San Jacinto Nutrient Management Plan

FINAL REPORT

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Santa Ana Watershed Project Authority
Santa Ana Regional Water Quality Control Board
San Jacinto River Watershed Council
Santa Ana Watershed Association of Resource Conservation Districts

Advisory Group of the Lake Elsinore and San Jacinto Watershed Authority

The process for developing an effective Nutrient Management Plan involved the cooperation and utilization of all stakeholders within the watershed. To best achieve input from all aspects relevant to the watershed, an Advisory Group of the Lake Elsinore and Canyon Lake Watershed Authority was developed. This group met monthly to provide input and guidance to the direction of the Nutrient Management Plan. The project team would like to acknowledge the following participants of the Advisory Group:

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Executive Summary

In 1998, the Santa Ana Regional Water Quality Control Board (RWQCB) included Lake Elsinore and Canyon Lake as impaired waterbodies on its Clean Water Act Section 303 (d) list for excessive levels of nutrients in both lakes, low DO in Lake Elsinore, high bacteria in Canyon Lake, and unknown sources of toxicity in Lake Elsinore. In response to this Section 303 (d) listing, the Clean Water Act and California's Nonpoint Source Pollution Control Plan requires that total maximum daily loads (TMDLs) be established for these waterbodies. The RWQCB, in cooperation with various stakeholders in the watershed, has been developing nutrient TMDL's for Canyon Lake and Lake Elsinore. To support this initiative, the Santa Ana Watershed Project Authority (SAWPA) coordinated the Lake Elsinore and Canyon Lake Nutrient Source Assessment (Tetra Tech, Inc., 2003) in cooperation with the RWQCB and the Lake Elsinore and San Jacinto Watershed Authority (LESJWA). Results of the Nutrient Source Assessment, TMDL study, and other efforts have provided a sound basis and a good opportunity to develop an overall Nutrient Management Plan for the San Jacinto River watershed.

The development of a watershed strategy for nutrient management was a multi-step process that required assessment of previous studies, input from stakeholders, and modeling analysis. The San Jacinto Nutrient Management Plan was developed using information and modeling tools utilized for TMDL development. Therefore, the recommended strategy is consistent with future goals for the watershed. To guide the decision process for strategy development, an Advisory Group, a subcommittee of the San Jacinto River Watershed Council consisting of key stakeholders in the watershed, was consulted on a regular basis for input and updates on the progress of the project. Utilization of previous modeling tools and studies, combined with consultation with local experts and stakeholders for guidance, resulted in the development of a strategy based on the best and most complete information available so that solutions to nutrient impairments in the watershed are scientifically sound and justified.

The San Jacinto Nutrient Management Plan provides a guidance document or roadmap for nutrient management strategy in the watershed. The report discusses key issues regarding watershed characteristics and waterbody impairments, and provides a comprehensive pollutant source assessment with identification and recommendation of projects to reduce those source contributions and improve the water quality in the watershed. Section 1 and 2 of the report provide an overview of background studies, a list of project objectives, an overview of the process for development of the Nutrient Management Plan, and a comprehensive summary of watershed characteristics. Section 3 reviews the pollutant source assessment and outlines sources of nutrients in the watershed, sources of nutrients in the lakes, and the status of the Bacteria Source Assessment. Section 4 outlines strategy development for nutrient management in the watershed, and outlines *planned* and *recommended* projects for watershed improvement. Planned projects are those projects already identified and funded to reduce nutrient loads to Lake Elsinore or Canyon Lake. Recommended projects are those projects that require additional study or data for quantifying or refining estimates of source loads or to provide guidance for future management decisions. The final list of projects provides a comprehensive plan addressing a holistic watershed-based approach for managing nutrients by implementing specific BMPs or providing information needed to guide decision-makers in policy development and future project planning. To summarize the relative benefits of each projected included in this report, Section 5 provides an overall review of benefits and issues addressed by each project, and concludes the Nutrient Management Plan with recommendations and considerations for project implementation.

To guide the process of project identification to address multiple nutrient sources and processes in the watershed, projects were categorized and identified specific to Lake Elsinore, Canyon Lake, and sources of nutrients in the watershed. For each category, specific projects were identified to:

- Provide the information necessary for better management of nutrients in the watershed;
- Implement BMP's to reduce nutrient loads from key sources; and
- Implement BMP's to improve water quality in Lake Elsinore and Canyon Lake.

The San Jacinto Nutrient Management Plan consists of nineteen projects. These include two currently planned projects for Lake Elsinore, and two planned projects for Canyon Lake. Table 1 provides a list of planned projects and benefits expected as a result of their implementation. These benefits include: pollutant load control, habitat protection, aesthetic value, lake water quality, lake water quantity, and consistency with TMDL implementation using best management practices (BMPs) to control nutrient loading or improve the assimilative capacity in the lakes.

Table 1. Planned Projects Included in the Nutrient Management Plan

Project No.	Project Name	Pollutant Load Control	Habitat Protection	Aesthetic Value	Lake Water Quality	Lake Water Quantity	Addresses TMDL Implementation & BMPs
1	Lake Elsinore In-Lake Nutrient Treatment	X	X	X	X	X	
2	Lake Elsinore Aeration	X	X	X	X		X
3	Canyon Lake Aeration/ Destratification	X	X	X	X		X
4	Canyon Lake Dredging	X	X	X	X	X	X

Fifteen projects are identified and recommended in the Nutrient Management Plan to address a wide range of issues in the watershed specific to nutrient loading characteristics in the lakes and various sources in the watershed. These are either unique recommendations or are projects that have been identified but have not received full funding as of February 2004. Table 2 provides a list of recommended projects and expected benefits. Many of the recommended projects in Table 2 can result in data collection or studies that provide additional information to potentially justify the re-open and revision of TMDLs in the future, and thus include an additional benefit labeled "Addresses TMDL Development."

Table 2. Recommended Projects in the Nutrient Management Plan

Project No.	Project Name	Pollutant Load Control	Habitat Protection	Aesthetic Value	Lake Water Quality	Lake Water Quantity	Addresses TMDL Development	Addresses TMDL Implementation & BMPs
5	Lake Elsinore Water Quality Monitoring				X	X	X	X
6	Development of a Dynamic Water Quality Model of Lake Elsinore				X	X	X	X
7	Canyon Lake Water Quality Monitoring				X	X	X	X
8	Development of a Dynamic Water Quality Model of Canyon Lake				X	X	X	X
9	Structural Urban BMPs	X			X			X
10	Sewer and Septic Improvements	X			X			X
11	Control of Trash in Stream Channels	X	X	X	X			
12	Interception and Treatment of Nuisance Urban Runoff	X			X			X
13	Riparian Habitat Restoration and Development of Agricultural Buffers	X	X	X	X			X
14	Determination of Crop-Specific Agronomic Rates for Guidance in Fertilizer and Manure Application Management	X			X		X	X
15	Assessment of Nutrient Loads to the San Jacinto Watershed as a Result of Flooding in Agricultural Areas	X			X		X	X
16	Regional Organic Waste Digester	X			X			X
17	Development of a Pollutant Trading Model							X
18	Data Collection for Mystic Lake to Support Development of Future Projects		X		X		X	
19	Continued Monitoring of Streamflow and Water Quality Throughout the Watershed				X		X	X

For each of the benefits listed for planned and recommended projects listed in Tables 1 and 2, the Nutrient Management Plan provides detailed discussion and comprehensive information for future project planning, funding, and implementation. This information is presented in easy-to-use matrices for relative project comparison to assist LESJWA, SAWPA, and the RWQCB in project prioritization and selection.

The Bacteria Source Assessment, which is being developed as a supplement to the Nutrient Source Assessment, is not yet complete and requires additional data collection, model development, and study. Following completion of the Bacteria Source Assessment, a Bacteria Management Plan can be developed. However, implementation of specific projects recommended in the Nutrient Management Plan will also potentially address bacteria issues, which would require validation through completion of the Bacteria Source Assessment. Once guidance is provided through completion of the Bacteria Source Assessment and bacteria TMDL development for Canyon Lake, information will be available to determine a strategy for reduction of bacteria loads in the watershed to improve water quality of Canyon Lake.

Ultimately, a San Jacinto Watershed Management Plan will be developed which capitalizes on findings of these separate pollutant management plans and provides LESJWA, SAWPA, and the RWQCB a roadmap for improvement of water quality and health of Lake Elsinore, Canyon Lake, and the San Jacinto River and tributaries. A comprehensive and holistic Watershed Management Plan will require cooperation with other planning agencies in the watershed and consistency with all project plans ensuring a comprehensive management strategy for the watershed and a unified approach for future project planning, funding, and implementation.

