Analysis of potential nutrient load allocation for the reaches of the Santa Clara River considered in the 1998 303(d) list

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1. Introduction

This study evaluates a number of nutrient load allocations from Point and Non-Point Sources (PS and NPS) present in the reaches of the Santa Clara River (SCR) considered in the 1998 303(d) listing, namely Reaches 3, 7 and 8 based on the US EPA designation (Figure 1 and 2). For modeling purposes, these reaches have been segmented further, providing an opportunity to consider water quality monitoring data for a number of segments, and to evaluate the PS and NPS loads for each segment. The segments are presented in Figures 1 and 2, using the identification number used in the WARMF model; the approximate location of the segment boundaries is presented in Table 1 for reference, as well as a descriptor of each segment. For this analysis, the WARMF model was used as described in the Task 2 Linkage Analysis, with a refined calibration of the nitrogen processes as described in Appendix A.

Table 1. Identification of river segments in Santa Clara River

ID	Segment Designation	Approximate boundaries of SCR segment
7	Reach 3 below Santa Paula	Between Adams Canyon and Todd Barranca
9	Reach 3 at Santa Paula	Between Todd Barranca and Santa Paula Creek
69	Reach 3 above Santa Paula	Above Santa Paula Creek and below Reach 4
111	Reach 7 at County Line	Between Salt Canyon and Potrero Canyon Creeks
56	Reach 7 below Valencia	Between Castaic Creek and Valencia WWTP*
129	Reach 7 above Valencia	Between Valencia WWTP and Highway 5
159	Reach 8	Between Bouquet Canyon Creek and the South Fork

*WWTP = Waste Water Treatment Plant

The load allocations require a consideration of the Water Quality Objectives (WQO), which are defined in the LA RWQCB Basin Plan. In addition, Numerical Targets have been defined by the LA RWQCB based on the WQO, with the intent of serving as an early warning system and thus prevent the exceedence of the WQO. For example, in most reaches the combined nitrate plus nitrite WQO is 5.0 mg/L as $N\text{-}NO_3$ + $N\text{-}NO_2$, except in Reach 8 where the WQO is 10.0 mg/L as $N\text{-}NO_3$ + $N\text{-}NO_2$. The Numerical Target has been set with a 10% explicit Margin of Safety (MOS), such that it is 4.5 mg/L as $N\text{-}NO_3$ + $N\text{-}NO_2$ in most reaches except Reach 8 where it is 9.0 mg/L as $N\text{-}NO_3$ + $N\text{-}NO_2$. The LA RWQCB expects that the Numerical Target will be met 95% of the time or better.

In the case of ammonia, the WQO is based on the US EPA 1999 Update of Ambient

Water Quality Criteria for Ammonia (ref.), which indicates that the thirty-day average concentration of total ammonia as nitrogen (in mg N/L) shall not exceed (more than once every three years on average) the criteria continuous concentration (CCC) calculated as follows:

Where early life stage fish are present:

$$CCC = \left(\frac{0.0577}{1 + 10^{7.688 - pH}} + \frac{2.487}{1 + 10^{pH - 7.688}} \right) * MIN(2.85, 1.45x10^{0.028*(25-T)})$$

Where early life stage fish are not present:

$$CCC = \left(\frac{0.0577}{1 + 10^{7.688 - pH}} + \frac{2.487}{1 + 10^{pH - 7.688}} \right) * 1.45x10^{0.028*(25-MAX(T,7))}$$

with T = temperature in ^{o}C.

The statistics of observed pH and temperature in the SCR are presented in Tables 2 and 3. For calculation of the CCC, the appropriate statistics are the 50-percentile pH and temperature. The 50-percentile pH generally increases while the 50-percentile temperature generally decreases from upstream to downstream locations. Using this information, the CCC for each segment are calculated using the two equations and are presented in Table 4. A 10% MOS is considered for the Ammonia Numerical Target, using the same rationale as for the Nitrate plus Nitrate Numerical Target. Note that based on the temperature in these segments of the SCR, there is no need to differentiate between the two CCC.

Table 2. Statistics of observed pH data

Statistic	Reach 8	Reach 7 above Valencia	Reach 7 below Valencia	Reach 7 at County Line	Reach 3 above Santa Paula	Reach 3 at Santa Paula	Reach 3 below Santa Paula
50 percentile	7.33	7.89	7.78	8.20	8.00	8.00	8.08
90 percentile	7.53	8.16	8.04	8.30	8.30	8.30	8.35
95 percentile	7.62	8.24	8.17	8.41	8.37	8.37	8.43
Mean	7.31	7.85	7.73	8.15	8.00	8.00	8.03
Std. deviation	0.22	0.29	0.31	0.21	0.26	0.26	0.31
CV*	0.03	0.04	0.04	0.03	0.03	0.03	0.04

*CV = coefficient of variation

Table 3. Statistics of temperature data (in ^{o}C)

Statistic	Reach 8	Reach 7 above Valencia	Reach 7 below Valencia	Reach 7 at County Line	Reach 3 above Santa Paula	Reach 3 at Santa Paula	Reach 3 below Santa Paula
50 percentile	19.89	18.23	20.22	19.03	16.68	16.81	16.81
90 percentile	24.34	23.68	25.32	24.59	19.00	19.73	19.87
95 percentile	25.02	24.58	25.90	25.41	19.48	20.44	20.57
Mean	19.55	18.43	20.21	19.22	16.39	16.52	16.52
Std. deviation	3.92	4.05	3.97	4.15	2.32	2.78	2.85
CV*	0.20	0.22	0.20	0.22	0.14	0.17	0.17

Table 4. Ammonia Water Quality Objective and Numerical Target (mg/L as N-NH_3)

	Reach 8	Reach 7 above Valencia	Reach 7 below Valencia	Reach 7 at County Line	Reach 3 above Santa Paula	Reach 3 at Santa Paula	Reach 3 below Santa Paula
CCC w/early life stages	3.50	2.19	2.23	1.29	2.06	2.04	1.80
CCC w/o early life stages	3.50	2.19	2.23	1.29	2.06	2.04	1.80
Numerical Target	3.15	1.97	2.00	1.16	1.85	1.84	1.62

The Total Maximum Daily Load (TMDL) for each segment must be divided into a Waste Load Allocation (WLA) from point sources and a Load Allocation (LA) from non-point sources. In addition, the TMDL must consider an MOS and Future Growth (FG), such that:

TMDL = WLA + LA + MOS + FG

MOS can be implicit or explicit. For example, considering a 10% MOS for the WQO in determining the Numerical Targets is an explicit MOS. If an additional MOS is considered based on uncertainty in the model, due to data limitations and/or model assumptions, this is considered an implicit MOS.

FG can be considered in several ways. For the two WWTP in LA County, Saugus and Valencia, the information from the LA County Sanitation Districts (LACSD) indicates that these two plants will be upgraded to a capacity of 6.5 MGD and 21.6 MGD, respectively. For the Fillmore and Santa Paula area, we have considered that the Fillmore plant will be phased out and that all of its flow will be directed to the upgraded Santa Paula WWTP. We then applied a growth factor of 1.2 to their combined flow, considering the slower growth rate in this area. The current and projected flowrates for these facilities is presented in Table 5. For agricultural NPS, no additional future growth was considered since the acreage devoted to agriculture is unlikely to increase, given the increasing urbanization of the watershed. There is the potential to convert orchards (e.g. citrus or avocado) to row crops, but this was not evaluated in this analysis given the lack of information on such plans.

Table 5. Current and projected flowrates of major point sources in SCR (in m^3/s)

	Current	Projected	Increase
Saugus	0.24	0.28475	18.6%
Valencia	0.50	0.94625	89.3%
Santa Paula & Fillmore	0.15	0.18	20 %

2. PS Loading Analysis

The scenarios were constructed using observed meteorological conditions from 10/01/1989 to 9/30/2000, based on the calibrated WARMF model. Several PS loading scenarios were considered by modifying the ammonia, nitrate and nitrate concentrations in the treated WWTP effluent at the flowrates indicated in Table 5. One important consideration is the interaction between various nitrogen species, since ammonia oxidizes to nitrite which then oxidizes to nitrate. Ammonia, nitrite and nitrate can also be assimilated by the in-stream and riparian vegetation, and ammonia may also be lost to the atmosphere due to volatilization. Nitrate might be reduced to nitrogen gas under low oxygen conditions, such as those that might exist in some sediments and in slow-flowing pools along the river. Thus, loading scenarios have to consider all these interactions.

One possible scenario would be to consider PS effluent concentrations at the Numerical Targets for the respective nutrients. Simulations for various segments of the SCR are presented in Figures 3-16, considering the effluent concentrations presented in Table 6.

Table 6. Effluent Concentrations at Numerical Targets for each segment

	NH_3 (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	Flowrate (m^3/s)
Saugus	3.15	0.1	9.0	0.28475
Valencia	2.00	0.1	4.5	0.94625
Santa Paula + Fillmore	1.84	0.1	4.5	0.18

This scenario results in concentrations in the SCR below the Numerical Targets at all times for all segments below the Valencia WWTP. However, due to some episodic NPS load of ammonia and nitrate entering Reach 8, the ammonia Numerical Target could be exceeded 10 % of the time, during the first significant storms of the winter (Figure 3). It is important to note that the ammonia WQO is based on a 30-day average concentration, not an instantaneous sample or even a daily average value. The ammonia WQO for a daily average is approximately an order of magnitude greater than the CCC, such that these levels of ammonia would have no observable effect on even the most sensitive species. Nitrate + nitrite concentrations would exceed the Numerical Target 6 % of the time, generally during the same rain events (Figure 4). The nitrate + nitrite WQO would only be exceeded less than 0.1 % of the time in Reach 8. Ammonia concentrations decrease noticeably in the upper part of Reach 7, such that in the segment between Highway 5 and the Valencia WWTP the Numerical Target is only exceeded one day (Figure 5) through the eleven-year simulation period (compliance better than 99.9% of the time). Nitrate + nitrite concentrations in this segment of Reach 7 above the Valencia WWTP could exceed the Numerical Target around 21 % of the time, at the end of the dry-weather season and during the first significant storms. Nitrate + nitrite concentrations rise in these upper segments of Reach 7 as ammonia is partially transformed to nitrite and nitrite to nitrate.

One alternative scenario involves reducing the ammonia loading from the Saugus WWTP, by reducing effluent concentrations for example to 2.0 mg/L as N-NH_3, leaving all other effluent concentrations as shown in Table 6. The results for Reach 8 and the Reach 7 segment immediately above the Valencia WWTP are presented in Figures 17 and 18. Under these conditions, the ammonia Numerical Target is met at all times with only one exceedence through the 11-year simulation period. Nitrate + nitrite concentrations would still exceed the Numerical Target around 6 % of the time, although the nitrate + nitrite WQO might only be exceeded less than 0.1 % of the time in Reach 8. The concentrations of ammonia and nitrate + nitrite at the segment above Valencia WWTP would decrease, with only one day of exceedence of the ammonia Numerical Target and WQO, and compliance with the nitrate + nitrite Numerical Target 91.5% of the time. However, the nitrate + nitrite WQO would be exceeded about 1 % of the time during the eleven years. Concentrations of ammonia and nitrate + nitrate are slightly lower in the lower segments of the SCR, since the overall nitrogen loading is reduced upstream.

Another scenario considers the expected performance of upgraded WWTPs. The LACSD and the Santa Paula WWTP plants are in the process of upgrading to include a Nitrification-Denitrification (NDN) module. From practical experience with the NDN process at the Whittier WWTP, the LACSD considers that it can control ammonia effluent concentrations to below 2.0 mg/L as $N\text{-}NH_3$, 0.1 mg/L as $N\text{-}NO_2$ and around 8.0 mg/L as $N\text{-}NO_3$. The statistics of the performance of the Whittier WWTP for the last two years (January 2001-January 2003) are presented in Table 7. Nitrate concentrations in the Whittier effluent varied significantly, possibly due to seasonal variations in performance. It is assumed that the upgraded Santa Paula facility can also meet these conditions.

Table 7. Performance of Whittier WWTP

	NH_3 (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)
Number of observations	112	33	32
50 percentile	1.13	0.03	6.36
90 percentile	1.73	0.09	7.55
95 percentile	1.86	0.11	7.83
99 percentile	1.99	0.16	8.03

The effluent conditions considered in this scenario are presented in Table 8. Although the scenario was evaluated with both current and future flowrates, only the higher flowrate is presented here.

Table 8. Effluent Concentrations considering Whittier WWTP experience

	NH_3 (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	Flowrate (m^3/s)
Saugus	3.15	0.1	8.0	0.28475
Valencia	2.00	0.1	8.0	0.94625
Santa Paula + Fillmore	1.84	0.1	8.0	0.18

Based on this scenario, ammonia concentrations in Reach 8 remain at the same level as presented in Figure 3, with a 10% exceedence of the numerical target. Nitrate + nitrite concentrations in Reach 8 (Figure 21) decrease to a level where the numerical target is achieved more than 99% of the time and the WQO is not exceeded in the 11-year simulation.

Ammonia concentrations in the segment of Reach 7 above the Valencia WWTP are the same as presented in Figure 5. Nitrate + nitrite are under the numerical target 87% of the time, with exceedences most likely at the end of the dry season or the first strong storm events (Figure 22). Ammonia concentrations below Valencia are the same as in Figures 7. Nitrate + nitrite concentrations below Valencia would exceed the numerical target in this reach (ID 56) around 47% of the time (Figure 23). The 90-percentile concentration is 5.43 mg/L. In the segment at the County Line (ID 111), the concentrations of ammonia are the same as in Figure 9; nitrate + nitrite concentrations are under the numerical target more than 99% of the time (Figure 24).

Ammonia concentrations in all segments of Reach 3 are the same as presented in Figures 11, 13 and 15. Nitrate + nitrite concentrations above Santa Paula are only slightly increased from Figure 12, due to the higher nitrate loading upstream, but are well under the numerical target all of the time. At Santa Paula, nitrate + nitrite concentrations increase by around 22% (Figure 25), but would still be well below the numerical target, with compliance throughout the entire 11-year simulation period. The situation below Santa Paula is also under compliance with the numerical target.

