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United States Bureau of Reclamation
Southern California Area Office

Phase 3A Report
Santa Margarita Watershed Supply Augmentation, Water Quality Protection, and Environmental Enhancement Program

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Final Report

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Introduction

1.1 Purpose of Preliminary Santa Margarita River Watershed Model

The purpose of Phase 3A of the Santa Margarita Watershed Supply Augmentation, Water Quality Protection and Environmental Enhancement Program (SMR Study) was to develop a preliminary model to address the water quality issues and evaluate the effectiveness of the model for determining the assimilative capacity of the Santa Margarita River and its ability to resolve long-term issues of effluent discharge to the river. The tool selected for this effort is the Watershed Analysis Risk Management Framework (WARMF) Model.

By utilizing the WARMF Model to create the preliminary Santa Margarita River Watershed Model (SMRWM) based on data collected by entities within the watershed, the following recommendations outlined in the April 2001 Framework Monitoring Plan for the Santa Margarita Watershed have been evaluated:

- Identify potential models that would be appropriate for preliminary and ultimate water quality modeling in the watershed to meet the Santa Margarita River Executive Management Team (SMR EMT) goals such as addressing total maximum daily load (TMDL) development and assimilative capacity. The proposed model(s) must be able to address water quantity and quality in the surface and groundwater to accurately address the questions posed by the SMR Group it its list of goals during the Phase I, Framework Monitoring Plan. Develop and apply screening level model to identify key water quality areas to assist in developing the final monitoring locations and to support the program justification with the San Diego Regional Water Quality Control Board.

- Support scientific development of TMDL: Apply data from a comprehensive monitoring program to screen and select appropriate water quality model(s) for the development of the rationale and documentation of a TMDL in order to best prepare for a proactive role for local agencies in any TMDL regulatory processes that may occur on the watershed.

- Estimate assimilative capacity of the SMR: Apply data to the watershed model to estimate the assimilative capacity of the river and address the issues associated with the Four-Party Agreement between Rancho California Water District (RCWD), Eastern Municipal Water District (EMWD), Fallbrook Public Utilities District (FPUD), and the United States Department of the Navy, United States Marine Corps, Marine Corps Base, Camp Pendleton (the Base) (Four-Party Agreement).

- Identify relationships between habitat health and water quality: Apply the data to the watershed model to compare current and projected water quality and quantity to habitat needs in the critical reaches of the watershed.

The focus of the preliminary SMRWM is nitrogen and phosphorus as the assimilative capacity of these two constituents is of concern for the lagoon TMDL. In addition, these constituents were initially of concern in addressing potential reclaimed water discharges from EMWD and RWCD.

Description of the SMRWM development is contained in Appendix A. This description includes an overview of the data provided by the SMR EMT, which was used for model development. In addition, it discusses other data inputs for the SMRWM that were available from other sources such a precipitation and streamflow records.

1.2 Report Overview

This report provides a summary of the SMRWM calibration, scenarios, and data gaps. It contains the following sections:

- Section 2: SMRWM Calibration – provides model parameters in the WARMF software, which were modified for the hydrology and water quality calibration.
- Section 3: SMRWM Scenarios – provides a discussion regarding scenarios addressing water quality effects of nonpoint source and point source loadings in the watershed and also a description of the SMRWM data gaps.
- Section 4: References – provides a list of references used in the report.

Section 2
Santa Margarita River Watershed Model Calibration

2.1 Calibration Overview

The results of loading and receiving water simulations are more meaningful when they are accompanied by some sort of confirmatory analysis. The capability of any model to accurately depict water quality conditions is directly related to the accuracy of input data and the amount of data available for comparison. Calibration involves minimization of deviation between measured field conditions and model output by adjusting parameters of the model. Data required for this step are a set of known input values along with corresponding field observation results. If the model is calibrated properly, the model predictions will be acceptably close to the field predictions. Model calibration is critical for using the SMRWM in predicting water quality throughout the watershed when addressing future changes or improvements to current water quality conditions within the watershed.

The SMRWM was calibrated based on existing data and will be explained throughout the remainder of this section. For the hydrology calibration, simulated average daily flows were compared to historical average daily flows and model parameters were adjusted accordingly so that there was a close match between observed and predicted flows. For the water quality calibration, observed total phosphorus and total nitrogen concentrations were compared to what the SMRWM predicted for average daily total nitrogen and total phosphorus concentrations and model parameters were adjusted accordingly to achieve a sufficient match between observed and predicted concentrations.

2.2 Hydrology Calibration

The purpose of the hydrology calibration is to create a model that compares well to historical data in the watershed. Calibration of flows is critical for any further use of the model for predicting water quality. The period of time for the calibration simulation is from October of 1989 until September of 2001.

2.2.1 Hydrology Calibration Locations

In order to calibrate the SMRWM to hydrology, the simulated and observed stream flows were compared for 11 locations within the Santa Margarita Watershed. Figure 2-1 shows the USGS stream flow gage locations throughout the watershed. Locations were selected in order to best represent flows from all subwatersheds throughout the basin as well as multiple locations along the Santa Margarita River. Not all gage locations shown in Figure 2-1 were used for the calibration as some did not measure stream flow during the calibration period of 1989 through 2001. The period of record of each USGS gage is discussed in Appendix A.

2.2.2 Hydrology Calibration Parameters

Following is a discussion of the WARMF model parameters that were modified so that SMRWM predicted or modeled stream flow matched observed stream flow throughout the watershed. Calibration parameters provided by the WARMF software are either applied to the entire watershed or on a subwatershed basis. The parameters that were modified for the entire watershed include:

- Evaporation Magnitude – a unitless scaling factor for evaporation
- Evaporation Skewness – a unitless degree of variation of evaporation between the seasons
- Snow Formation Temperature – the temperature at which snow forms
- Open Area Melting Rate – the rate at which snow melts in that fraction of each land use that is open in winter
- Forested Area Melting Rate – the rate at which snow melts in that fraction of each land use that is not open in winter
- Snow Melting Temperature – the temperature at which snow melts

The snow melt coefficients listed above are what control the rising limb of the hydrograph during snow melt. Although snowmelt is not a large factor in the watershed, it is important to address potential extreme events within the watershed. In addition to the parameters that were applied to the entire watershed, the following subwatershed parameters were modified for the hydrology calibration:

- Precipitation Weighting Factor – a multiplier applied to the precipitation in the meteorological file to account for local variations in precipitation amount due to orographic effects (i.e., changes in elevation that impact rainfall amounts)
- Average Temperature Lapse – the average amount subtracted from the temperature in the meteorological file to account for regional variations in temperature due to orographic effects
- Detention Storage – the percent of surface water that is not available for surface runoff because it is held within the watershed
- Soil Layer Thickness – the average thickness of each of the three soil layers
- Initial Soil Moisture – the initial volume fraction of water in each soil layer
- Soil Moisture Field Capacity – the volume fraction of water in each soil layer that does not flow out of the soil

- Soil Saturation Moisture – the maximum volume fraction of water in each soil layer

- Horizontal Hydraulic Conductivity – the ratio of velocity to hydraulic gradient and indicates the permeability of the soil

The values used in the SMRWM for each parameter listed above are contained in Appendix D.

2.2.3 Hydrology Calibration Results

Figures 2-2 through 2-12 show the hydrology calibration results. Each figure represents one location within the watershed and contains two graphs:

- The top graphic shows the observed average daily flows versus the calibrated or predicted average daily flows. The calibrated flows are plotted in a solid line while the observed flows have been plotted as individual data points. Comparing predicted versus average daily flow shows how well the model predicts flow over the entire simulation.

- The bottom plot in each figure shows the observed cumulative volume of water plotted against the calibrated cumulative volume of water. The cumulative curve for both observed and predicted values show the accumulation of flow over the course of the simulation. This calibration tool shows a measure of how well a scenario predicts seasonal and annual flow.

Figures 2-2 through 2-12 show a good correlation between average daily observed flow and average daily calibrated flow (top graph in each figure). In general, the model predicts periods of high flow and low flow well. During periods of extreme low flow within the watershed, the model slightly under predicts flow within the watershed. Figures 2-2 through 2-12 also demonstrate a good correlation between observed and predicted cumulative flow at all locations (bottom graph in each figure). In most cases the modeled cumulative flow is slightly higher than the observed cumulative flow.

2.2.4 Hydrology Calibration Relative Error Statistics

In order to assess the hydrology calibration efforts, the relative error was calculated for each calibration location. Relative Error is the average of all errors (difference between predicted and observed flow) over all timesteps for which it can be calculated and is a measure of model accuracy. The values for relative error at each calibration location are shown in Table 2-1. Most relative error values shown in Table 2-1 are positive percentages, which indicates that the model is over predicting at those locations. The relative error at all locations is low and is typical of other water quality modeling efforts.

Table 2-1 Relative Error Calculation Results at Calibration Locations within the Santa Margarita River Watershed

Gage Number	Station Name	Relative Error
11042700	Murrieta Creek at Tenaja Road	-8.3%
11042800	Warm Springs Creek	0.7%
11042900	Santa Gertrudis Creek	-0.8%
11043000	Murrieta Creek near Temecula	2.7%
11042631	Pechanga Creek	1.2%
11044000	Santa Margarita River near Temecula	4.4%
11044250	Rainbow Creek	0.3%
11044300	Santa Margarita River near Fallbrook	2.6%
11044350	Sandia Creek	-1.3%
11044800	DeLuz Creek	1.8%
11045700	Santa Margarita River at Ysidora	2.6%

2.3 Water Quality Calibration

The purpose of the water quality calibration, similar to the hydrology calibration, is to make sure that the SMRWM predicts water quality values that compare well to historical data in the watershed. Adequate water quality calibration is required for confidence in model predictions of various conditions within the watershed. The period of time for the calibration simulation is from October of 1989 until September of 2001.

2.3.1 Water Quality Calibration Locations

In order to calibrate the model for water quality, the simulated and observed total nitrogen and total phosphorus were compared for four locations within the Santa Margarita Watershed. Figure 2-13 shows the water quality calibration locations throughout the watershed. Locations were selected based on the amount of available data for total nitrogen and total phosphorus in the simulation period of record as well as geographical position within the watershed. The locations shown in Figure 2-13 cover the major tributaries within the watershed with exception of Rainbow Creek, Sandia Creek, and De Luz Creek. Limited nitrate and phosphate data were available for these locations. Available data was considered in the overall water quality calibration. However, fewer sample points were available and therefore calibration results are not shown for these locations in this report.

2.3.2 Water Quality Calibration Parameters

Following is a discussion of the model parameters in the WARMF software that were modified for the SMRWM so that predicted or modeled water quality matched observed water quality throughout the watershed. Calibration parameters for total nitrogen and total phosphorus are impacted by input data for point and nonpoint source loadings. After this data was confirmed, rate coefficients such as nitrification and denitrification were considered. Nitrification is the conversion of ammonia to nitrate, which is typically done by bacteria in rivers. Denitrification is conversion of

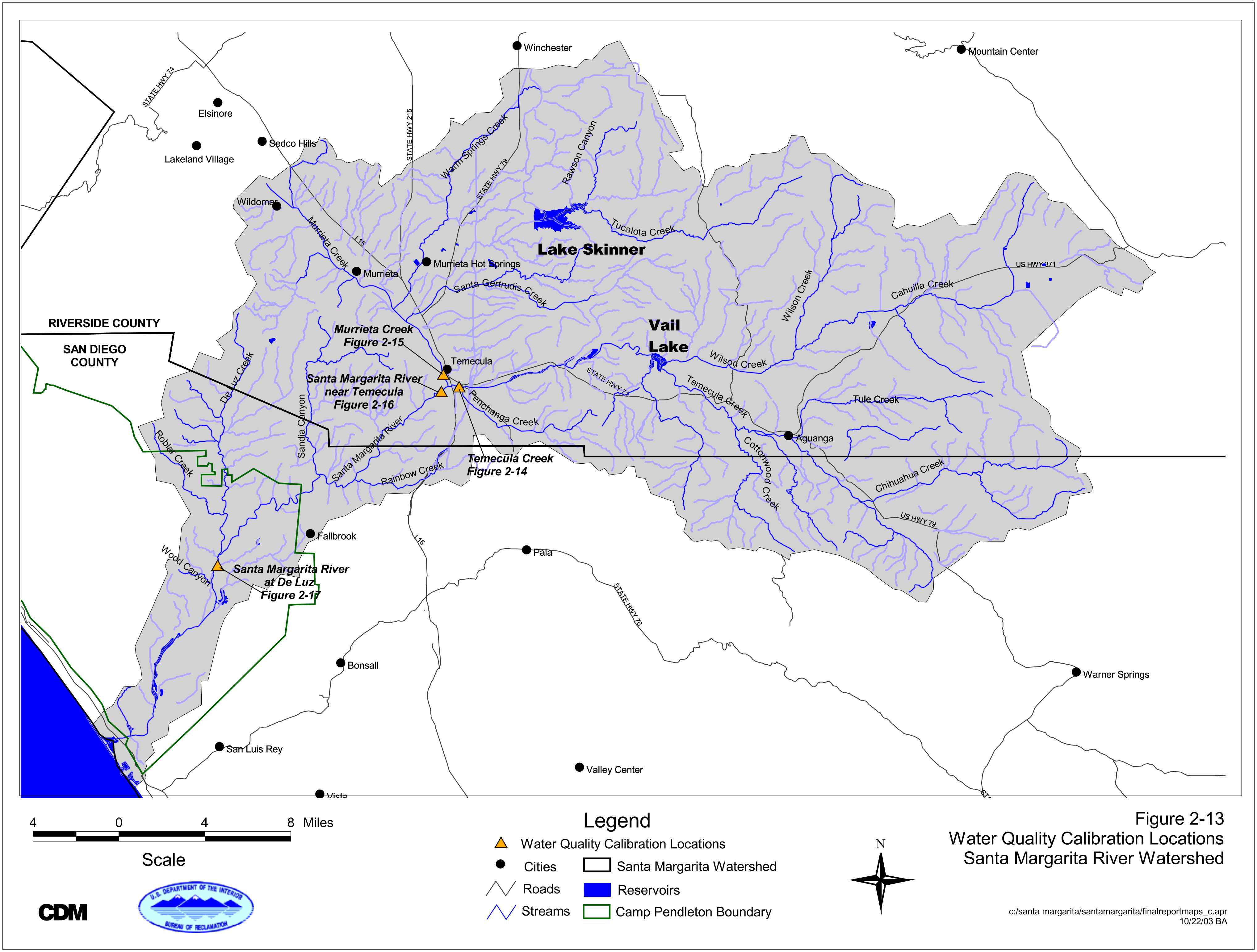


Figure 2-13
Water Quality Calibration Locations
Santa Margarita River Watershed

nitrate into nitrogen gas, which is typically done by bacteria under anoxic conditions (i.e., during periods of low oxygen such as low flow conditions).

WARMF provides plots for various statistics similar to those available for stream flow. However, because the amount of water quality data is less than stream flow data, time series plots were the main tool utilized for comparing modeled versus observed water quality for the SMRWM.

2.3.3 Water Quality Calibration Results

Figures 2-14 through 2-17 show the water quality calibration results. Each figure represents one location within the watershed and has two graphics:

- The top graphic shows the observed total nitrogen concentrations (individual data points) versus the predicted average daily total nitrogen concentrations (solid line).
- The bottom graphic shows the observed total phosphorus concentrations (individual data points) versus the predicted average daily total phosphorus concentrations (solid line).

Two calibrated lines are shown for both the total nitrogen and total phosphorus graphic in each figure. During portions of the year when the RCWD demonstration project reclaimed water was discharged to Murrieta Creek (December 1997 until October 2002), the river system experienced effluent dominated conditions. An effluent dominated condition is when the majority of the flow in a river is comprised of reclaimed water effluent. During these conditions in the river, observed total nitrogen and total phosphorus concentrations at Murrieta Creek, Santa Margarita River near Temecula, and Santa Margarita River near De Luz were significantly less than the total nitrogen and total phosphorus concentrations predicted by the SMRWM.

For the total nitrogen calibration, the nitrification and denitrification rate coefficients were initially set at conservative (low) values. The results of conservatively setting these rate coefficients are represented by the green solid line in each of the total nitrogen graphics shown in Figures 2-14 through 2-17. Because of the over prediction by the SMRWM of total nitrogen concentrations during effluent dominated conditions, the nitrification and denitrification rate coefficients were increased in select areas of the watershed. These rate coefficients were increased within the U.S. Environmental Protection Agency's (EPA) recommended range for these coefficients (EPA 1985). The results of modifying these coefficients are shown in the pink solid line in each to the total nitrogen graphics shown in Figures 2-14 through 2-17. Predictions of total nitrogen fall within the range of measured values and in general follow patterns of the observed data. Overall there is a better match between observed and predicted total nitrogen values with the modified rate coefficients.

For the total phosphorus calibration, there are not specific rate coefficients to modify during simulation of effluent dominated conditions. However, the WARMF software does have a periphyton module, which could be utilized in the future to adjust the model to better calibrate for phosphorus. It was not used for this effort because site-specific data was not available to develop the module. Periphyton is defined as the community of organisms that is attached to or lives upon submerged surfaces and can consume phosphorus. A sensitivity analysis of the reclaimed water effluent total phosphorus concentrations was completed that reduced effluent total phosphorus concentrations so that observed total phosphorus data matched the predicted total phosphorus values. The results of this effort are shown in the lower half of Figures 2-14 through 2-17. The green solid line in the total phosphorus graphics show the results without the effluent total phosphorus concentration reduction and the pink line shows the results with the total phosphorus concentration reduction. Even with the reduction in effluent total phosphorus concentration, there is still a slight over prediction of total phosphorus concentrations during effluent dominated conditions. In general, predictions of total phosphorus fall within the range of measured values. During non-effluent dominated conditions, the predicted total phosphorus concentrations are at times less than the maximum observed values. To increase predicted values during non-effluent dominated conditions, the nonpoint source loading factors would have to be increased to unrealistic values. Because the observed values are single point samples and do not represent an average daily concentration, it is assumed that the current calibration is adequate for all flow conditions within the watershed.

2.3.4 Water Calibration Relative Error Statistics

In order to assess the water quality calibration efforts, the relative error was calculated for each calibration location. Relative Error measures the difference between observed and predicted values and is a measure of model accuracy. The values for relative error at each calibration location are shown in Table 2-2. The error percentages shown in Table 2-2 are typical of water quality modeling efforts. Areas of improvement include refining the model to account for phosphorus reductions during effluent dominated conditions and accounting for dry-weather flow within the watershed.

Table 2-2 Water Quality Relative Error Calculation Results at Calibration Locations within the Santa Margarita River Watershed

Station Name	Total Nitrogen with Modified Rate Coefficients Relative Error	Total Phosphorus with Effluent Concentration Reduction Relative Error
Temecula Creek	40%	-17%
Murrieta Creek	22%	30%
Santa Margarita River near Temecula	20%	-9%
Santa Margarita River near De Luz	28%	-32%

2.4 Calibration Summary

Accurate input data and field measurements are important to model calibration. There is uncertainty in both of these items and it is not possible to achieve a close match at all locations at all times. The current SMRWM model should be considered a work in progress and while the model is adequately set up to evaluate potential scenarios within the watershed, further data collection efforts and calibration improvements in the future will only make the tool more useful to achieve the goals of the SMR EMT.