Acronyms

AF	acre-feet
BMPs	best management practices
CWA	Clean Water Act
DFG	Department of Fish and Game
DOE	Department of Energy
EFDC	Environmental Fluid Dynamics Code
EMWD	Eastern Municipal Water District
ENT	enterococcus
EVMWD	Elsinore Valley Municipal Water District
FC	fecal coliform
IWP	Integrated Watershed Plan
LESJWA	Lake Elsinore San Jacinto Watershed Authority
LSPC	Loading Simulation Program C++
MSHCP	Multi-Species Habitat Conservation Plan
NMP	Nutrient Management Plan
NPS	nonpoint source
RCD	Resource Conservation District
RCFC&WCD	Riverside County Flood Control & Water Conservation District
RWQCB	Santa Ana Regional Water Quality Control Board
SAWPA	Santa Ana Watershed Project Authority
SJRWC	San Jacinto River Watershed Council
SWRCB	State Water Resources Control Board

TC	total coliform
TMDL	Total Maximum Daily Loads
TN	total nitrogen
TP	total phosphorous
TDS	total dissolved solids
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
EPA	United States Environmental Protection Agency
WY	water years

Glossary

303(d) list - A list prepared by each state to identify waters that do not or are not expected to meet applicable water quality standards with technology-based controls alone.

atmospheric deposition -The accretion of chemicals including nitrogen and phosphorous attached to dust materials during dry weather or as part of raindrops during wet weather, which deposit onto the land or water surfaces from the air.

BATHTUB - A steady-state euthrophication model specifically designed for lakes and uses empirical relationships for prediction of water quality conditions including total phosphorous, total nitrogen, chlorophyll *a,* transparency, organic nitrogen, nonortho-phosphorous, and hypolimnetic oxygen deletion rate (Walker 1996).

beneficial uses -Uses of water identified in the state and regional water quality control plans that must be achieved and maintained. Designated uses, together with water quality objectives, form water quality standards as mandated under the California Water code and Federal Clean Water Act. There are 24 beneficial use designations in California.

benthos - Plants and animals that live in or near the lake bottom.

best management practices (BMP's) -Structural, nonstructural and managerial techniques that are recognized to be the most effective and practical means to control non point source pollutants yet are compatible with the productive use of the resource to which they are applied. BMPs are used in both urban and agricultural areas.

Biochemical oxygen demand (BOD) - The amount of oxygen consumed by microorganisms (mainly bacteria) and by chemical reactions in the biodegradation of organic matter. A standard measure of water quality.

cyanobacteria (blue green algae) - Photosynthetic bacteria, uniquely using chlorophyll *a*. Nitrogen fixers.

Dissolved oxygen (DO) -Atmospheric oxygen dissolved in the water or wastewater, commonly employed as a measure of water quality; low levels adversely affect aquatic life.

epilimnion- Well lit surface zone area.

eutrophic - A nutrient rich trophic condition.

first-flush rain -In Southern California, many months can pass between one rainstorm and the next. During this time, pollution and grime build up. The next rainstorm can wash the accumulated pollution and grime off the streets and into the storm drain system.

This is a "first flush rain." It can carry very large amounts of suspended and dissolved pollutants.

100-Year Storm - There is a 1 in 100 chance of a storm of this magnitude happening in any one year. Flood flow rates from hundred-year storms are recalculated over time due to changes in the landscape (e.g., increased urbanization).

Hypolimnion-Dimly lit or deep water zone

impaired Waters -Waters that fail to meet applicable water quality standards or to protect designated uses (such as fishing or swimming).

Limnological data -Scientific data including physical, chemical, geological, and biological factors that affect aquatic productivity and water quality in freshwater ecosystems such as lakes and reservoirs.

midges - Tiny two-winged fly. In their early aquatic life stages, they can tolerate low levels of oxygen in the water column.

nonpoint source - Pollution sources that are diffuse and do not have a single point of origin or are not introduced into a receiving stream from a specific outlet. The pollutants are generally carried off the land by stormwater runoff. The commonly used categories for nonpoint sources are: agriculture, forestry, urban, mining, construction, dams and channels, land disposal and saltwater intrusion.

nutrient - Any substance that is assimilated (taken in) by organisms and promotes growth. Nitrogen and phosphorous are nutrients which promote the growth of algae. There are other essential and trace elements that are also considered nutrients.

pathogens - Microorganisms that can cause disease in other organisms or in humans, animals and plants. They may be bacteria, viruses, or parasites and are found in sewage in runoff from animal farms and rural areas populated with domestic and/or wild animals, and in water used for swimming. Fish and shellfish contaminated by pathogens, or the contaminated water itself, can cause serious illnesses.

phytoplankton – Tiny pigmented primary producer plants floating or drifting in the water column.

piscivorous birds – Birds that feed on fish.

point Source - A stationary location or fixed facility from which pollutants are discharged or emitted. Also, any single identifiable source of pollution, e.g., a pipe, ditch.

Pollutant - Generally, any substance introduced into the environment that adversely affects the usefulness of a resource.

pollution - Generally, the presence of matter or energy whose nature, location or quantity produces undesirable environmental effects. Under the Clean Water Act, for example, the term is defined as the man-made or man-induced alteration of the physical, biological, and radiological integrity of water.

polymictic – Several circulatory or mixing periods of surface and deeper waters in a lake per year.

potable water-Water that is safe and clean for cooking and drinking.

receiving waters - All distinct bodies of water that receive runoff or wastewater discharges, such as streams, rivers, ponds, lakes and estuaries.

resuspension - Material such as detritus, plankton or sediment that previously settled to the depths of a lake and have been re-suspended in the water column by various processes (i.e. wind, fish foraging in bottom sediments) in the water column.

stratification - Formation of water layers each with specific physical, chemical, and biological characteristics; as density of water decreases due to heating, a stable situation develops with lighter water overlaying and denser water.

surface runoff - Precipitation, snowmelt, or irrigation in excess of what can infiltrate into the soil or be stored in small surface depressions.

surface water - All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.)

thermocline -Transition zone where temperatures decrease rapidly

Total Maximum Daily Load (TMDLs) - A number that represents the assimilative capacity of a waterbody to absorb a pollutant. A TMDL process is used to reallocate waste loads among point and nonpoint sources. The TMDL is the sum of the individual waste load allocations for point source, load allocations for nonpoint sources plus an allotment for natural background loading and a margin of safety.

total dissolved solids (TDS) - All the dissolved solids in a water. TDS is measured on a sample of water that has passed through a very fine mesh filter to remove suspended solids. The water passing through the filter is evaporated and the residue represents the dissolved solids.

urban runoff - Stormwater from city streets and adjacent domestic or commercial properties that may carry pollutants of various kinds into the stormwater systems and/or receiving waters.

watershed - A region or area bound peripherally by a divide or ridge, all of which drains to a particular watercourse or body of water. Also defined as the drainage of a river or stream system.

watershed management plan -A planning document often produced by watershed stakeholder groups that addresses water quality and other concerns and recommends specific management strategies to resolve identified problems in a cooperative and coordinated manner.

wetlands - Any number of tidal and nontidal areas characterized by saturated or nearly saturated soils that form an interface between terrestrial (land-based) and aquatic environments. These include freshwater marshes around ponds and channels (rivers and streams), brackish and salt marshes.

1 Introduction

1.1 Background

The Santa Ana Regional Water Quality Control Board (RWQCB) has identified Lake Elsinore and Canyon Lake on its Clean Water Act Section 303(d) list as impaired waterbodies. The causes of impairment are excessive levels of nutrients in both lakes; high bacteria levels in Canyon Lake; and low dissolved oxygen (DO), excessive sedimentation, and unknown sources of toxicity in Lake Elsinore. Nutrients from the San Jacinto River watershed delivered to these lakes cause significant algae growth, resulting in unpleasant odors, adverse effects on aesthetics, and impaired recreational use. Moreover, excessive algae growth causes depletion of DO in Lake Elsinore and results in occasional massive fish kills.

The RWQCB, in cooperation with various stakeholders in the watershed, has been developing nutrient Total Maximum Daily Loads (TMDL's) for Canyon Lake and Lake Elsinore. To support this initiative, the Santa Ana Watershed Project Authority (SAWPA) coordinated the Lake Elsinore and Canyon Lake Nutrient Source Assessment (hereafter referred to as Nutrient Source Assessment) (Tetra Tech, Inc., 2003) in cooperation with the RWQCB and the Lake Elsinore and San Jacinto Watershed Authority (LESJWA). Results of the Nutrient Source Assessment, TMDL study, and other efforts have provided a sound basis and a good opportunity to develop an overall Nutrient Management Plan for the San Jacinto River watershed.

The Nutrient Management Plan provides guidance regarding the control of nutrients in the watershed to assist in the restoration of the lakes to meet beneficial uses. The Nutrient Management Plan uses the results of the Nutrient Source Assessment and identifies contaminant loadings from various sources throughout the watershed. The Bacteria Source Assessment, which is being developed as a supplement to the Nutrient Source Assessment, is not yet complete and requires additional data collection, model development, and study. Therefore, a specific Bacteria Management Plan is not included in this report. However, implementation of specific projects recommended in the Nutrient Management Plan will also potentially address bacteria issues, which would require validation through completion of the Bacteria Source Assessment.

1.2 Objectives

The overall goal of this project is to identify specific and implementable measures to control contaminants to meet new TMDL's for nutrients and thereby restore the beneficial uses of the lakes — recreation, warm freshwater habitat, and wildlife habitat for both lakes and municipal supply, agricultural supply, and groundwater recharge for Canyon Lake. The objective of this report is to summarize the findings of the Nutrient Source Assessment and public involvement/stakeholder activities and provide a Nutrient Management Plan that is technically sound and defensible for making informed watershed protection decisions while balancing economic growth with the long-term health of Lake Elsinore, Canyon Lake, and the San Jacinto River watershed. This plan should provide flexible watershed protection strategies that can be successfully implemented to restore or maintain water quality in the future. The major elements of the document are the following:

- <u>Watershed Background</u> describes the study area, flow characteristics and rainfall, hydrology, land use, nutrient sources, designated uses, and water quality status of the watershed;

- <u>Pollutant Source Assessment</u> outlines sources of nutrients in the watershed, sources of nutrients in the lakes, and the status of the Bacteria Source Assessment for Canyon Lake; and

- <u>Watershed Management Recommendations</u> outlines strategy development, stakeholder involvement, an implementation strategy, and recommendations for watershed improvement, lake projects, watershed projects, future plans, implementation, and funding.