Based on these initial results, an Intermediate scenario was constructed, with the goal of meeting the numerical targets and yet recognize the feasibility of performance of the upgraded NDN processes at the WWTPs. Presented here is the result of many iterations to find a suitable balance between nitrogen compounds, as ammonia, nitrite and nitrate loading all contribute to the nitrate + nitrite numerical target. In addition, there is a need to balance the total nitrogen loading from the Saugus and Valencia WWTP, since effluent from Saugus affects the levels of nitrate below Valencia. This is somewhat complicated due to the sharp change in the nitrate + nitrite WQO between Reach 7 and 8. The Intermediate scenario conditions are presented in Table 9.

Table 9. Effluent Concentrations for Intermediate scenario

	NH_3 (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	Flowrate (m^3/s)
Saugus	2.00	0.1	7.00	0.28475
Valencia	1.75	0.1	6.70	0.94625
Santa Paula + Fillmore	2.00	0.1	8.00	0.18

The simulation results are presented in Figures 26-37. With the lower effluent concentrations from the Saugus WWTP (even below the numerical targets for Reach 8), the ammonia and numerical targets for Reach 8 and segment 129 (Reach 7 above Valencia) are met throughout the 11-year simulation (Figures 26-29) more than 95 % of the time. Nitrite + nitrite concentrations in segment 129 are below 4.34 mg/L 95% of the time.

Ammonia concentrations below Valencia and down to the County Line (Figures 30 and 32) are well below the numerical target for these segments of Reach 7. Nitrate + nitrite in segment 129 is in compliance with the numerical target exactly 95% of the time (Figure 31). This is the tightest condition in the entire watershed and would require frequent monitoring to ensure compliance. Once the river flows down to the County Line, the nitrate + nitrite numerical target is met all the time throughout the 11-year simulation period (Figure 33).

Both the ammonia and nitrate + nitrite numerical targets are met above, at and below Santa Paula all the time throughout the 11-year simulation period under the Intermediate Scenario (Figures 34-37). The higher assimilative capacity in Reach 3 as well as reduced nitrogen loading relative to current operating conditions for the Santa Paula and Fillmore WWTPs results in full compliance.

The nitrogen compound loads corresponding to the Intermediate Scenario can be divided into current and future load, as presented in Table 10.

Table 10. Current and future loads considering Intermediate scenario

	Current Load			Future Load		
	NH_3 (kg/day)	NO_2 (kg/day)	NO_3 (kg/day)	NH_3 (kg/day)	NO_2 (kg/day)	NO_3 (kg/day)
Saugus	41.5	2.1	145.2	49.2	2.5	172.2
Valencia	75.6	4.3	289.4	143.1	8.2	547.8
Santa Paula + Fillmore	25.9	1.3	103.7	31.1	1.6	124.4

3. NPS Loading Analysis

The previous analysis considers changes in nitrogen loading from the three major point sources while the NPS nitrogen loading remains at levels similar to existing conditions. However, the flowrates will be higher than in the calibration scenario, given that we are considering a significant increase in overall WWTP flowrates (Table 5). Thus, the relative contribution of the NPS to overall in-stream loading varies with respect to the original calibration. One way to evaluate the role of these smaller sources, including the small PS as well as NPS such as atmospheric deposition, septic tanks, fertilizer application in farms and residential areas, etc., is to set the nitrogen compound loading to zero and observe the resulting water quality. The results of this simulation are presented in Figures 38-51.

NPS loading in Reach 8 and above is significant, both for ammonia and nitrate. Nitrite NPS loading in general is very low throughout the watershed, given that there sources are very small, so it won't be discussed in specific, although we do present the simulated nitrate + nitrite concentrations for an accurate comparison against the previous scenarios. Atmospheric deposition of both ammonia and nitrate is important in Reaches 8 and 9 of the Santa Clara River, given the proximity to the greater Los Angeles basin, where a significant amount of these air pollutants is emitted, and the very large surface area of these two Reaches. Nitrate is produced from the transformation of nitrogen oxides (NOx) to nitric acid and then nitrate. Ammonia appears to be delivered to the river mostly in storm events (Figure 38), while nitrate loading is also through shallow groundwater flows, with an average nitrate + nitrite concentration in the river of 1.5 mg/L (Figure 39). Large storm events flush the landscape, resulting in some peak concentrations.

The contribution from NPS loading of ammonia and nitrate decreases in Reach 7, as these compounds are assimilated. The overall surface area of Reach 7 is smaller, decreasing the magnitude of the loading from atmospheric deposition. The population served by septic systems is also much smaller, given the higher level of urbanization than in Reaches 8 and 9 in particular. Thus, the in-stream concentrations generally decrease going downstream. As in Reach 8, ammonia contributions are mostly driven by storm events (Figures 40, 42 and 44), while nitrate has both groundwater and storm event contributions (Figures 41, 43 and 45).

In Reach 3, NPS ammonia loading is negligible (Figures 46, 48 and 50). Nitrate loading is quite significant above Santa Paula (Figure 47), with an average nitrate + nitrite concentration of 1.26 mg/L. The contributions from NPS nitrate loads decreases going downstream, both due to dilution in WWTP effluent and assimilation or transformation of nitrate.

With respect to increases in NPS loading in the future, the conditions at and below the Valencia WWTP dictate what can be done in Reaches 8 and 9. Additional NPS loading in these areas needs to be assimilated before it reaches the Valencia WWTP, or be associated with sufficient flow to dilute the concentrations in the river.

In Reach 7 below segment 129, the proportion of farmland relative to other land uses increases to 7-8% of the total land surface, and is generally located close to the river. Although there is room for additional NPS loading in these segments (Figures 32 and 33), this region should also be monitored frequently to ensure compliance with the numerical targets. If urbanization of this region is approved, a reevaluation of loading should be considered, even if most of the loading is in the form of subsurface discharges.

4. Margin of Safety

An explicit 10% MOS has been considered in all the numerical targets. For regions with frequent monitoring, such as segment 159 of Reach 8 and segments 56 and 129 of Reach 7, this safety level appears adequate. Monitoring in these segments should be increased during the critical conditions, namely at the end of the dry season and during the first strong storm events. It would also be recommendable to increase monitoring above the Saugus WWTP, to have a better picture of NPS loading from Reach 9 and tributaries in that area. Given the sparseness of monitoring data in this upper part of the watershed, partially as a result of very low flows during most of the year, these segments of the river could not be calibrated in the WARMF model. Additional information might allow for a reassessment of PS and NPS loading in Reaches 7 and 8.

For the region below segment 129, as the river enters the farmland in the lower Reach 7, the 95 percentile nitrate + nitrite concentration is 3.55 mg/L. Under current conditions, the difference between the WQO of 5 mg/L and this concentration is around 30%. This should be sufficiently ample difference to meet the WQO. Increased frequency of monitoring during the critical conditions should result in higher confidence in model results, without the need to formally establish a higher MOS.

In Reach 3, the simulation results indicate that ammonia and nitrate + nitrite concentrations will be more than 30% below the WQO, and in some cases even 80 or 90% below the WQO. Thus, there is no need to formally establish a larger MOS. However, monitoring data in Reach 3 has been sparse in the past, so an increased monitoring frequency is recommendable, particularly during the critical conditions.

5. Discussion and Recommendations

The guiding objective of this load allocation analysis was to meet the Water Quality Objectives. To ensure that the objectives are met, a 10% explicit Margin of Safety was incorporated into the Numerical Targets. A 95% compliance of the Numerical Targets or better was considered appropriate. There are a number of approaches to developing scenarios, and the interests of the various stakeholders must be taken into consideration. The Intermediate Scenario attempts to strike a balance, providing the desired environmental benefit by protecting the intended uses of the Santa Clara River at a reasonable cost, which will be borne mostly by the residents of the Santa Clara River watershed.

There are a number of built-in assumptions in the Intermediate Scenario, which provide additional safety. For example, the simulations have been conducted at higher flowrates than the situation that will be present during the first few years of operation of the upgraded WWTP. Thus, nitrogen loading will be lower than the scenario considers. PS loading has been considered towards the upper range of the experience at the Whittier WWTP, to provide an additional margin of safety. The calibration refinement tends to slightly overpredict concentrations in most cases.

In addition, an increased monitoring program, particularly in those segments where the concentrations are close to the numerical target, and during the critical conditions, should adequately provide information to make refinements in the load allocations in future years.

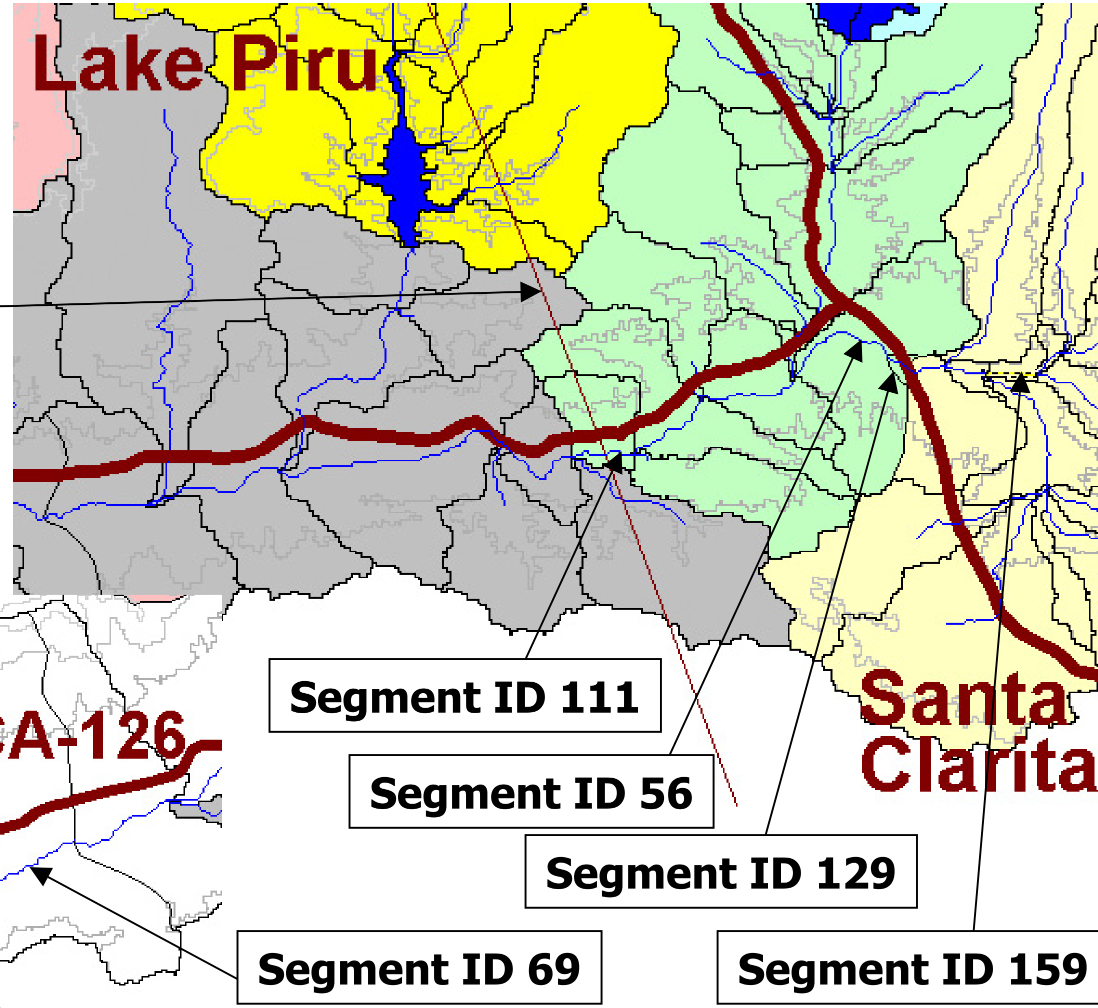
In addition, studies should be conducted to address the follow assumptions:

- **Rapid nitrogen compound disappearance in Reaches 7 and 8**: the observed data implies a rapid disappearance of ammonia, nitrite and nitrate in the upper SCR. Whether this will continue to be the case when the WWTP are upgraded to NDN needs to be monitored. Changes in conditions might result in the need to refine the model and revisit the load allocations.
- **Atmospheric deposition**: an important NPS load in the upper watershed is atmospheric deposition. The magnitude of this load was estimated in the source analysis, but it would be of use to all the stakeholders in the upper watershed to know if the assumptions are correct, and it might lead to either increased or decreased loading from other sources.
- **Nitrate loading via groundwater discharge**: The WARMF model uses prescribed groundwater (GW) discharge flows along the various segments. Nitrate concentrations in these GW discharges is based on the initial condition in 1989 (from the USGS report), incremented over time with N loading to the surface that migrates into the various layers of the aquifer. However, given the nature of the WARMF model, the nitrate concentrations are homogeneous for each layer of the aquifer, based on the assumption of

immediate mixing in a layer. Thus, the nitrate loading via GW discharge might be underestimated in areas where the nutrient load is concentrated and is near the discharge area. A study to collect GW nitrate concentrations at the discharge points as well as corresponding surface water concentrations immediately above and below the discharge would reduce the uncertainty associated with this loading. The study should consider spatial and temporal variability.

Other studies might be recommended in the future, but these three issues are key for the current load allocation.

