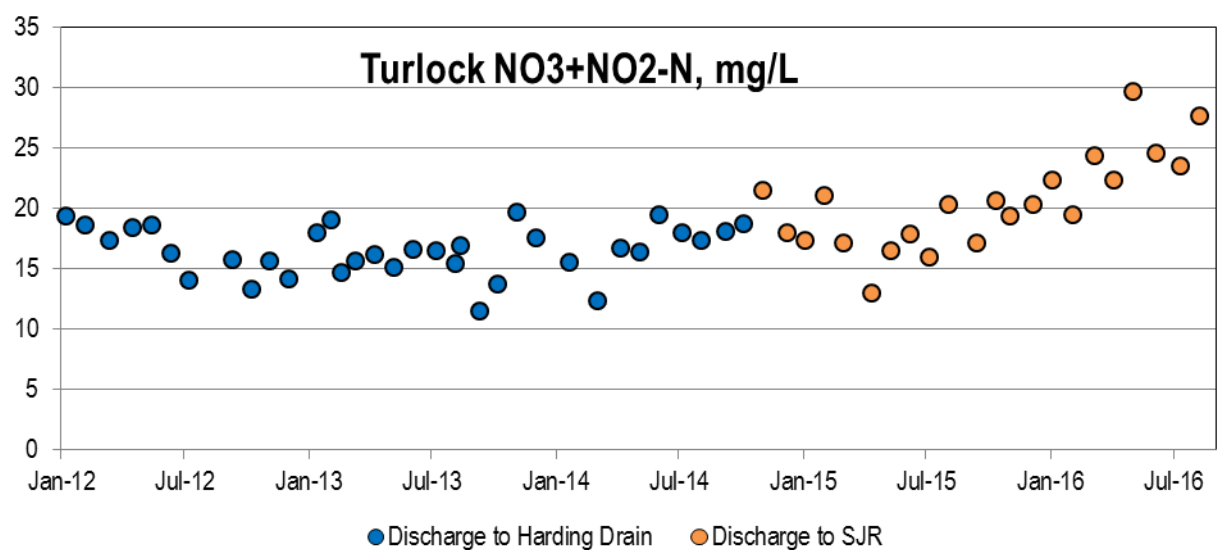
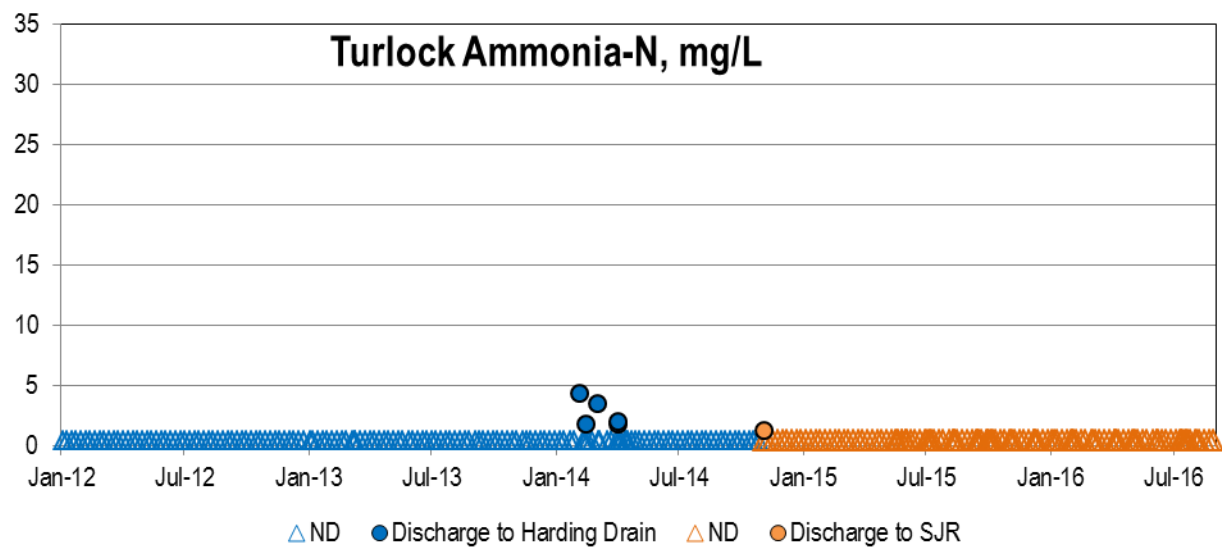