The Nutrient Management Plan provides an effective management strategy to implement nonpoint source pollution control measures, both structural and nonstructural, to resolve water quality problems. This plan also includes measures that provide environmental enhancements that may produce multiuse benefits. Stakeholder involvement and participation were encouraged during the development process through participation in a stakeholder Advisory Group and project briefings for the San Jacinto River Watershed Council. Key stakeholders and agencies involved in the process include:

- California Department of Fish and Game
- City of Canyon Lake
- City of Lake Elsinore
- Eastern Municipal Water District (EMWD)
- Elsinore Valley Municipal Water District (EVMWD)
- LESJWA
- Riverside County Farm Bureau
- Riverside County Flood Control and Water Conservation District (RCFCWCD)
- RWQCB
- SAWPA
- San Jacinto Basin Resource Conservation District
- San Jacinto River Watershed Council
- Western Dairyman’s Association

1.3 The Nutrient Management Plan Process

Development of the Nutrient Management Plan consisted of a multistep process that used professional expertise and the best information available regarding the sources of nutrients and current project plans in the watershed. It took advantage of findings from separate ongoing studies to provide a comprehensive strategy for the management of nutrient sources that considers all current projects plans in the watershed and provides guidance for additional projects and studies to address key issues. Plan development involved the following tasks:

- Established the goals of the Nutrient Management Plan;
- Organized an Advisory Group of stakeholders and consulted the group throughout project development for guidance and input;
- Reviewed all studies and data in the watershed;
- Updated the modeling system (developed for the Nutrient Source Assessment) for validation to data collected in 2003;
- Summarized the results of the Nutrient Source Assessment to identify the key issues and nutrient source to address through specific project recommendations;
- Identified specific projects in the watershed to address nutrient management needs; and
- Prepared the Nutrient Management Plan.

Participation of stakeholders in development of the Nutrient Management Plan was a critical component of the project and ensured that all major concerns in the watershed specific to nutrient sources and transport were considered. Throughout each phase of the project, the Advisory Group of the San Jacinto Watershed Council was consulted and updated on development of the project and invited to provide recommendations. Participants in the Advisory Group were invited to provide any information relative to specific projects for inclusion in the report. Periodic reports of project status were provided to the San Jacinto Watershed Council.

Stakeholders contributed significant information specific to separate studies in the watershed that assisted greatly in project identification. These studies were reviewed thoroughly and referenced throughout project identification. In addition, stakeholders were consulted regarding the current status of project plans to determine whether the projects should be included in the Nutrient Management Plan.

Results of the Nutrient Source Assessment were reviewed and summarized for development of the Nutrient Management Plan. For assessment of nutrient sources, Tetra Tech, Inc (2003) developed a modeling system of the San Jacinto River watershed consisting of a watershed model linked to a separate model of Canyon Lake (see Section 3.1). To confirm the findings of the Nutrient Source Assessment, the modeling system was validated with data collected in 2003. Using the findings of the Nutrient Source Assessment and model validation, specific nutrient sources were addressed.

The primary product of the Nutrient Management Plan is a list of recommended projects to (1) reduce nutrient loads to Lake Elsinore and Canyon Lake or (2) obtain more data for quantifying or refining source loads to provide guidance for future management decisions. The Nutrient Management Plan recommends several projects in the watershed or the lakes that seek to improve water quality or reduce nutrient loads from runoff. For example, aeration of Lake Elsinore and Canyon Lake is recommended to improve in-lake water quality. Also recommended are specific studies that seek to answer many questions posed by decision-makers and stakeholders. For instance, little information is currently available regarding the spatial distribution of specific crops in the watershed and associated management of manure or fertilizer application for those crops. A study is recommended to determine spatial information on crops in the watershed, as well as agronomic rates of nutrients for guidance in management of these crops. The final list of projects provides a comprehensive plan for managing nutrients by implementing specific BMP's or providing information needed to guide decision-makers in the policy development and future project planning.

2 Watershed Background

This section reviews the characteristics of the San Jacinto River watershed, and discusses beneficial uses of waterbodies in the watershed, water quality status of the watershed, climate, waterbody characteristics and flow, land cover and use, and sources of nutrients. This information is critical to understanding the hydrology and nutrient loading and transport processes in the watershed for guidance in development of the Nutrient Management Plan. Although the Nutrient Source Assessment provides much information regarding the magnitude of nutrient loads from various sources (see Section 3.1), insight into the processes for loading and delivery of these loads assists greatly in identification of key implementation goals and projects to better manage nutrients in the watershed.

2.1 Study Area Description

The San Jacinto River watershed (U.S. Geological Survey- HUC 18070202), which covers approximately 770 square miles is located almost 60 miles southeast of Los Angeles. It extends from the San Jacinto Mountains in the north and east to Lake Elsinore in the west (Figure 2-1). Most of the watershed (99.75 percent) falls within Riverside County with only a small portion (0.25 percent) extending into Orange County.

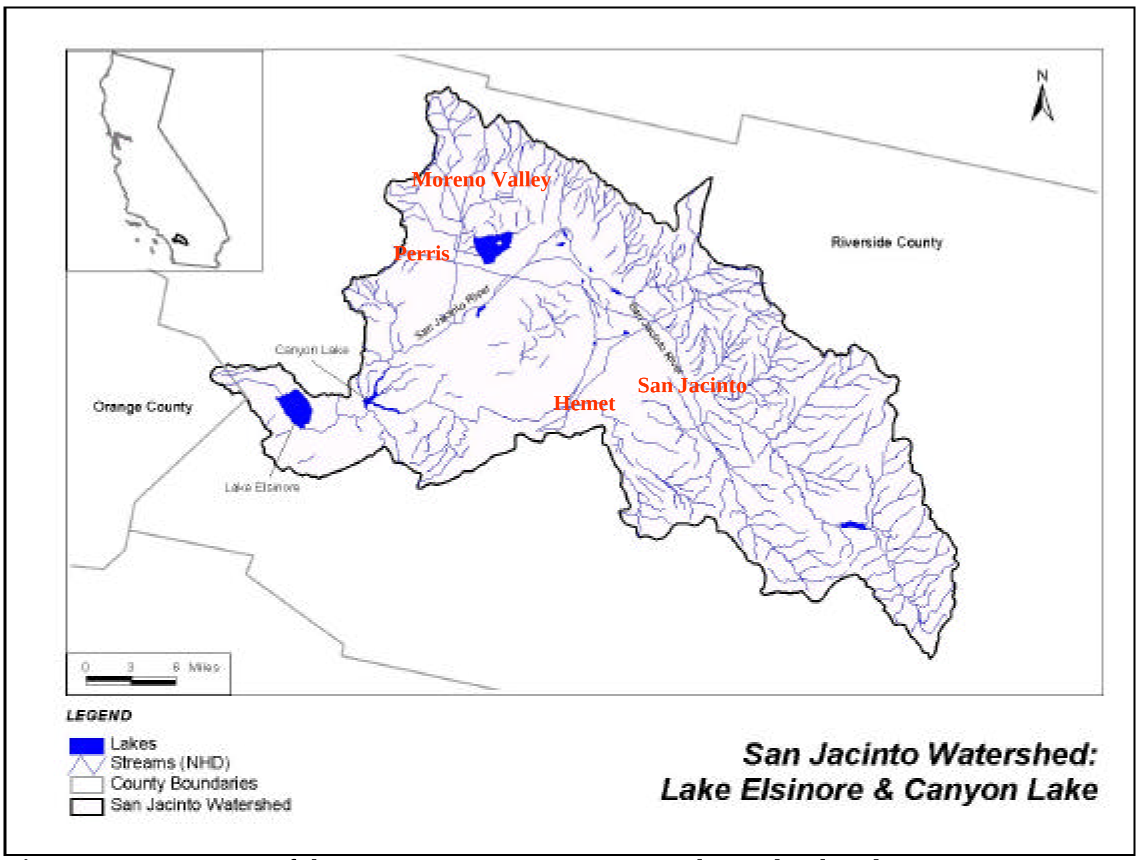

Figure 2-1. Locations of the San Jacinto River, Canyon Lake, and Lake Elsinore

Perris, Moreno Valley, San Jacinto, Hemet, and Canyon Lake are the most populated urban areas in the watershed (Table 2-1). Moreno Valley has the largest population in the San Jacinto River watershed, with a total of 150,200 people. The watershed has experienced a large amount of growth in recent years. In 1991, the population in Moreno Valley was 126,291 people (EVMWD, 1995). According to the Elsinore Valley Municipal Water District (EVMWD) (1995), the growth is expected to continue, as more agricultural land is converted to urban land.