Figure 1. Reach 7 & 8 segments; Reach 8 in light yellow, Reach 7 in green



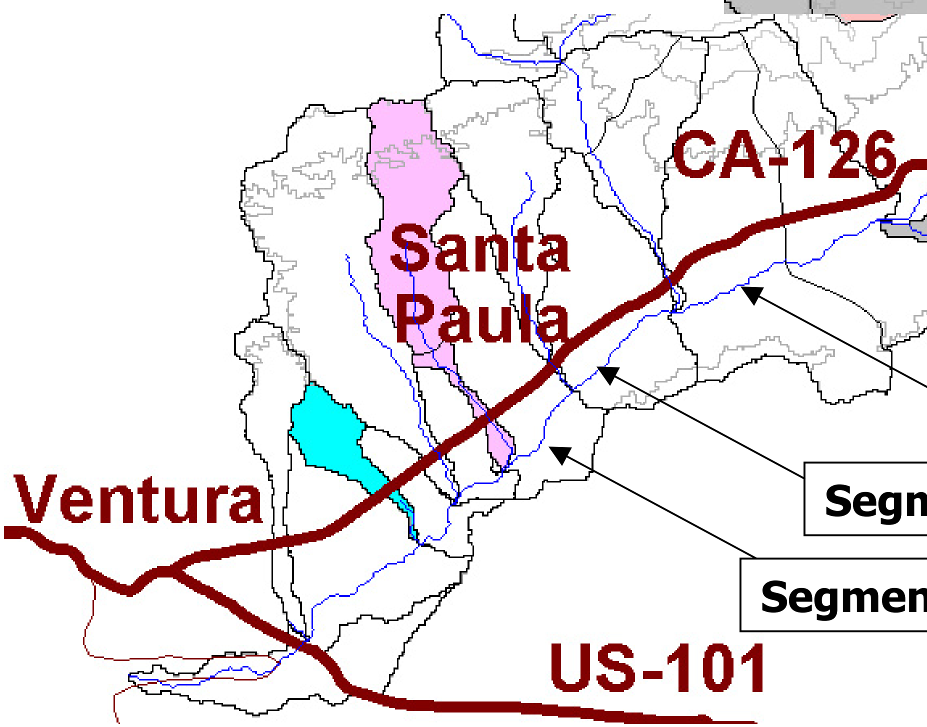


Figure 2. Reach 3 segments

Figure 3. Simulated ammonia concentrations in Reach 8 considering Saugus effluent at numerical targets

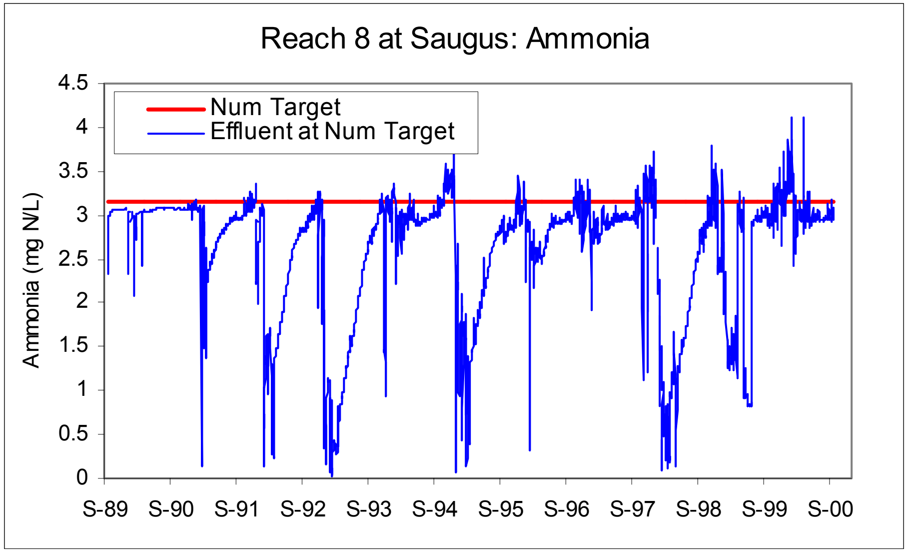


Figure 4. Simulated nitrate + nitrite concentrations in Reach 8 considering Saugus effluent at numerical targets

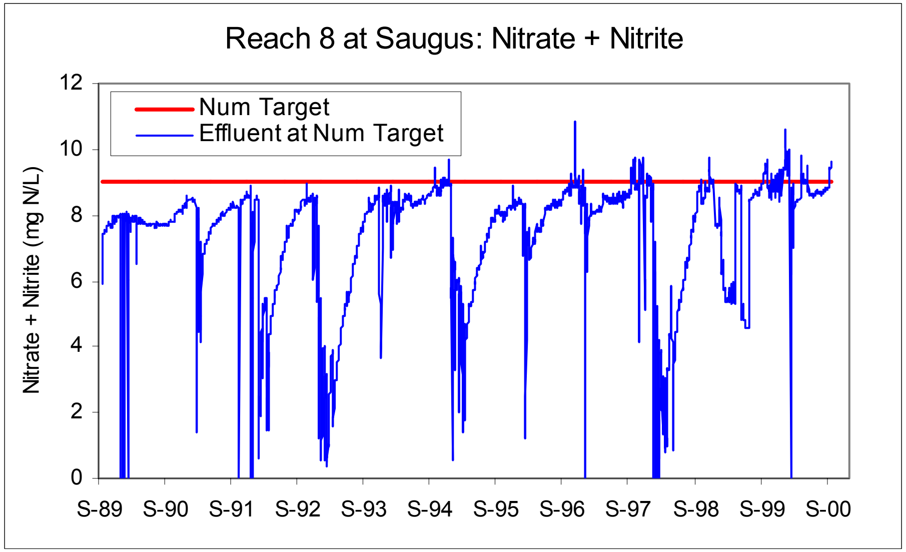


Figure 5. Simulated ammonia concentrations in Reach 7 above Valencia considering Saugus effluent at numerical targets

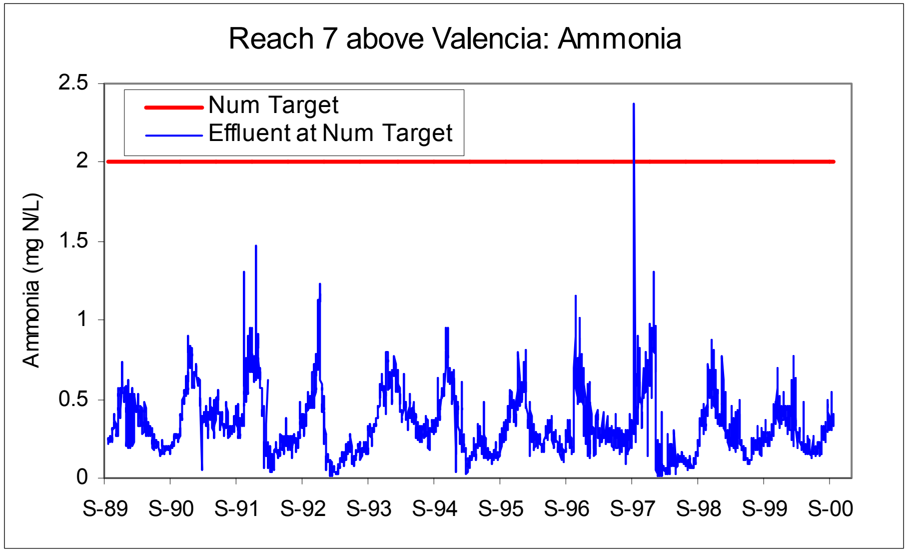


Figure 6. Simulated nitrate + nitrite concentrations in Reach 7 above Valencia considering Saugus effluent at numerical targets

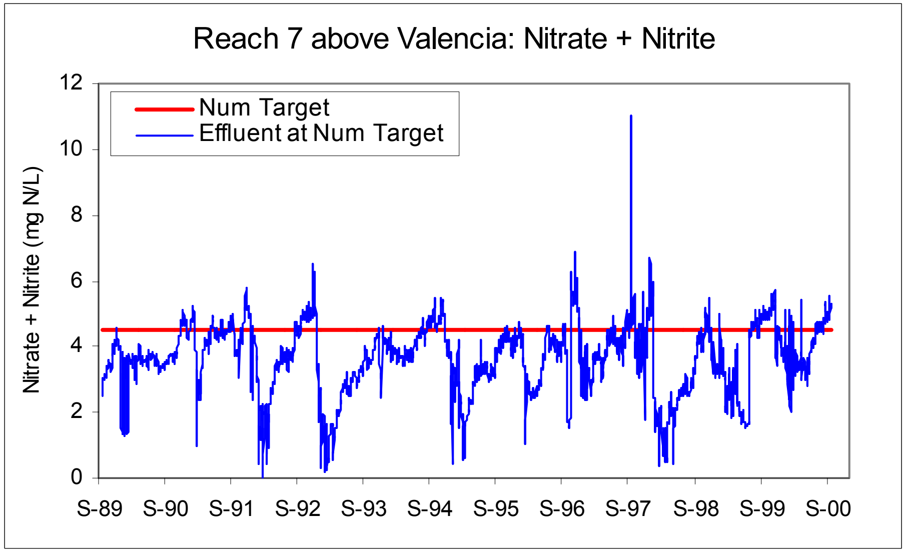


Figure 7. Simulated ammonia in Reach 7 below Valencia considering Saugus and Valencia effluent at Numerical Targets

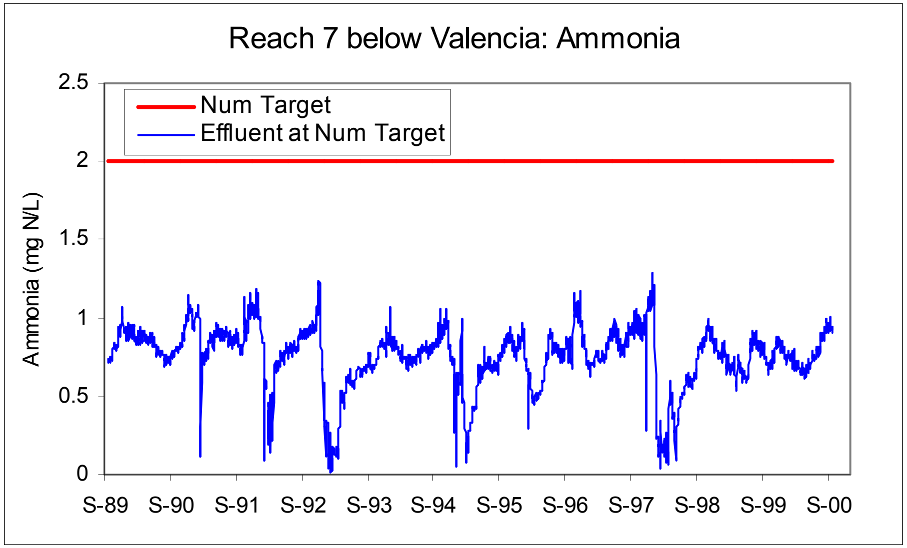


Figure 8. Simulated nitrate + nitrite in Reach 7 below Valencia considering Saugus and Valencia effluent at Numerical Targets

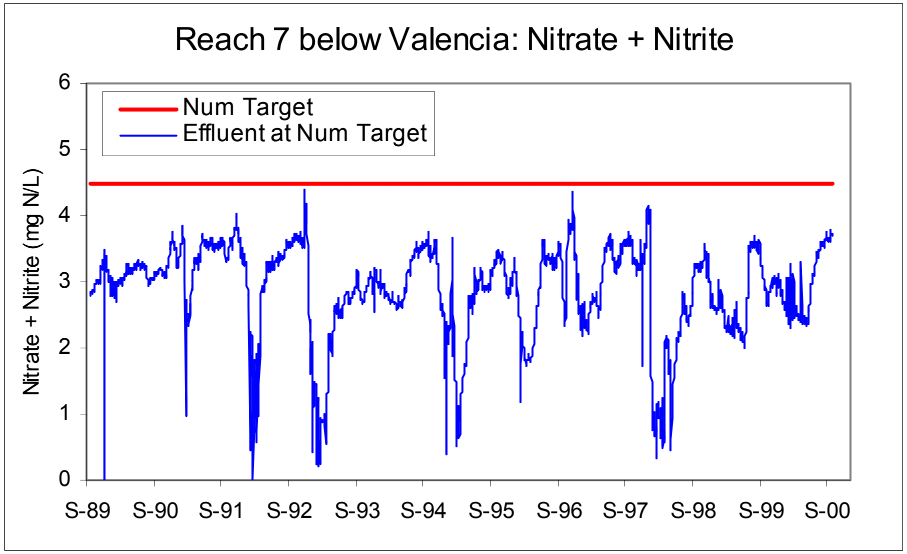


Figure 9. Simulated ammonia in Reach 7 at County Line considering Saugus and Valencia effluent at Numerical Targets

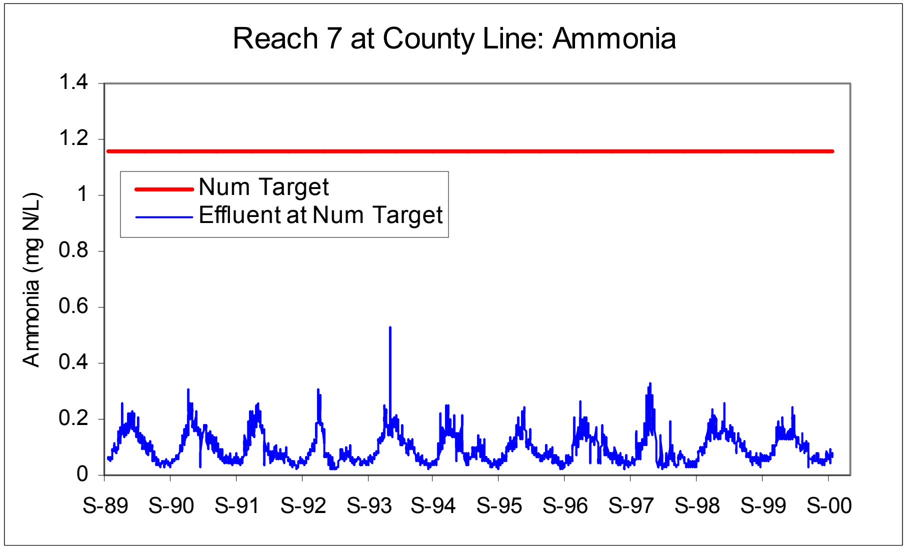


Figure 10. Simulated nitrate + nitrite in Reach 7 at County Line considering Saugus and Valencia effluent at Numerical Targets

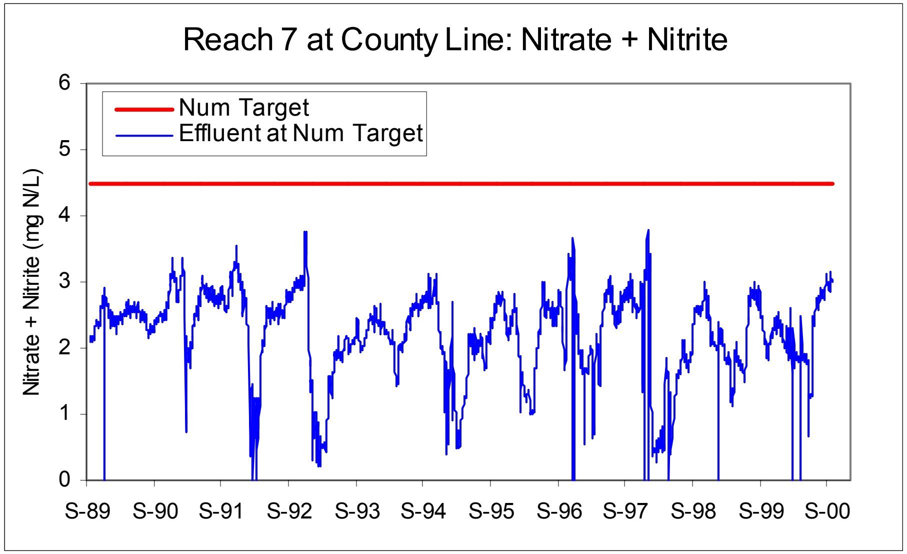


Figure 11. Simulated ammonia in Reach 3 above Santa Paula considering Saugus and Valencia effluent at Numerical Targets