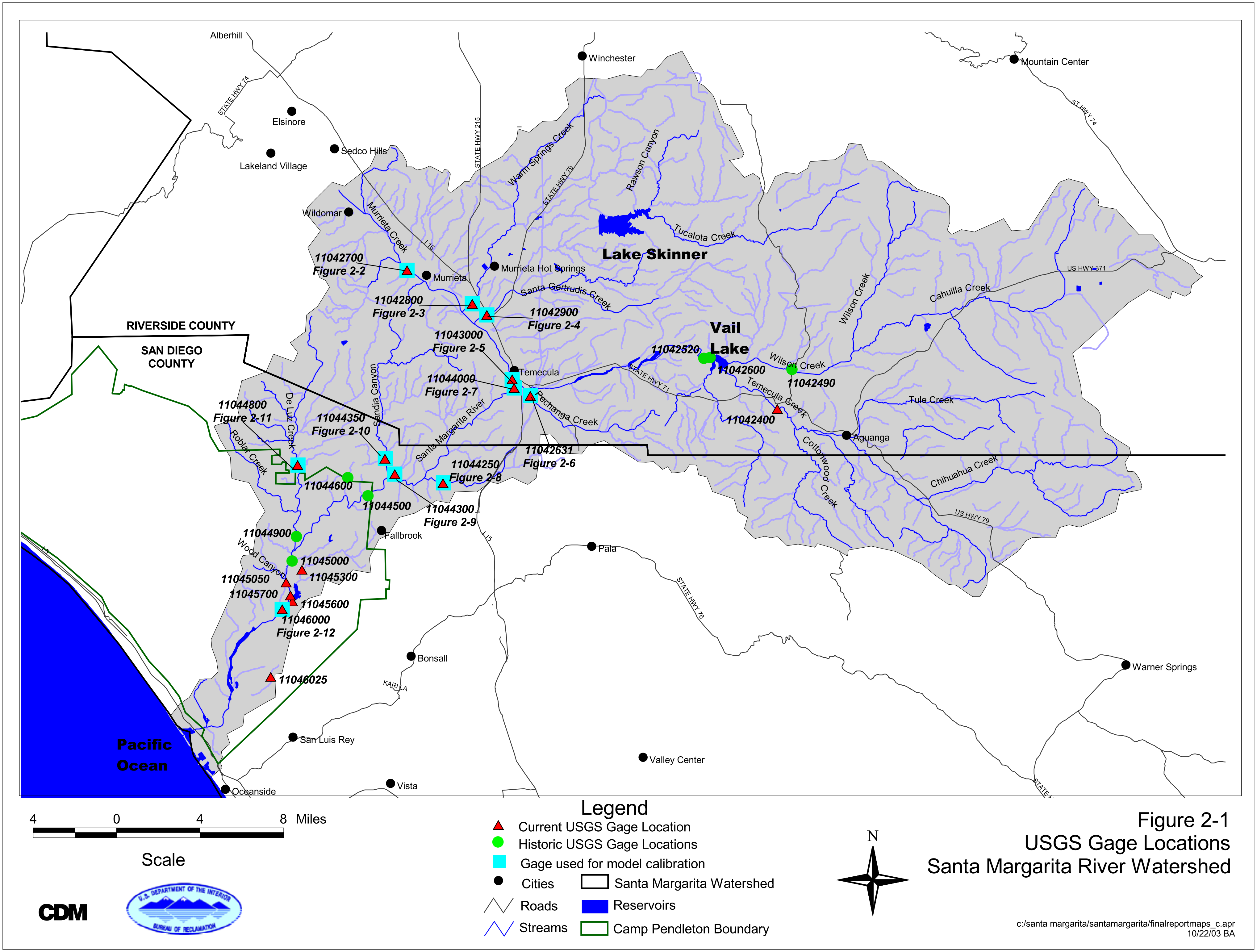
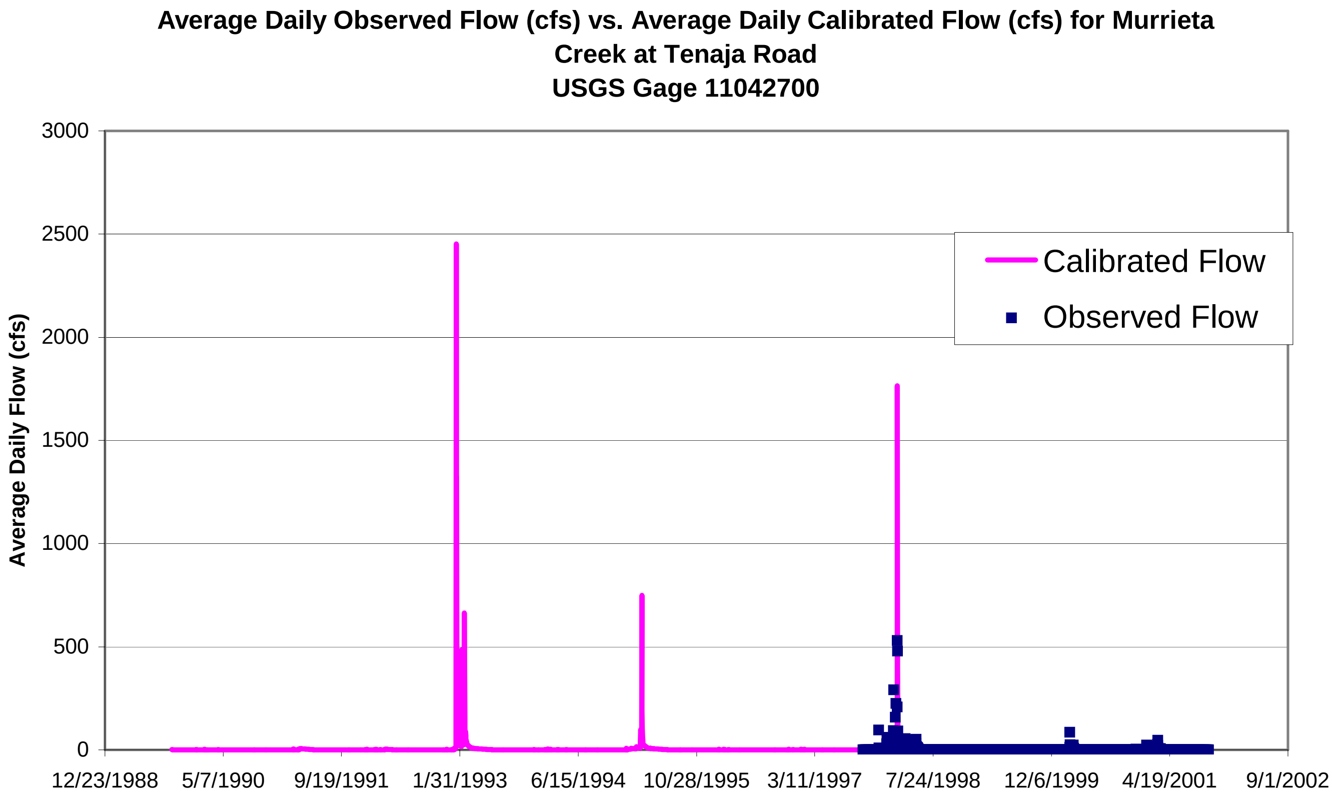


Figure 2-1
USGS Gage Locations
Santa Margarita River Watershed



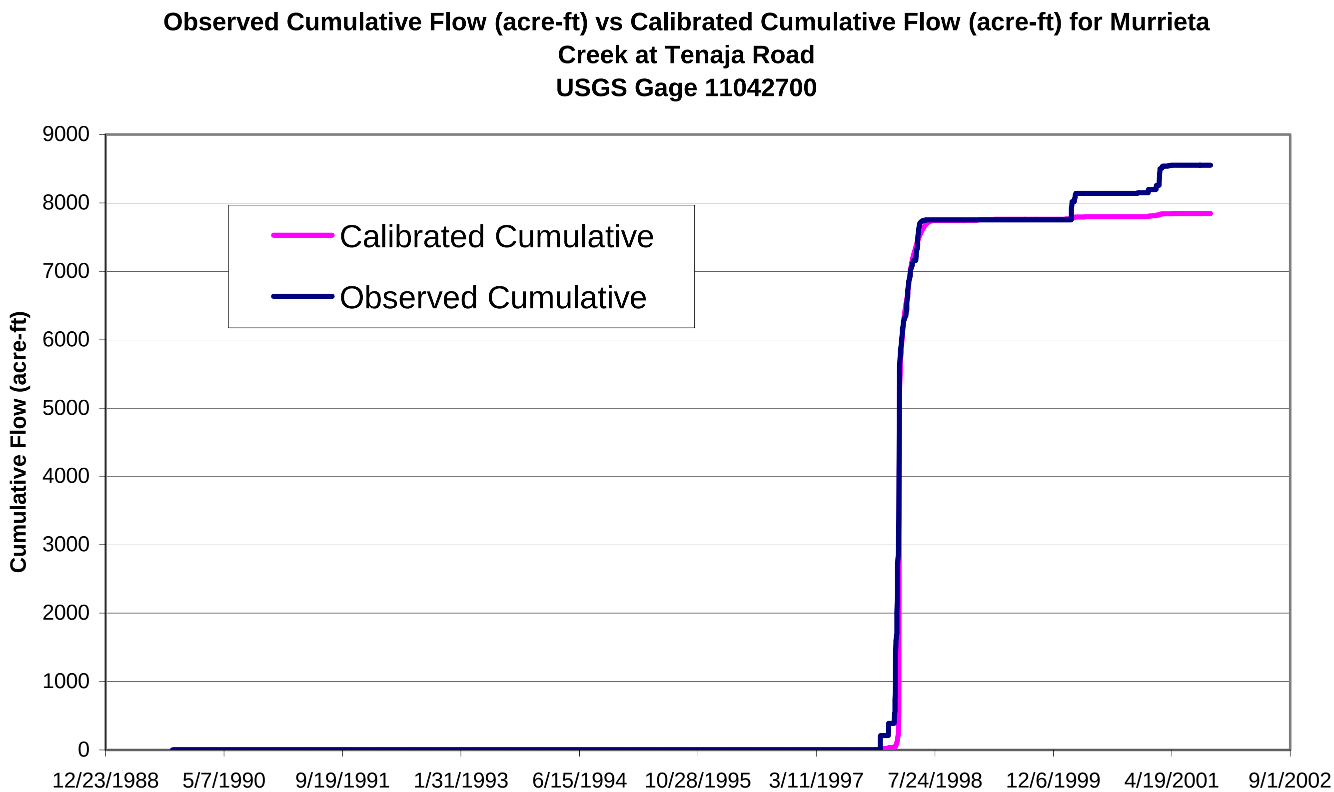
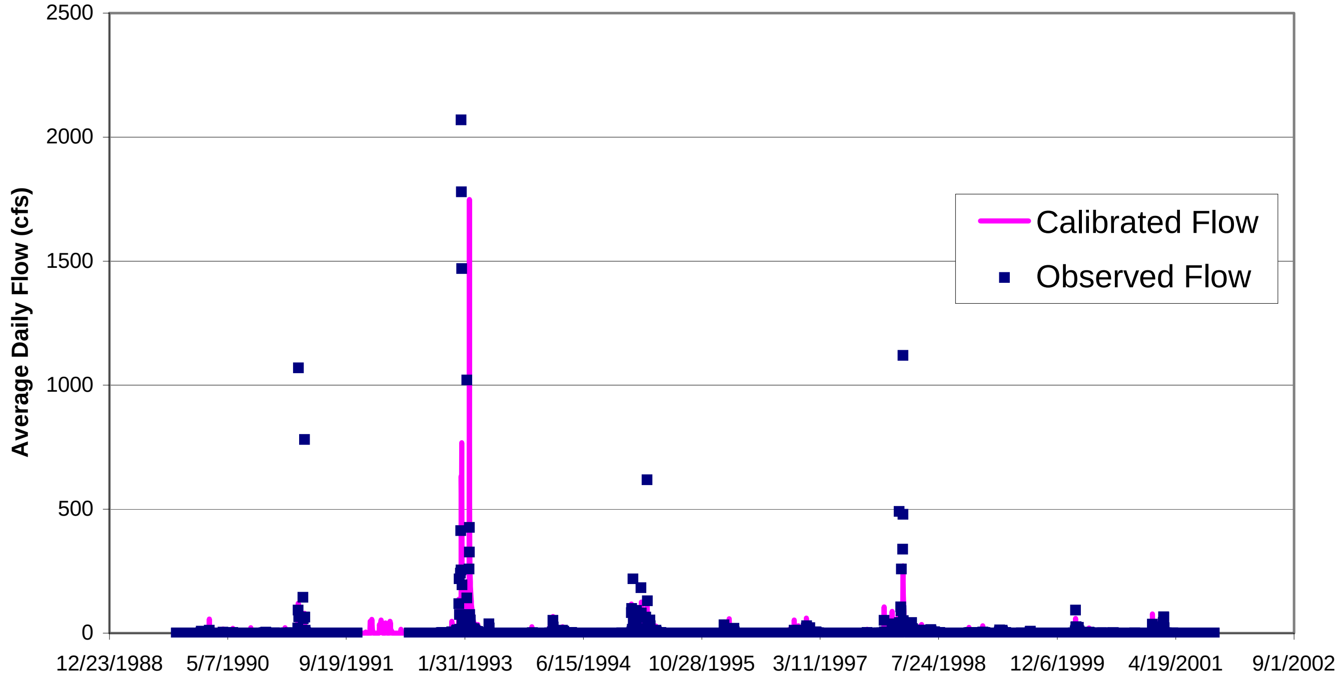


Figure 2-2 Hydrology Calibration Charts for Murrieta Creek at Tenaja Road

Average Daily Observed Flow (cfs) vs Average Daily Calibrated Flow (cfs) for Warm Springs Creek
USGS Gage 11042800



Observed Cumulative Flow (acre-ft) vs. Calibrated Cumulative Flow (acre-ft) for Warm Springs Creek
USGS Gage 11042800

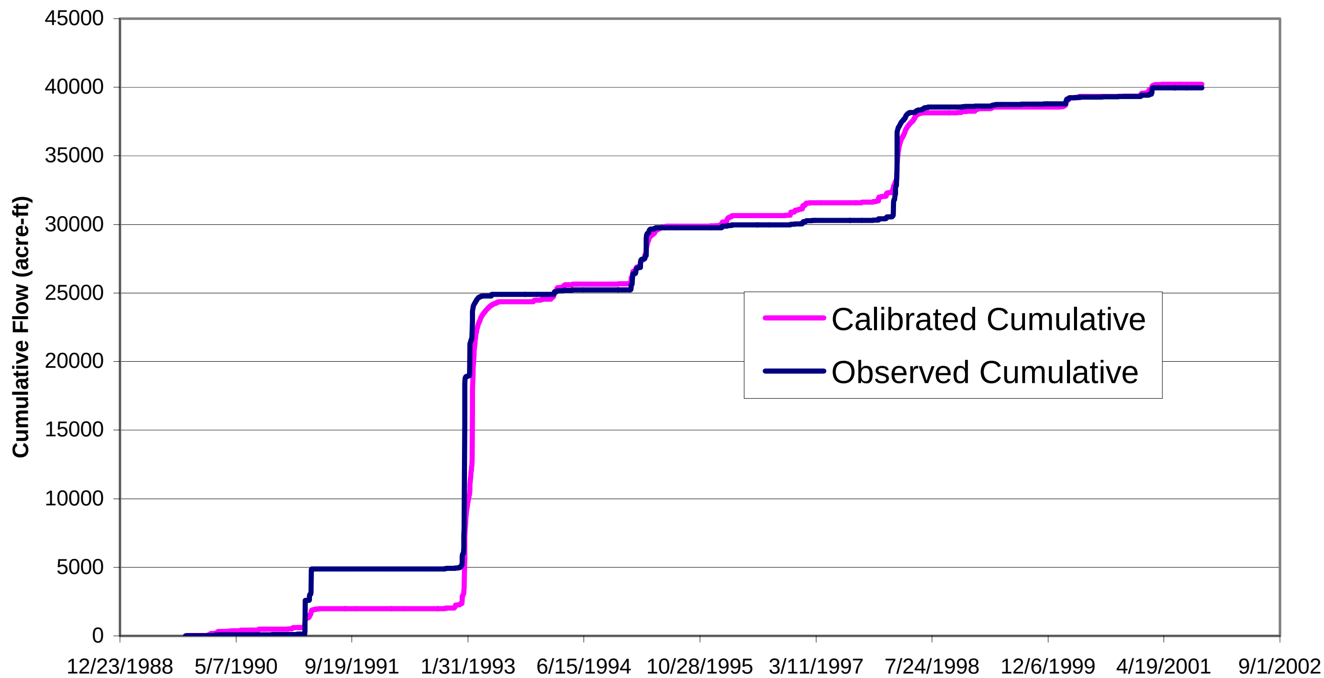
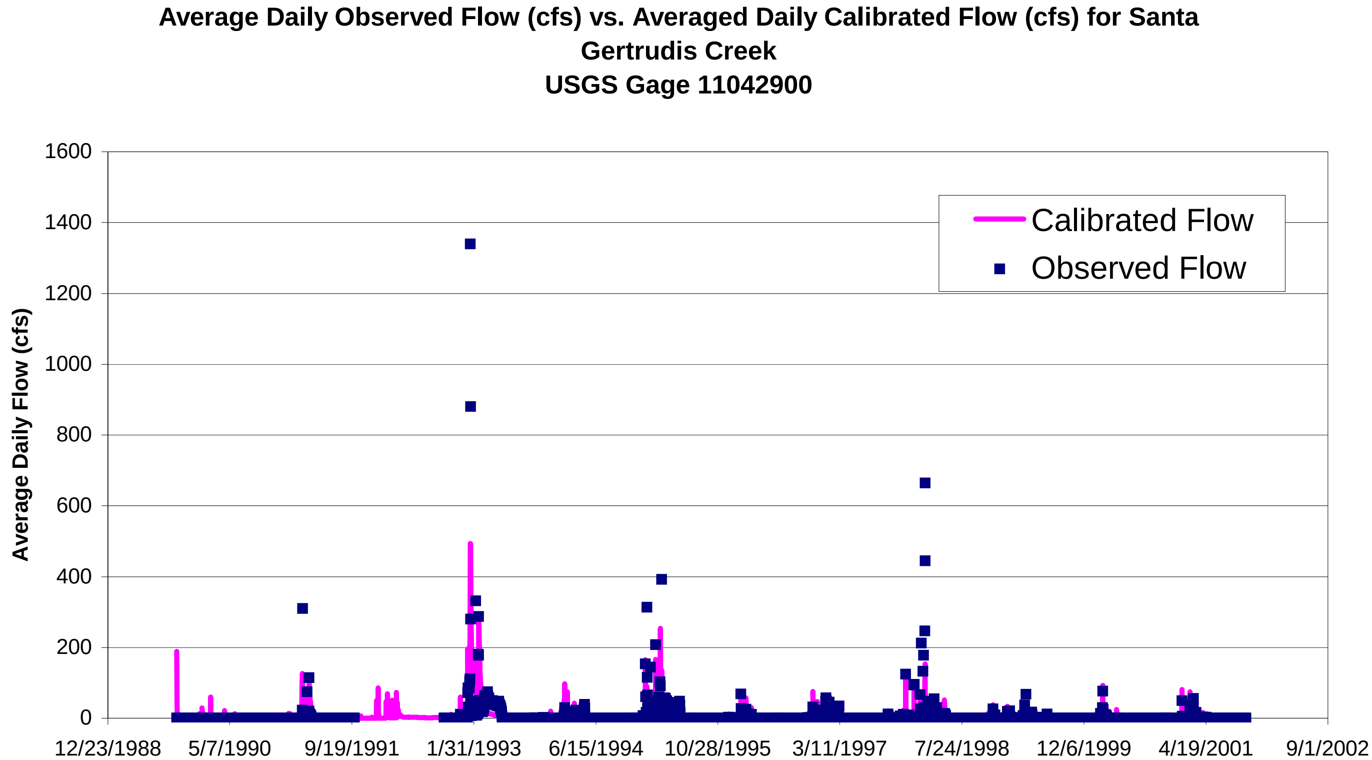


Figure 2-3 Hydrology Calibration Charts for Warm Springs Creek



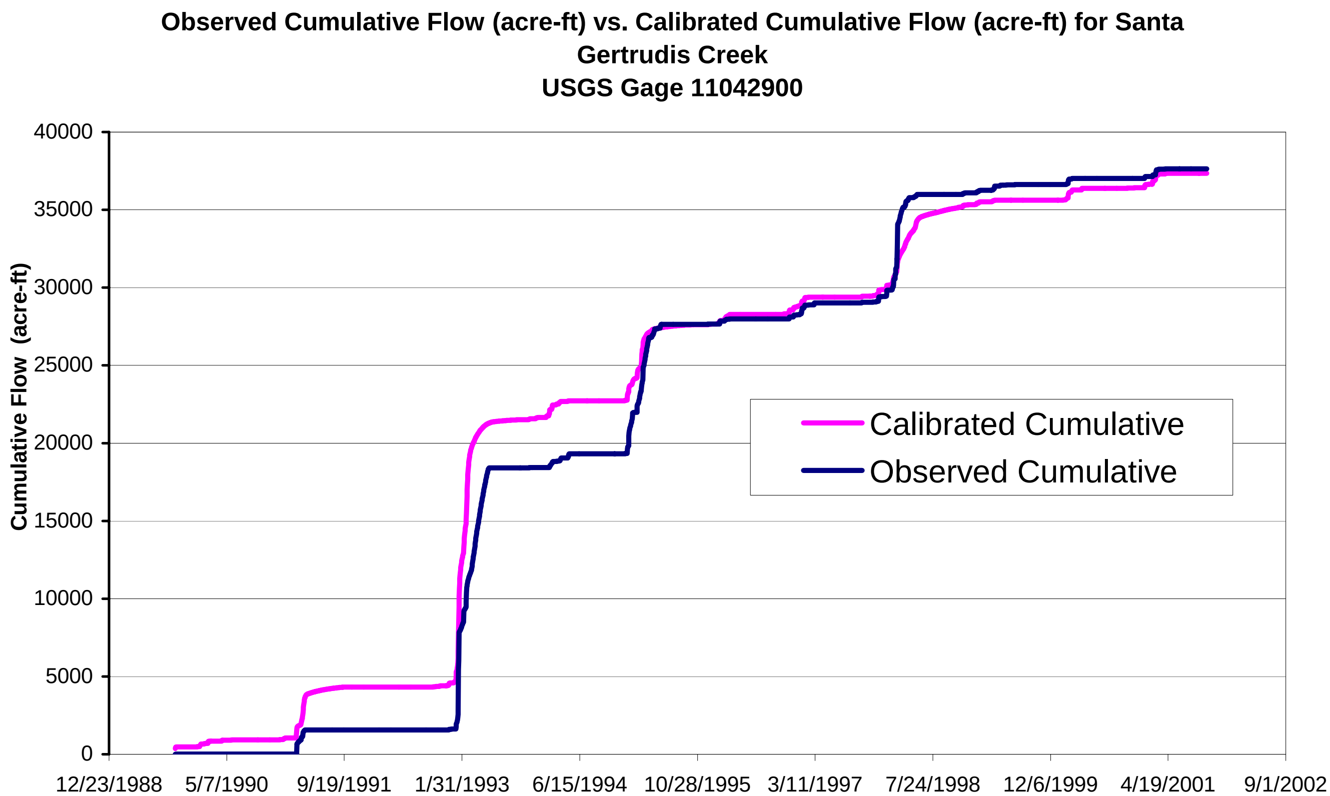
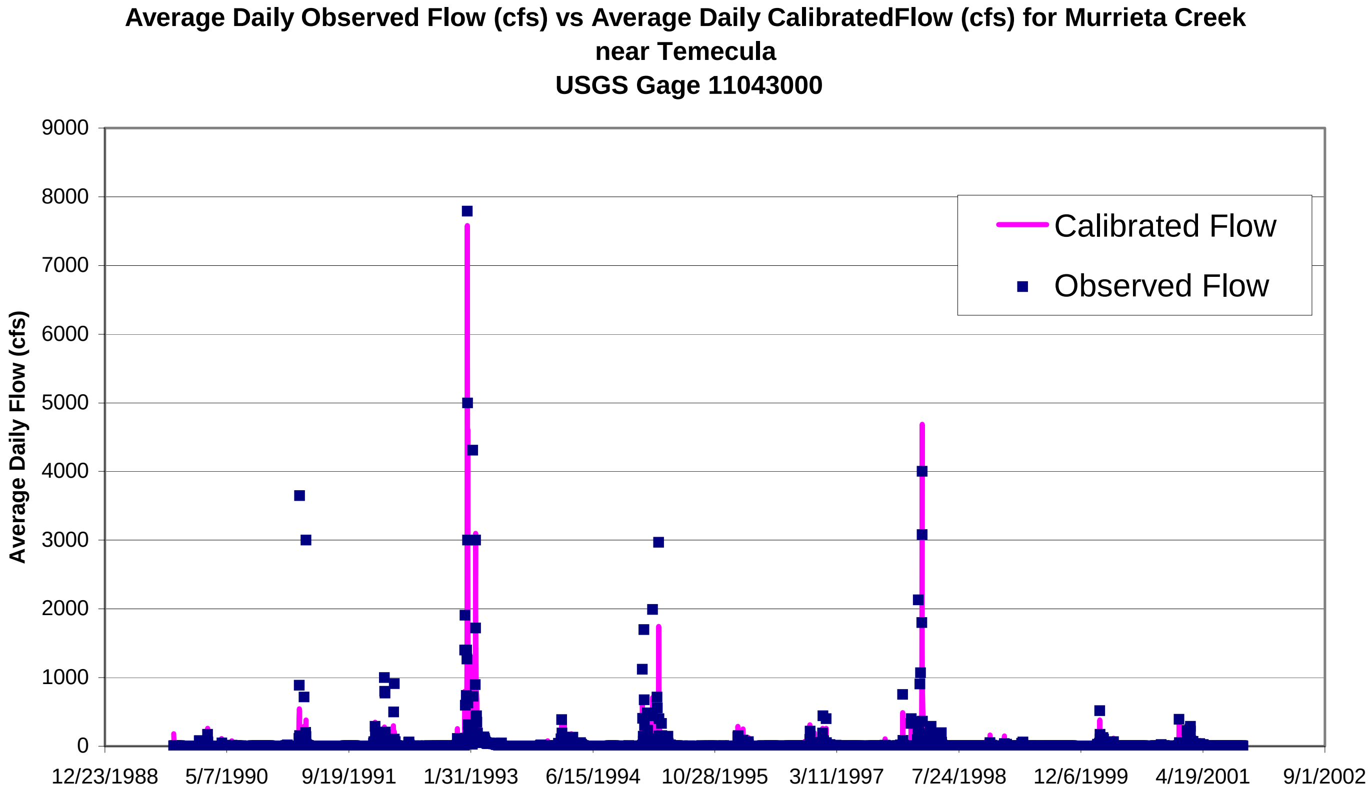