Table 2-1. Population estimates for cities in the San Jacinto River watershed

Community	2001	2003
San Jacinto	25,300	26,050
Hemet	61,500	62,200
Moreno Valley	146,500	150,200
Perris	37,550	38,200
Canyon Lake	10,350	10,500
Lake Elsinore	31,100	33,050
Beaumont	12,200	13,800

Source: State of California, Dep. of Finance

2.2 Beneficial Uses

Under federal regulations and the Water Quality Control Plan of the Santa Ana River Basin (Santa Ana RWQCB, 1995) (hereafter referred to as Basin Plan), water uses are categorized as *beneficial uses*. As stated in the Basin Plan, "a beneficial use is one of the various ways that water can be used for the benefit of people and/or wildlife."

Beneficial uses in California are considered to be *existing, potential, or intermittent* beneficial uses as described below.

- Existing - Uses attained for a waterbody on or after November 28, 1975, are designated as "existing;" the U.S. Environmental Protection Agency (EPA) first issued water quality standard regulations on November 28,1975. An existing use, because it has been attained, may not be modified or changed, unless uses are added that require more stringent criteria.

- Potential - Beneficial uses may be designated as potential for any of the following reasons:
    - Implementation of the State Board's "Sources of Drinking Water Policy"(State Board Resolution No. 88-63, 1988).
    - Plans to put the water to such future use
    - Potential to put the water to such future use
    - Designation of a use by the Regional Board as a regional water quality goal
    - Public desire to put water to such future use.

- Intermittent **-** Beneficial uses of streams that do not flow continuously, as is typical of many streams in southern California, are designated as intermittent. In cases where beneficial uses such as wildlife habitat can be supported by small pools of water or shallow groundwater (e.g., water that is flowing in a shallow, subsurface environment), such uses must be protected throughout the year and are designated "existing." Seasonal beneficial uses are allowed where the use is intermittent due to seasonal environmental influences (e.g., water temperature to support seasonal fish spawning).

The listing of waters designated with beneficial uses attempt to include all significant waterbodies in the basin. If no uses have been established for a tributary stream to a waterbody, the downstream uses are applicable to the upstream or tributary areas (Santa Ana RWQCB, 1995). Different beneficial uses may apply for different segments of a waterbody or reach. The following are California's beneficial uses (Santa Ana RWQCB, 1995):

- Municipal and Domestic Supply (MUN)
- Agricultural Supply (AGR)
- Industrial Service Supply (IND)
- Industrial Process Supply (PROC)
- Groundwater Recharge (GWR)
- Navigation (NAV)
- Hydropower Generation (POW)
- Water Contact Recreation (REC1)
- Non-contact Water Recreation (REC2)
- Commercial and Sports fishing (COMM)
- Warm Freshwater Habitat (WARM)
- Limited Warm Freshwater Habitat (LWRM)
- Cold Freshwater Habitat (COLD)
- Preservation of Biological Habitats of Special Significance (BIOL)
- Wildlife Habitat (WILD)
- Rare, Threatened or Endangered Species (RARE)
- Spawning, Reproduction, and Development (SPWN)
- Marine Habitat (MAR)
- Shellfish Harvesting (SHEL)
- Estuarine Habitat (EST)

Lake Elsinore and Canyon Lake receive flow from all tributaries of the San Jacinto River watershed and therefore set water quality goals for the entire basin. Lake Elsinore is a natural freshwater lake that provides a variety of natural habitats to terrestrial and aquatic species. The beneficial uses of the lake include water contact recreation (REC1), non-contact recreation (REC2), warm freshwater habitat (WARM), and wildlife habitat (WILD). Canyon Lake was constructed in 1928 as the Railroad Canyon Reservoir. The beneficial uses of Canyon Lake include municipal and domestic water supply (MUN), agricultural supply (AGR), groundwater recharge (GWR), water contact recreation (REC1), non-contact water recreation (REC2), warm freshwater habitat (WARM), and wildlife habitat (WILD). Beneficial uses of waterbodies in the in the San Jacinto River watershed are listed in Tables 2-2 and 2-4 (Santa Ana RWQCB, 1995). The waterbodies include inland surface streams, wetlands, lakes and reservoirs, and groundwater subbasins.

Table 2-2. Beneficial uses for lakes and reservoirs in San Jacinto River watershed

LAKES AND RESERVOIRS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	**Primary**	**Secondary**
Canyon Lake (Railroad Canyon Reservoir)	X	X			X			X	X		X				X						802.11	802.12
Elsinore, Lake	+							X	X		X				X						802.31	
Fulmor, Lake	X	X						X	X		X		X		X						802.21	
Hemet, Lake	X	X			X		X	X	X		X		X		X		X				802.22	
Perris, Lake	X	X	X	X	X			X	X		X		X		X							
San Jacinto Wildlife Preserve (WETLAND)	+							X	X		X			X	X	X						

X Present or Potential Beneficial Use, I Intermittent Beneficial Use, + Excepted from MUN

Table 2-3. Beneficial uses for inland surface streams in the San Jacinto River watershed

INLAND SURFACE STREAMS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	**Primary**	**Secondary**
Reach 1 - Lake Elsinore to Canyon Lake	I	I			I			I	I		I				I						802.32	802.31
Reach 2 - Canyon Lake																						
Reach 3 - Canyon Lake to Nuevo Road	+	I			I			I	I		I				I						802.11	
Reach 4 - Nuevo Road to North-South Mid Section Line, T4S/R1W-SB	+	I			I			I	I		I				I						802.14	802.21
Reach 5 - North-South Mid Section Line, T4S/R1W-SB to Confluence with Poppet Creek	+	I			I			I	I		I				I						802.21	
Reach 6- Poppet Creek to Cranston Bridge	+	I			I			I	I		I				I						802.21	
Reach 7 Cranston Bridge to Lake Hemet	X	X			X			X	X				X		X						802.21	
Bautista Creek - Headwaters to Debris Dam	X	X			X			X	X				X		X						802.21	802.23
Strawberry Creek and San Jacinto River, North Fork	X	X			X			X	X				X		X						802.21	
Fuller Mill Creek	X	X			X			X	X				X		X						802.22	
Stone Creek	X	X			X			X	X				X		X						802.21	
Salt Creek	+							I	I		I				I						802.12	
Other Tributaries: Logan, Black Mountain, Juaro Canyon, Indian, Hurkey, Poppet and Protero Creeks, and other Tributaries to these Creeks.	I	I			I			I	I		I				I						802.21	802.22

X Present or Potential Beneficial Use, I Intermittent Beneficial Use, + Excepted from MUN

Table 2-4. Beneficial uses for groundwater subbasins in the San Jacinto River watershed

GROUNDWATER SUBBASINS	BENEFICIAL USE																				Hydrologic Unit	
	MUN	AGR	IND	PROC	GWR	NAV	POW	REC1	REC2	COMM	WARM	LWRM	COLD	BIOL	WILD	RARE	SPWN	MAR	SHEL	EST	Primary	Secondary
Garner Valley	X	X																			802.22	
Idyllwild Area	X		X																		802.22	802.21
San Jacinto – Canyon	X	X	X	X																	802.21	
San Jacinto - Lower Pressure	X	X	X																		802.21	
San Jacinto – Intake	X	X	X	X																	802.21	
San Jacinto - Upper Pressure	X	X	X	X																	802.21	
Hemet	X	X	X	X																	802.15	802.21
Lakeview	X	X	X	X																	802.14	
Perris North	X	X	X	X																	802.11	
Perris South I	X	X																			802.11	
Perris South II	X	X																			802.11	
Perris South III	X	X																			802.11	
Winchester	X	X																			802.13	
Menifee I	X	X																			802.12	
Menifee II	X	X																			802.12	
Elsinore	X	X		X																	802.31	802.32

X Present or Potential Beneficial Use, I Intermittent Beneficial Use, + Excepted from MUN

2.3 Water Quality Status of Lake Elsinore and Canyon Lake

Section 303 (d) of the Clean Water Act requires states to identify surface waterbodies that do not meet designated uses. The RWQCB has identified such impaired waterbodies in the Santa Ana Region and a priority schedule of TMDL development on the 2002 303(d) list (Table 2-5). Canyon Lake is listed for nutrients and pathogens and is considered to be a low priority. Lake Elsinore is listed for nutrients, unknown toxicity, low dissolved oxygen, and sedimentation and is considered a high priority. The third listed water body in the watershed is Fulmor Lake, which is near Indian Creek, an upper tributary to the South Fork of the San Jacinto River. Fulmor Lake is listed for pathogens and is considered a low priority. Total Maximum Daily Loads (TMDL's) are required for these water bodies. Table 2-6 presents the RWQCB's surface water quality standards for the designated uses of Canyon Lake, Lake Elsinore, and Fulmor Lake.