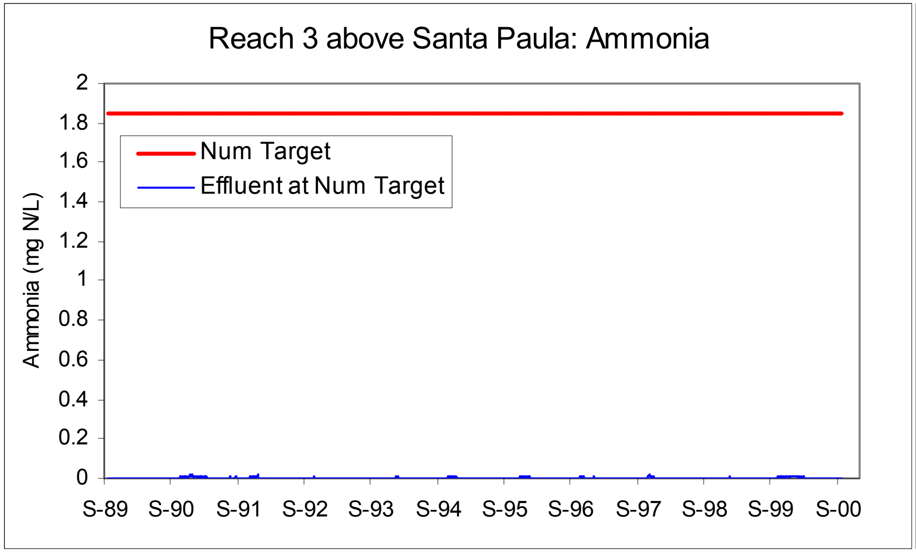


Figure 12. Simulated nitrate + nitrite in Reach 3 above Santa Paula considering Saugus & Valencia effluent at Numerical Targets

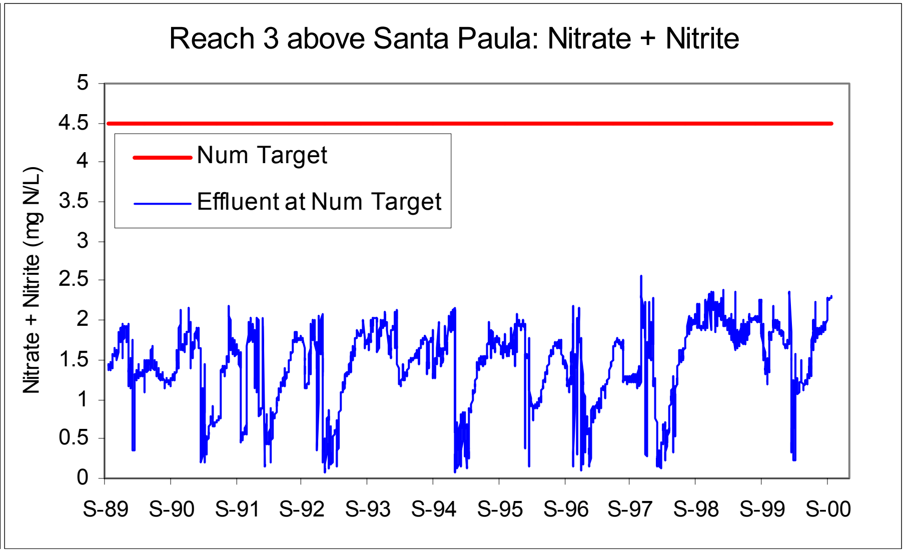


Figure 13. Simulated ammonia in Reach 3 at Santa Paula with Saugus, Valencia and Santa Paula effluent at Numerical Targets

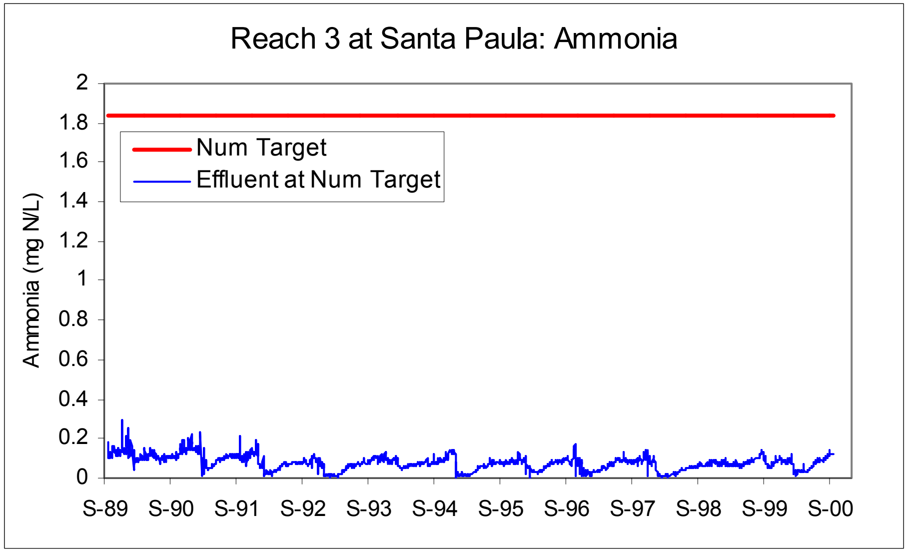


Figure 14. Simulated nitrate + nitrite in Reach 3 at Santa Paula with Saugus, Valencia and Santa Paula effluent at Numerical Targets

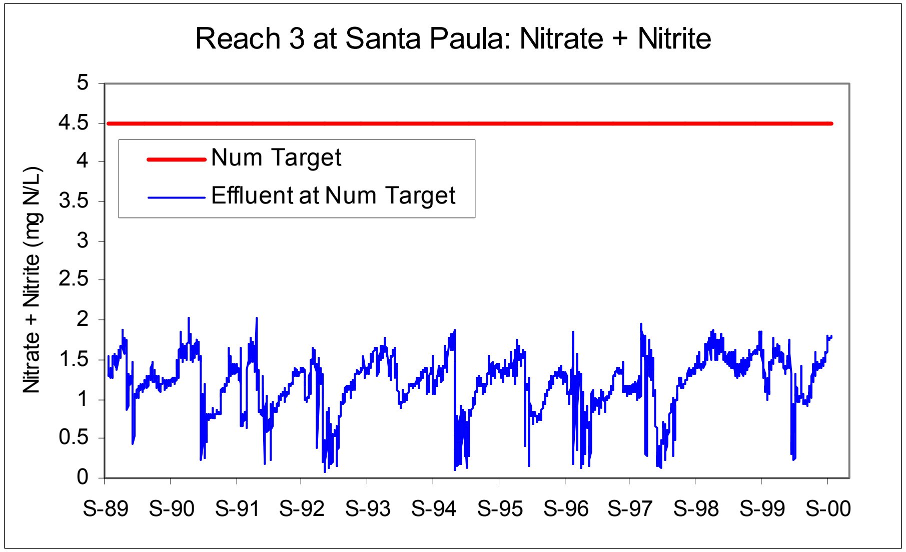


Figure 15. Simulated ammonia in Reach 3 below Santa Paula with Saugus, Valencia & Santa Paula effluent at Numerical Targets

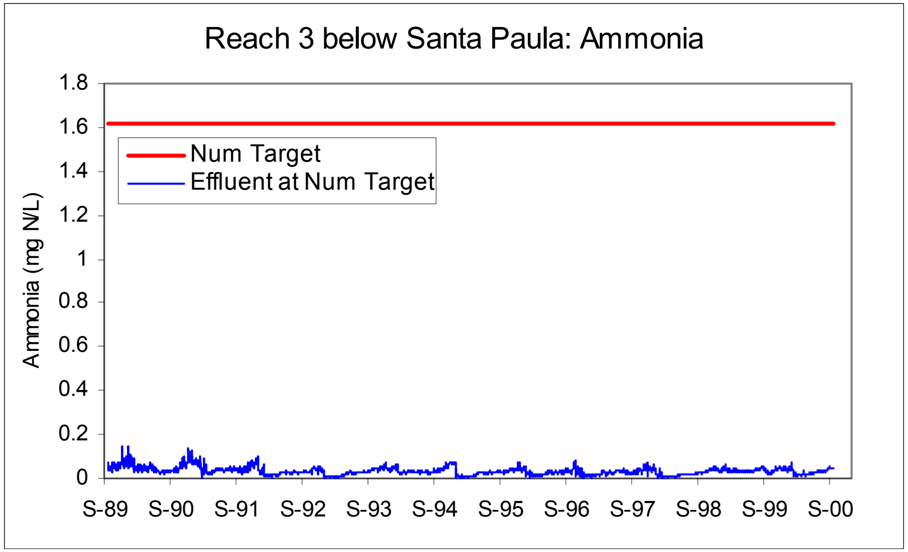


Figure 16. Simulated nitrate + nitrite in Reach 3 below Santa Paula with Saugus, Valencia & Santa Paula effluent at Numerical Targets

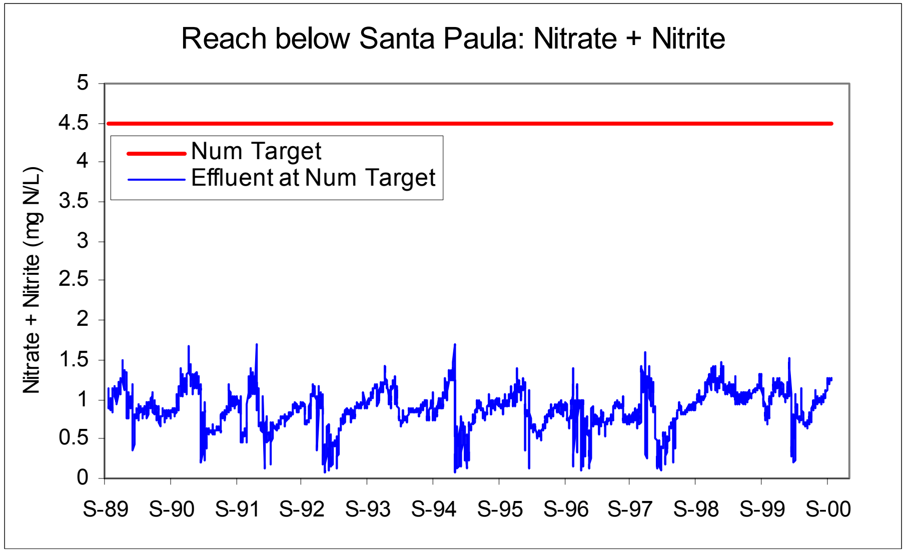


Figure 17. Simulated ammonia in Reach 8 considering Saugus effluent at Numerical Targets except ammonia at 2 mg/L

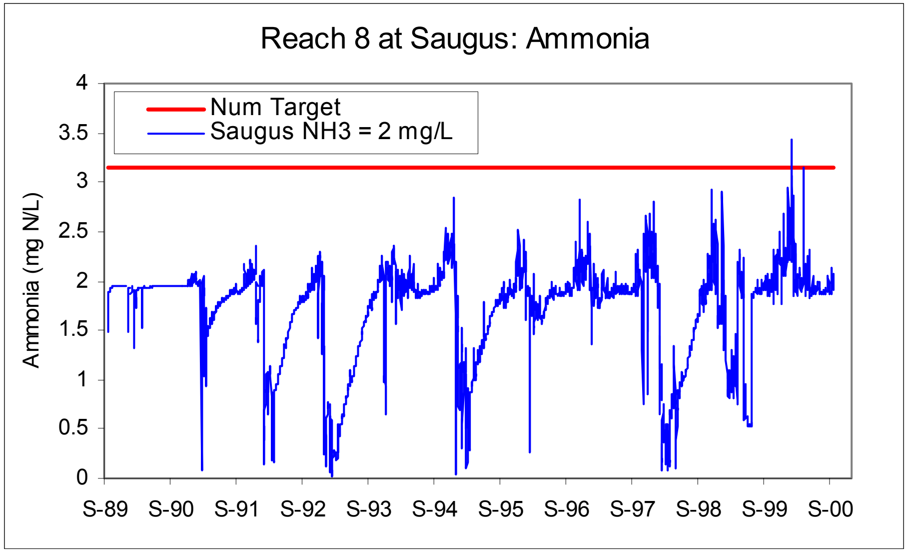


Figure 18. Simulated nitrate + nitrite in Reach 8 considering Saugus effluent at Numerical Targets except ammonia at 2 mg/L

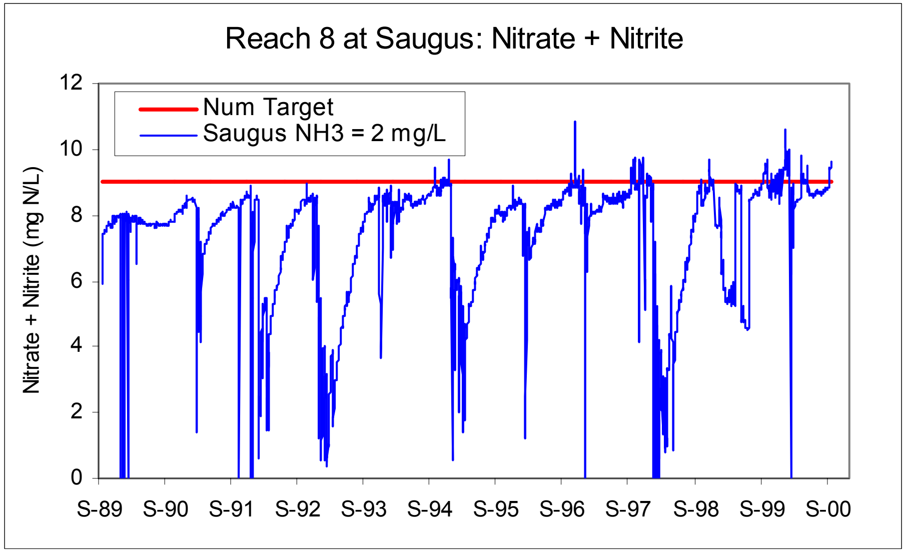


Figure 19. Simulated ammonia in Reach 7 above Valencia with Saugus effluent at Numerical Targets except ammonia at 2 mg/L