Figure 2-4 Hydrology Calibration Charts for Santa Gertrudis Creek



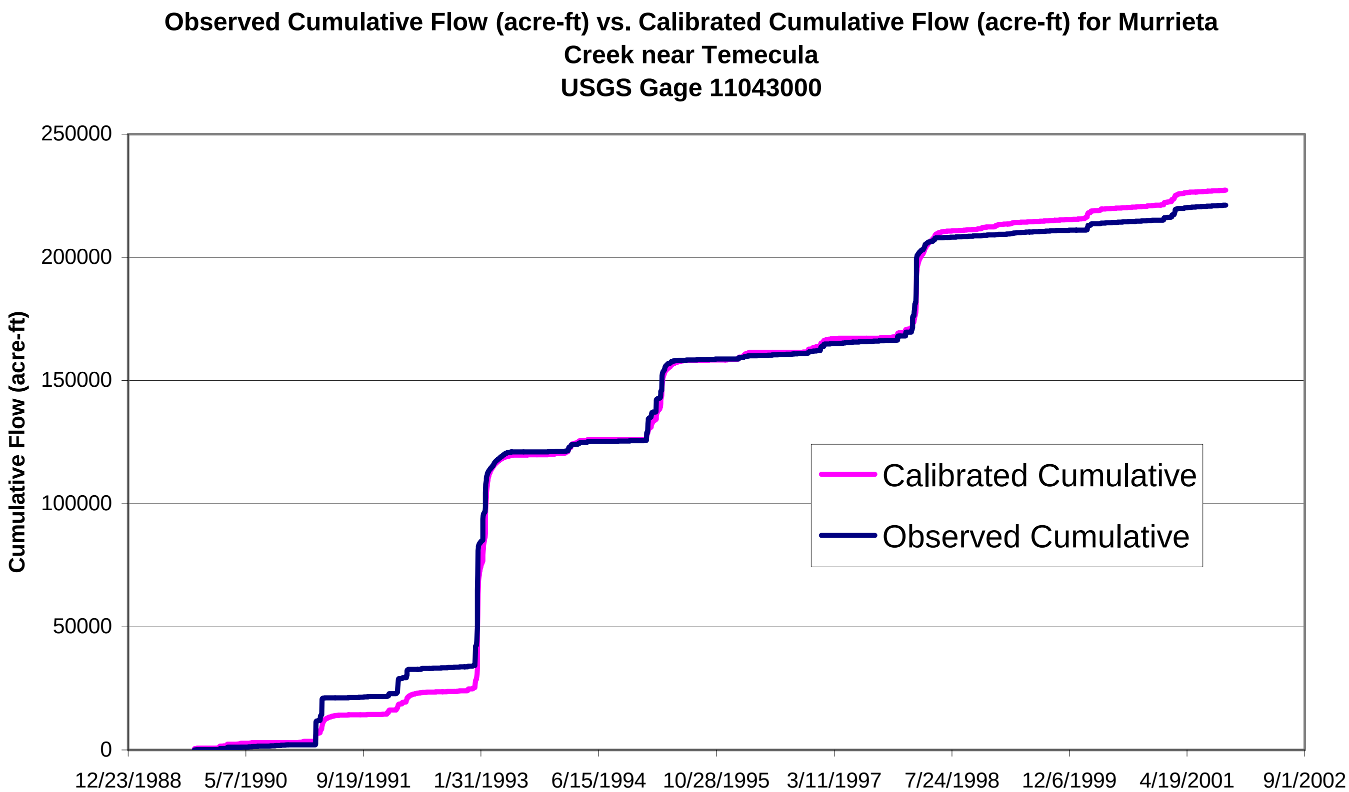
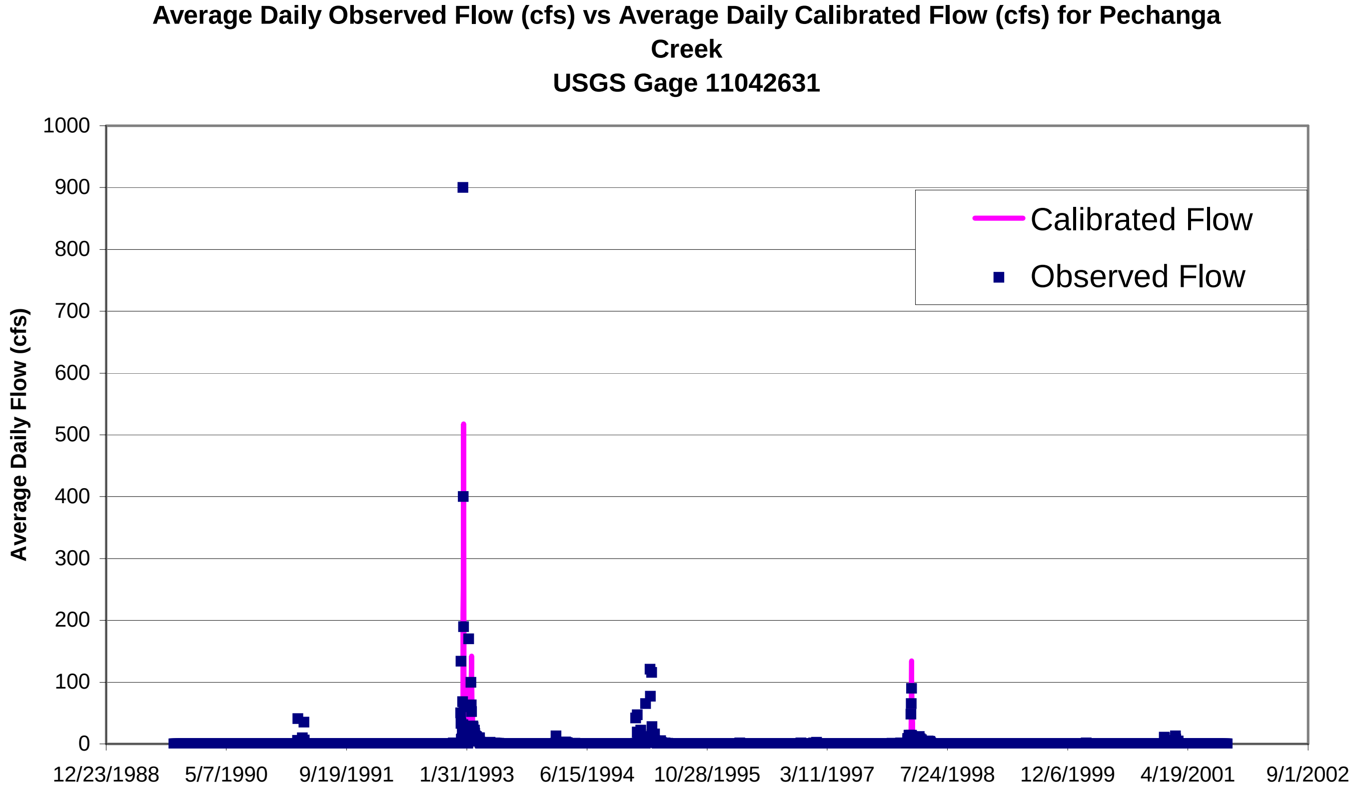


Figure 2-5 Hydrology Calibration Charts for Murrieta Creek near Temecula



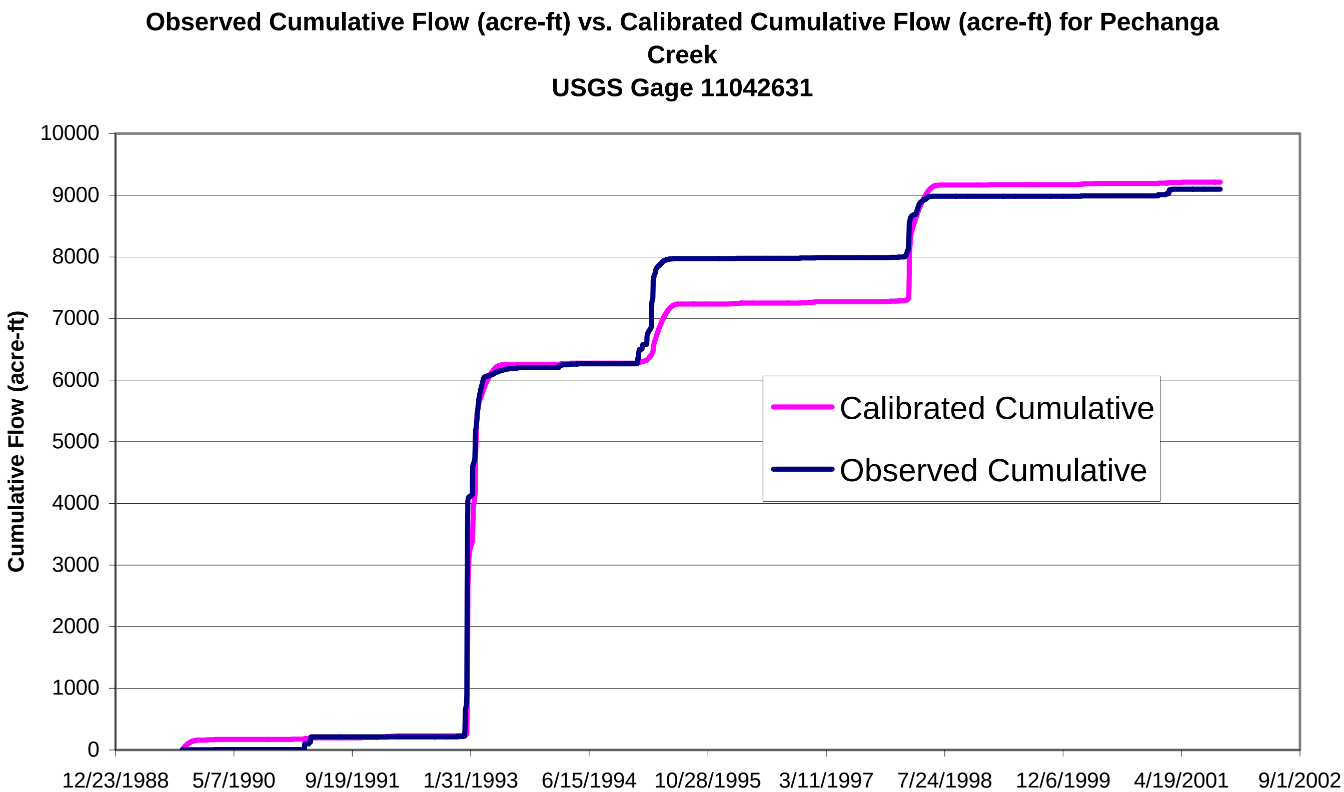
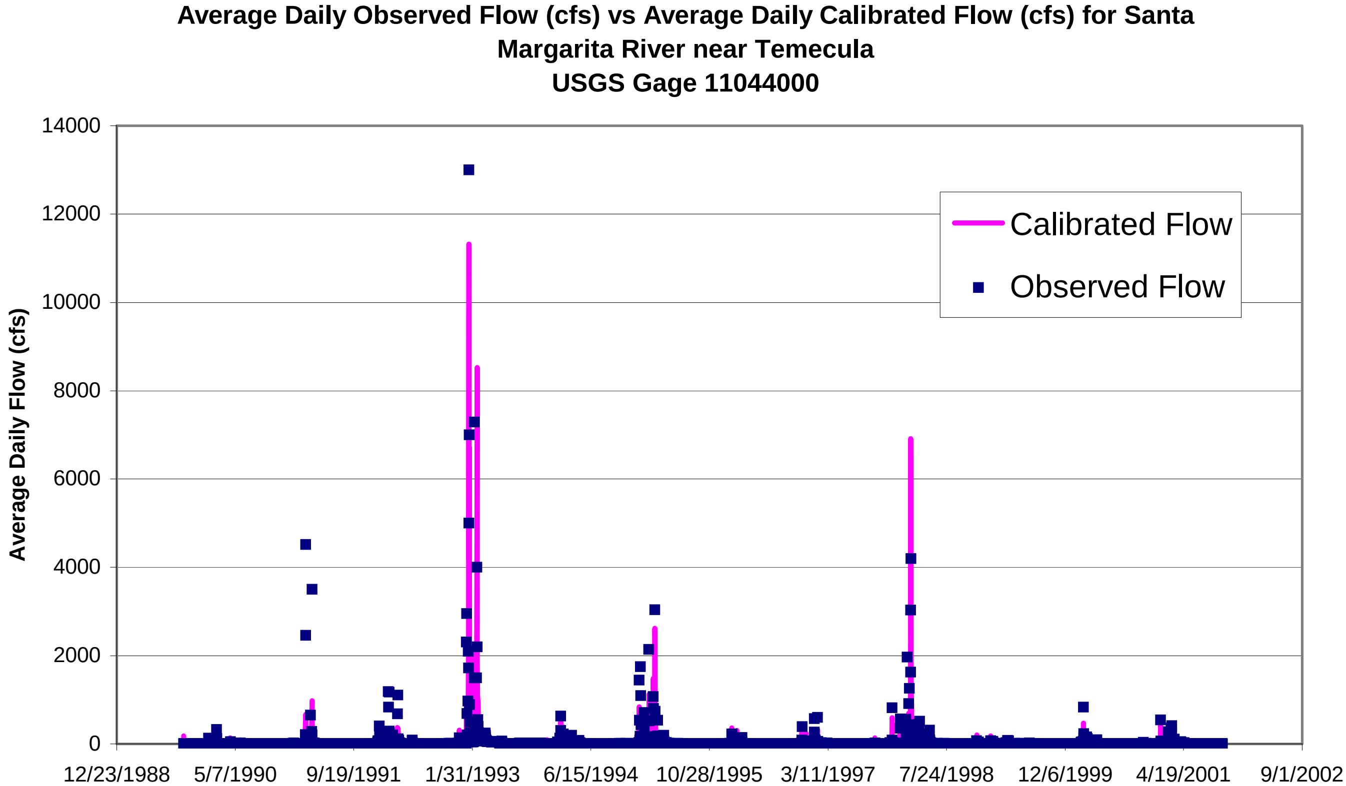


Figure 2-6 Hydrology Calibration Charts for Pechanga Creek



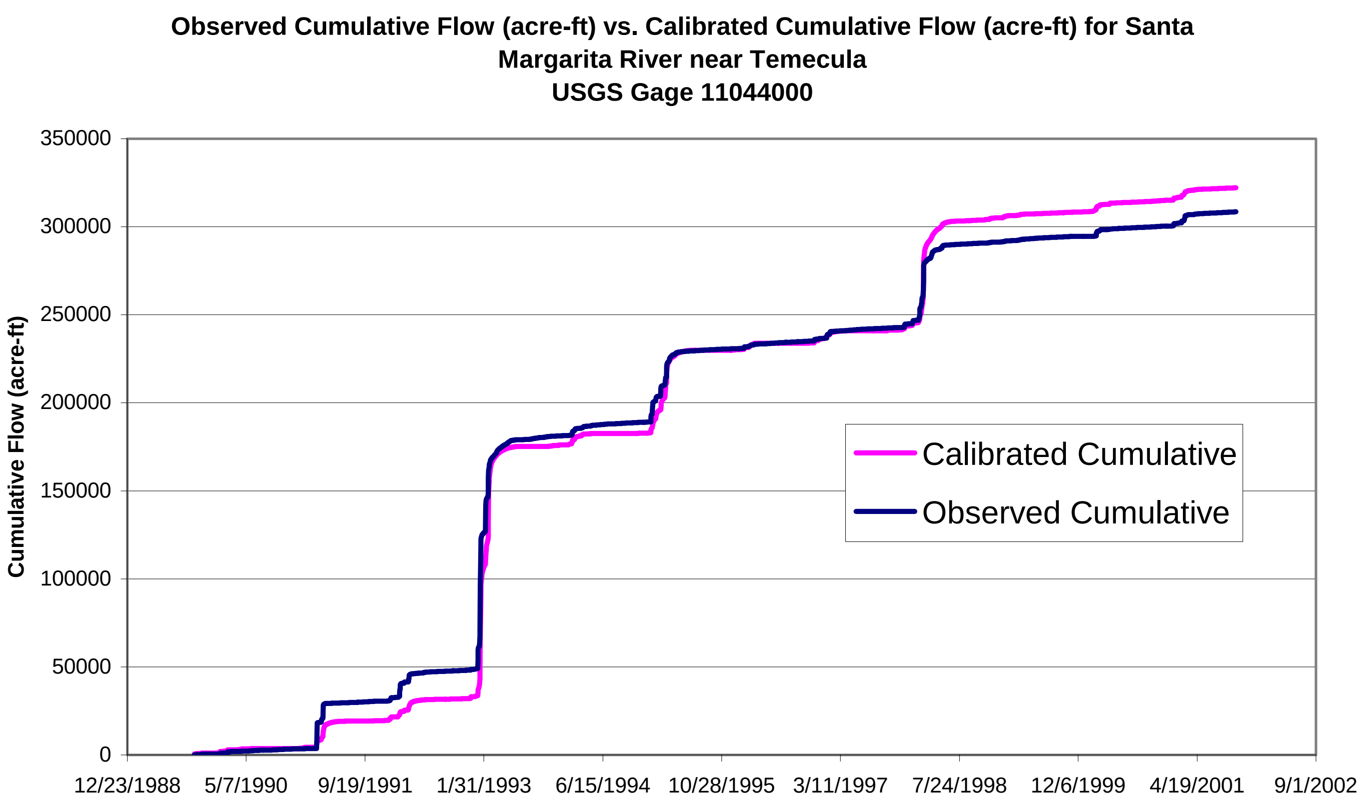
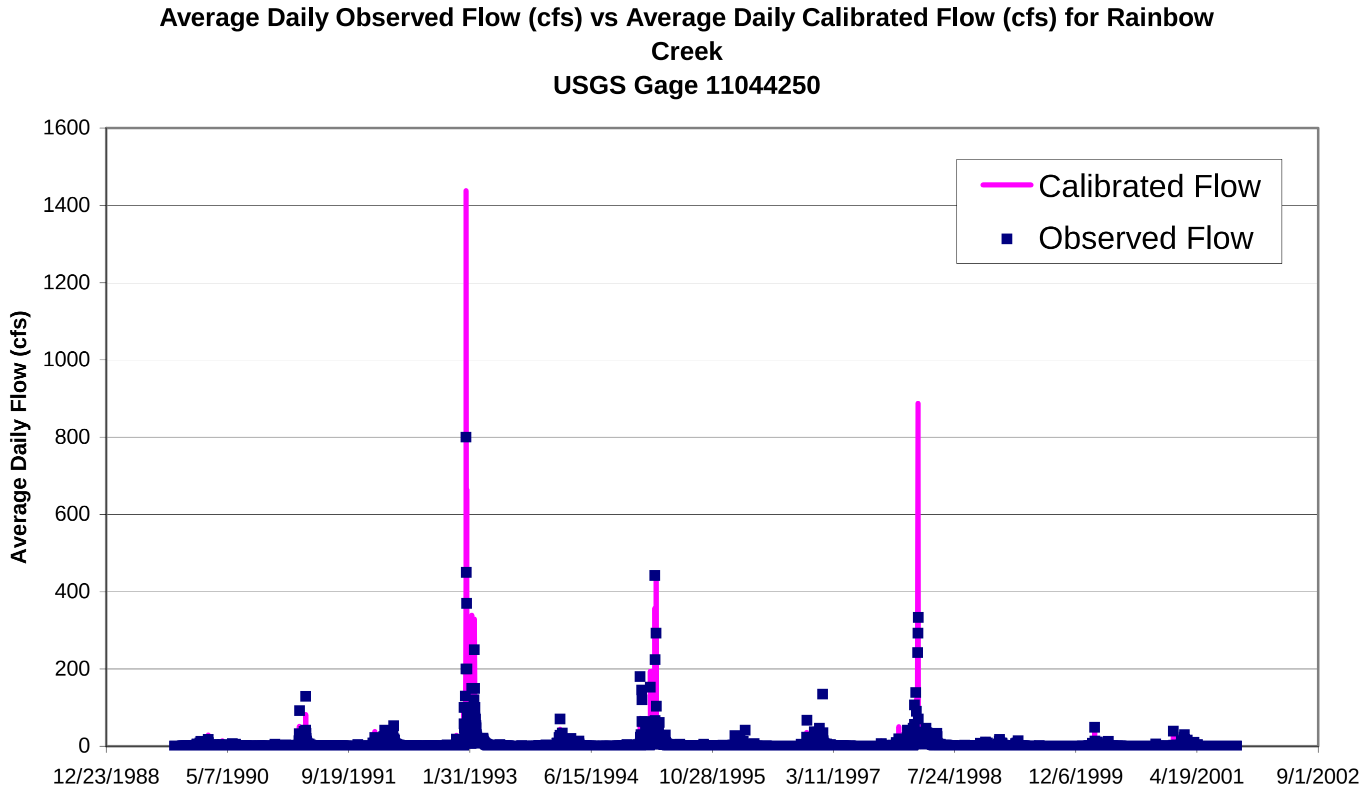