Table 2-5. Waterbodies on the 2002 303(d) list

Waterbody Name	Waterbody Size (acres)	Pollutant of Concern	Primary Source of Impairment
Canyon Lake	453	Nutrients, Pathogens	Nonpoint Source
Lake Elsinore	2431	Unknown Toxicity, Nutrients, Sedimentation/siltation, Organic Enrichment/Low Dissolved Oxygen	Urban Nonpoint Source
Fulmor Lake	4.2	Pathogens	Nonpoint Source

Table 2-6. Applicable water quality standards

Selected Water Quality Objectives - Surface Waters

Reference: Basin Plan (1995)

Parameter	Water Quality Objective	
	Canyon Lake	Lake Elsinore
Algae	Waste discharges shall not contribute to excessive algal growth	
Ammonia, Un-ionized	Criteria calculated based on pH and temperature data. WARM and COLD criteria	
Bacteria, Coliform	(MUN): Total coliform: less than 100 count/100 mL	(REC-1): Fecal coliform: log mean less than 200 count/100mL with 5 or more samples within a 30-day period, and not more than 10% of the samples exceed 400 count/100 mL for any 30-day period.
Chloride	90 mg/L	not given
Dissolved Solids, Total	700 mg/L	2000 mg/L
Hardness (as $CaCO_3$)	325 mg/L	not given
Nitrate	10 mg/L (as N)	45 mg/L (as NO3)
Nitrogen, Total Inorganic	8 mg/L	1.5 mg/L
Oxygen, Dissolved	WARM: Not be depressed below 5 mg/L	
pH	Not above 8.5 or below 6.5	
Sodium	100 mg/L	not given
Sulfate	290 mg/L	not given
Temperature	Not above 90^{o}F June through October or above 78^{o}F in other months. Lake temperature shall not be raised more than 4^{o}F above established normal values.	
Turbidity	Dependent on natural turbidity levels (maximum increase allowed in parentheses): 0-50 NTU (20%), 50-100 (10 NTU), >100 NTU (10%)	

In addition to the water quality standards listed in Table 2-6, the RWQCB has proposed more specific numeric targets to ensure that the beneficial uses of the lakes are achieved (Table 2-7 and 2-8) (Santa Ana RWQCB, 2003). These targets are based on water quality data collected from each lake, and they are subject to revision as more data becomes available (personal communication with Cindy Li, RWQCB).

Table 2-7. Proposed numeric interim TMDL targets

Parameter	Interim TMDL Targets	
	Canyon Lake	**Lake Elsinore**
Chlorophyll a	Summer mean less than 40 ug/L; to be attained by 2024	Summer mean less than 40 ug/L; to be attained by 2007
Dissolved Oxygen	Daily average at hypolimnion greater than 5 mg/L; to be attained by 2009	Daily average greater than 5 mg/L; to be attained by 2007
Total Nitrogen	Annual mean less than 1.0 mg/L; to be attained by 2009	Annual mean less than 1.0 mg/L; to be attained by 2007
Total Phosphorus	Annual mean less than 100 ug/L; to be attained by 2009	Annual mean less than 100 ug/L; to be attained by 2007

Table 2-8. Proposed numeric long term TMDL targets

Parameter	Long term TMDL Targets	
	Canyon Lake	**Lake Elsinore**
Chlorophyll a	Summer mean less than 10 ug/L; to be attained by 2024	Summer mean less than 10 ug/L; to be attained by 2019
Dissolved Oxygen		Greater than 5 mg/L 1 meter above lake bottom and no less than 2 mg/L from 1 meter to lake sediment; to be attained by 2019
Total Phosphorus	Annual mean less than 20 ug/L; to be attained by 2024	Annual mean less than 20 ug/L; to be attained by 2019
Total Nitrogen	Annual mean less than 0.5 mg/L; to be attained by 2024	Annual mean less than 0.5 mg/L; to be attained by 2019

2.4 Climate/Rainfall

The San Jacinto River watershed is essentially a desert region that is considered to have a Mediterranean climate. The average annual rainfall in the San Jacinto River watershed is approximately 15 inches (Santa Ana RWQCB, 1995). Three types of storms dominate the region: general winter storms, general summer storms, and high-intensity thunderstorms. Winter storms typically last for several days and occur in the wet period that extends from November through May. Thunderstorms can occur at any time of the year, but are most common between July and September. These storms are characterized by short periods of high-intensity rainfall. General summer storms, which normally occur from July through September, are rare events. When these storms do occur, they can result in heavy rainfalls over the course of several days (RCFCWCD – Hydrology Manual).

The western part of the watershed receives less rainfall on average than the eastern part. The rainfall in the eastern part of the watershed is influenced by orographic lifting, in which precipitation occurs as the clouds lift due to the change in topography, causing the temperature of the clouds to cool and the moisture to condense into rain drops (Mays, 2001). The effect from orographic lifting can be observed by comparing the monthly average precipitation gages in the eastern part of the watershed (NCDC stations Idyllwild

Fire Dept. CA4211 and Hurkey Creek Park CA4181) to the precipitation gages in the western part of the watershed (NCDC stations Elsinore CA2805 and San Jacinto CA7813) (Figure 2-2).

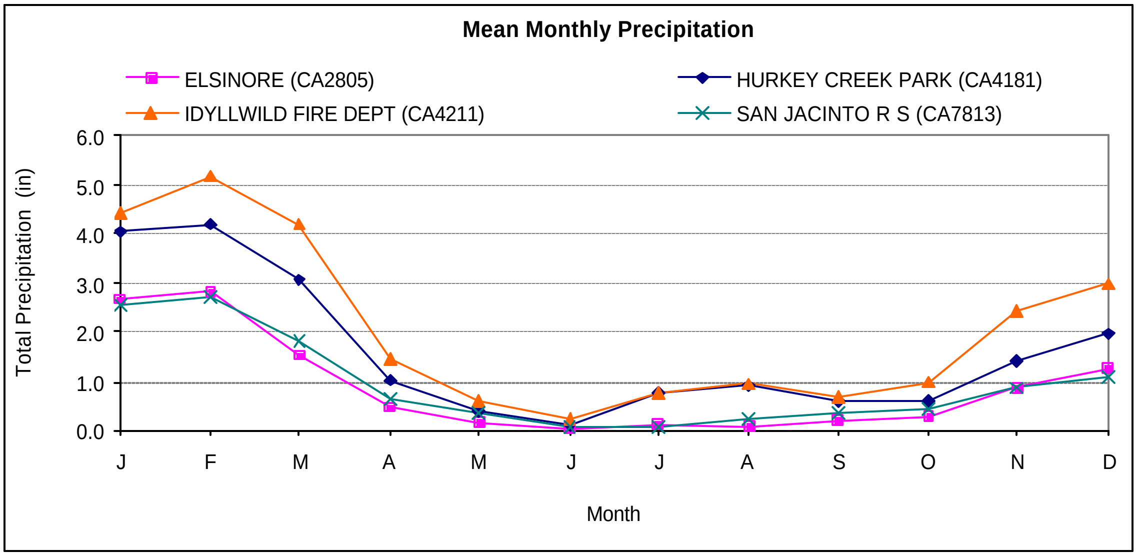

Figure 2-2.The mean monthly precipitation in the San Jacinto River watershed

2.5 Waterbody Characteristics

The San Jacinto River watershed is a dynamic system with various unique conditions that either enhance or restrict flows through the watershed. The San Jacinto River, Salt Creek, Perris Valley Storm Drain, Mystic Lake, Perris Reservoir, Canyon Lake, and Lake Elsinore are the dominant hydrologic features in the watershed (Figure 2-3). In many cases, lakes, reservoirs, and other detention facilities impound streamflow. These impoundments can have major impacts on the quantity and quality of the water transported throughout the watershed. Storage of water results in not only the attenuation of peak flows, but also increased soil infiltration and other associated losses. In agricultural areas, the operation of stormwater detention ponds can have pronounced effects on the magnitude of peak runoff from the San Jacinto River watershed. The water quality can also be affected by storage facilities; impacts are caused by settling, biological uptake, etc. The discussion below provides hydrologic and geographic details of major features of the San Jacinto River watershed and explains how each feature affects the hydrology of the system.