Turlock RWQCF

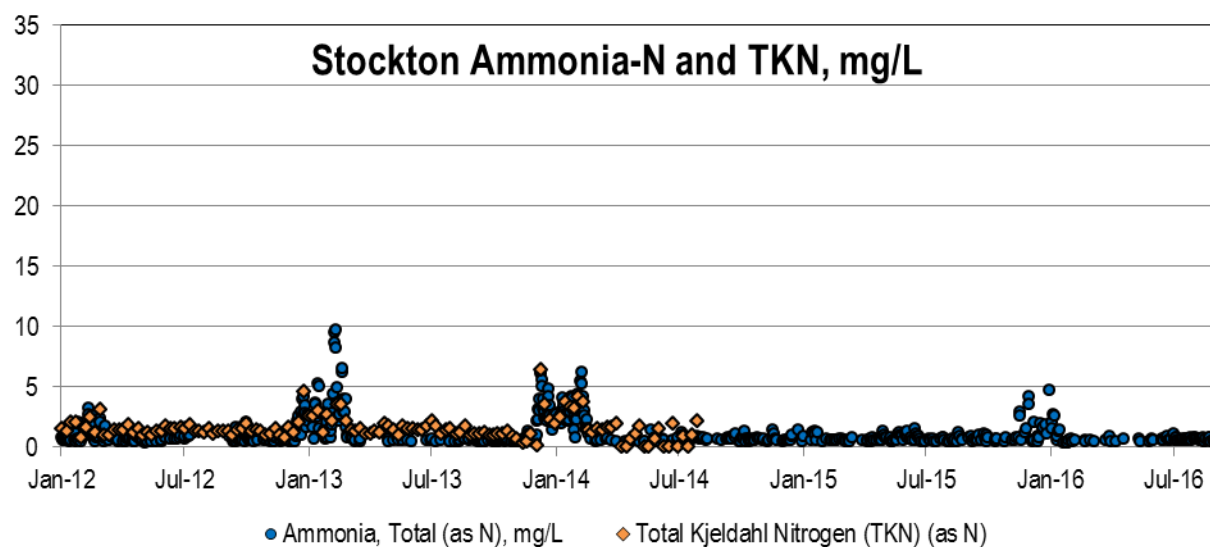
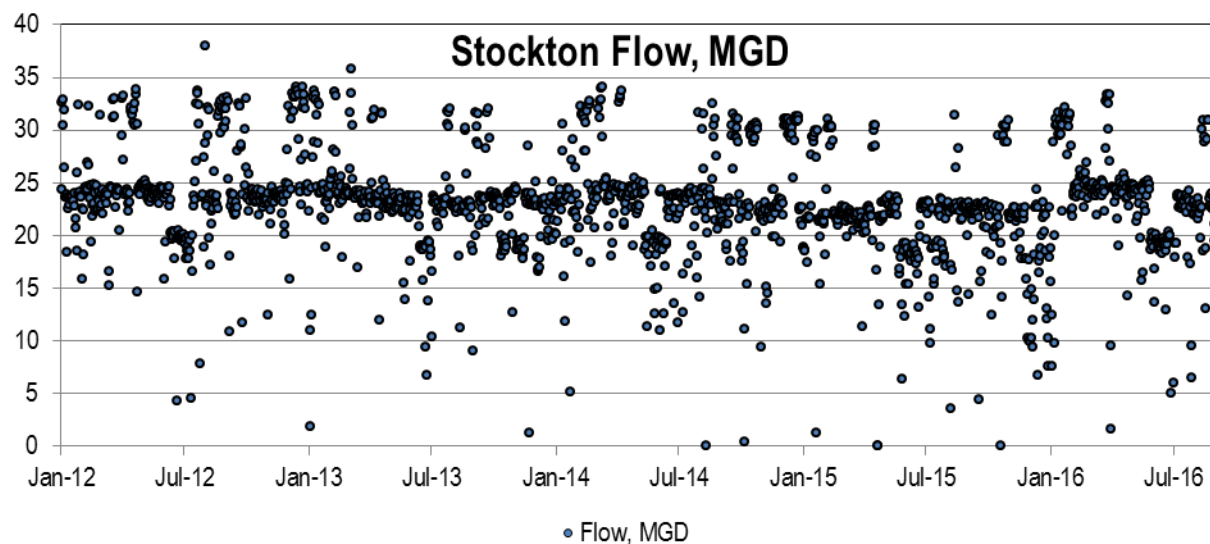
A treatment plant conversion to tertiary occurred at the Turlock RWQCF in spring 2006. Discharge to the Harding Drain occurred through October 2014, after which discharge was relocated to the San Joaquin River. Ammonia data were reported weekly and were generally non-detected at 0.5 mg/L. Nitrate & nitrite were reported monthly. Organic nitrogen and TKN were not monitored. Therefore, total nitrogen was calculated monthly from the nitrate & nitrite and ammonia results. Phosphorus was not monitored in Turlock effluent between 2012-2016.