Figure 2-7 Hydrology Calibration Charts for Santa Margarita River near Temecula



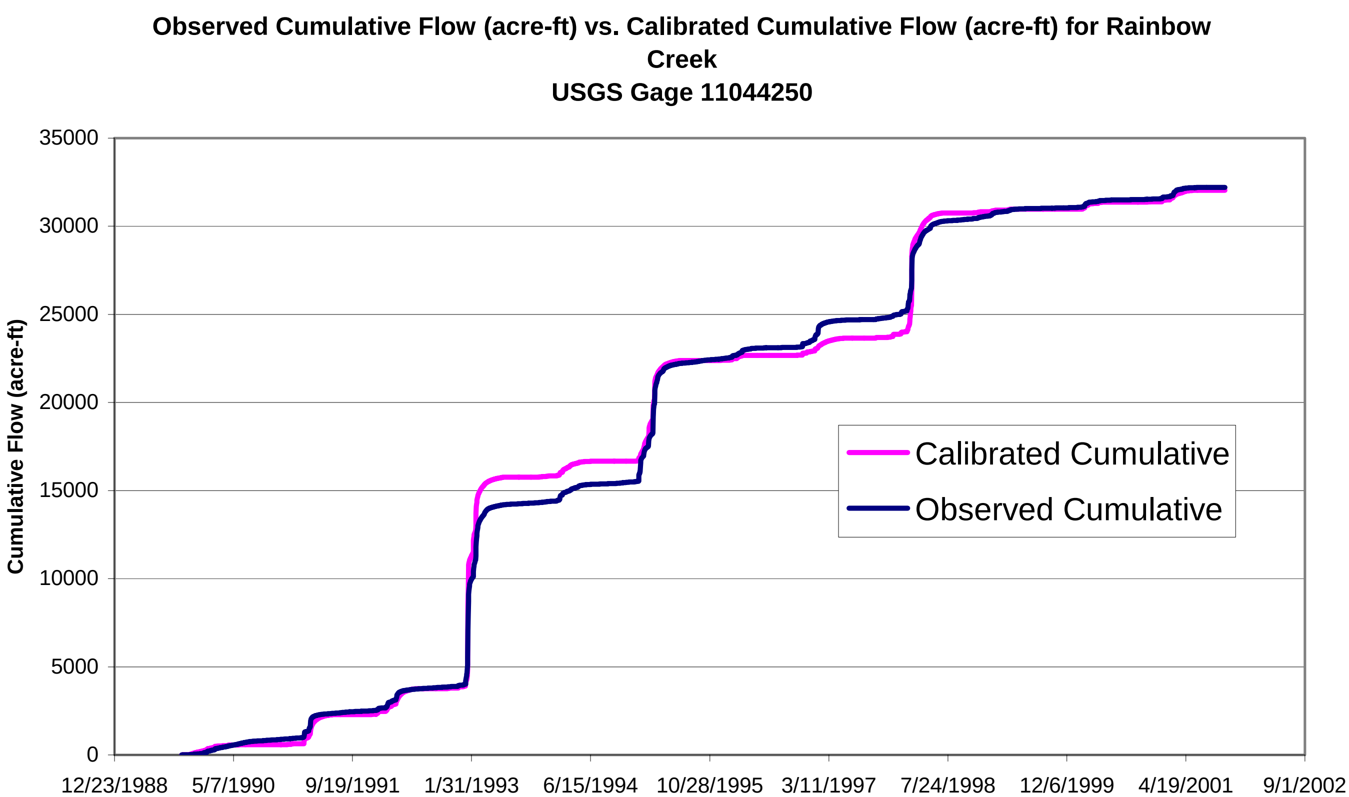
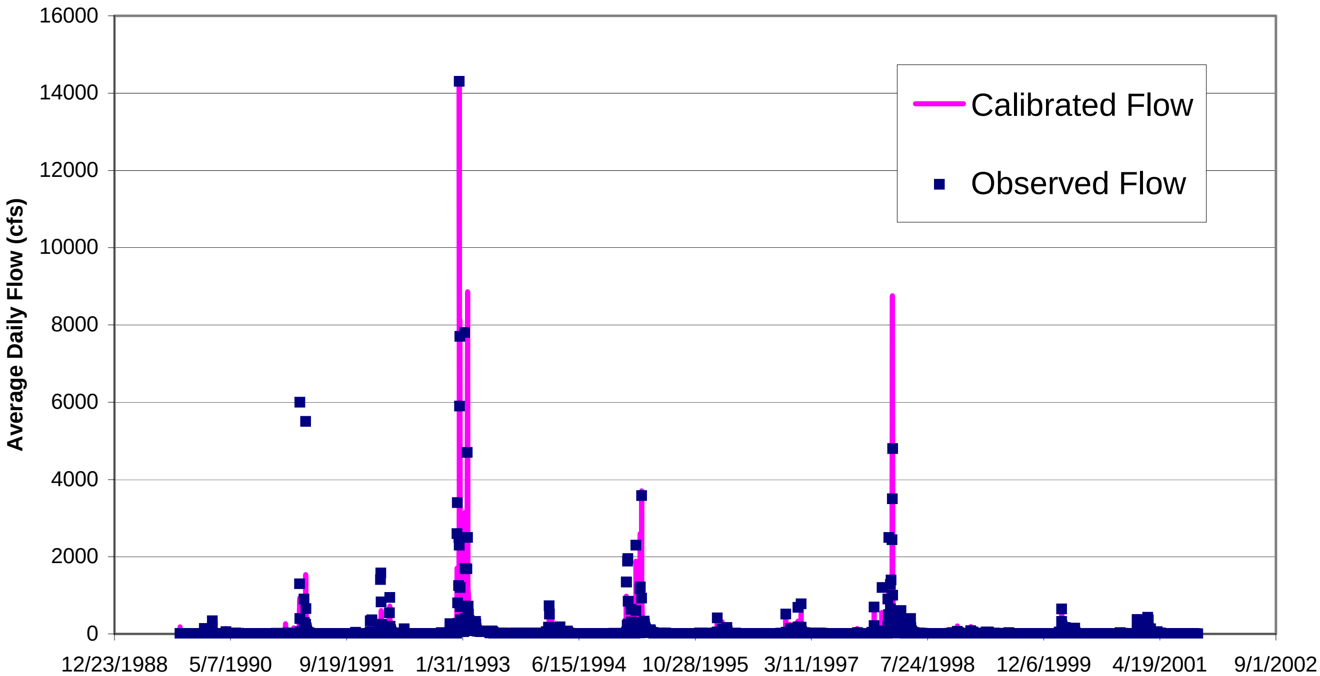


Figure 2-8 Hydrology Calibration Charts for Rainbow Creek

Average Daily Observed Flow (cfs) vs Average Daily Calibrated Flow (cfs) for Santa Margarita River near Fallbrook
USGS Gage 11044300



Observed Cumulative Flow (acre-ft) vs. Calibrated Cumulative Flow (acre-ft) for Santa Margarita River near Fallbrook
USGS Gage 11044300

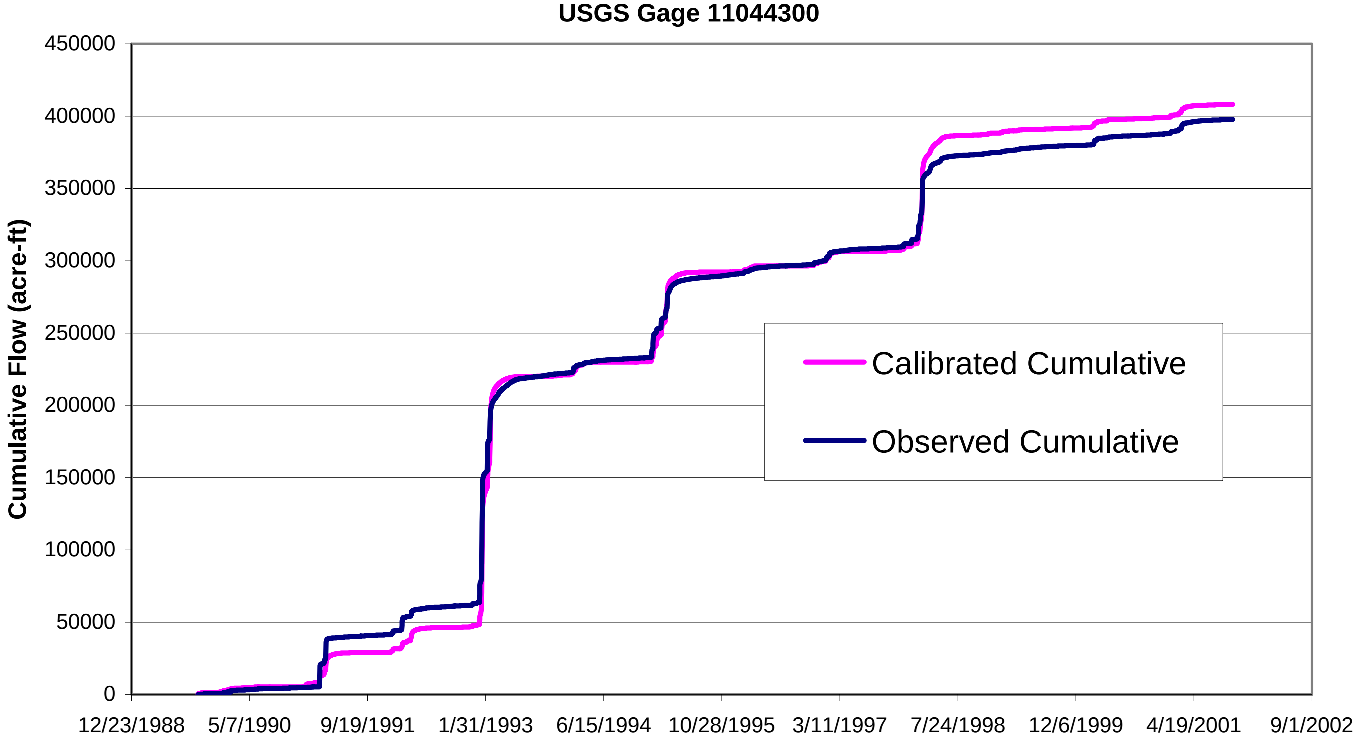
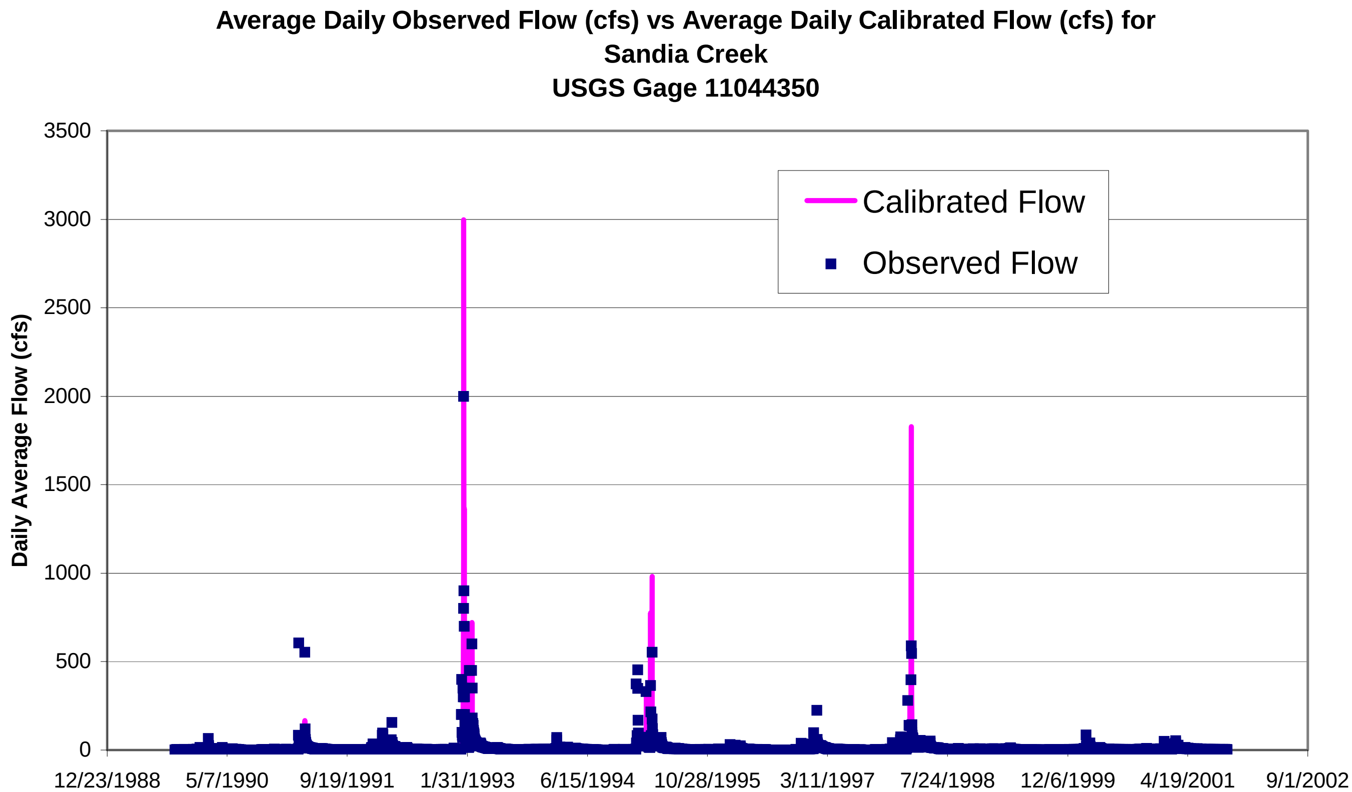


Figure 2-9 Hydrology Calibration Charts for Santa Margarita River near Fallbrook



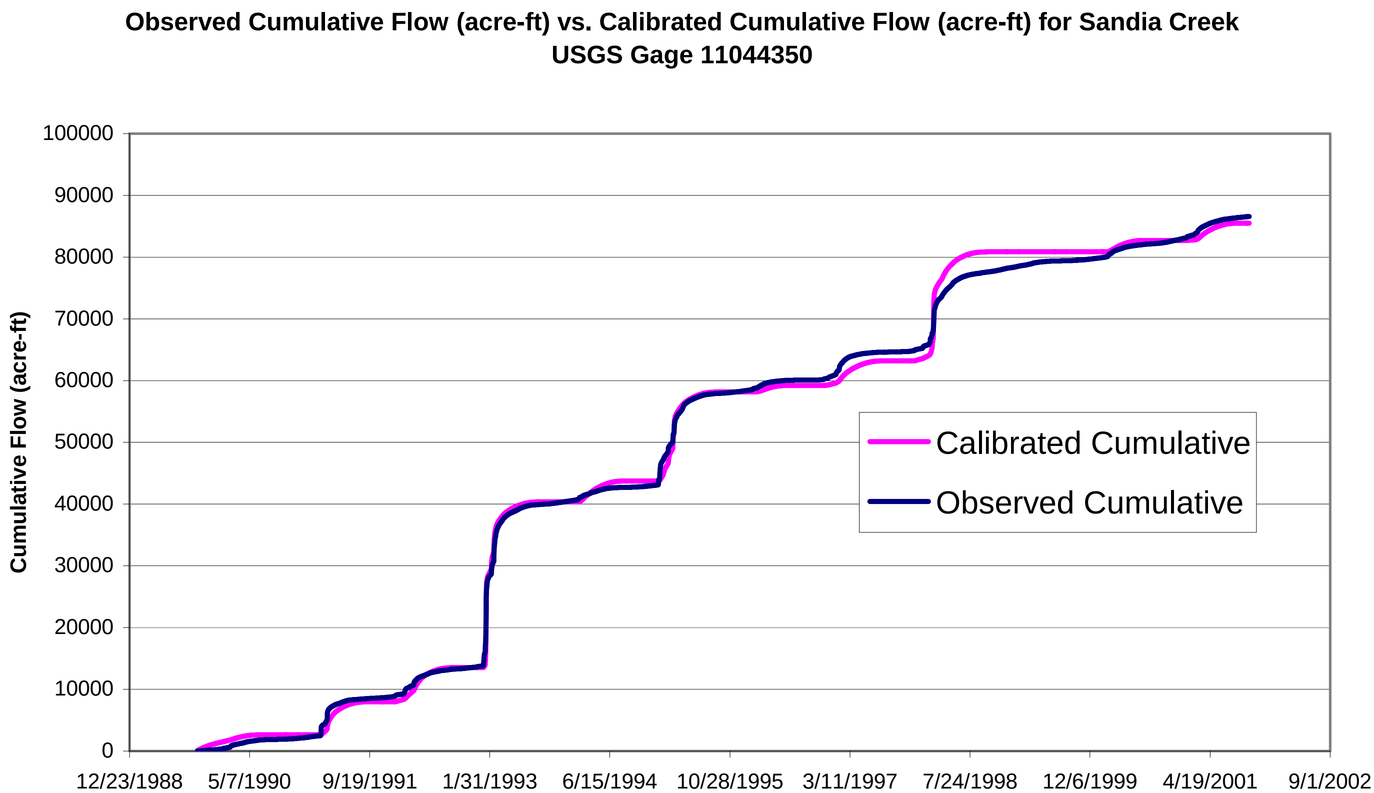
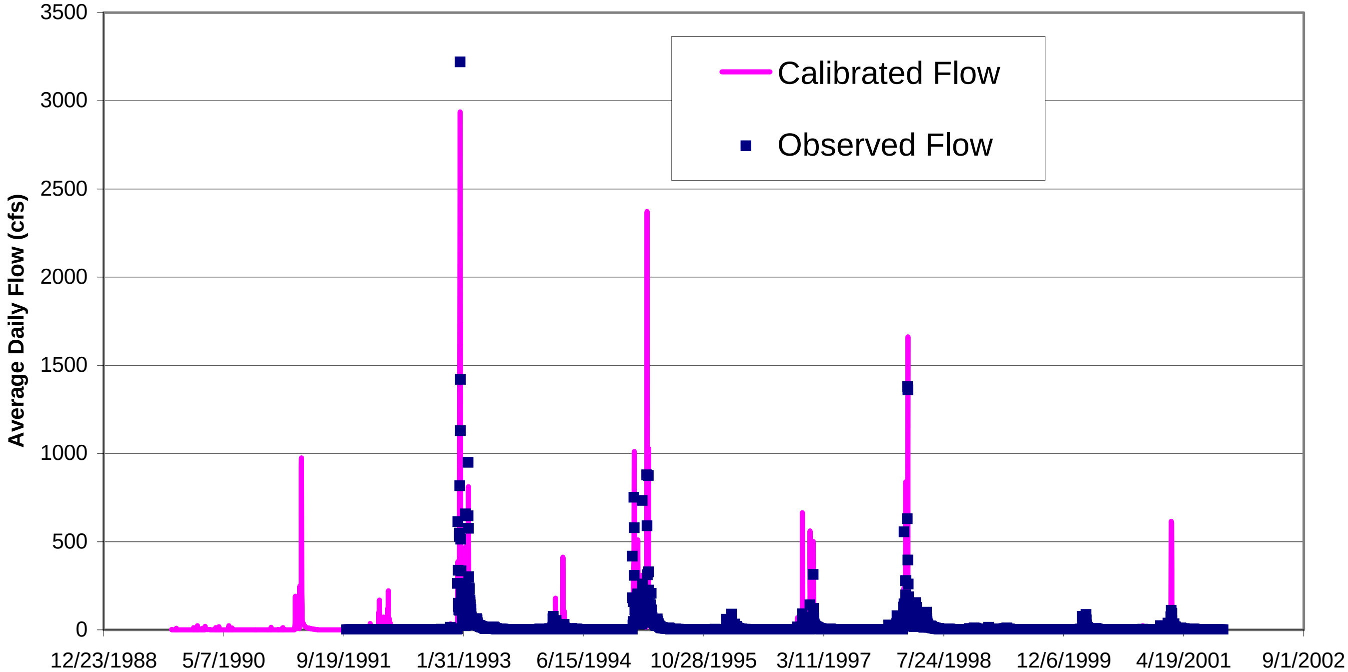


Figure 2-10 Hydrology Calibration Charts for Sandia Creek

Average Daily Observed Flow (cfs) vs. Average Daily Calibrated Flow (cfs) for De Luz Creek near De Luz
USGS Gage 11044800



Observed Cumulative Flow (acre-ft) vs. Calibrated Cumulative Flow (acre-ft) for De Luz Creek near De Luz
USGS Gage 11044800