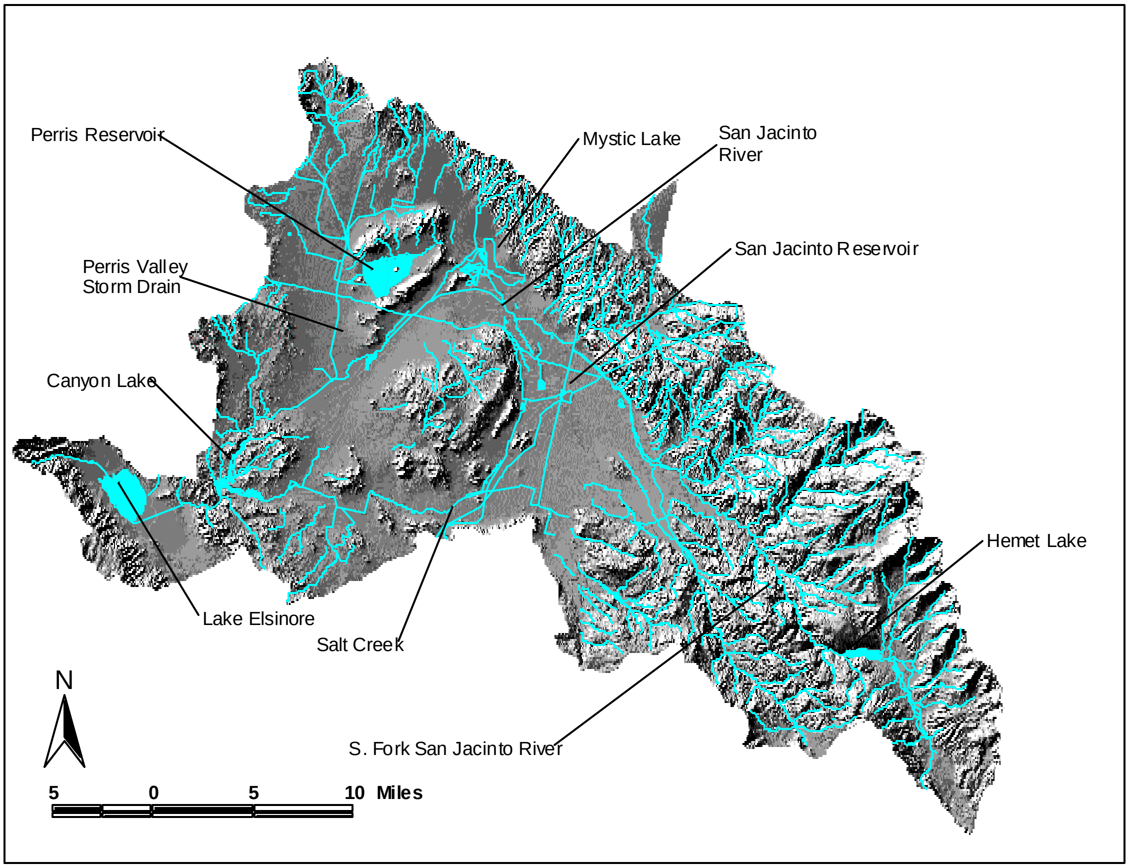

Figure 2-3. The dominant hydrologic features in the San Jacinto River watershed

2.5.1 San Jacinto River

The San Jacinto River originates in the San Jacinto Mountains and follows the San Jacinto Valley through the eastern portion of the watershed. For analysis of historical trends, six United States Geological Survey (USGS) gages have measured average daily flow in the watershed over extended periods (Figure 2-4). These data helped to characterize the river as an ephemeral system, with flow reaching Canyon Lake and Lake Elsinore only during wet periods.

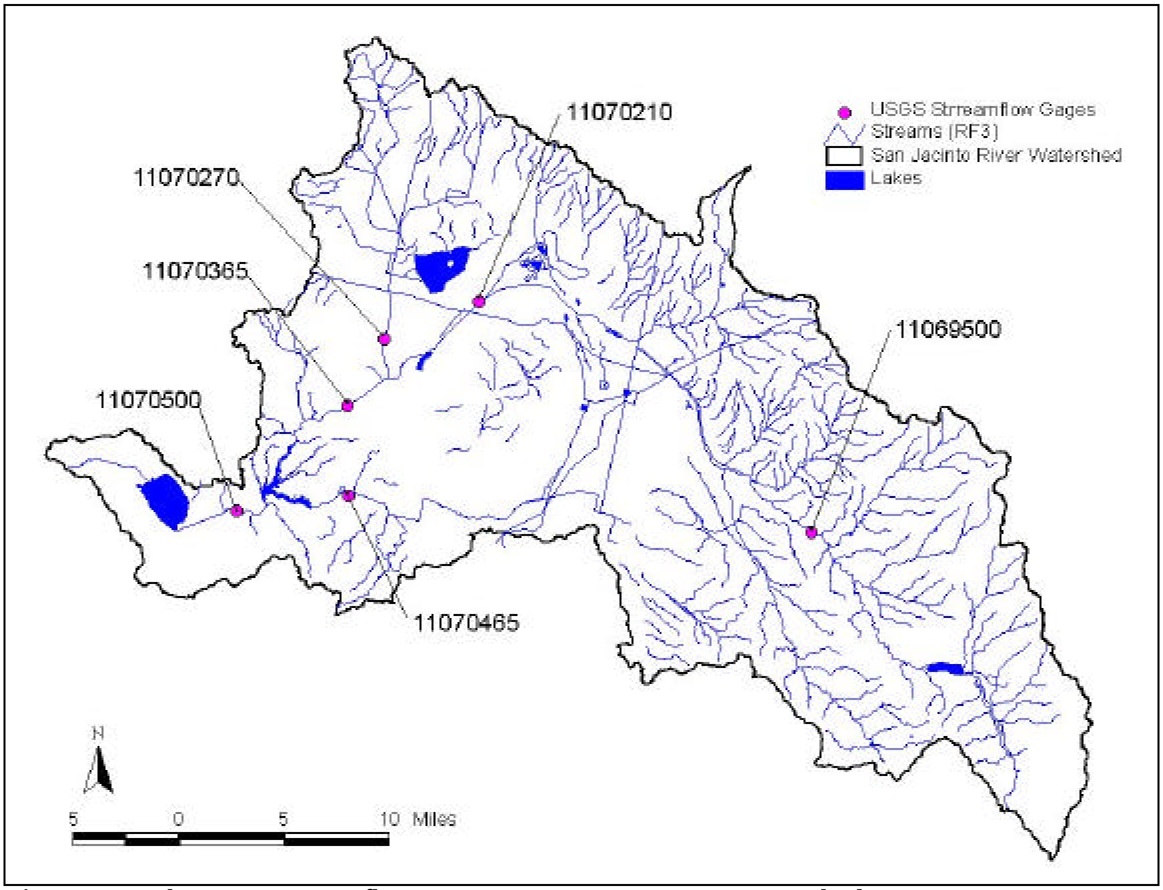

Figure 2-4. The USGS streamflow gages in San Jacinto River watershed

Streamflows in the headwater portions of the San Jacinto River are quantified by USGS flow gage 11069500 (Figure 2-5). The hydrograph for this flow gage shows a gradual increase and decline of flow throughout storm seasons. This pattern suggests that the headwater portions of the watershed are influenced by groundwater, interflow, or both.

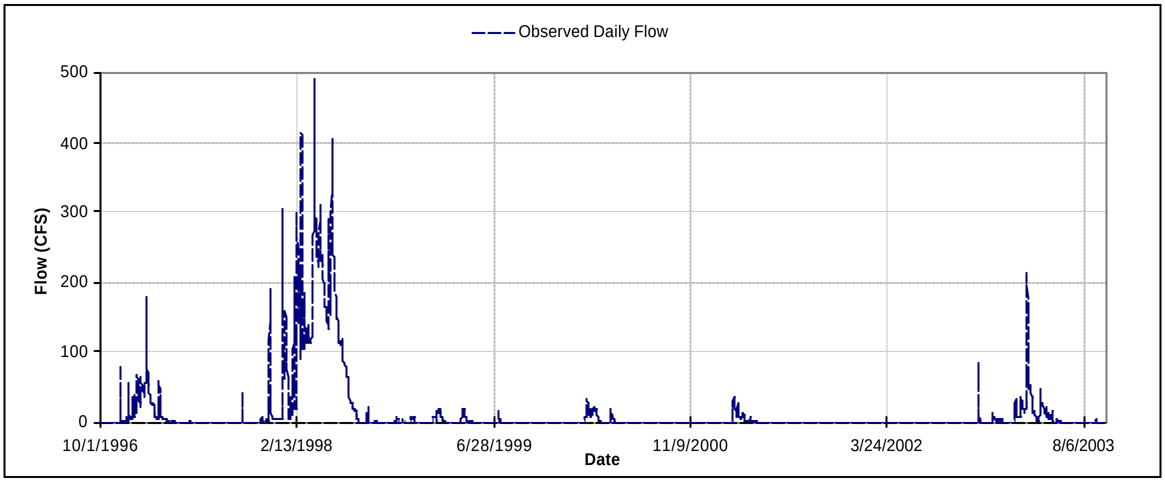

Figure 2-5. Average daily flow data for San Jacinto River near San Jacinto (USGS 11069500) from October 1996 to August 2003

As the San Jacinto River leaves the San Jacinto Valley, it passes through the San Jacinto fault zone. This fault zone is responsible for relatively high subsidence rates, which have resulted in the formation of a closed system that periodically fills with water from the river. This depression forms Mystic Lake (see Section 2.5.4).

Downstream of Mystic Lake, the San Jacinto River forms a wide fluvial plain. When Mystic Lake does not overflow, downstream river reaches are often dry. The majority of water that infiltrates the ground is understood to be lost from the system, as groundwater levels are low due to excessive pumping and limited recharge. Infiltration losses occur during transport processes of watershed runoff or streamflow (personal communication with Steven Clark, RCFCWCD). Ultimately, it is expected that San Jacinto River groundwater sources will be limited.

Between Mystic Lake and Canyon Lake is the confluence with the Perris Valley Storm Drain (Section 2.5.2). USGS gage 11070365 is the first gage to quantify the confluence of Perris Valley Storm Drain, Mystic Lake overflow, and additional San Jacinto River streamflow downstream of Mystic Lake. The available data for this gage are limited from August 1996 to September 2002 (Figure 2-6). The San Jacinto River then flows through the narrow Railroad Canyon before draining into Canyon Lake. The Canyon Lake dam controls the flow downstream of Canyon Lake, which dominates the inflow to Lake Elsinore (Santa Ana RWQCB, 2001).