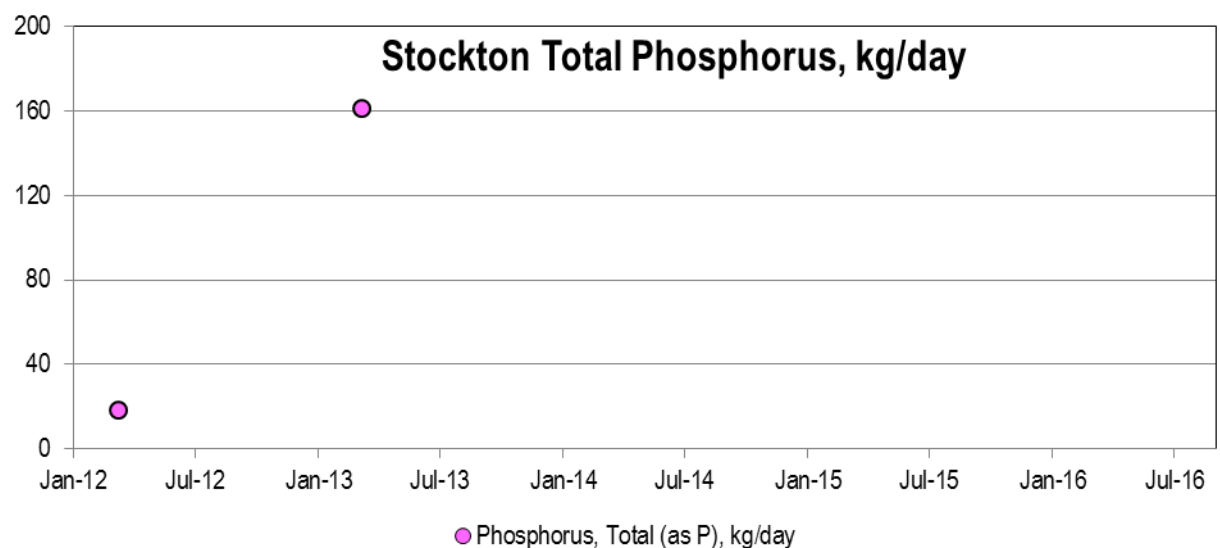
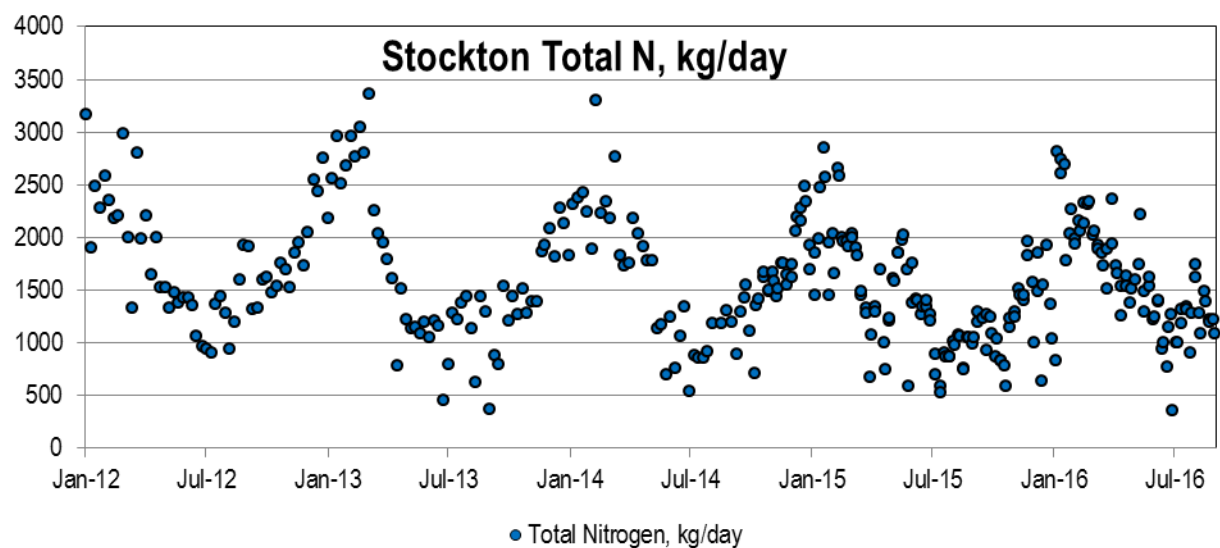
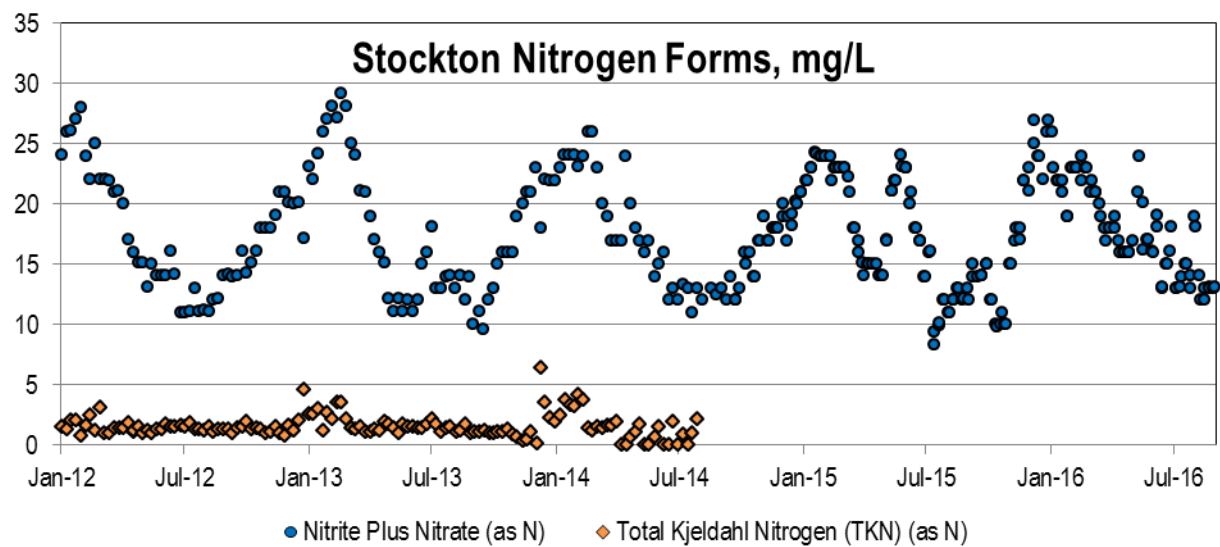