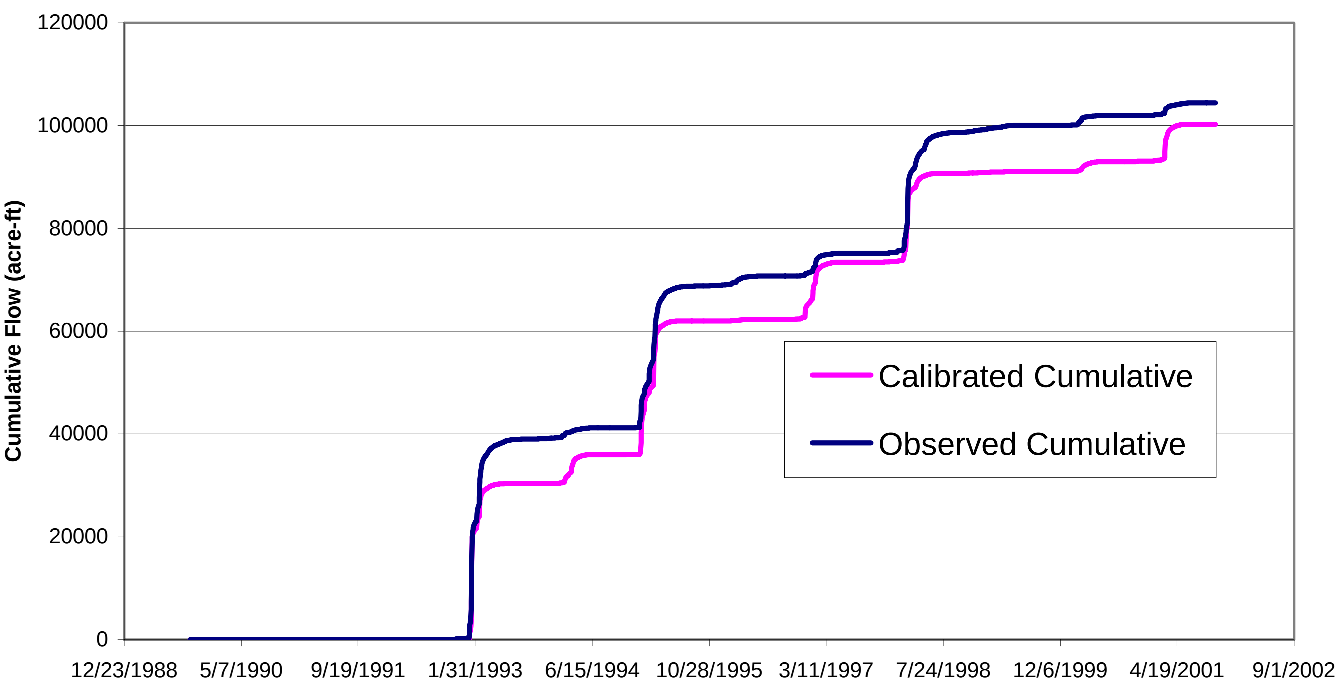
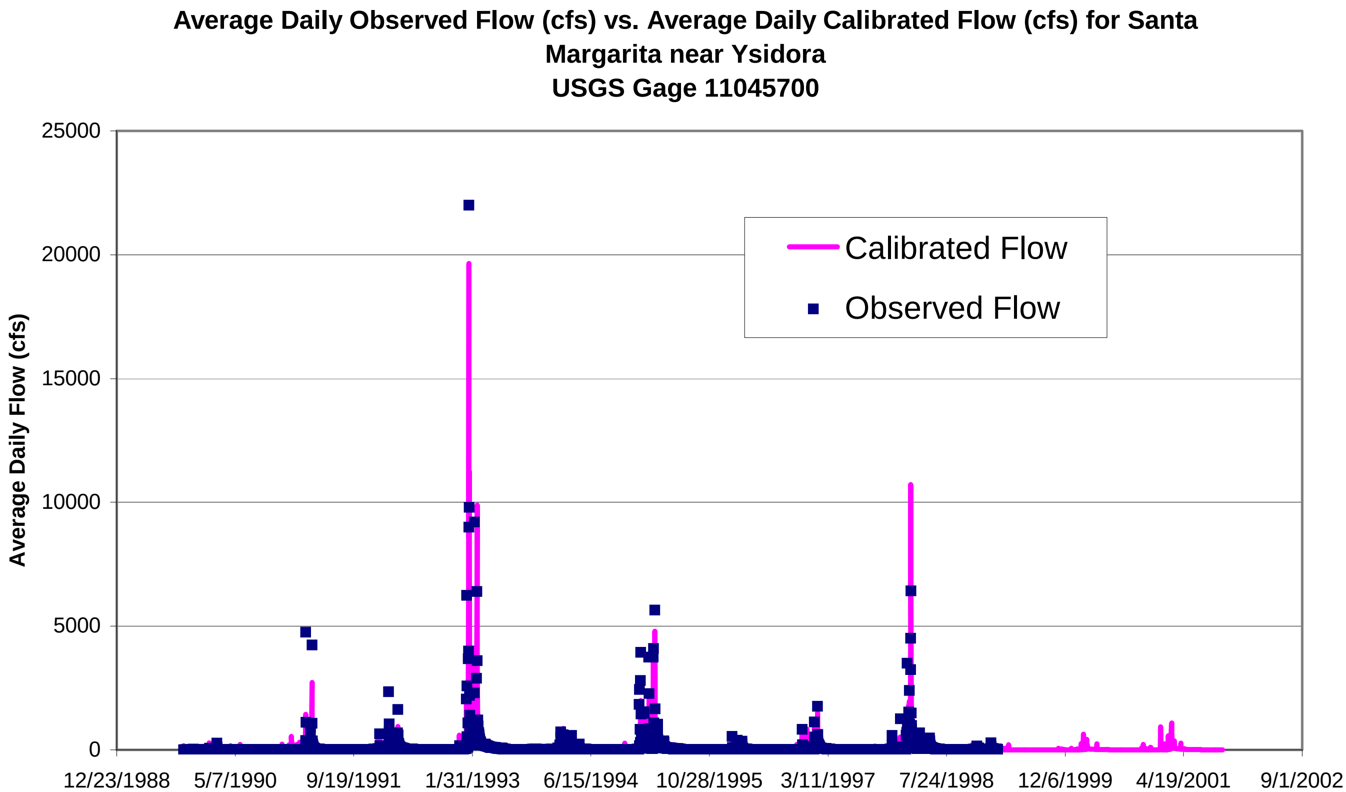


Figure 2-11 Hydrology Calibration Charts for De Luz Creek near De Luz



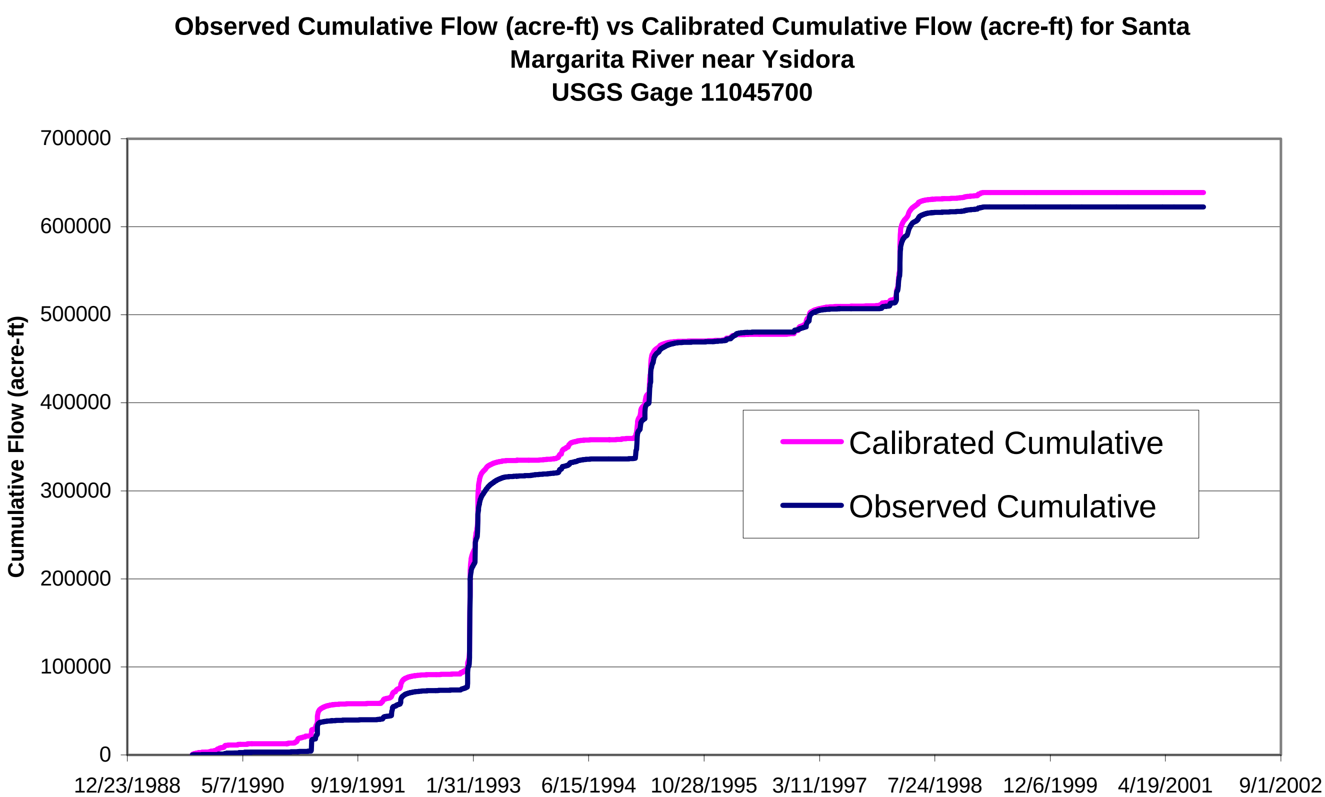
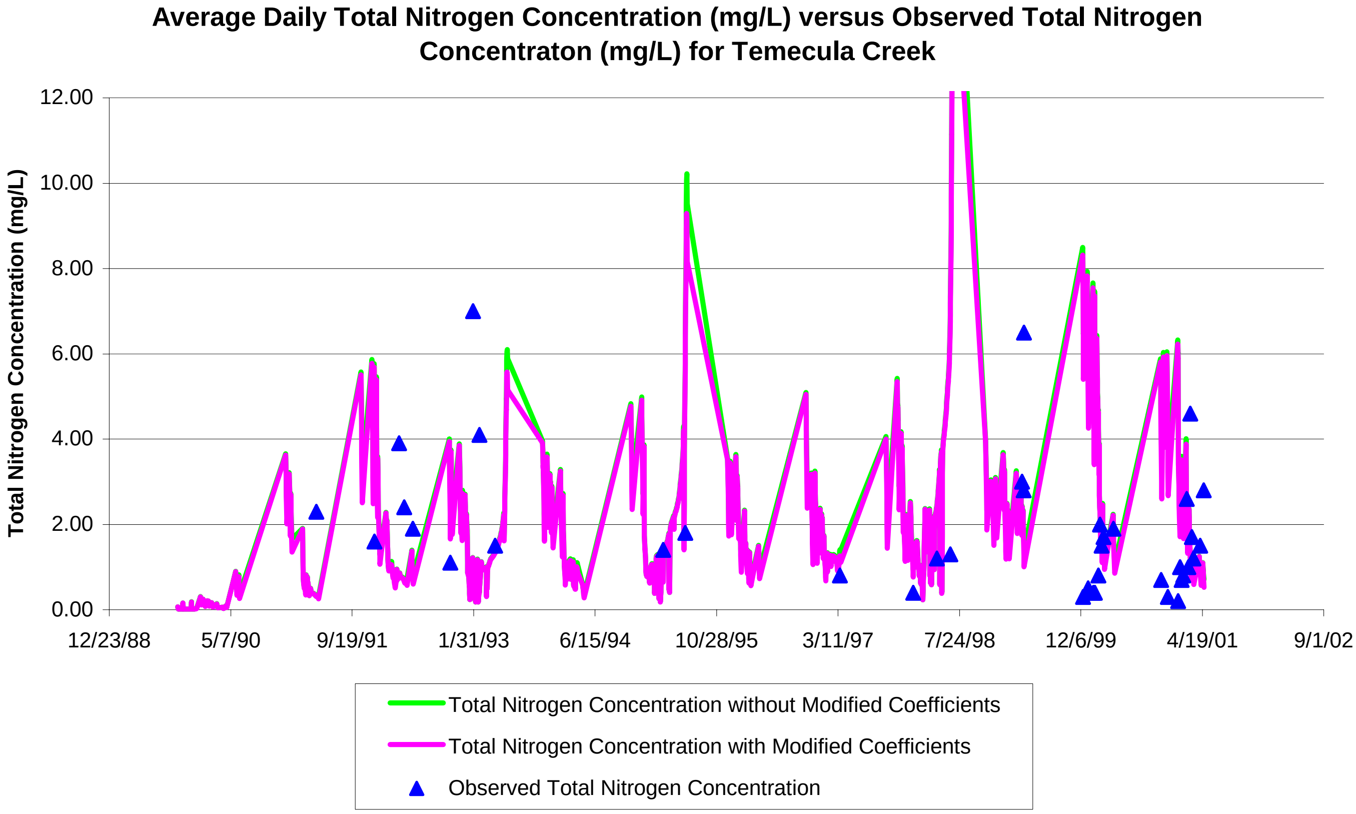


Figure 2-12 Hydrology Calibration Charts for Santa Margarita River near Ysidora



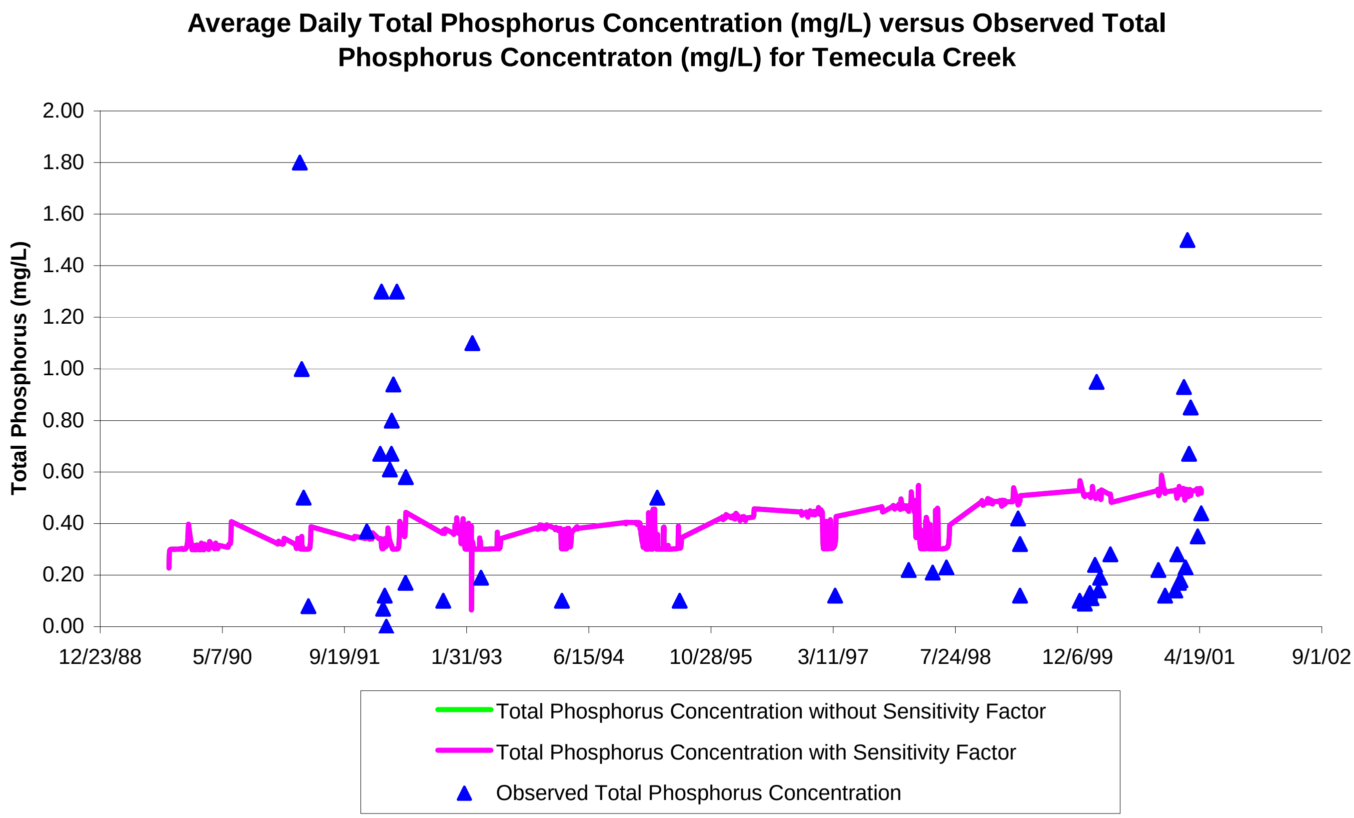
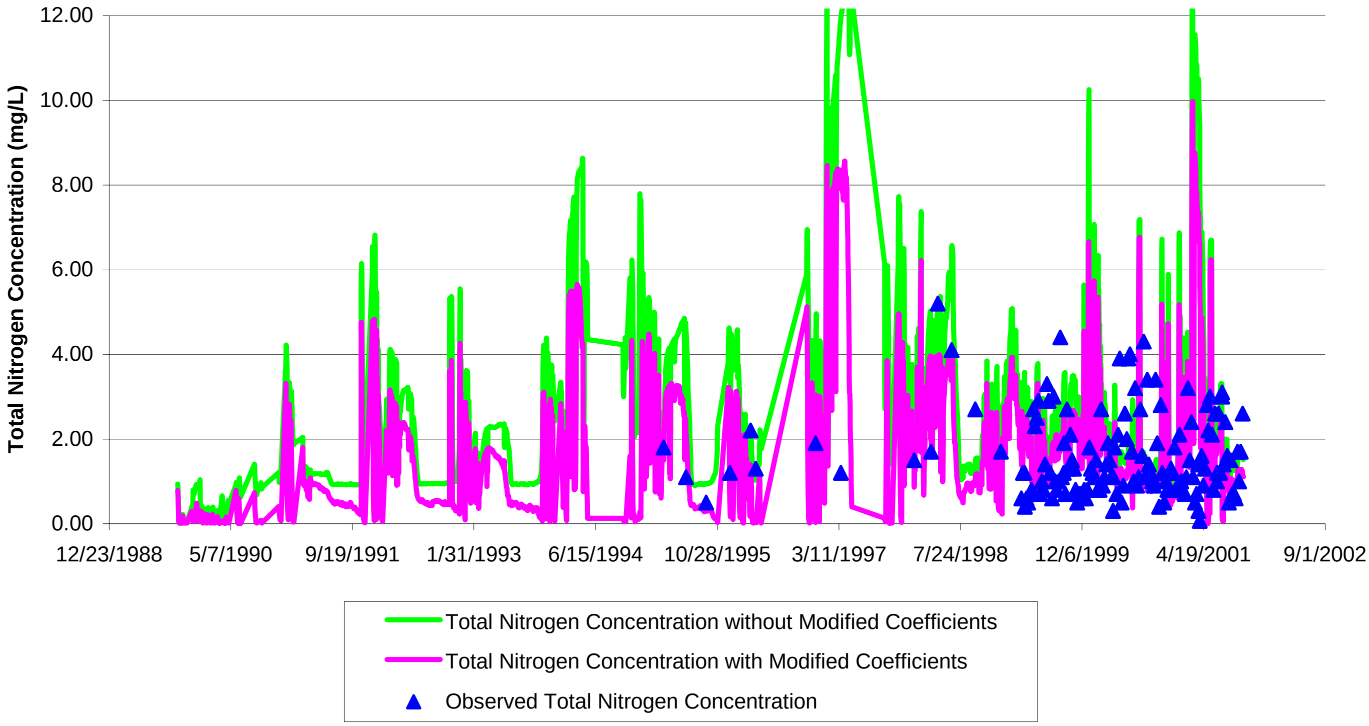


Figure 2-14 Water Quality Calibration Charts for Temecula Creek

Average Daily Total Nitrogen Concentration (mg/L) versus Observed Total Nitrogen Concentraton (mg/L) for Murrieta Creek



Average Daily Total Phosphorus Concentration (mg/L) versus Observed Total Phosphorus Concentraton (mg/L) for Murrieta Creek