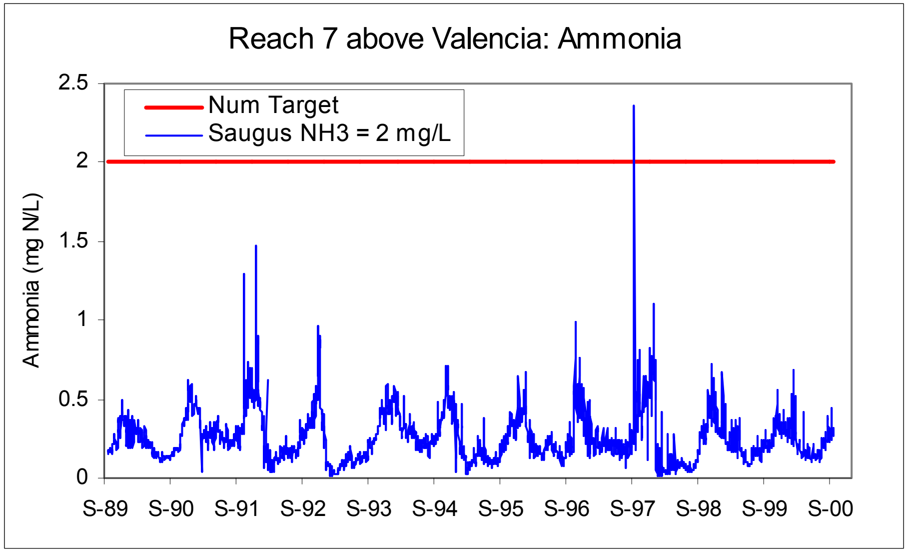


Figure 20. Simulated nitrate + nitrite in Reach 7 above Valencia with Saugus effluent at Numerical Targets except ammonia at 2 mg/L

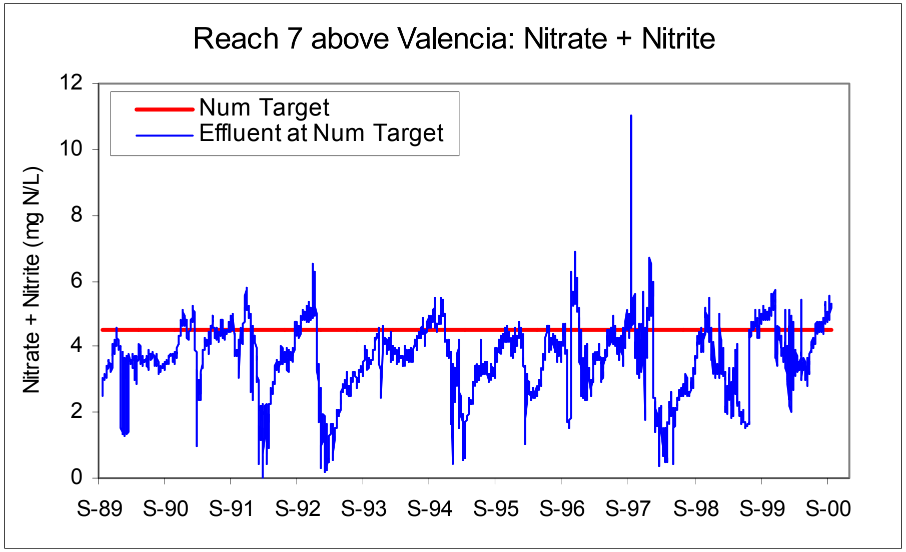


Figure 21. Simulated nitrate + nitrite in Reach 8 considering Saugus effluent at 3.15 mg/L as NH_3-N, 0.1 mg/L as NO_2-N, 8 mg/L as NO_3-N

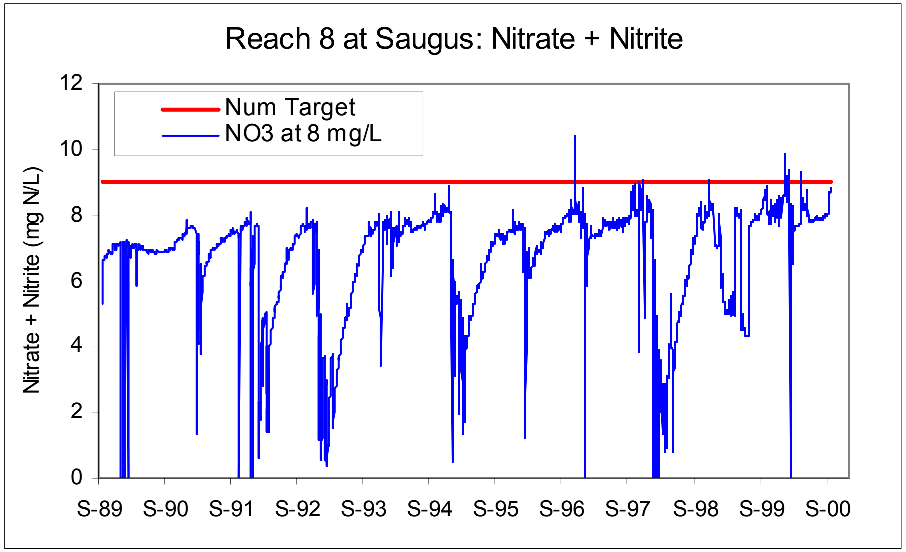


Figure 22. Simulated nitrate + nitrite in in Reach 7 above Valencia with Saugus effluent at 3.15 mg/L as NH_3-N, 0.1 mg/L as NO_2-N, 8 mg/L as NO_3-N

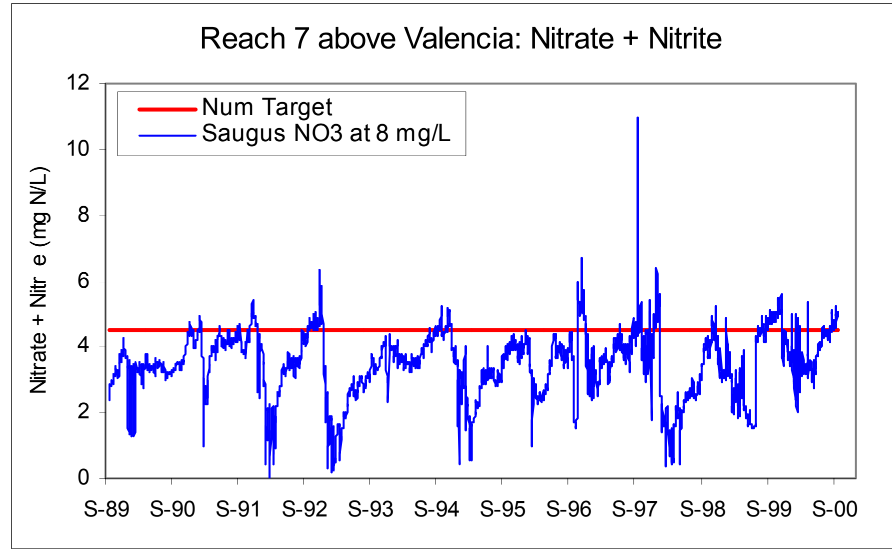


Figure 23. Simulated ammonia in Reach 7 below Valencia with Saugus effluent at 3.15 mg/L as NH_3-N, 0.1 mg/L as NO_2-N, 8 mg/L as NO_3-N

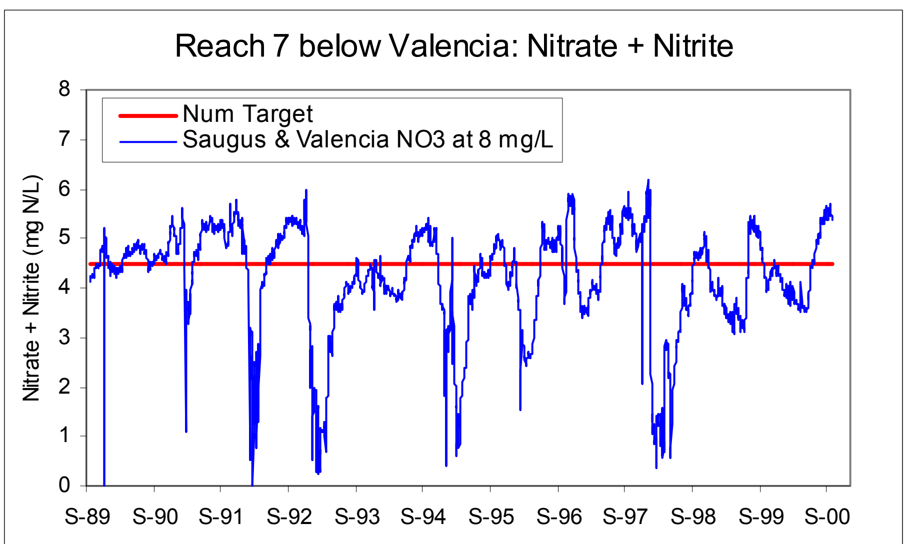


Figure 24. Simulated nitrate + nitrite in Reach 7 at County Line with Saugus effluent at 3.15 mg/L as NH_3-N, 0.1 mg/L as NO_2-N, 8 mg/L as NO_3-N

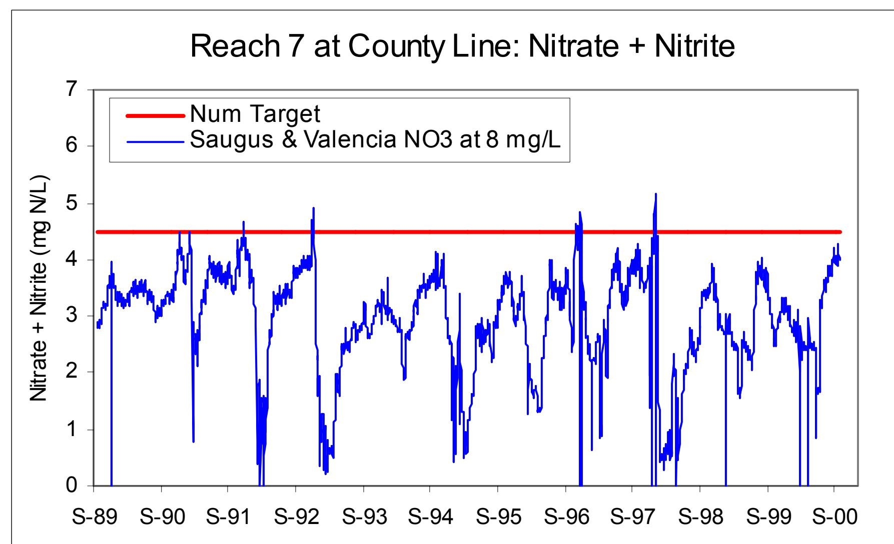


Figure 25. Simulated nitrate + nitrite concentrations in Reach 3 at Santa Paula with Saugus, Valencia and Santa Paula effluent at 8 mg/L as NO_3-N

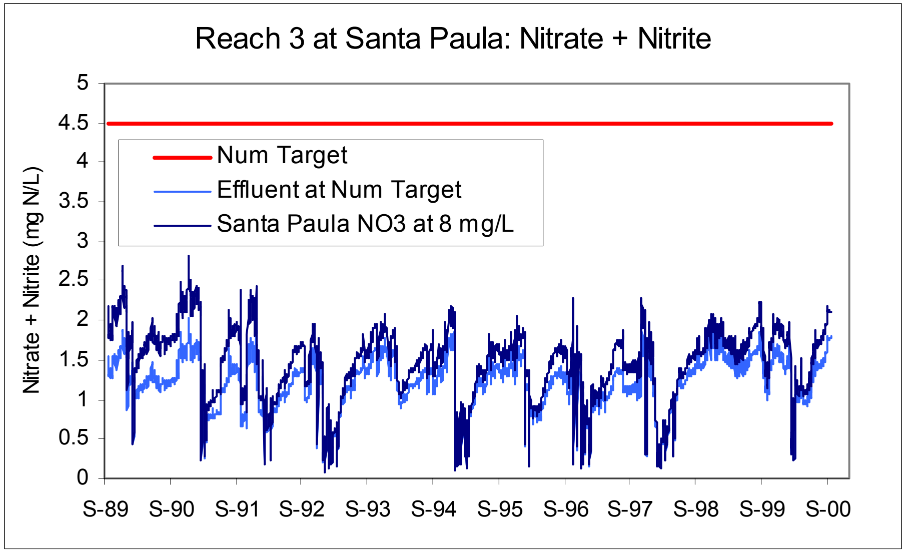


Figure 26. Simulated ammonia concentrations in Reach 8 considering Intermediate scenario

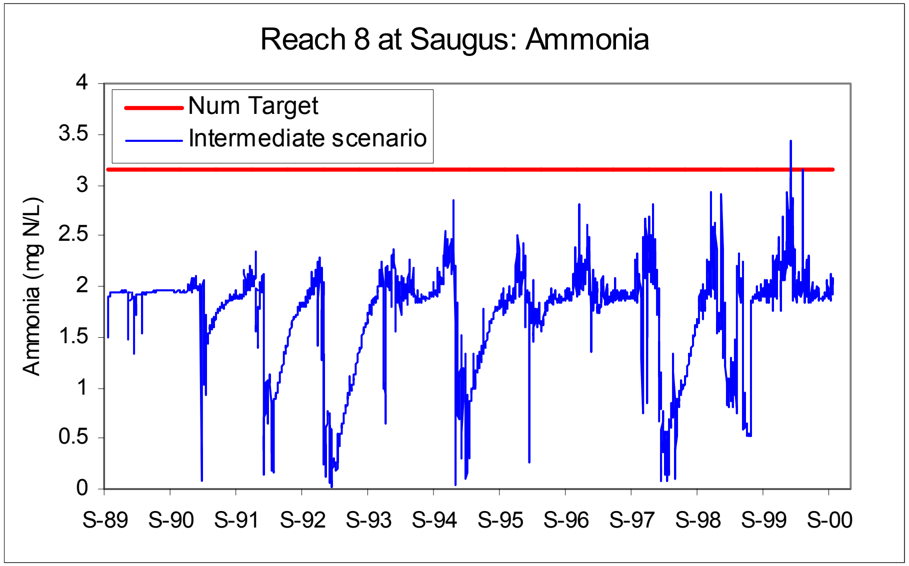


Figure 28. Simulated ammonia concentrations in Reach 7 above Valencia considering Intermediate scenario