Stockton RWCF

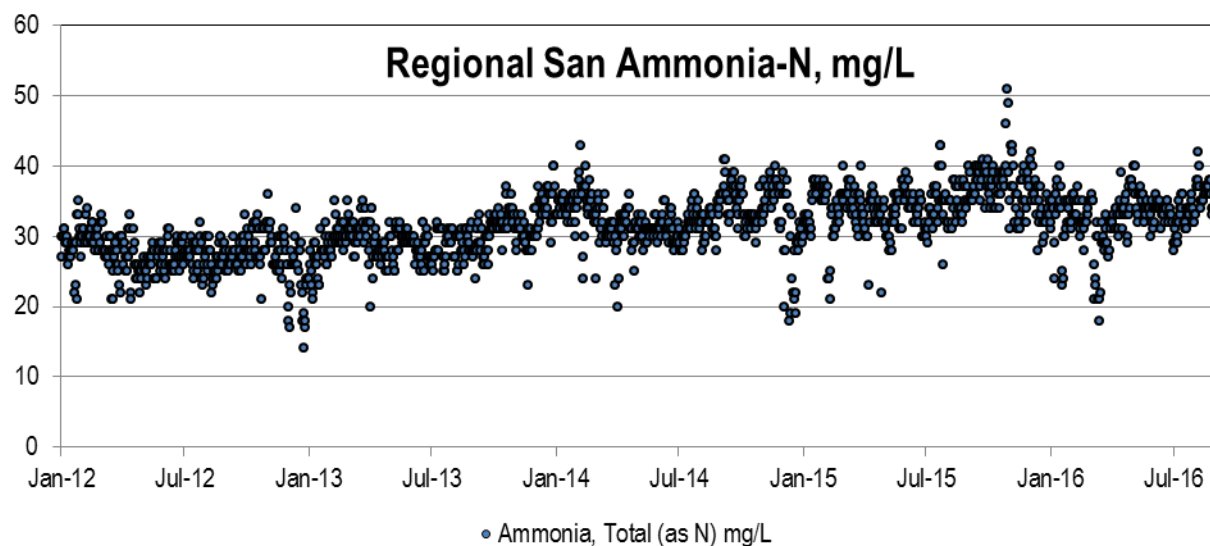
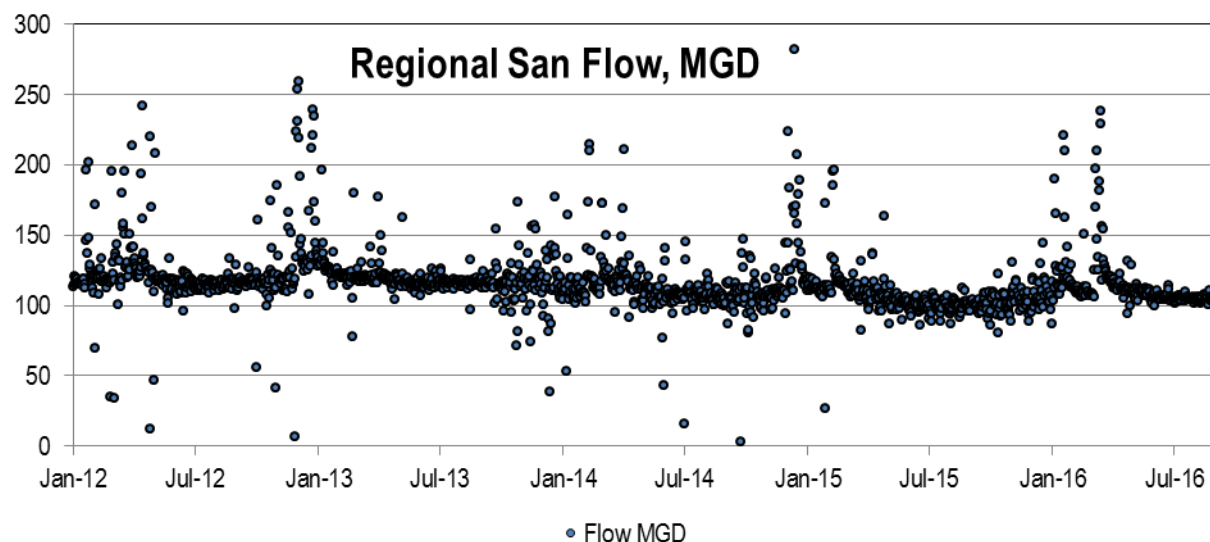
A treatment plant upgrade to tertiary occurred at the Stockton RWCF in June 2007. Ammonia and nitrate & nitrite were reported for effluent weekly or twice weekly between 2012-2016, and TKN was reported weekly from 2012 to July 2014. Therefore, total nitrogen was calculated from nitrate & nitrite and TKN until July 2014, and from nitrate & nitrite and ammonia (without TKN, the organic portion is unknown) from August 2014 onward. Only two phosphorus results were available.