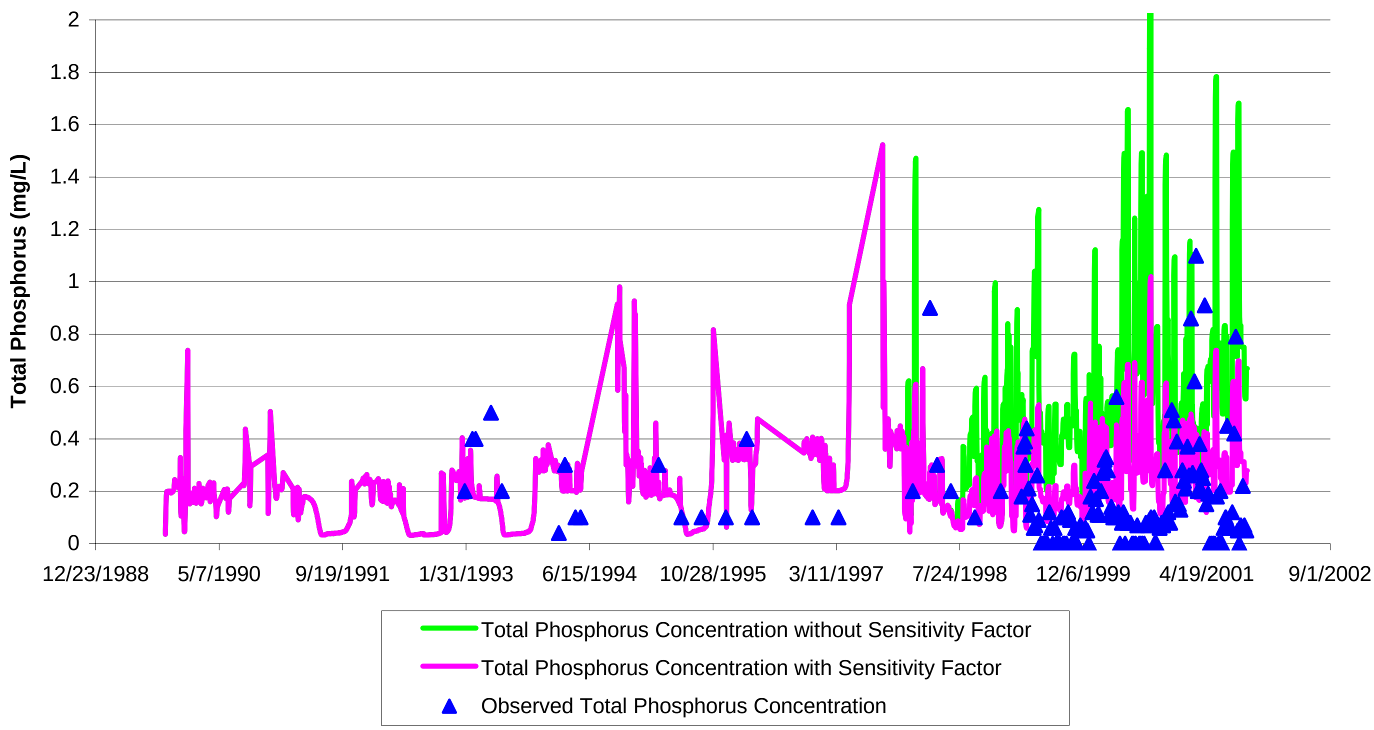
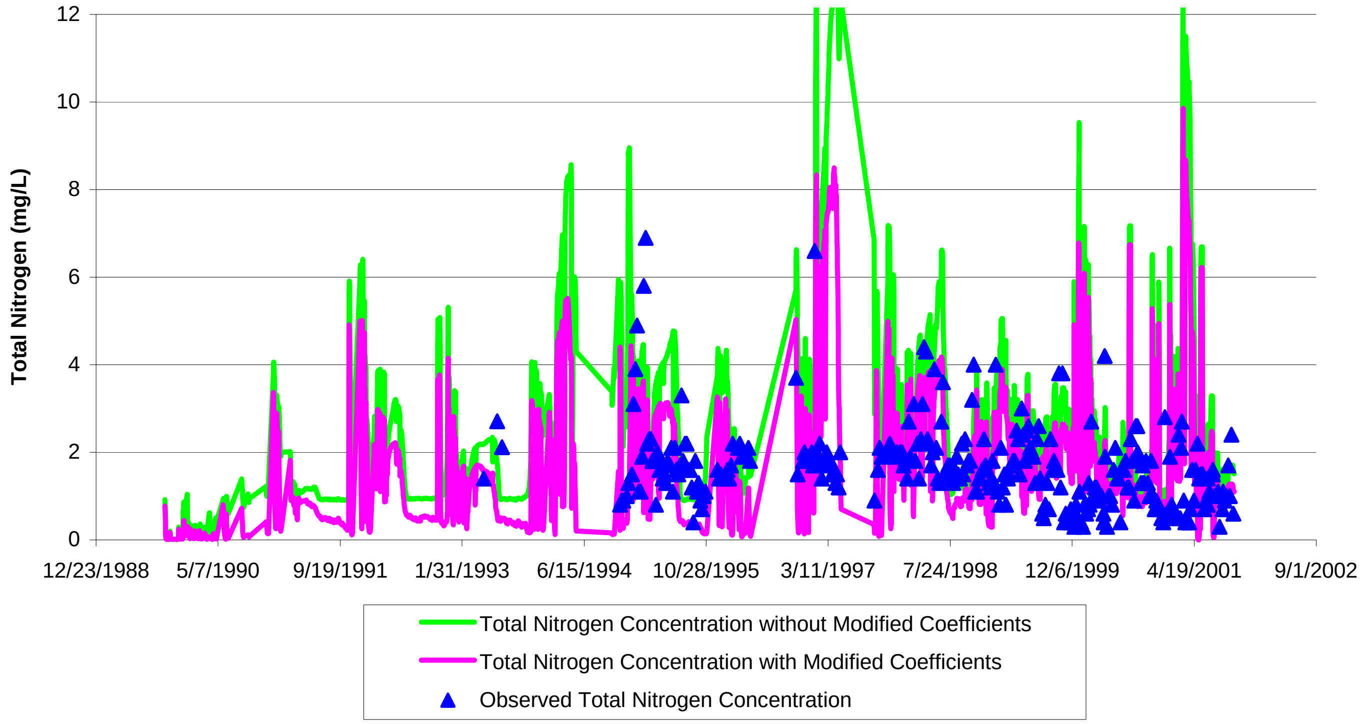


Figure 2-15 Water Quality Calibration Charts for Murrieta Creek

Average Daily Total Nitrogen Concentration (mg/L) versus Observed Total Nitrogen Concentraton (mg/L) for Santa Margarita River near Temecula



Average Daily Total Phosphorus Concentration (mg/L) versus Observed Total Phosphorus Concentraton (mg/L) for Santa Margarita River near Temecula

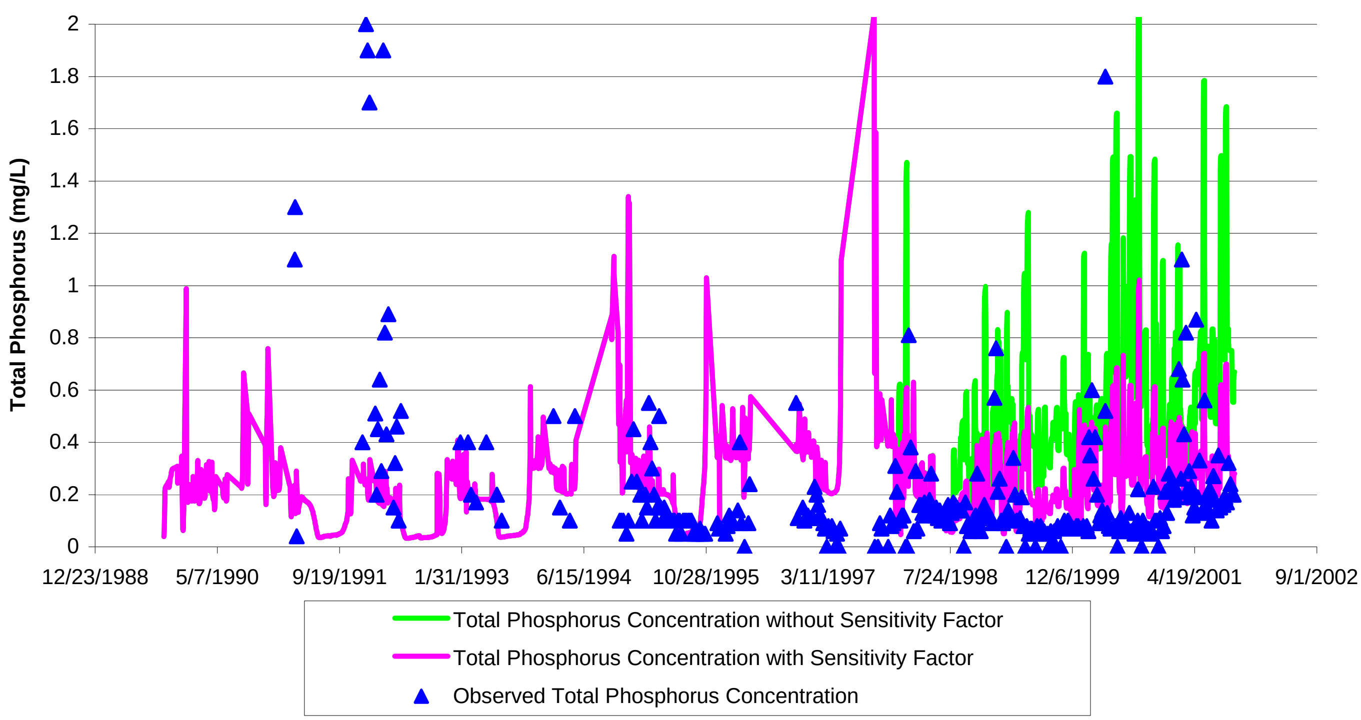
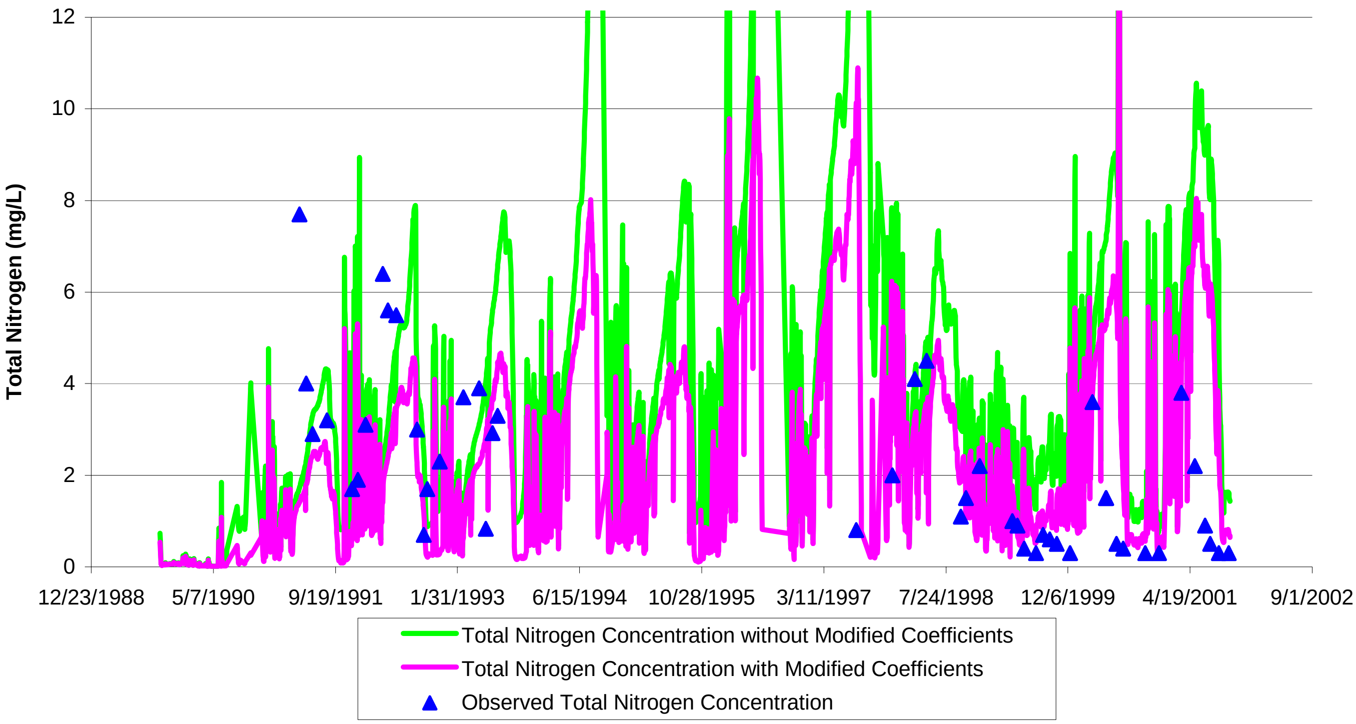


Figure 2-16 Water Quality Calibration Charts for Santa Margarita River near Temecula

Average Daily Total Nitrogen Concentration (mg/L) versus Observed Total Nitrogen Concentraton (mg/L) for Santa Margarita River near De Luz



Average Daily Total Phosphorus Concentration (mg/L) versus Observed Total Phosphorus Concentraton (mg/L) for Santa Margarita River at De Luz

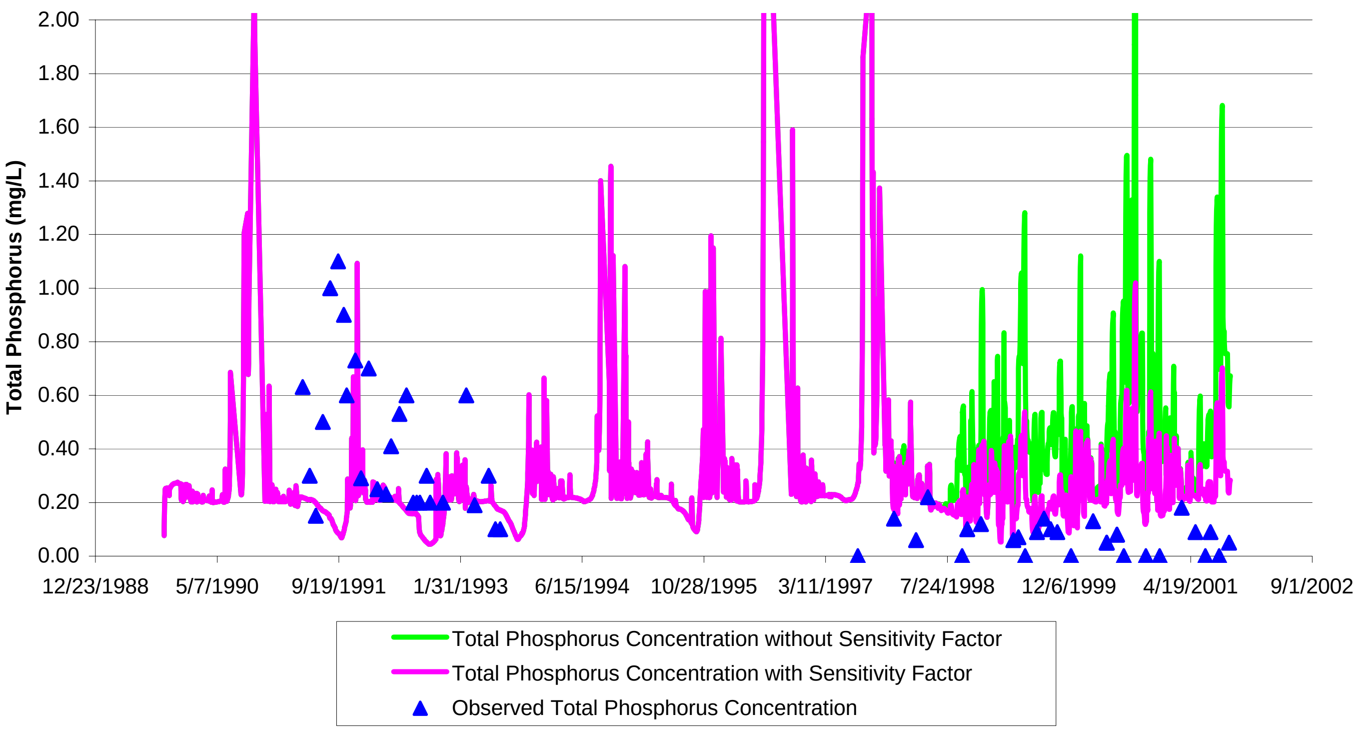


Figure 2-17 Water Quality Calibration Charts for Santa Margarita River near De Luz

Section 3
Santa Margarita River Watershed Model Scenarios

3.1 Scenario Overview

The SMR EMT developed three scenarios for the initial applications of the SMRWM. These preliminary analyses were intended to look at a range of issues and to identify improvements and future applications of the model to address watershed issues. The three scenarios evaluated included:

- Changing land use
- Changes in watershed management due to water rights agreements
- Additions of point source discharges

The purpose of these scenarios was to assess a range of impacts due to changing land use, new water management rules, and the addition of point sources on water quality within the watershed. Impacts were addressed under wet, average, and dry conditions. For this analysis, the watermaster assisted in identifying the appropriate years to use for the preliminary scenario evaluations: 1991 for Wet Year, 1996 for Average Year, and 1987 for Dry Year.

3.2 Impacts of Scenarios on Loadings

This section describes how the scenarios cause changes in the loads of nutrients on the land surface within the subwatersheds. These loadings are later applied to the SMRWM to determine the changes in water quality on the waterways. Not all the loadings directly impact the quality in the waterways due to natural processes.

3.2.1 Land Use Effects

Three temporal periods were modeled: past conditions, current conditions, and future conditions. Land use for past conditions was derived from the EPA Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) model data, which represents land use conditions during the late 1970s/early 1980s. Land use for existing and future conditions was derived from three sources: San Diego County, EMWD, and the BASINS data. Data from San Diego is reflective of 2000 land use and data from EMWD represents 1999 land use. For future conditions, San Diego's and EMWD's data is reflective of year 2020 land use.

To assess how loading has changed over time, average daily total nitrogen and total phosphorus loads were predicted for each major tributary within the watershed based on the temporal condition. These results are presented in Figure 3-1. The loads shown in Figure 3-1 are based on average loads generated from nonpoint sources such as runoff from urban and agricultural areas. The loads do not include any point sources.

Figure 3-1 shows that average daily total phosphorus loads increase slightly over time from past conditions to future conditions. In addition, the phosphorus loads generated above the gorge are about equal to loads generated below the gorge. For total nitrogen loads, Figure 3-1 shows average daily total nitrogen loads were predicted to be larger in the past than during current conditions. However, Figure 3-1 shows that predicted total nitrogen loads for future conditions exceed both past and current conditions. With exception of the current conditions, loads generated above the gorge exceed those generated below the gorge.

Figures 3-2 and 3-3 show the percentage contribution of the average daily total nitrogen and total phosphorus loads by land use type for the past, current, and future conditions. The contributions shown represent the entire watershed as measured at the Santa Margarita River at Basilone Road. The percentage of loadings by each source is shown. For total nitrogen (Figure 3-2), the contribution of nutrient loading from agriculture land uses decreases from past to future conditions and nutrient loading from urban sources increases from past to future conditions. The percent contribution of the total nitrogen load by residential areas was predicted to increase significantly based on projected future conditions within the watershed. A similar trend is shown for the percentages of total phosphorus contribution (Figure 3-3). However, agriculture remains a larger percent of the loading because less phosphorus is typically applied to urban areas than to agricultural areas (Henry et al. 2002). In general, the phosphorus loadings increase from past to future conditions.

3.2.2 Water Management Effects

Water management effects were evaluated by consideration of revised operations of Skinner Reservoir and required guaranteed flows on the Santa Margarita River near Temecula (the gorge). On May 1st of each year the rainfall amounts (October through April) at a designated gage in the watershed is assessed to establish what the guaranteed flows at the gorge shall be for a given year. The year is then classified as critically dry, below normal, above normal, and very wet, and monthly guaranteed flows are set accordingly. Note that the water management scenarios are added to the land use scenarios.

Water quality for these two water management operations was derived from Metropolitan Water District (MWD) data. For guaranteed flows that were derived from imported water, the water quality applied in the model was a total nitrogen concentration of 1 mg/L and a total phosphorus concentration of 0.03 mg/L.

The assessment of contribution of total nitrogen and total phosphorus loads from the guaranteed flow at the gorge are shown in Figures 3-4 and 3-5. Figure 3-4 shows percentage contribution of the total load from different land uses and the gorge flows. The gorge contributes a larger percentage of the total nitrogen load than it contributes to the percentage of the total phosphorus load. This result is not surprising as the MWD data used to represent the quality for gorge discharge was higher in nitrogen concentration than phosphorus concentration.

The water management scenario does not significantly increase the total loadings. Nitrogen increases by about 2.5 percent and phosphorus increases by less than 1 percent.

3.2.3 Point Source Effects

Point source effects were modeled by an addition of reclaimed water into Murrieta Creek with the following quantity and quality:

- Quantity of 16 mgd and 8 mgd
- Total phosphorus effluent concentration of 4 mg/L and 1 mg/L
- Total nitrogen effluent concentration of 10 mg/L and 1 mg/L

For this discharge scenario, the future land use scenario was applied but water management changes were not included. This approach allowed a focused look at the point source impacts. Also, the assumption was made that there could be a tradeoff between using imported water and recycled water for meeting water rights needs.

The effects on loadings of inclusion of recycled water into the watershed are shown in Figures 3-6 and 3-7. Figure 3-6 shows the relative contribution of loads for nitrogen resulting from two discharges (8 mgd and 16 mgd) and two qualities of discharge (total nitrogen concentration of 10 mg/L and 5 mg/L.) Figure 3-7 shows the relative contribution of loads for phosphorus resulting from two discharges (8 mgd and 16 mgd) and two qualities of discharge (total phosphorus concentration of 4 mg/L and 1 mg/L). The figures represent the loadings under average hydrologic conditions.

For the recycled water discharge with higher total nitrogen and total phosphorus concentrations, the load from the recycled water discharge comprises the majority of the relative contribution of the total phosphorus and total nitrogen load. For the recycled water discharge with lower total nitrogen and total phosphorus concentrations, the load from the recycled water discharge amounts to one-half or less of the relative contribution of the total phosphorus and total nitrogen load.

3.3 Impacts of Scenarios on Instream Water Quality

Instream water quality total nitrogen and total phosphorus concentrations were estimated using the SMRWM for the scenarios and loadings discussed above. The resulting instream concentrations are shown in Figures 3-8 (nitrogen) and 3-9 (phosphorus). On each figure, the top graphic shows the concentrations using the conservative calibration factors for addressing apparent instream reductions of nitrogen and phosphorus that occur under effluent dominated conditions as discussed in Section 2.3.3 "Water Calibration Results." The bottom graphic shows the instream concentrations if the calibration corrections are not included. The resulting concentrations, calculated at Basilone Road, are the results of averaging 3 years of data representing dry, average, and wet conditions in the watershed. The following scenarios are displayed on Figures 3-8 and 3-9 from left to right:

- Past conditions (Scenario 1)
- Current conditions with guaranteed flow at gorge (Scenario 2)
- Future conditions with guaranteed flow at gorge (Scenario 2)
- Future conditions with recycled water: 8 mgd at total nitrogen concentration of 10 mg/L and total phosphorus concentration of 4 mg/L (Scenario 3)
- Future conditions with recycled water: 8 mgd at total nitrogen concentration of 5 mg/L and total phosphorus concentration of 1 mg/L (Scenario 3)
- Future conditions with recycled water: 16 mgd at total nitrogen concentration of 10 mg/L and total phosphorus concentration of 4 mg/L (Scenario 3)
- Future conditions with recycled water: 16 mgd at total nitrogen concentration of 5 mg/L and total phosphorus concentration of 1 mg/L) (Scenario 3)

All scenarios resulted in nitrogen concentrations that exceeded the current water quality standard in the watershed of 1.0 mg/L. Current conditions with discharges at the gorge resulted in slightly lower concentrations than past conditions and the future illustrated some increase. The impacts of recycled water discharges varied with flow rate and concentrations. Predicted concentrations of total nitrogen resulting from a recycled water concentration of 5 mg/L total nitrogen are slightly higher than concentrations predicted from nonpoint source loads only (past conditions). There appears to be a significant change in impacts going from nitrogen concentrations of 5 mg/L to 10 mg/L. Increase in discharge rate from 8 mgd to 16 mgd did not exhibit a large change in impacts.

Similar to nitrogen, all scenarios resulted in an average concentration (Figure 3-8) that exceeds the current total phosphorus water quality standard in the watershed of 0.1 mg/L. For example, concentrations range from 1.3 mg/L under future land use with discharges at the gorge to 2.6 mg/L for Scenario 3 with 8 mgd of recycled water with a total phosphorus concentration of 4 mg/L. Average predicted concentrations with recycled water with total phosphorus concentrations of 1 mg/L are only slightly higher than the past, current, and future scenarios.