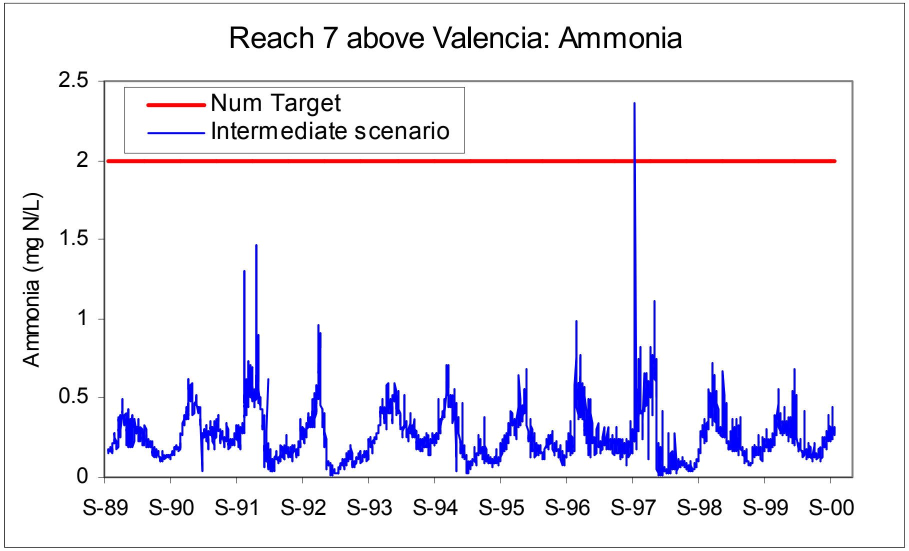


Figure 27. Simulated nitrate + nitrite concentrations in Reach 8 considering Intermediate scenario

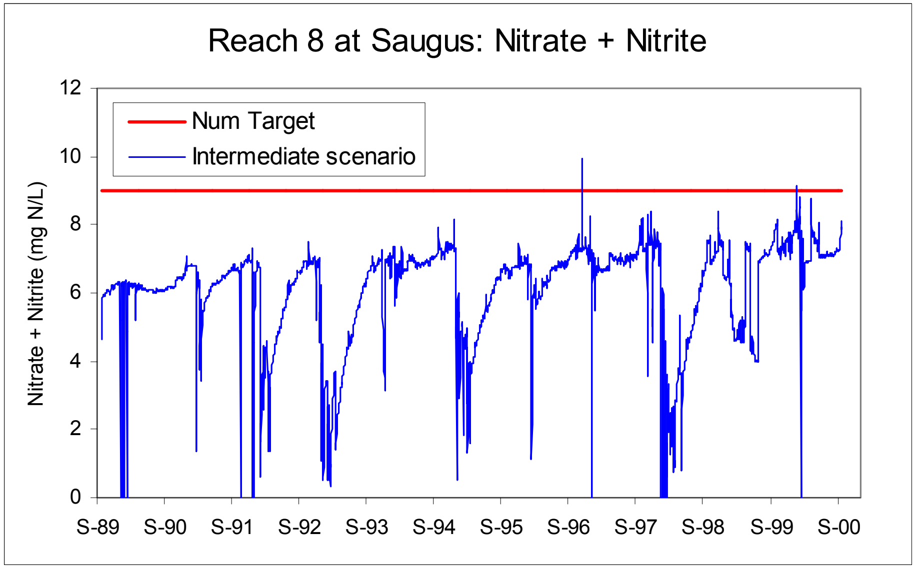


Figure 29. Simulated nitrate + nitrite concentrations in Reach 7 above Valencia considering Intermediate scenario

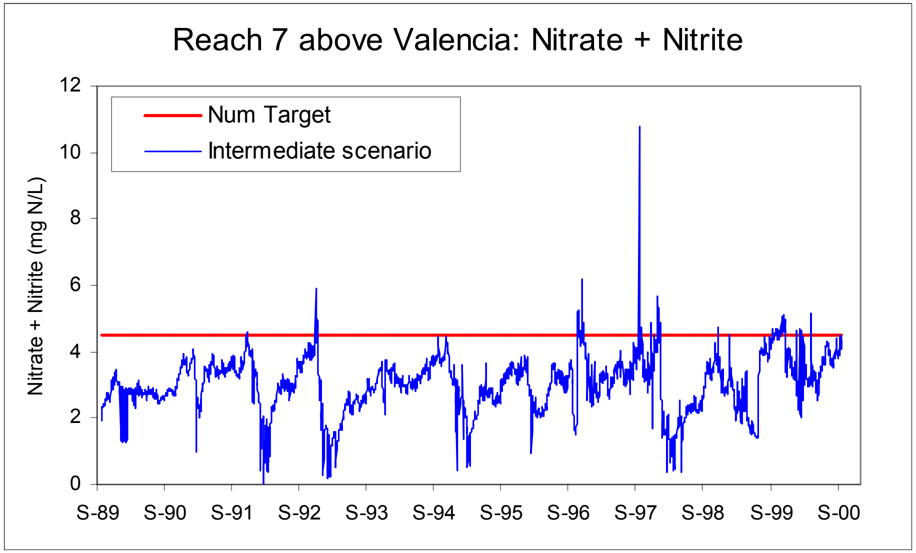


Figure 30. Simulated ammonia in Reach 7 below Valencia considering Intermediate scenario

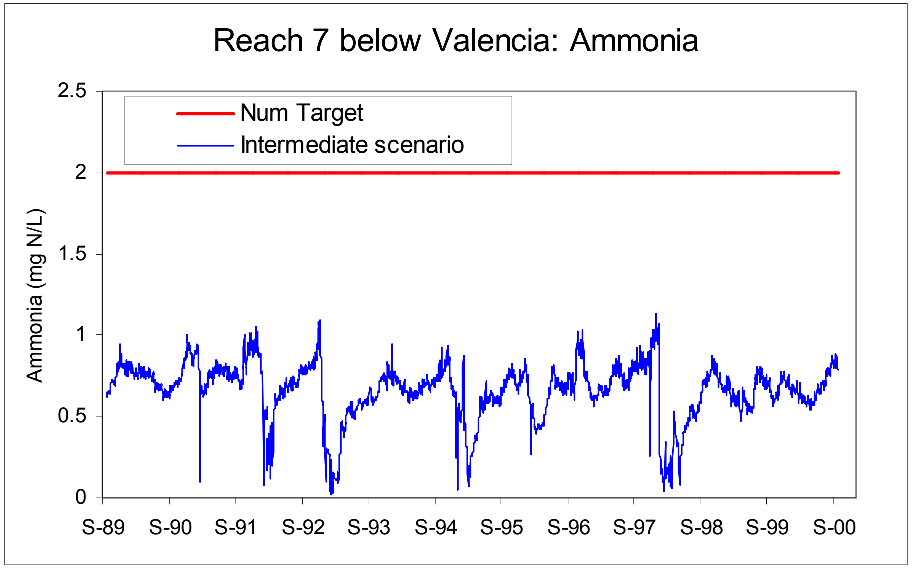


Figure 31. Simulated nitrate + nitrite in Reach 7 below Valencia considering Intermediate scenario

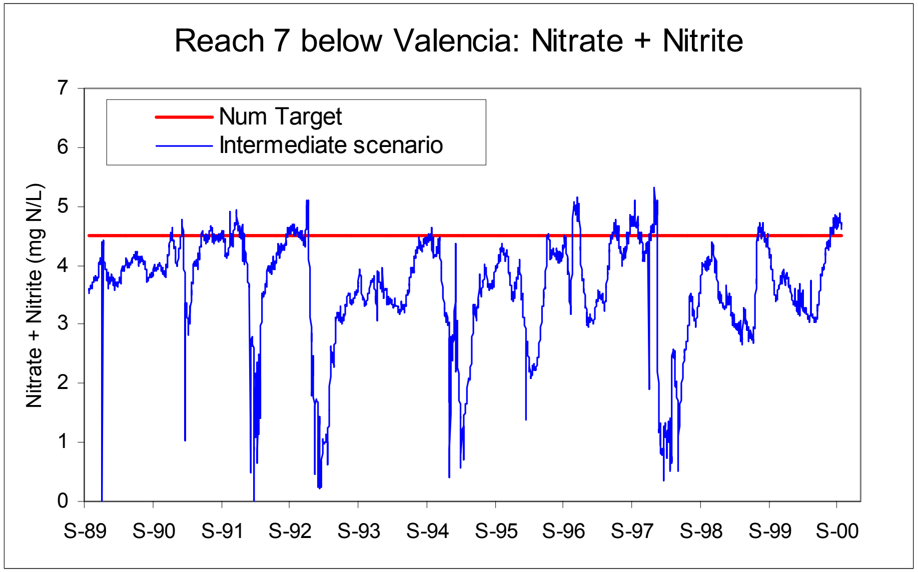


Figure 32. Simulated ammonia in Reach 7 at County Line considering Intermediate scenario

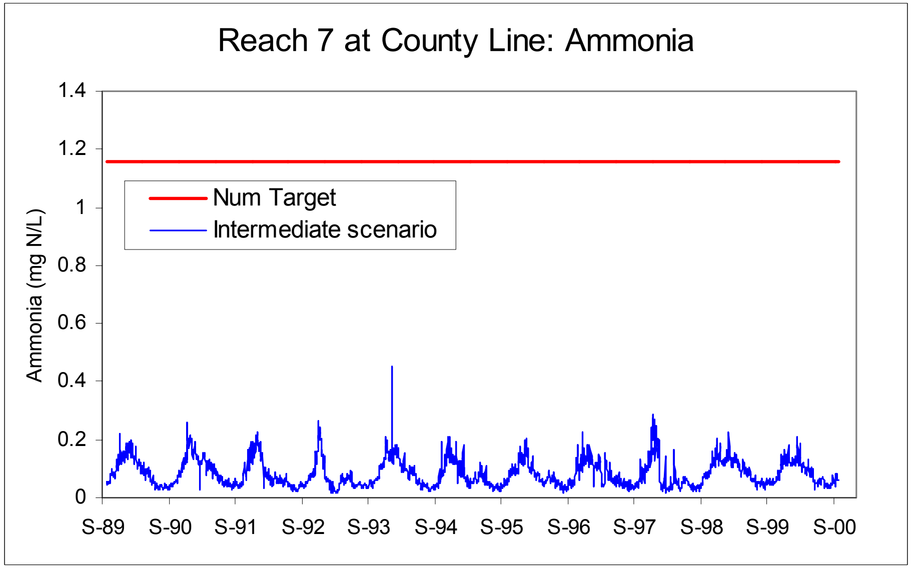


Figure 33. Simulated nitrate + nitrite in Reach 7 at County Line considering Intermediate scenario

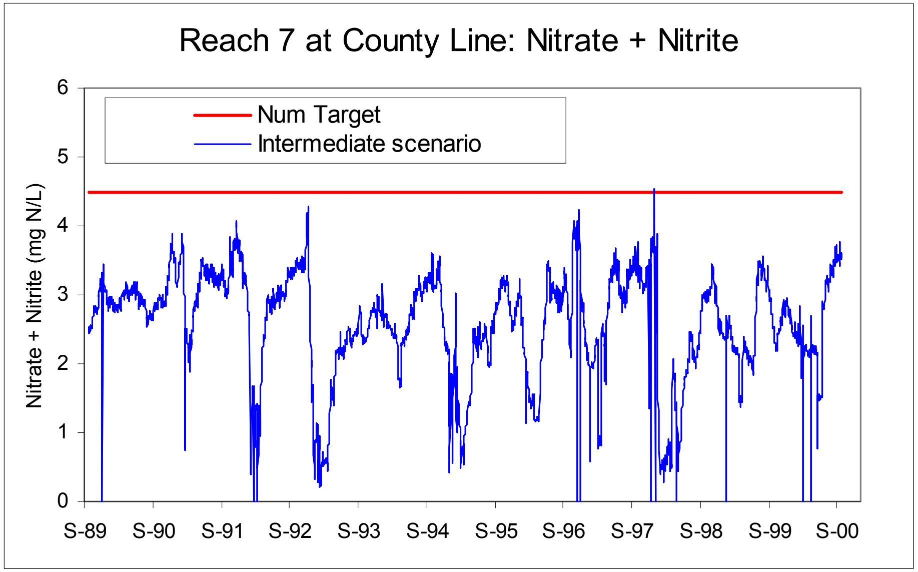


Figure 34. Simulated ammonia concentrations in Reach 3 at Santa Paula considering Intermediate scenario

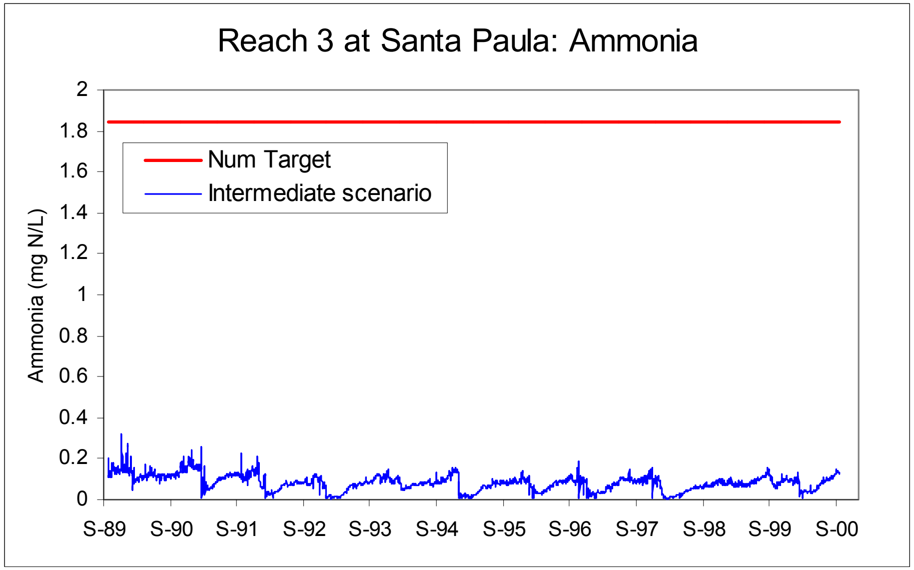


Figure 35. Simulated nitrate + nitrite concentrations in Reach 3 at Santa Paula considering Intermediate scenario