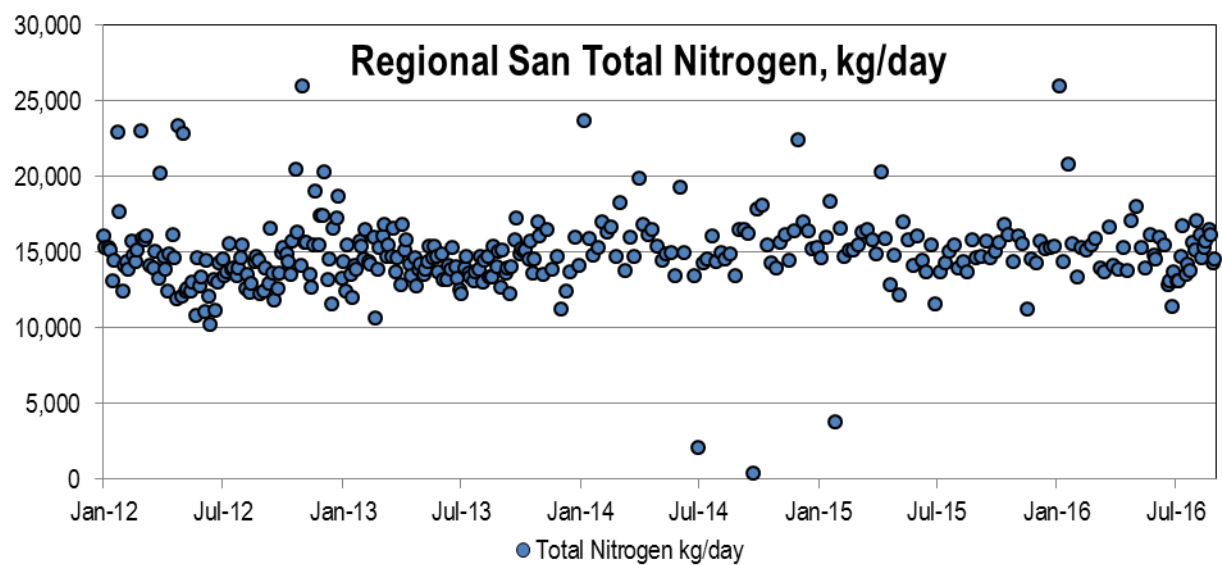
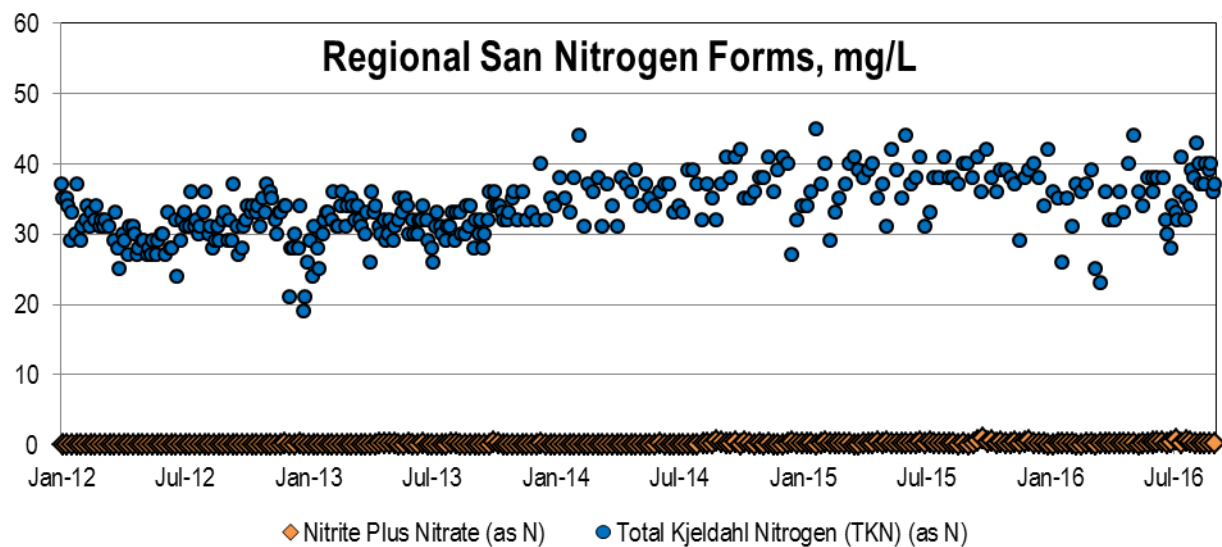




Regional San WWTP

Daily flow and ammonia data were available for the secondary discharge from Regional San WWTP. Weekly nitrate & nitrite and TKN data were also available. Therefore, weekly total nitrogen was calculated from TKN and nitrate & nitrite. No phosphorus data were available during this timeframe, but an average concentration of 2.28 mg/L was available from the EchoWater treatment plant upgrade EIR, based on data collected between 2009-2012.





The permitted flows, current (2012-2016) effluent flows, and calculated loads for ammonia-N, total nitrogen and total phosphorus are shown in Table 1.

Table 1. Current Nutrient Loads Discharged by Four POTWs

Parameter by Facility	Current Treatment	Permitted Dry Weather Flow (MGD)	Average Effluent Flow Rate (MGD)	Average Effluent Load	
				(lbs/day)	(kg/day)
Ammonia as N					
Modesto	Secondary	70	16	491	223
	Tertiary with nitrification	2.3	1.4	1.2	0.54
Turlock	Tertiary with nitrification	20	9.0	188	85.3
Regional San	Secondary	181	116	29,969	13,594
Stockton	Tertiary with nitrification	55	23	252	114
Total Nitrogen as N					
Modesto	Secondary	70	16	1,353	614
	Tertiary with nitrification	2.3	1.4	29.9	13.6
Turlock	Tertiary with nitrification	20	9.0	1,263	573
Regional San	Secondary	181	116	32,669	14,818
Stockton	Tertiary with nitrification	55	23	3,480	1,579
Total Phosphorus as P					
Modesto	Secondary	70	16	332	151
	Tertiary with nitrification	2.3	1.4	5.18	2.35
Turlock	Tertiary with nitrification	20	9.0	340 ^[a]	154 ^[a]
Regional San	Secondary	181	116	2,900 ^[a]	999 ^[a]
Stockton	Tertiary with nitrification	55	23	198	89.9

[a] These values are the current conditions determined in a 2011 West Yost study³, as no 2012-2016 data are available.

PROJECTED FUTURE CONDITIONS

The projected future nutrient load conditions were taken largely from a study performed by West Yost Associates in 2011² and supplemented with more recent information. The West Yost study calculated the then-current concentration, flow and load discharged by POTWs, and predicted three levels of future loads for the year 2030:

- Scenario 1, planned changes: the load based on currently mandated (but not yet implemented) treatment;
- Scenario 2, plausible changes: the load based on mandated treatment plus enhanced biological nutrient removal followed by chemical phosphorus removal with tertiary clarification, tertiary filtration (if not mandated) and UV disinfection (if not currently mandated);
- Scenario 3, outer boundary prediction: the load based on mandated treatment plus microfiltration (if not currently provided or planned), MF/RO and UV disinfection (if not currently mandated).