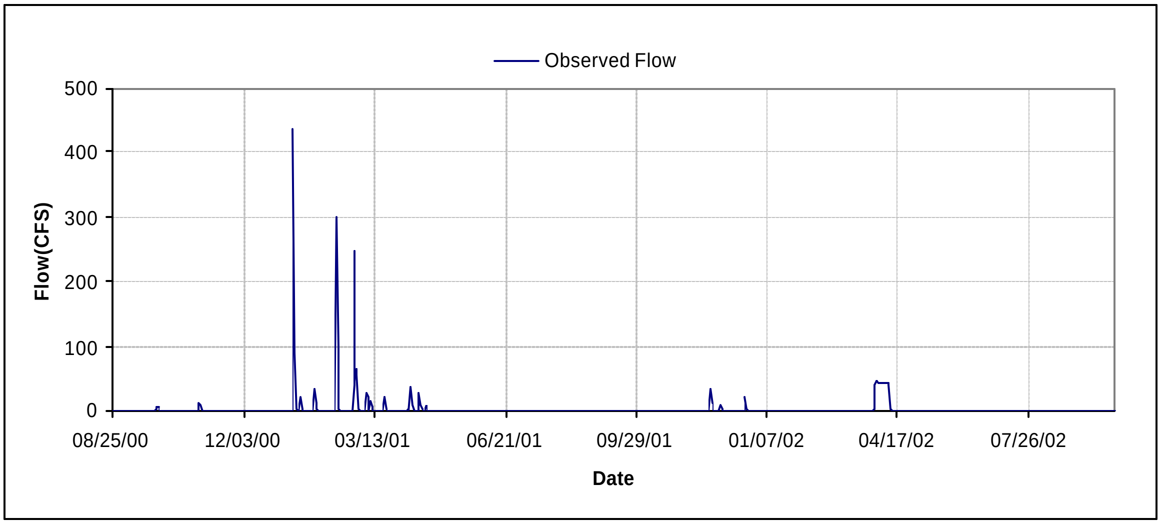

Figure 2-6. Average daily flow data for San Jacinto River upstream of Canyon Lake (USGS 11070365) from August 2000 to September 2002

The last streamflow gage on the San Jacinto River is located just above Lake Elsinore. The streamflow at USGS gage 11070500 displays extended dry periods followed by sharp peaks and abrupt recessions of flow (Figure 2-7). These flows are likely the result of stormwater runoff and overflows of Canyon Lake dam; there is very little contribution from groundwater or interflow. The San Jacinto River eventually drains into Lake Elsinore where the river ends.

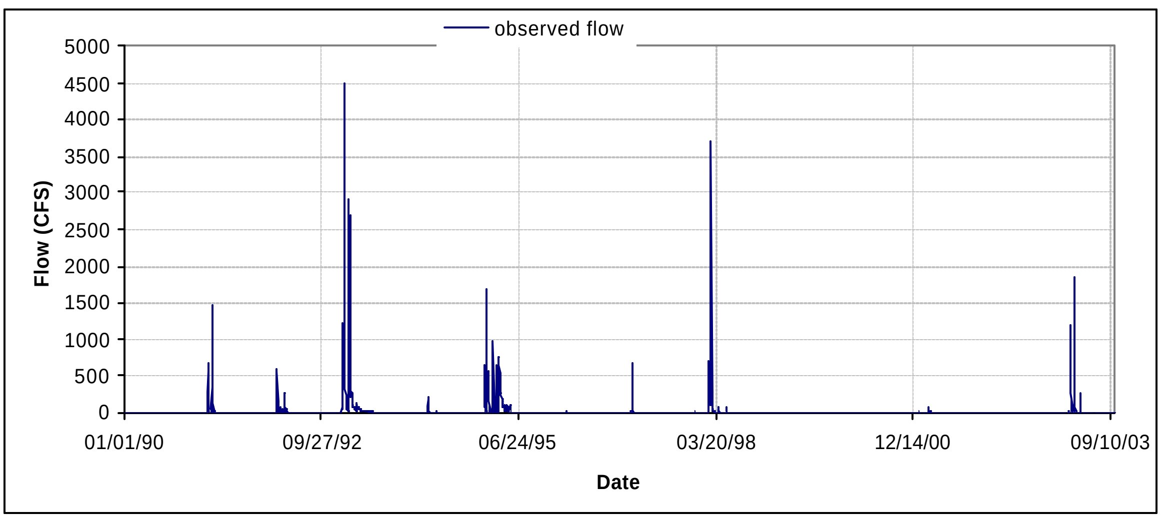

Figure 2-7. Average daily flow data for San Jacinto River near Elsinore (USGS 11070500)

2.5.2 Perris Valley Storm Drain

To the west of Perris Reservoir lie the communities of Perris and Moreno Valley. Runoff from this urban region drains into the Perris Valley Storm Drain, a major tributary of the

San Jacinto River downstream of the Perris Reservoir. This flow is measured by USGS flow gage 11070270 before entering into the main stem of the San Jacinto River. The hydrograph for this gage shows dry periods between storms, the streamflow rises in sharp peaks and then abruptly declines (Figure 2-8). These peaks are likely the result of stormwater runoff with very little contribution from groundwater or interflow.

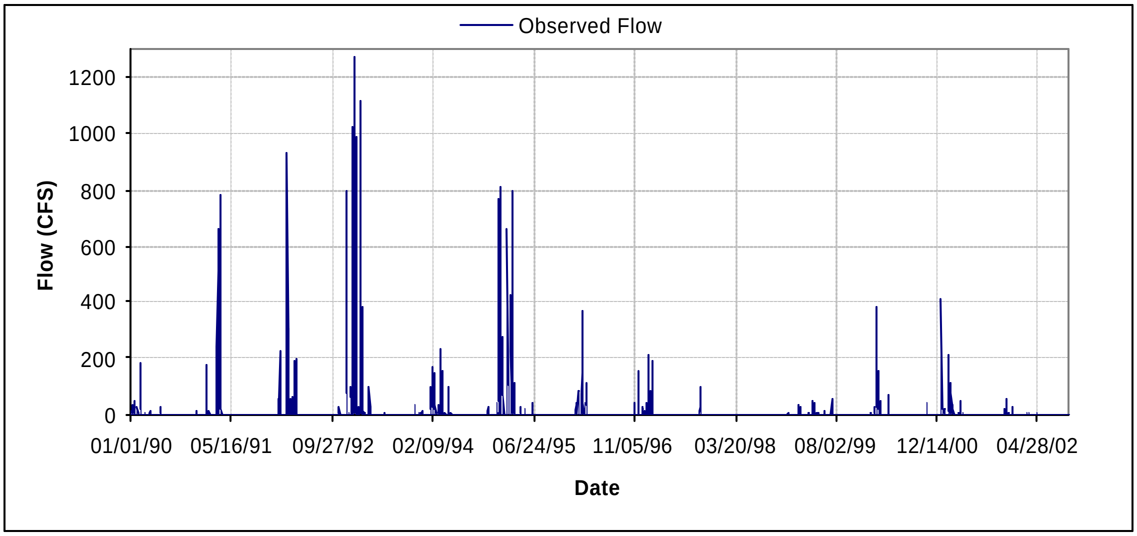

Figure 2-8. Average daily flow data for Perris Valley Storm Drain–Nuevo Rd (USGS 11070270)

2.5.3 Salt Creek

Salt Creek is one of the main tributaries to Canyon Lake. The headwaters are located in the city of Hemet. USGS gage 11070465 records the streamflow before Salt Creek drains into Canyon Lake (Figure 2-9). The available data are limited to the period of September 2000 to September 2002. As with Perris Valley Storm Drain, sharp peaks in flows are primarily the result of surface runoff from urban areas with little contributions from groundwater or interflow.

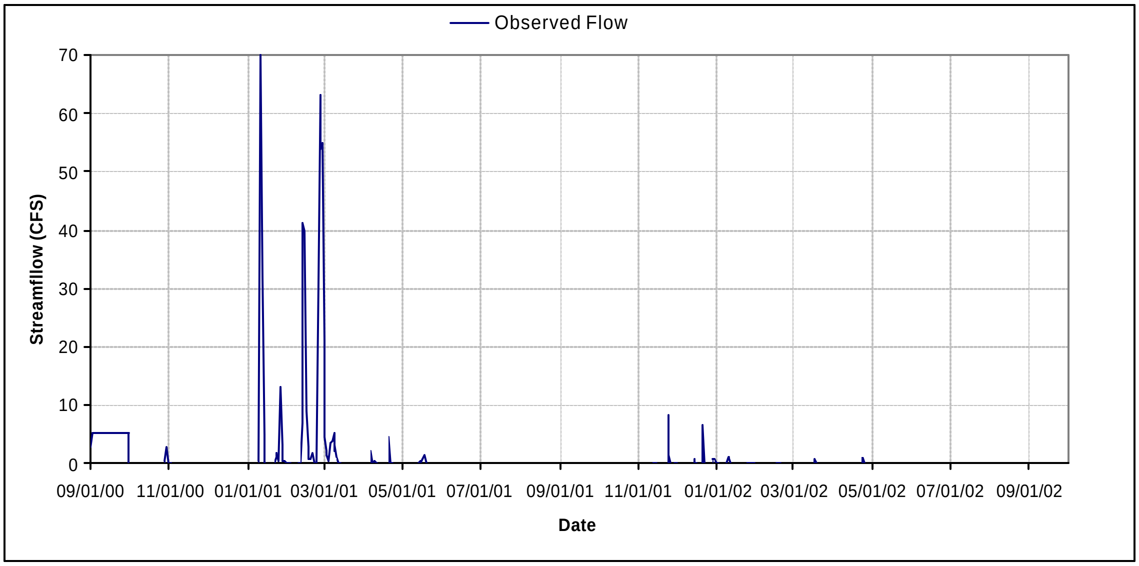

Figure 2-9. Average daily flow data for Salt Creek near Sun City (USGS 11070465) from September 2000 to September 2002

2.5.4 Mystic Lake

Mystic Lake is near the center of the San Jacinto River watershed (Figure 2-10). When formed, the lake is relatively shallow and has a large surface area, increasing losses to infiltration, groundwater recharge and evaporation. Many years ago local farmers constructed a low-flow channel to divert the San Jacinto River flow around Mystic Lake. According to local experts, siltation has closed the channel and it is no longer active during low flow periods. Therefore, all of the river flow drains directly to Mystic Lake where it is impounded during average and low flow years (personal communication with Stephen Stump, RCFCWCD, and Tom Paulek, California Department of Fish and Game).