3.4 Santa Margarita River Watershed Model Data Gaps

Although the purpose of Phase 3A of the Santa Margarita Watershed Supply Augmentation, Water Quality Protection, and Environmental Enhancement Program to develop a preliminary model for determining the assimilative capacity of the Santa Margarita River has been achieved, by addressing the following data gaps, the SMRWM will be able to further the goals of the SMR EMT. Current data gaps include:

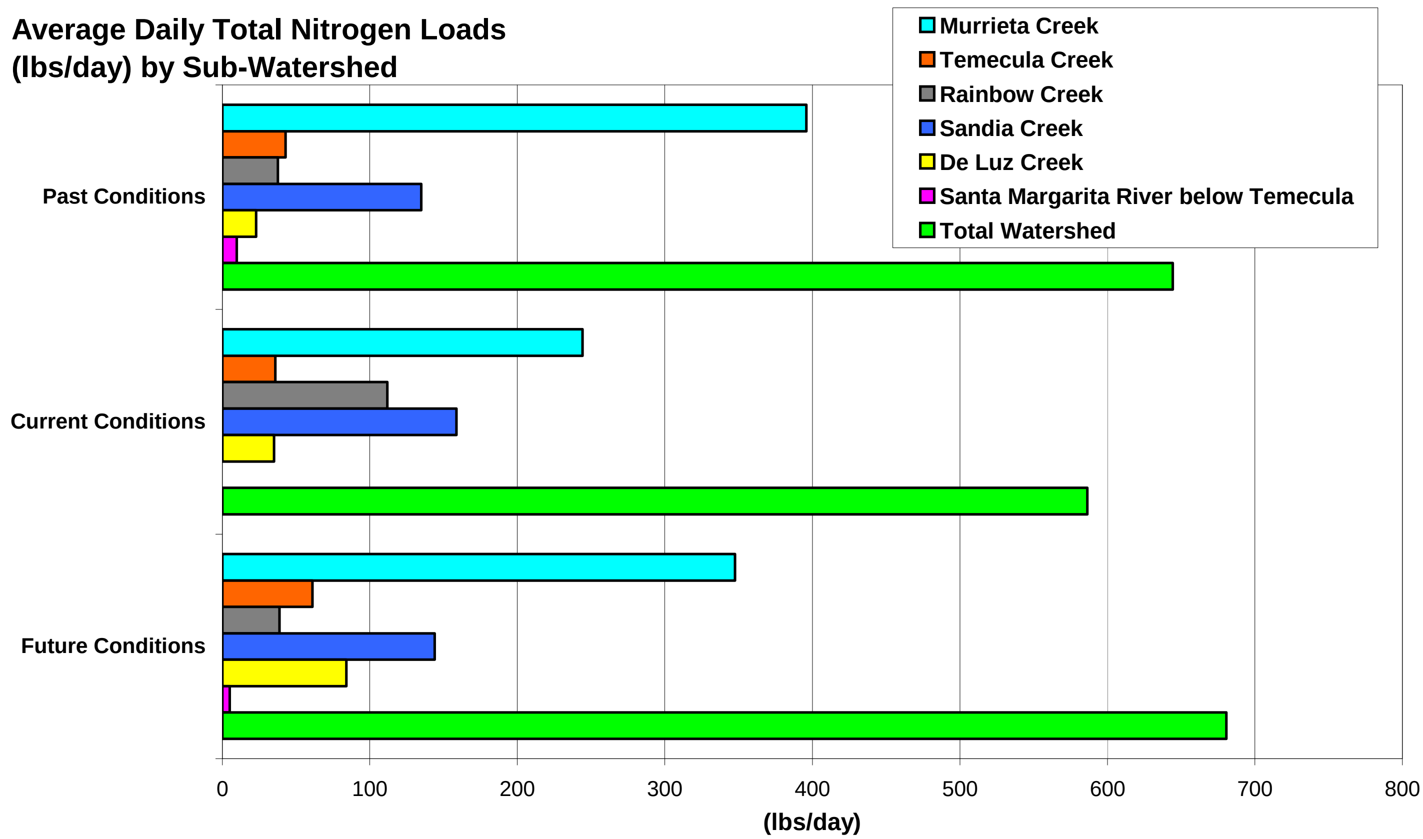
- Lack of current and future land use data for entire watershed
- Model methodology to assess impacts of dry weather flows
- Lesser amount of water quality data near the estuary in comparison to the data available near Temecula
- Inclusion of the periphyton module to address observed phosphorus assimilation

The portions of the watershed missing recent land use information are western and eastern portions of Riverside County. Because Vail Lake collects runoff from the eastern part of the watershed and historically has rarely discharged to the Santa Margarita River, this gap in land use is not as critical as other areas at this time. Future land use for Riverside County is available as part of the Riverside Integrated Resource Plan but it is in draft form and not available electronically. As more recent electronic data for the entire watershed becomes available, it can be incorporated into the SMRWM.

As explained in Section 2 "Santa Margarita River Watershed Model Calibration," during low flows within the watershed, the SMRWM under predicts flow when compared to observed historical flow. Inclusion of a dry weather run-off module or modifying the SMRWM to include runoff from irrigation in urban areas should eliminate this condition.

The quantity of water quality data is greater in upstream portions of the watershed than in the downstream portions near the estuary. While the amount of data is sufficient for this preliminary effort, as the SMR EMT begins to assess how to utilize the SMRWM to address TMDL development within the watershed, more specific data collection in specific areas of the watershed may be needed. There is data in at least one location on each of the major tributaries within the watershed, but if the model is to be used for just one tributary within the watershed, more spatial data within the single tributary may be necessary for a more refined calibration of the SMRWM in the areas of concern.

As discussed in Section 2 "Santa Margarita River Watershed Model Calibration," the periphyton module in the SMRWM is not currently utilized because more site-specific data is needed for inclusion of this module. As TMDLs addressing phosphorus begin to be developed within the watershed, it will be important to collect the data necessary to utilize this module so that assimilation of phosphorus within the watershed is included.



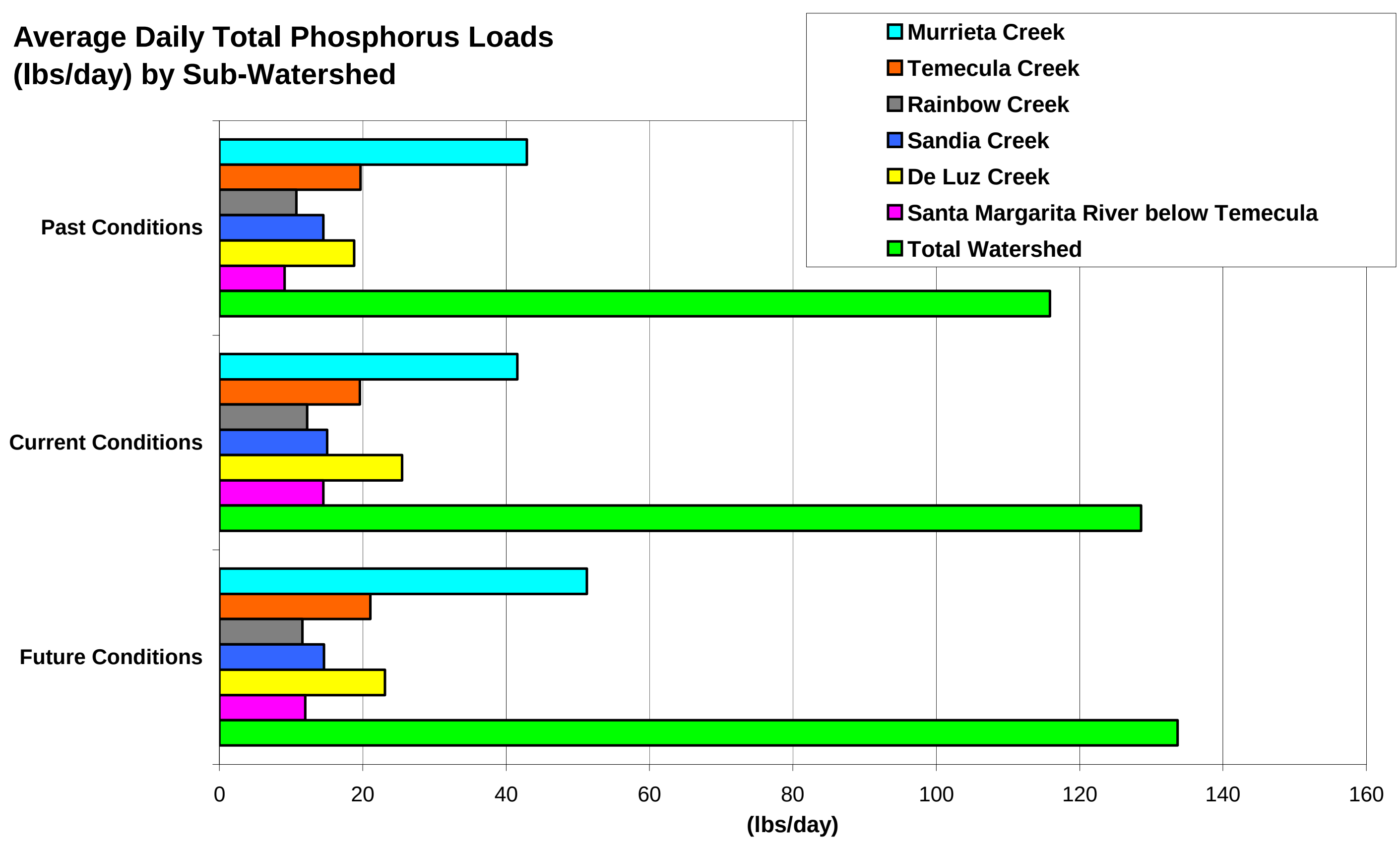


Figure 3-1 Total Phosphorus and Total Nitrogen Loads by Sub-Watershed

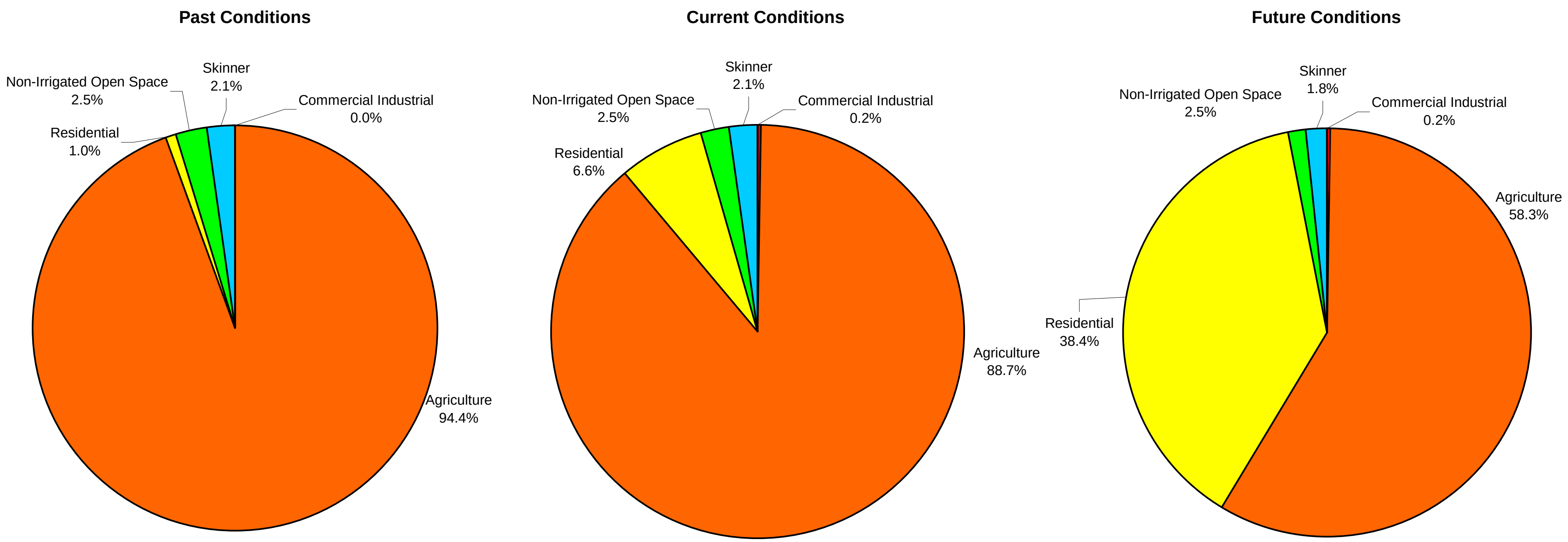


Figure 3-2 Santa Margarita Watershed Percentage of Total Nitrogen Load Contribution by Land Use Type at Basilone Road

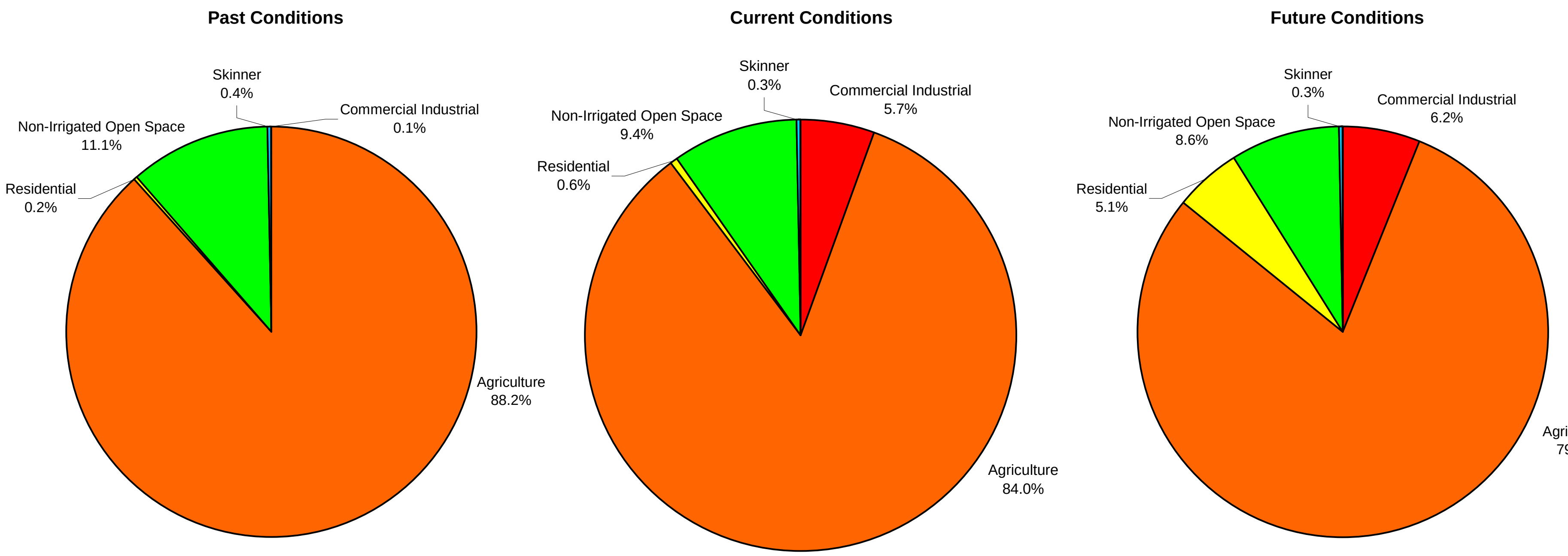
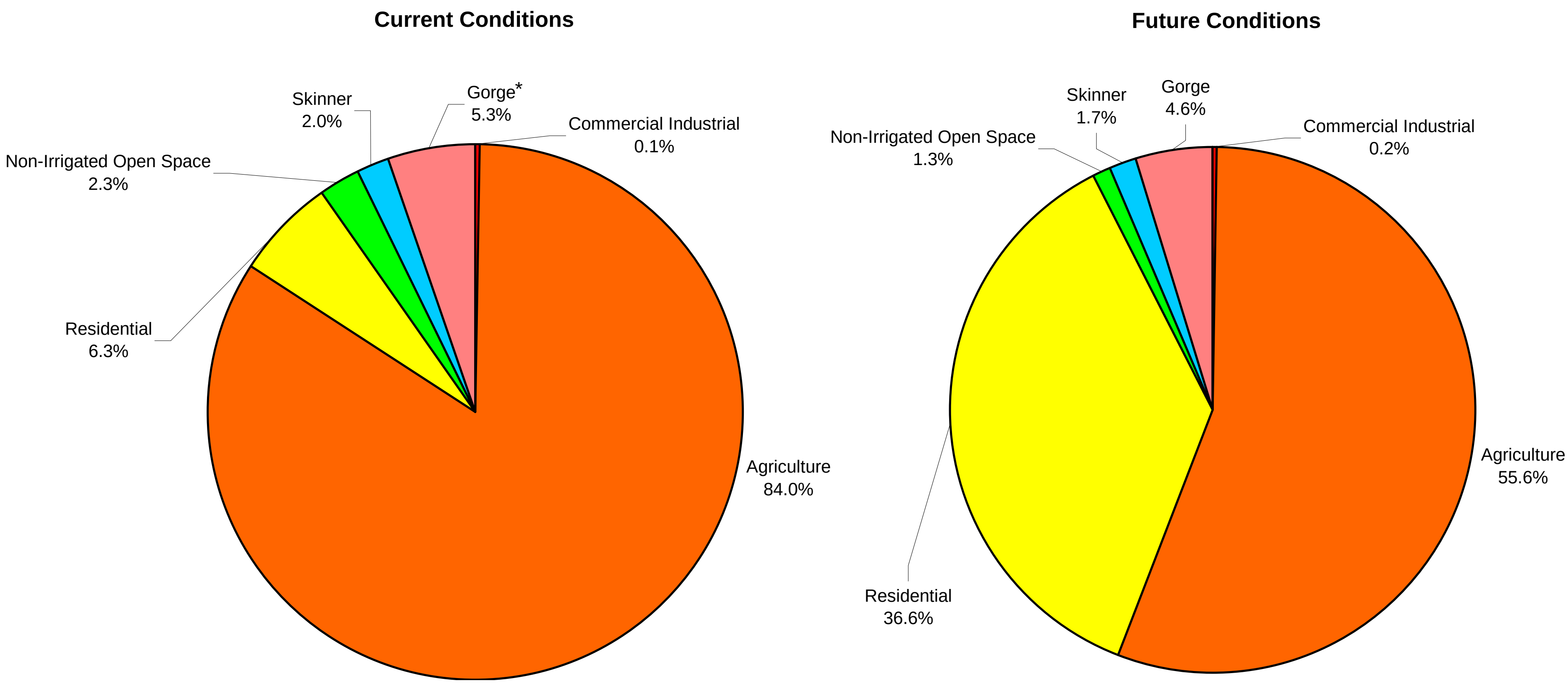


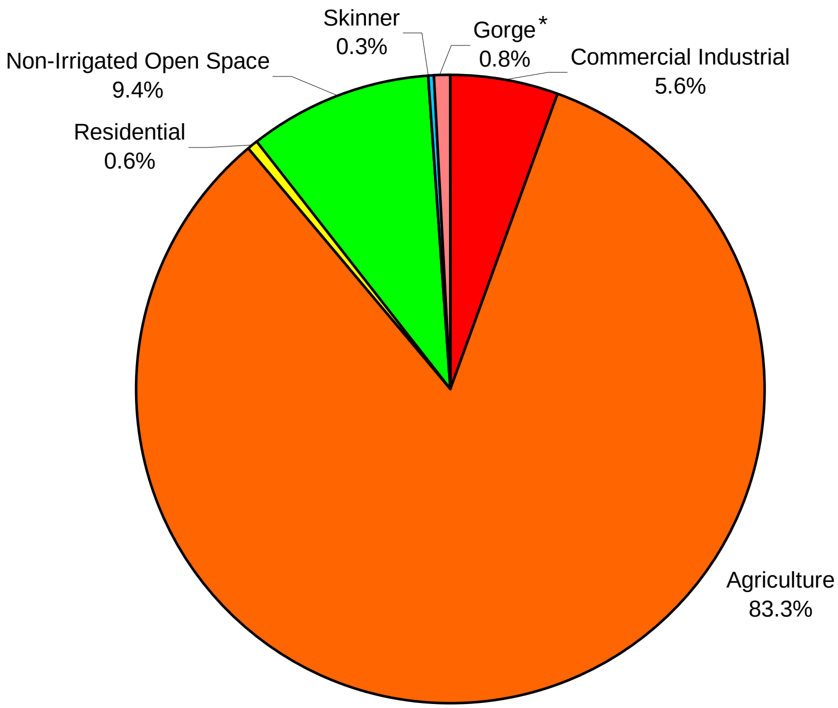
Figure 3-3 Santa Margarita Watershed Percentage of Total Phosphorus Load Contribution by Land Use Type at Basilone Road



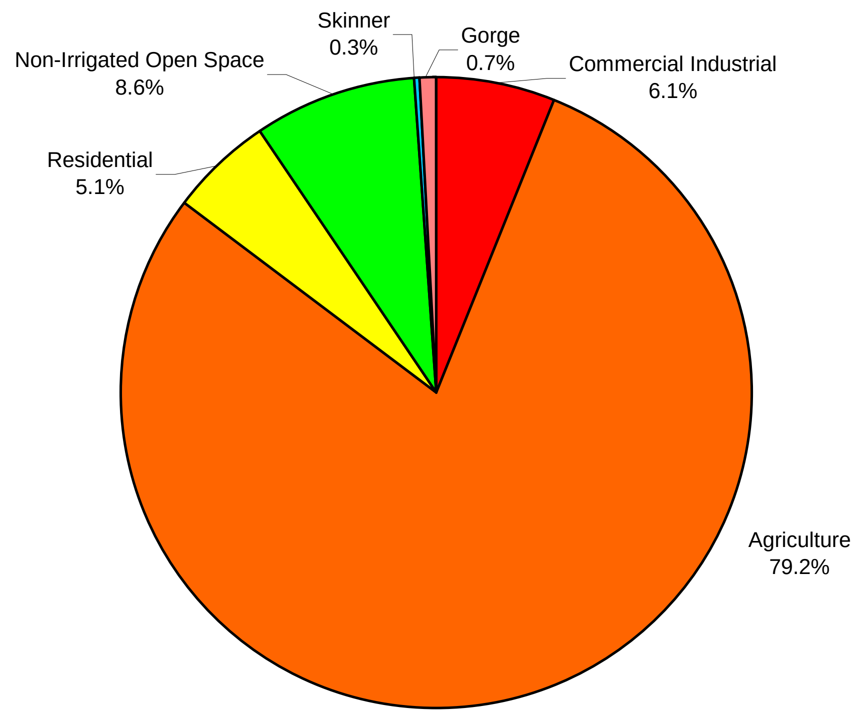
*Gorge flow is comprised of MWD water.