³ West Yost Associates. *Wastewater Control Measures Study*. Prepared for the Central Valley Water Quality Control Board Drinking Water Policy Workgroup. March 2011.

It should be noted that the total project capital costs for implementing Scenarios 2 and 3 were estimated in the 2011 West Yost study to be \$1.8 billion (of which \$0.1 billion is operation & maintenance) and \$9.5 billion (of which \$0.4 billion is operation & maintenance), respectively, for 13 POTW treatment upgrade projects, including the four POTWs in this review. These estimates are in addition to and do not include the costs for planned upgrades (Scenario 1). The estimates were performed by Delta region and treatment level type and represent 495 MGD of predicted 2030 treated POTW flow. The four POTWs represent 52% of the predicted future flow (assuming 20 MGD of permitted Turlock flow to the river), therefore the approximate costs for implementing Scenarios 2 and 3 for these four POTWs are \$0.93 billion and \$4.9 billion, respectively.

The predicted concentrations for each scenario were determined by West Yost based on literature values of average concentrations at the selected treatment levels for each facility. A service area growth factor was included in the prediction of future flows used to calculate loads. Flow decreases due to conservation were assumed to have no influence on loads due to corresponding increases in concentration. The assumptions for current and Scenario 1 treatment levels and service area growth rates (annual increase in flow) are shown in Table 2.

Table 2. Assumptions for Predicted Loads from 2011 Study

Facility	2010 treatment	Planned 2030 treatment (Scenario 1)	Service Area Growth Rate
Modesto	Secondary (pond treatment)	Tertiary with nitrification and denitrification (NDN)	1.90%
Turlock	Tertiary with nitrification, possibly partial denitrification	Tertiary with nitrification and denitrification (NDN)	2.70%
Regional San	Secondary pond treatment	Tertiary with nitrification and denitrification (NDN)	1.20%
Stockton	Tertiary with nitrification, possibly partial denitrification	Tertiary with nitrification, possibly partial denitrification	2.20%

Changes in 2011 Study Predictions

Since the West Yost study in 2011, the Modesto facility has installed tertiary treatment, as described in Current Conditions, and intends to increase the tertiary treatment capacity to 19.1 MGD. Additionally, the Modesto facility intends to remove discharge from the San Joaquin River within three years. The Turlock facility intends to remove most of its discharge to the San Joaquin River; however, it is keeping its permit available for up to 20 MGD of flow. These changes affect the comparison of current conditions and future predictions, as follows:

- The revised predicted load from Modesto (based on current tertiary concentrations and future permitted flow of 19.1 MGD) is lower than the load predicted by West Yost in the 2011 study.
- Regardless of treatment level, the predicted 2030 load discharged by Modesto to the Delta is zero (with the exception of emergency discharges), due to the removal of discharge from the San Joaquin River.

- The predicted 2030 load discharged by Turlock to the Delta is estimated to be 10% of the current load, due to plans for reducing discharge to the San Joaquin River. The loads that can be expected from the Modesto and Turlock facilities during periods of emergency discharge to the San Joaquin River are unpredictable, as the occurrence and duration of such discharges are unknown.
- The Regional San EIR performed for the EchoWater treatment plant upgrade predicted an increase in phosphorus concentrations from 2.28 mg/L to 3.14 mg/L, based on data collected between 2009-2012. The EIR also predicted future effluent concentrations for ammonia-N and total nitrogen, which were used with the current effluent flow to predict 2030 loads.

The three scenarios of future predicted loads, including the planned relocated discharges from the Modesto and Turlock facilities, are shown in Table 3.

Table 3. Nutrient Loads Discharged under Different Future Scenarios (2030)

Parameter by Facility	Current Load (kg/day)	2030 Future Load (kg/day) ^[a]		
		Scenario 1 [Planned]	Scenario 2 [Plausible]	Scenario 3 [Outer Boundary]
Ammonia as N				
Modesto	223	0 ^[b]	0 ^[b]	0 ^[b]
Turlock	85	8.5 ^[c]	8.5 ^[c]	7.3
Regional San	13,594	70 ^[d]	70 ^[d]	68
Stockton	114	114	50	16
Total Nitrogen as N				
Modesto	627	0 ^[b]	0 ^[b]	0 ^[b]
Turlock	573	57 ^[c]	57 ^[c]	57 ^[c]
Regional San	14,818	3,239 ^[d]	3,132	1,270
Stockton	1,579	1,179	499	295
Total Phosphorus as P				
Modesto	153	0 ^[b]	0 ^[b]	0 ^[b]
Turlock	154 ^[e]	15 ^[c]	3.7	0.23
Regional San	999 ^[d]	1,376 ^[d]	35	2.1
Stockton	90	90 ^[f]	8.6	0.50

[a] Predicted by the 2011 West Yost study, unless otherwise noted.

[b] Representing zero discharge to the San Joaquin River. Discharge would only occur as an emergency option.

[c] Set to 10% of the current effluent load.

[d] Calculated from current flows and concentrations predicted in the 2014 EchoWater Project EIR Water Quality Tech Memo (ammonia-N: page 20, total nitrogen: page 32, phosphorus: page 49).

[e] Set equal to the current load from the 2011 West Yost study, as no 2012-2016 data are available.

[f] Set equal to the current average 2012-2016 load, as the load predicted by the 2011 West Yost study was greater.