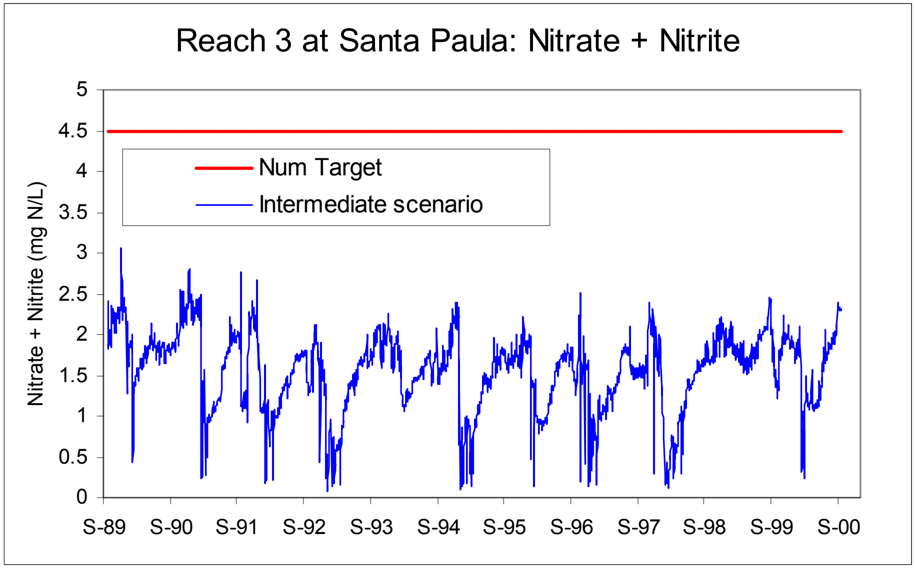


Figure 36. Simulated ammonia concentrations in Reach 3 below Santa Paula considering Intermediate scenario

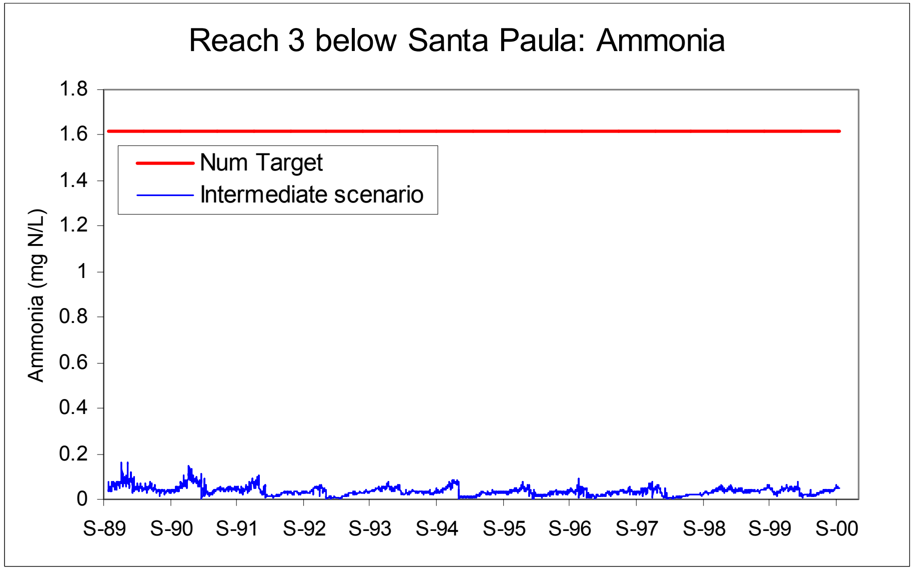


Figure 37. Simulated nitrate + nitrite concentrations in Reach 3 below Santa Paula considering Intermediate scenario

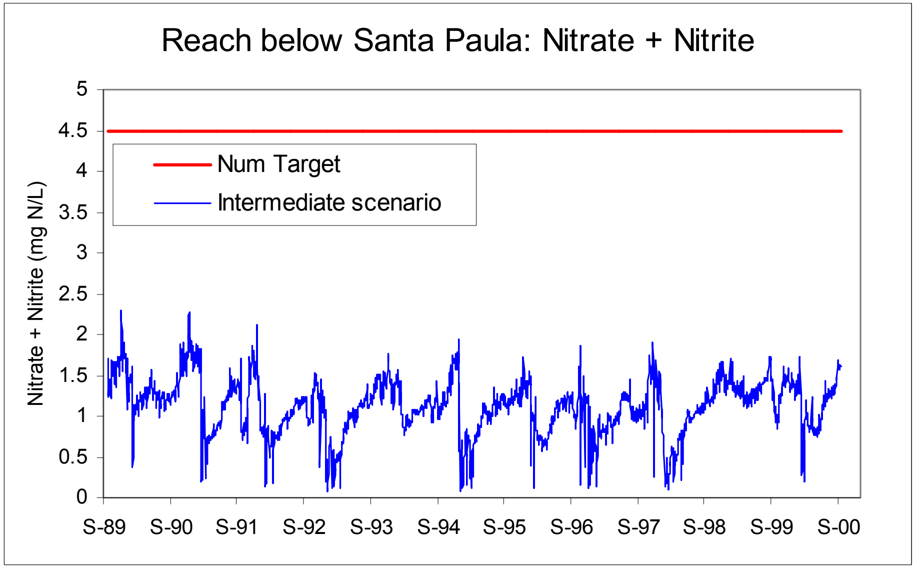


Figure 38. Simulated ammonia concentrations in Reach 8 due only to NPS load and minor PS loading

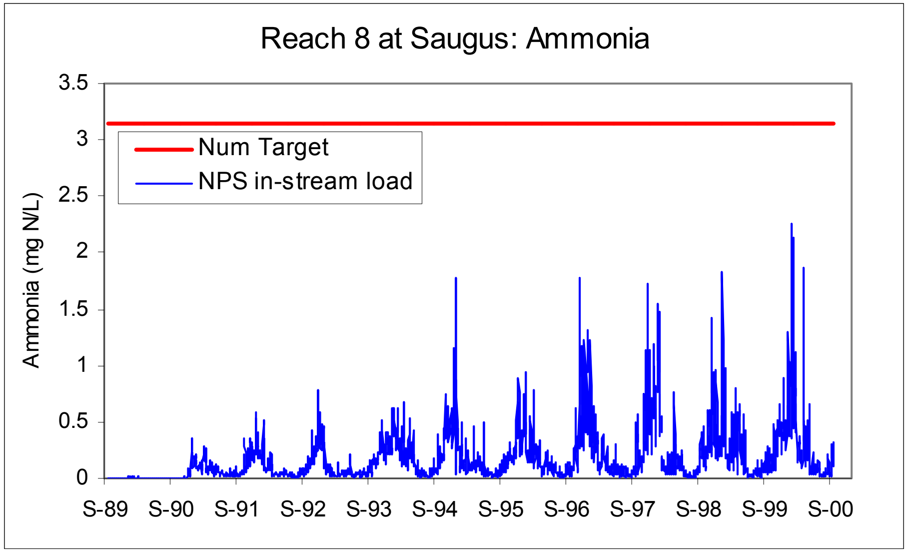


Figure 39. Simulated nitrate + nitrite concentrations in Reach 8 due only to NPS load and minor PS loading

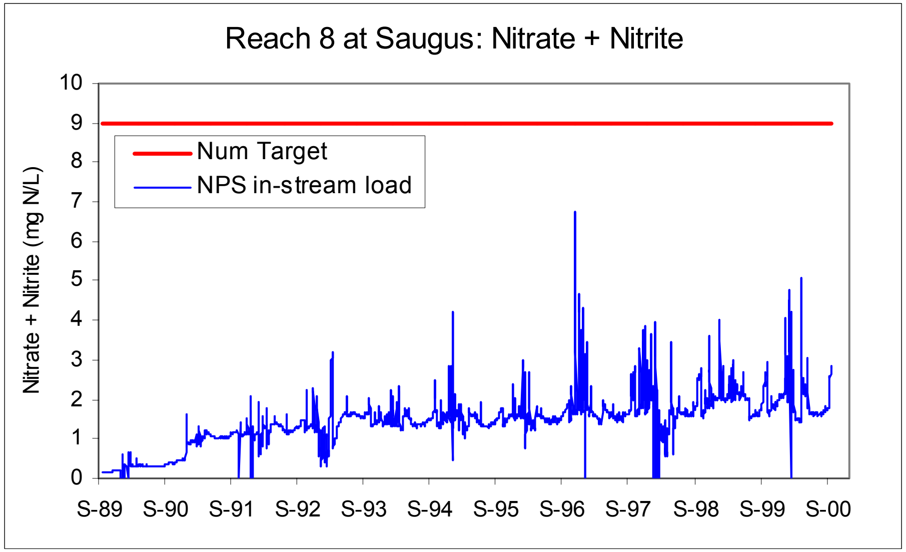


Figure 40. Simulated ammonia concentrations in Reach 7 above Valencia due only to NPS load and minor PS loading

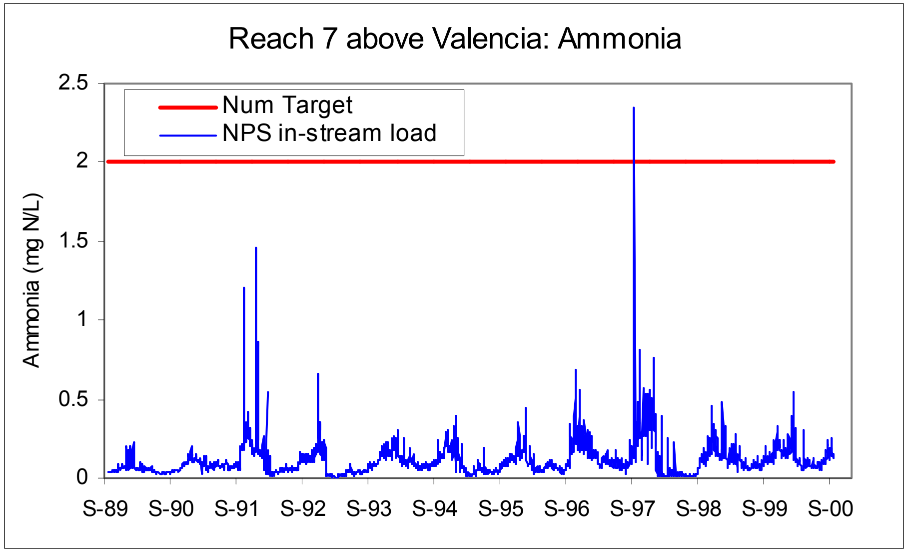


Figure 41. Simulated nitrate + nitrite concentrations in Reach 7 above Valencia due only to NPS load and minor PS loading

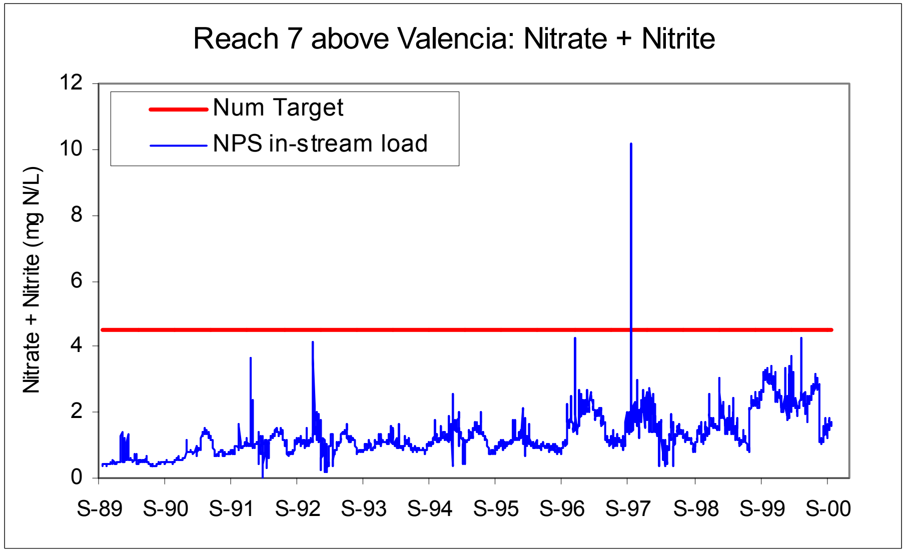


Figure 42. Simulated ammonia in Reach 7 below Valencia due only to NPS load and minor PS loading

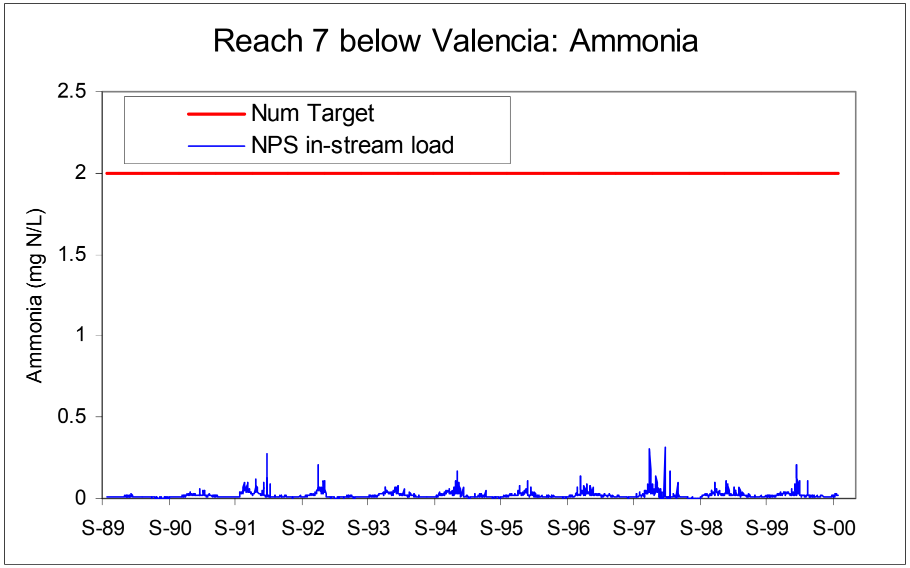


Figure 43. Simulated nitrate + nitrite in Reach 7 below Valencia due only to NPS load and minor PS loading