Figure 3-4 Santa Margarita Watershed with Guaranteed Flow at Gorge
Percentage of Total Nitrogen Load Contribution by Land Use Type at Basilone Road

Current Conditions



Future Conditions



*Gorge flow is comprised of MWD water.

Figure 3-5 Santa Margarita Watershed with Guaranteed Flow at Gorge
Percentage of Total Phosphorus Load Contribution by Land Use Type at Basilone Road

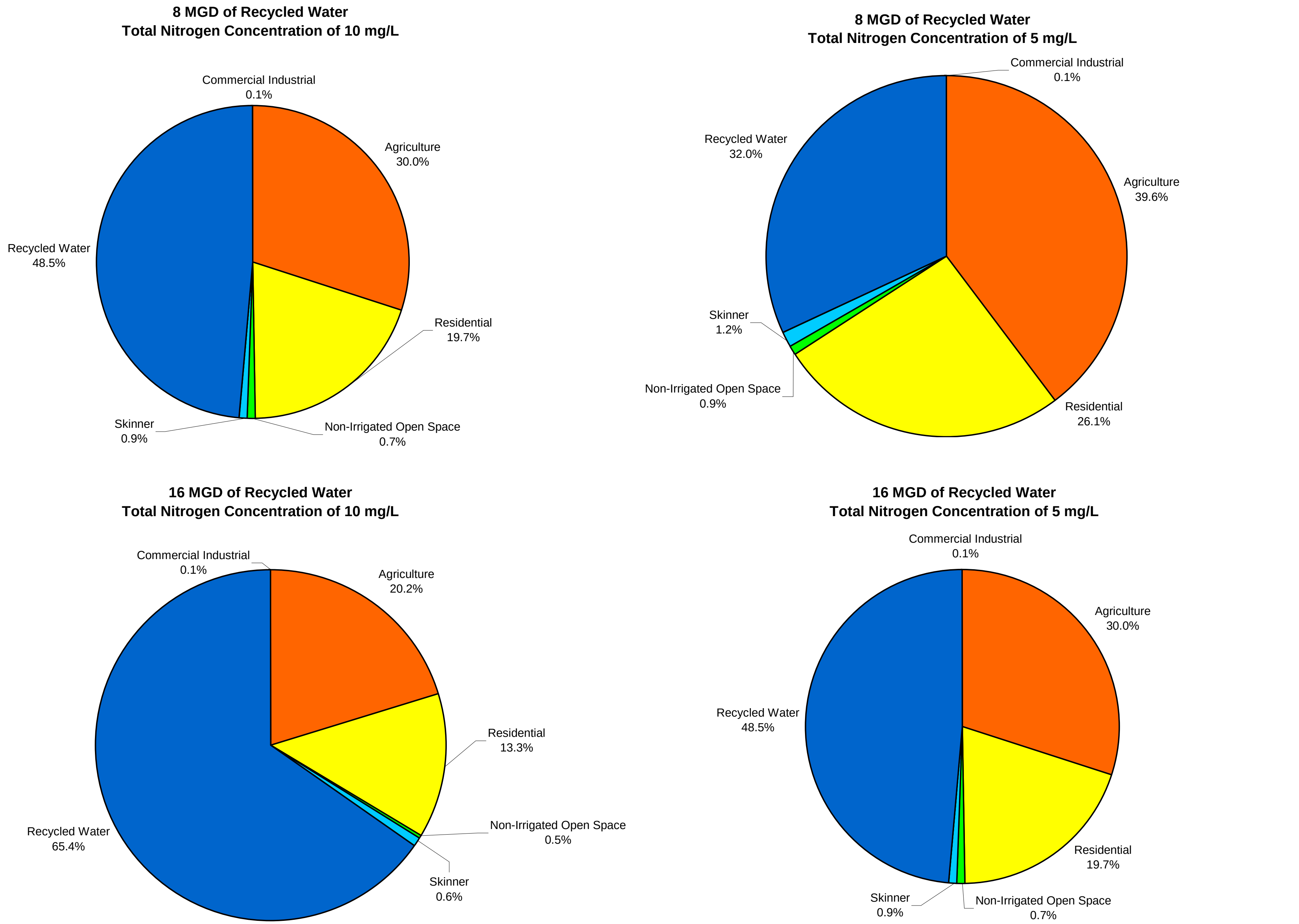


Figure 3-6 Santa Margarita Watershed with Recycled Water-Future Conditions
Percentage of Total Nitrogen Load Contribution by Land Use Type at Basilone Road

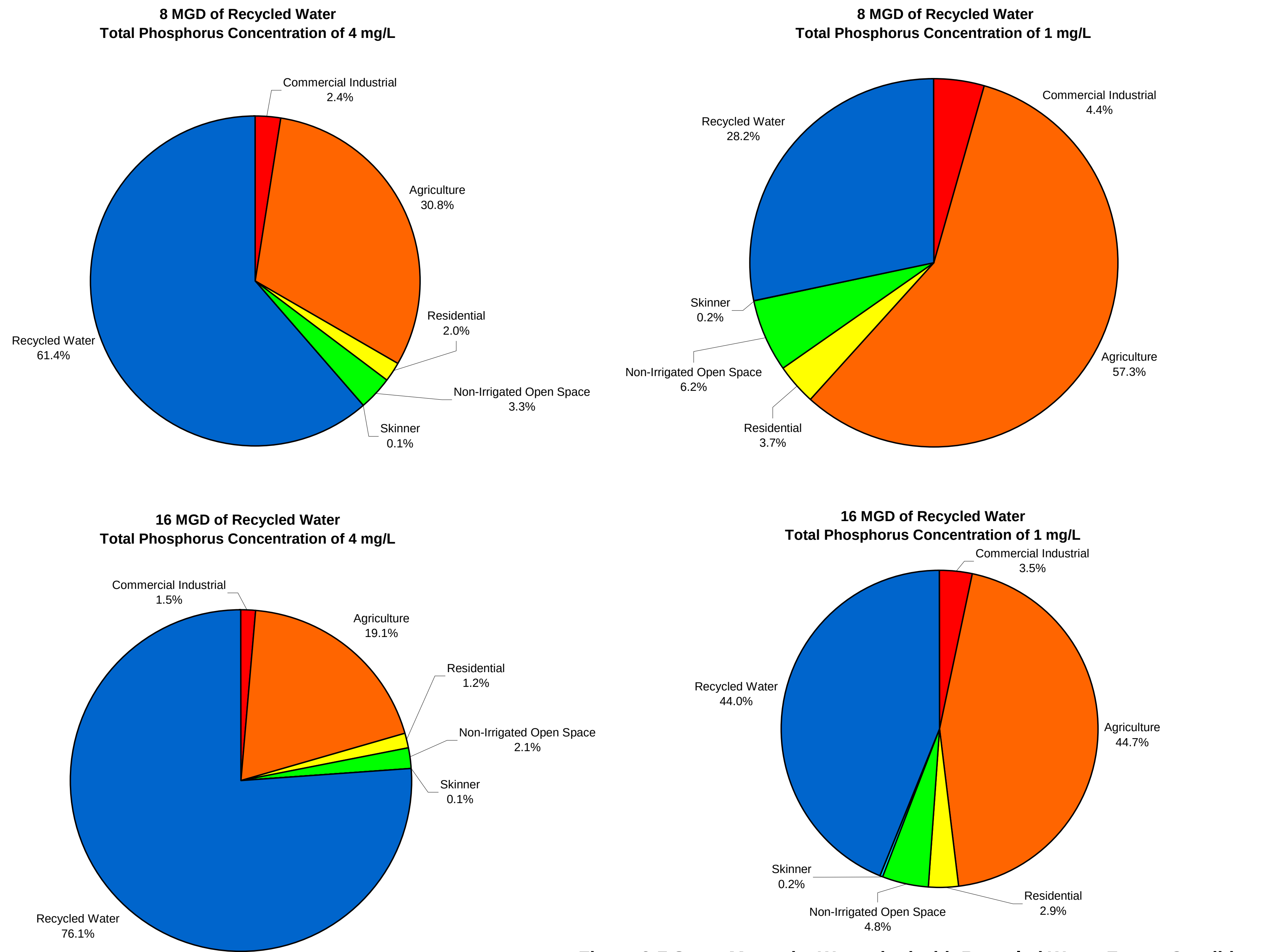
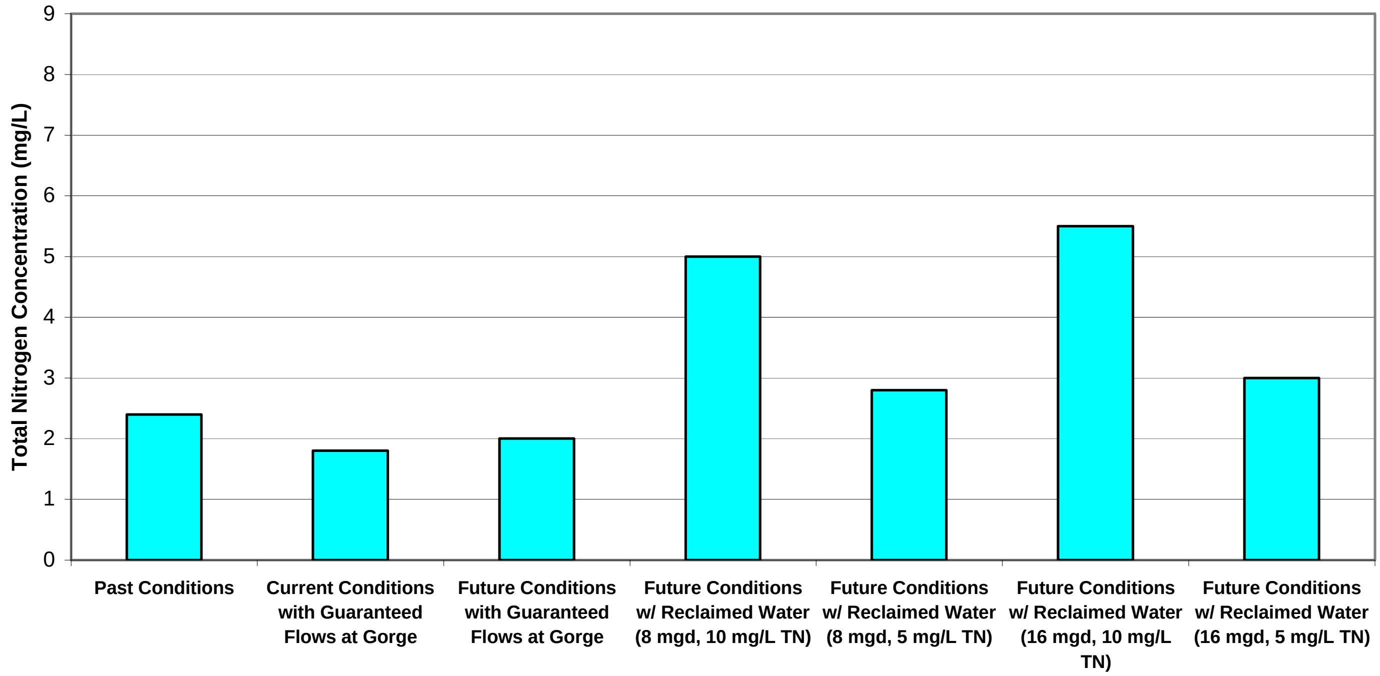


Figure 3-7 Santa Margarita Watershed with Recycled Water-Future Conditions
Percentage of Total Phosphorus Load Contribution by Land Use Type at Basilone Road

Average In-Stream Total Nitrogen Concentrations at Basilone Road with Modified Coefficients



Average In-Stream Total Nitrogen Concentrations at Basilone Road without Modified Coefficients

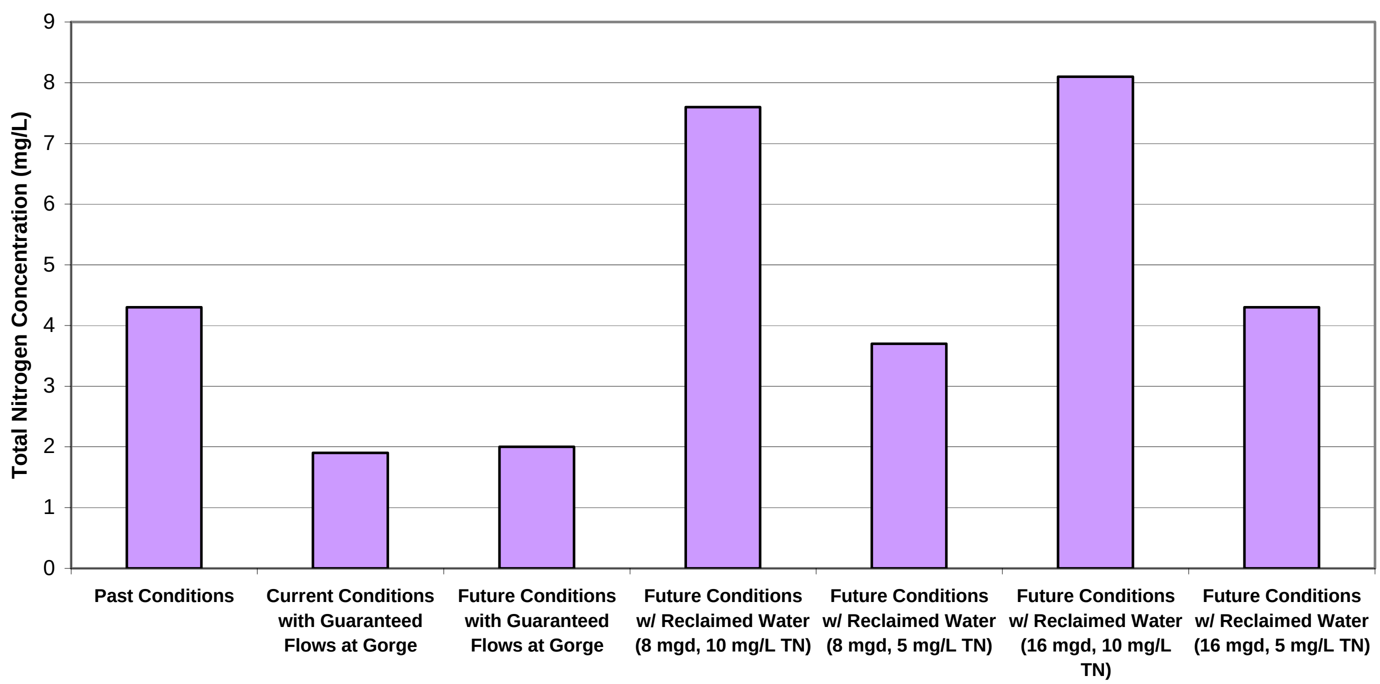
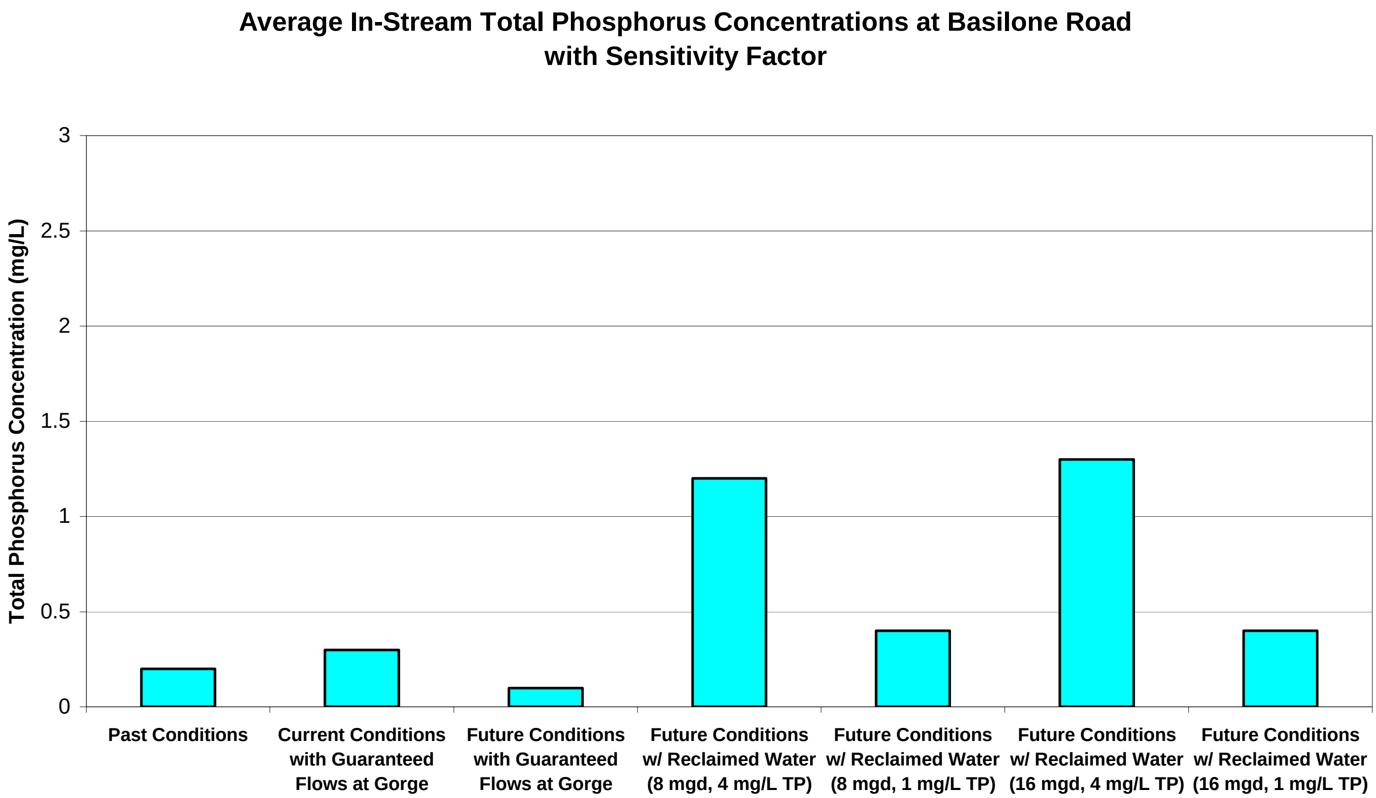


Figure 3-8 Resulting In-Stream Total Nitrogen Water Quality for Scenarios



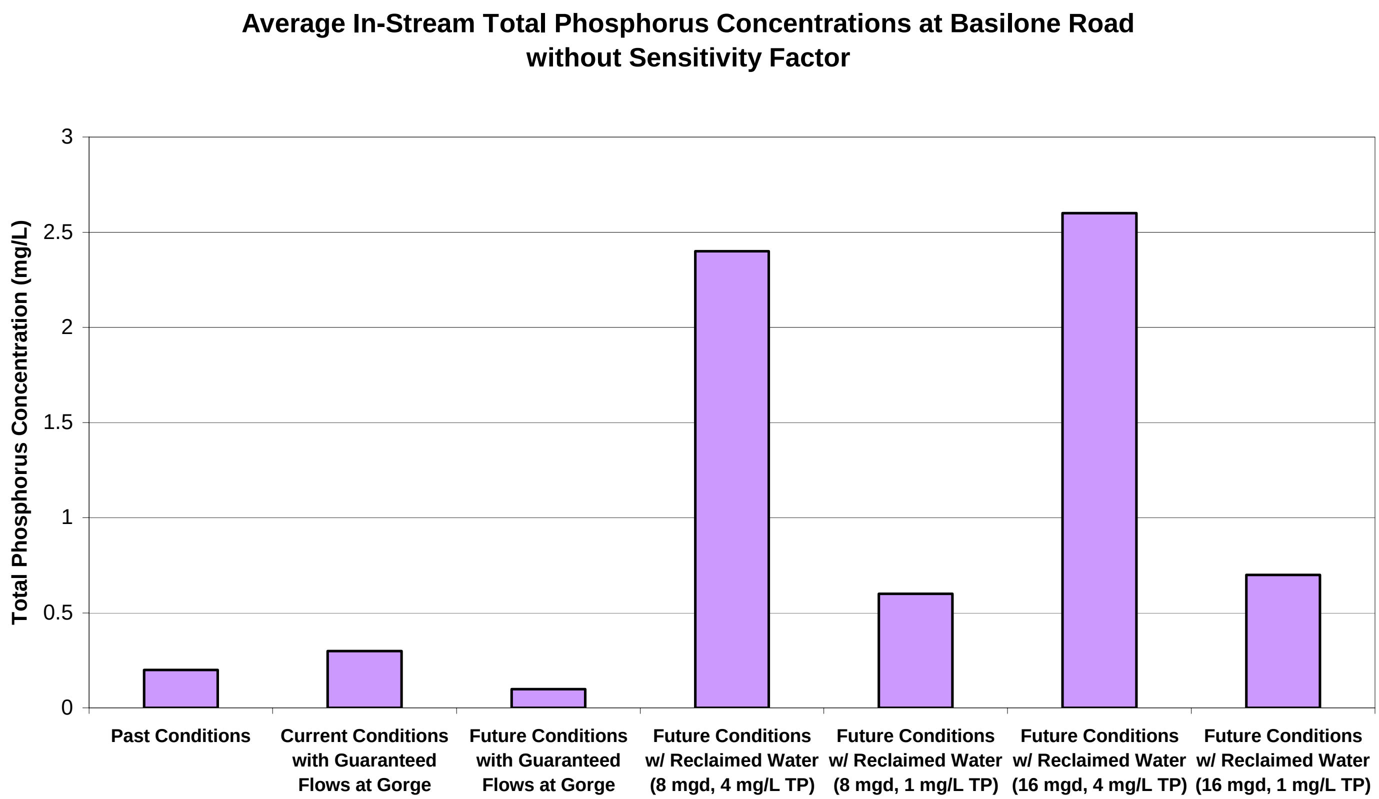


Figure 3-9 Resulting In-Stream Total Phosphorus Water Quality for Scenarios

Section 4 References

Henry, J.M. et al. 2002. Publication 8065 Practical Lawn Fertilization. University of California, Division of Agriculture and Natural Resources. Oakland, California.

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