PREDICTED PERCENT CHANGE

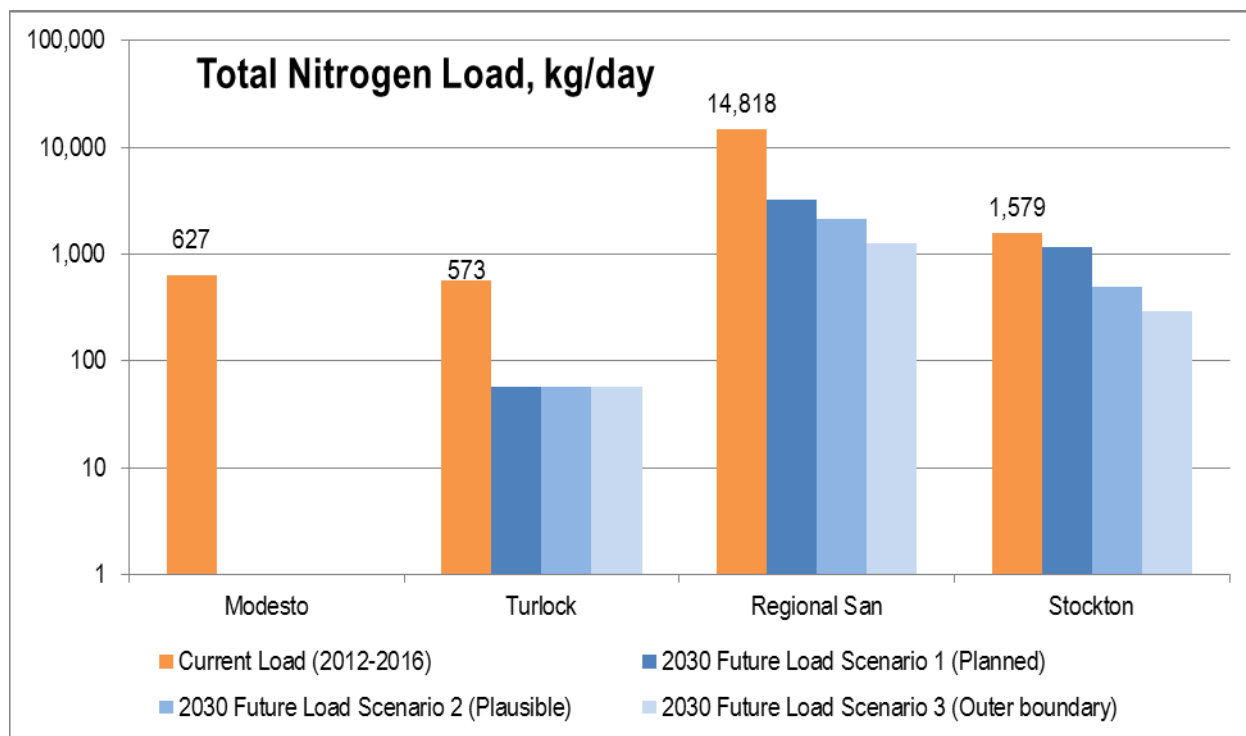
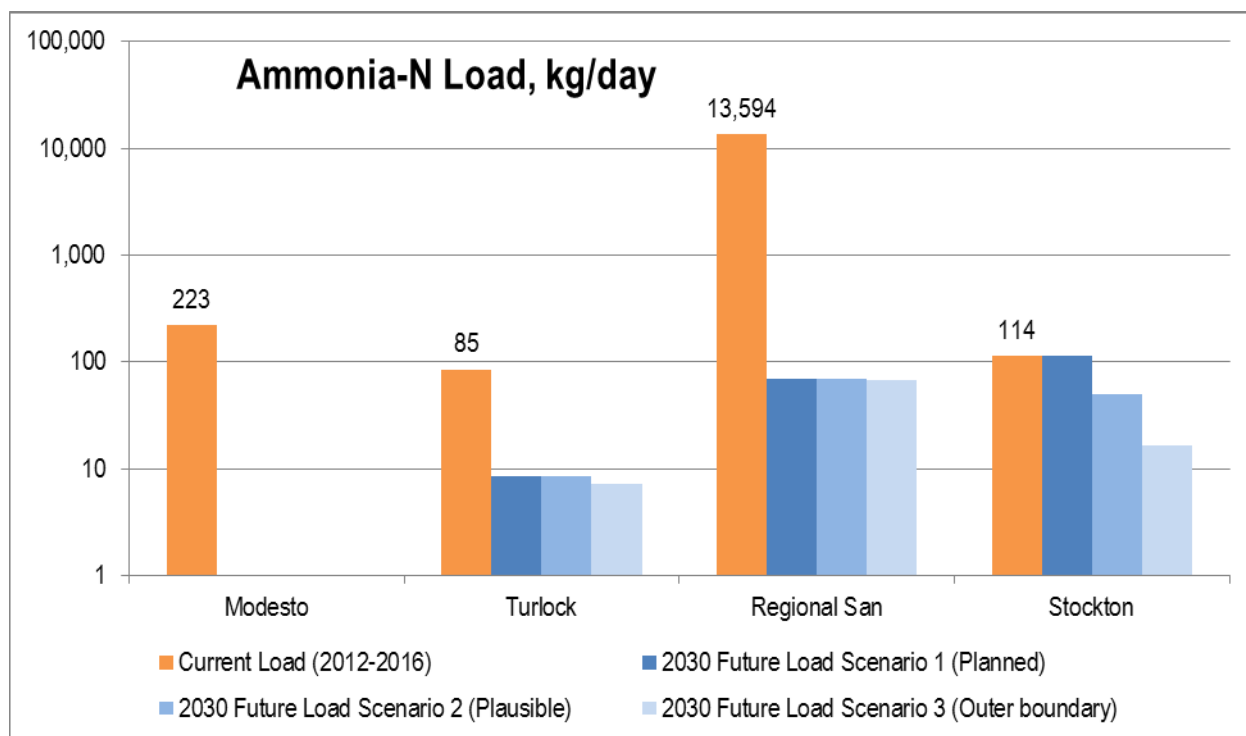
The percent reduction in nutrient load between the current and predicted future scenarios for the four POTWs is shown in Table 4. These percentages assume diversion of the full Modesto facility and 90% of the Turlock facility discharge from the San Joaquin River.