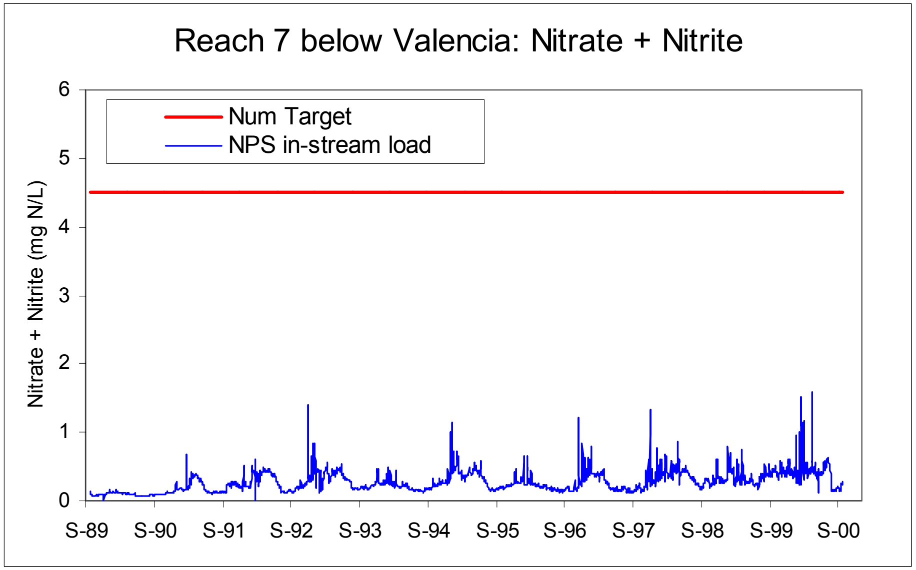


Figure 44. Simulated ammonia in Reach 7 at County Line due only to NPS load and minor PS loading

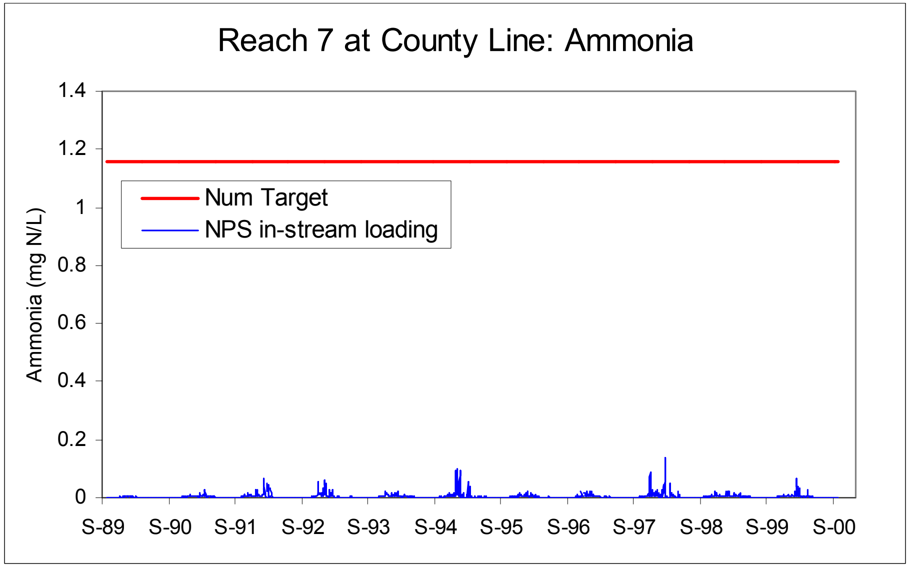


Figure 45. Simulated nitrate + nitrite in Reach 7 at County Line due only to NPS load and minor PS loading

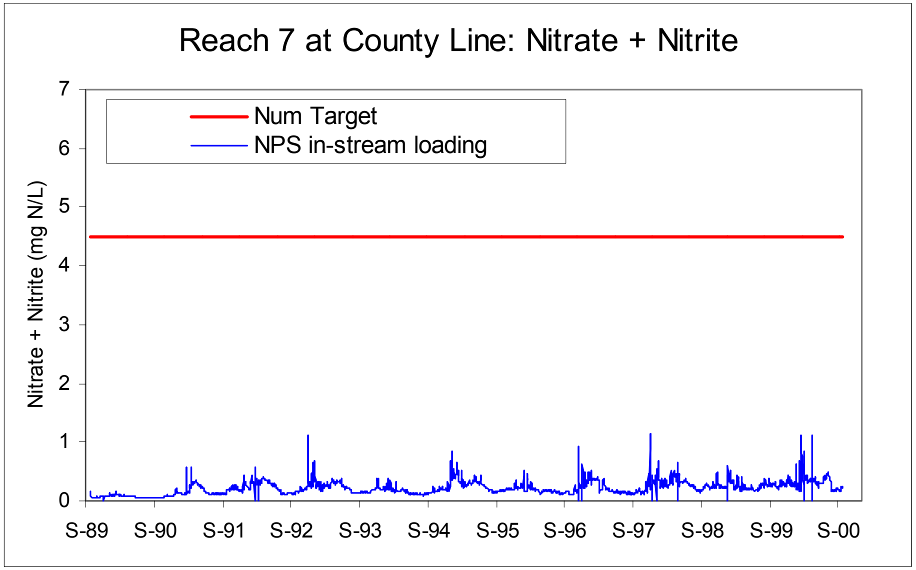


Figure 46. Simulated ammonia in Reach 3 above Santa Paula due only to NPS load and minor PS loading

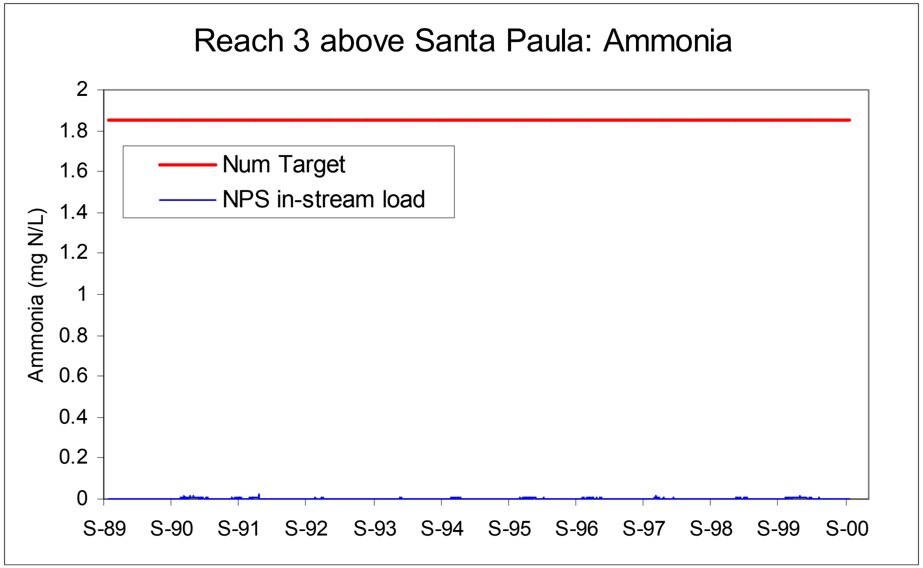


Figure 47. Simulated nitrate + nitrite in Reach 3 above Santa Paula due only to NPS load and minor PS loading

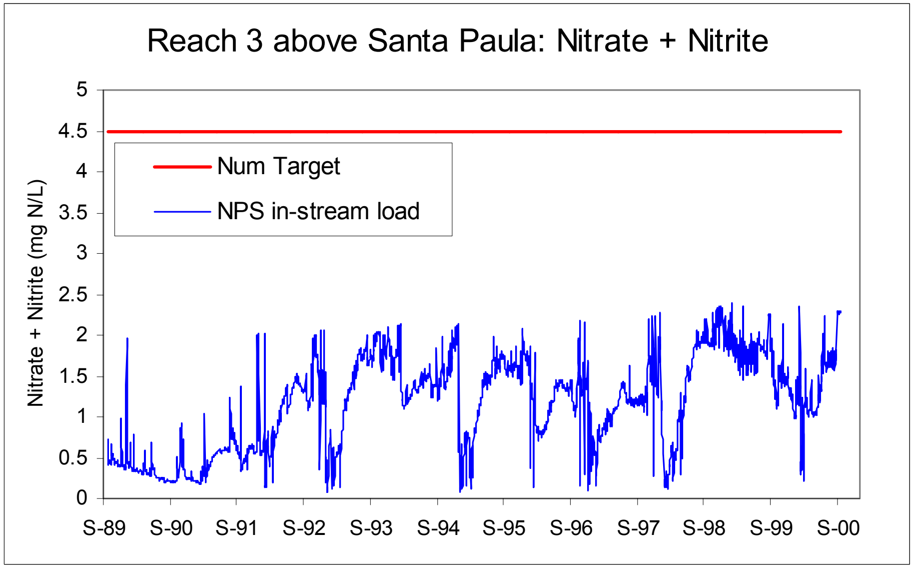


Figure 48. Simulated ammonia concentrations in Reach 3 at Santa Paula due only to NPS load and minor PS loading

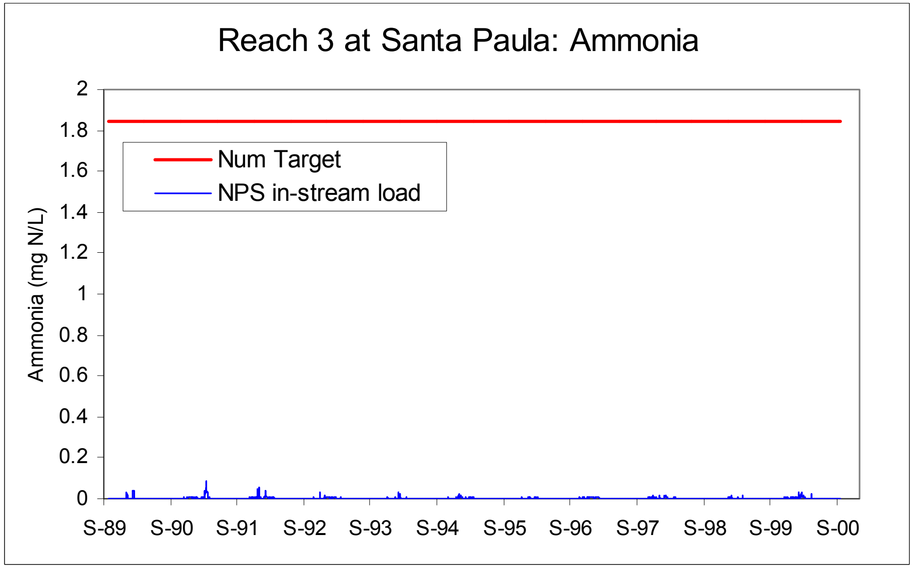


Figure 49. Simulated nitrate + nitrite concentrations in Reach 3 at Santa Paula due only to NPS load and minor PS loading

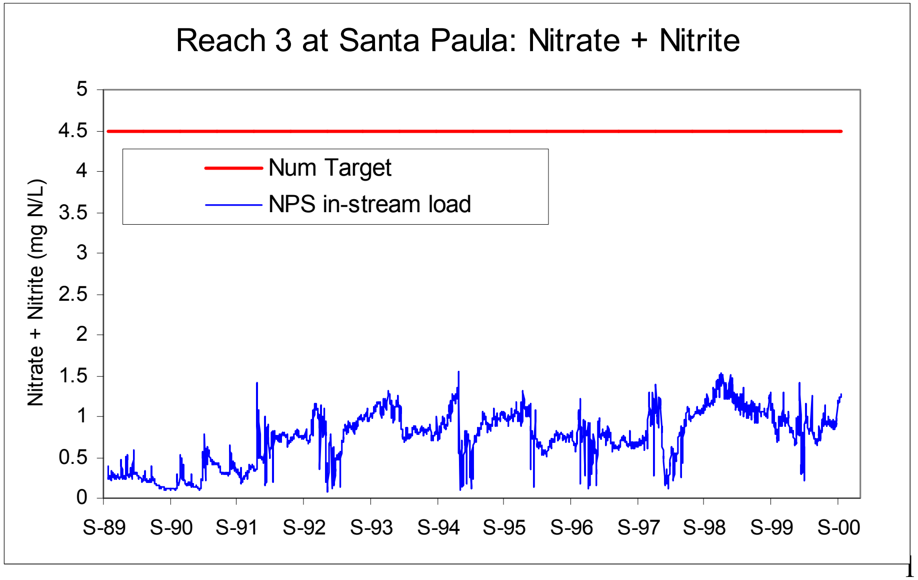


Figure 50. Simulated ammonia concentrations in Reach 3 below Santa Paula due only to NPS load and minor PS loading

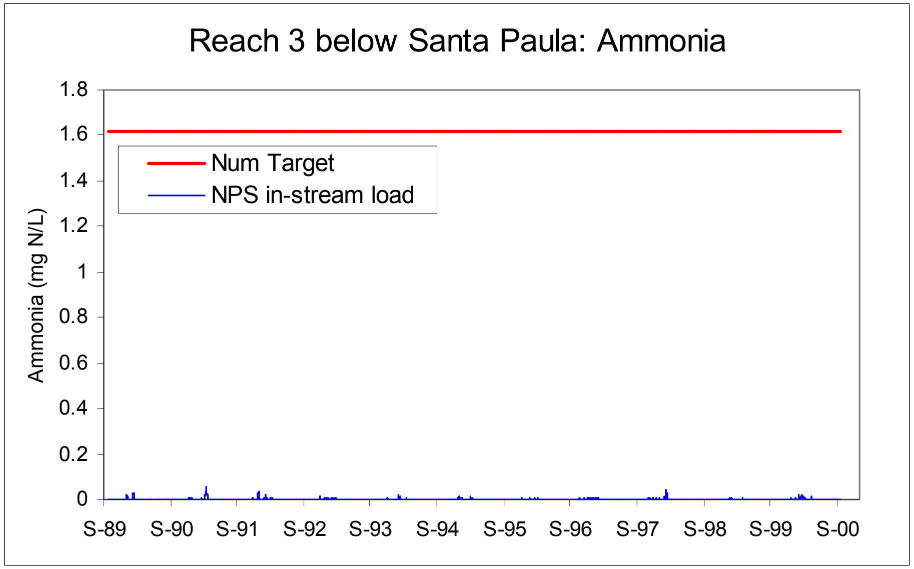


Figure 51. Simulated nitrate + nitrite concentrations in Reach 3 below Santa Paula due only to NPS load and minor PS loading