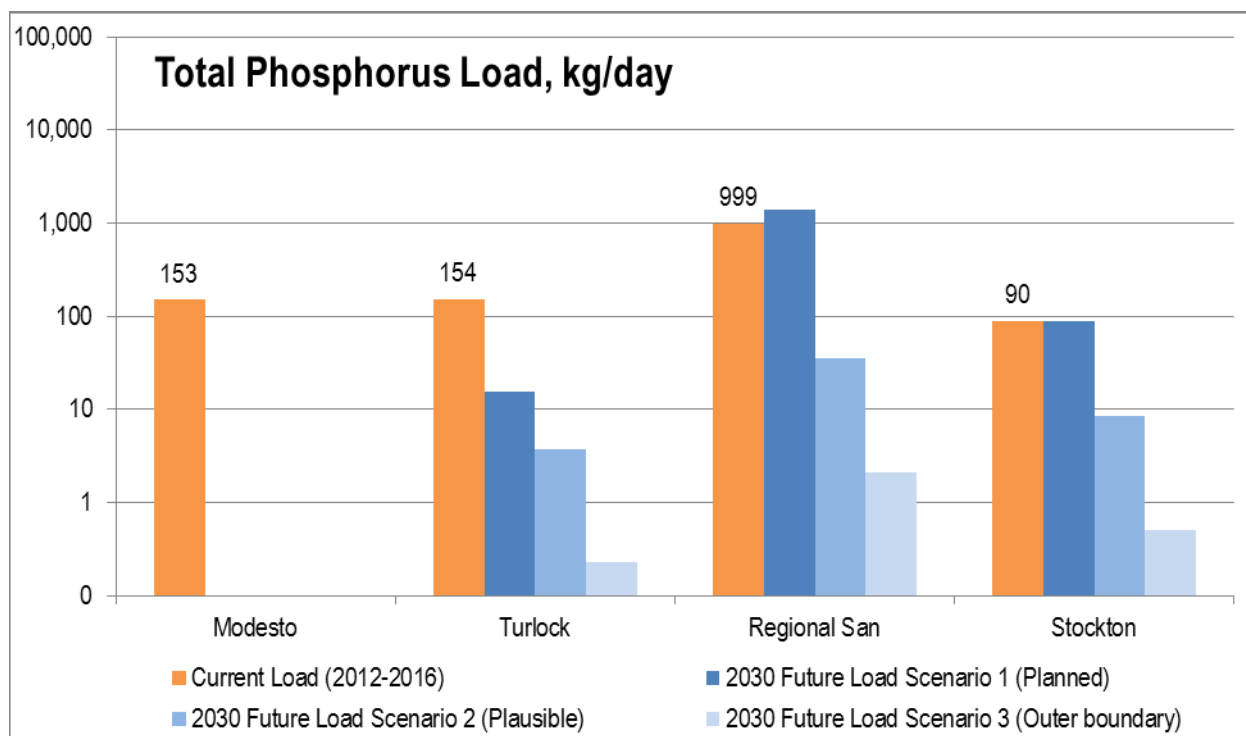
Table 4. Predicted 2030 Percent Reduction in Nutrient Load

Parameter by Facility	Current Load (kg/day)	Percent Reduction in Future 2030 Load ^[a]		
		Scenario 1 [Planned]	Scenario 2 [Plausible]	Scenario 3 [Outer Boundary]
Ammonia as N		99%	99%	99%
Modesto	223	100%	100%	100%
Turlock	85	90%	90%	91%
Regional San	13,594	99%	99%	99%
Stockton	114	0%	56%	86%
Total Nitrogen as N		75%	85%	91%
Modesto	627	100%	100%	100%
Turlock	573	90%	90%	90%
Regional San	14,818	78%	86%	91%
Stockton	1,579	25%	68%	81%
Total Phosphorus as P		-6%	97%	99.8%
Modesto	153	100%	100%	100%
Turlock	154	90%	98%	99.9%
Regional San	999	-5%	97%	99.8%
Stockton	90	0%	90%	99%

[a] Loads predicted by the 2011 West Yost study unless otherwise noted in Table 3.

A comparison between current and future loads is shown in the graphs below. Note the logarithmic scale used for loading values.





With planned future changes in treatment at Regional San and Stockton and changes to discharge location for Modesto and Turlock, it is predicted that nutrient loads from these four POTWs will decrease significantly by 2030 compared to current average loads discharged between 2012 and 2016, as shown in Table 5. The majority of the future predicted total nitrogen load under Scenario 1 will be comprised of nitrate-N.

Table 5. Summary of Average Percent Reductions for Loadings from Four POTWs (Scenario 1 (Planned) versus Current)

Parameter	Average Percent Reduction in Load in 2030
Ammonia as N	99%
Total Nitrogen as N	75%
Total Phosphorus as P	-6%