When full, the lake has been observed to maintain a substantial amount of volume for over a year with little or no transport back to the San Jacinto River. Due to the significant loss from evaporation, infiltration, and groundwater recharge, much of the volume stored in the lake is lost from the San Jacinto River system. During torrential rainfall events or periods of extended rain, however, the storage capacity of Mystic Lake can be exceeded, resulting in overflow back to the San Jacinto River.

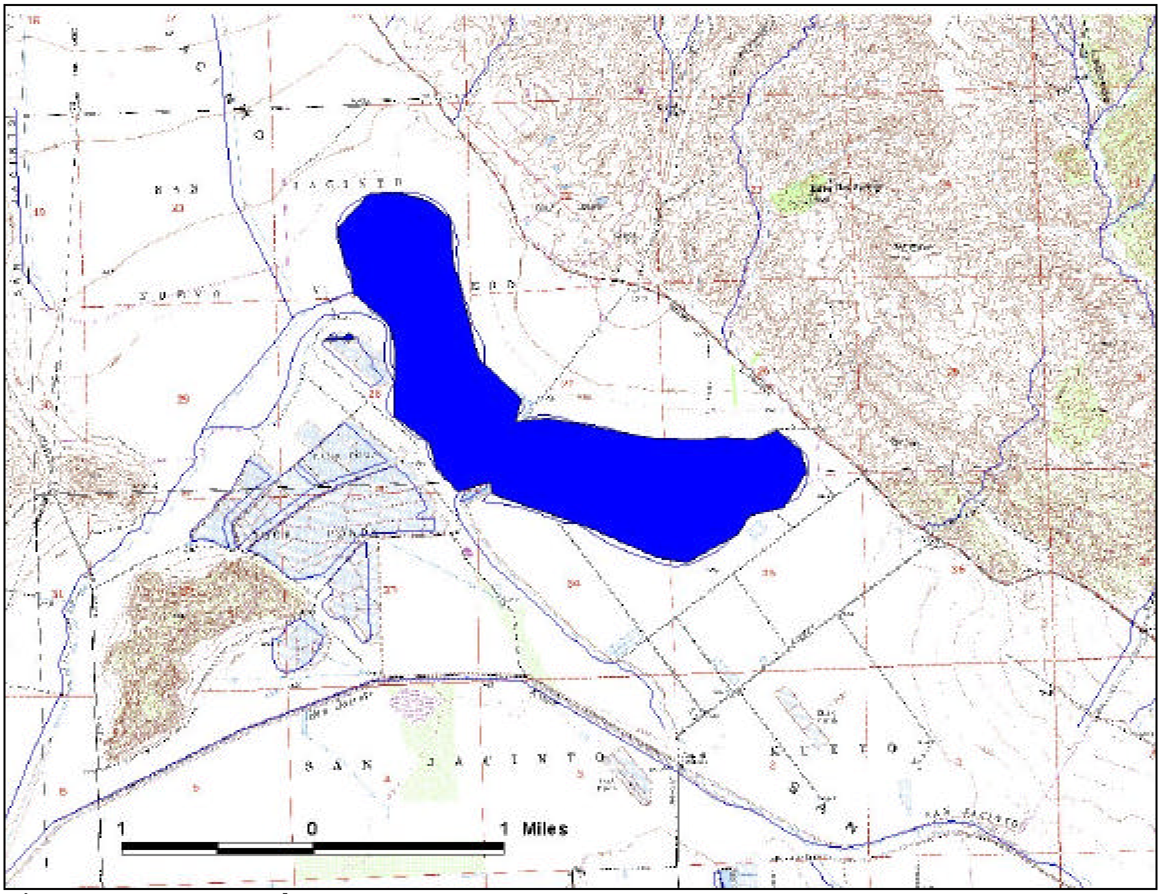

Figure 2-10. Mystic Lake

2.5.5 Perris Reservoir

Just to the west of Mystic Lake lies another major impoundment in the San Jacinto River watershed. The Perris Reservoir is on a northwest tributary to the San Jacinto River. It essentially functions as a sink and impounds the runoff to the river from a 10-square-mile subwatershed. Runoff from the entire subwatershed is considered lost to the San Jacinto system (personal communication with Steven Clark, RCFCWCD).

Perris Reservoir, which is part of the California State Water Project, is also the largest drinking water reservoir in the San Jacinto River watershed. Many of the local water districts receive water from Perris Reservoir along with water from the Colorado River and groundwater sources. Water from Perris Reservoir helps meet the demands of Elsinore, Corona, Norco, Riverside, Moreno Valley, Perris, San Jacinto Hemet, Temecula, Coachella Valley and Palm Springs.

2.5.6 Canyon Lake

Canyon Lake is at the confluence of the San Jacinto River, Salt Creek, and other small tributaries (Figure 2-11 and 2-12). Over 90 percent of the San Jacinto watershed drains to Canyon Lake. Runoff from as far as Moreno Valley, San Jacinto, Hemet, and Perris contribute to surface flows that reach Canyon Lake during rainfall events. During normal to dry periods, when the San Jacinto River and the surrounding tributaries are essentially dry, little or no flow enters Canyon Lake.

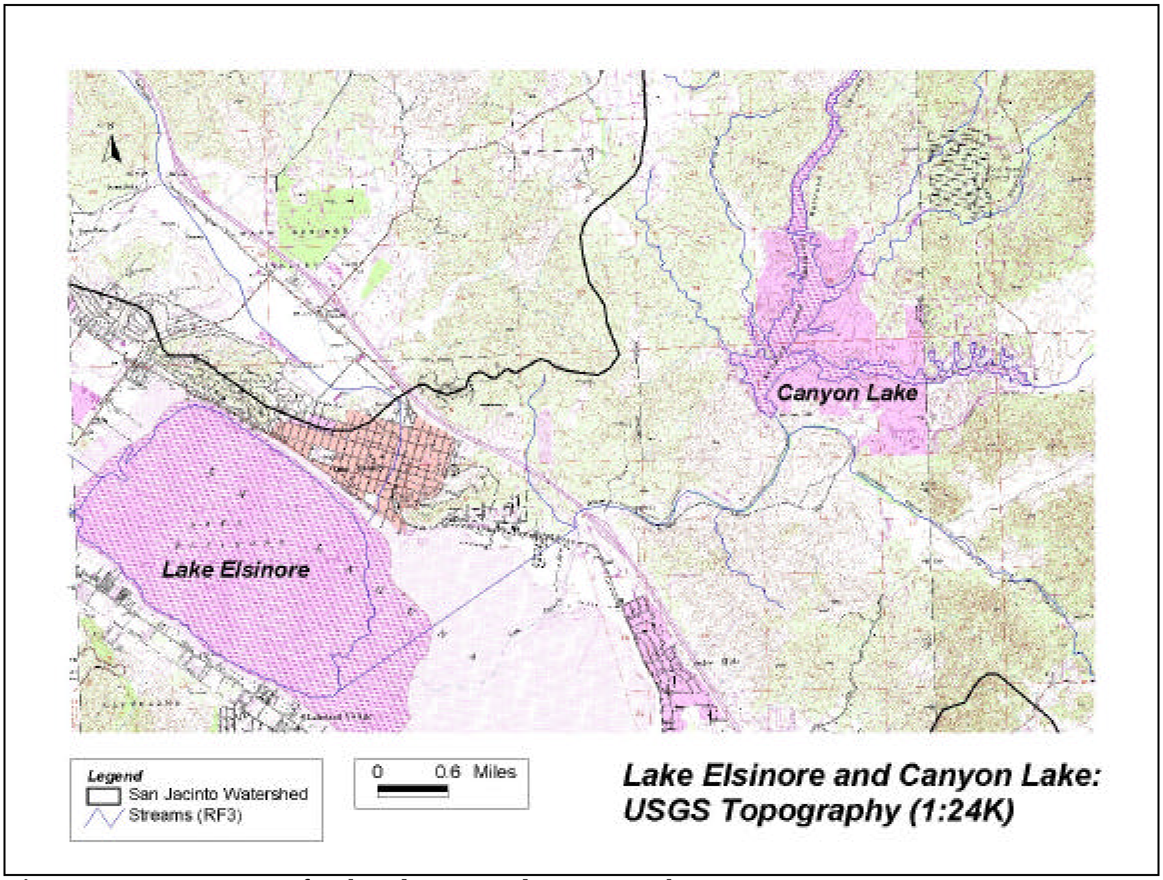

Figure 2-11. Locations of Lake Elsinore and Canyon Lake


Figure 2-12. Canyon Lake dam – facing southeast

The modeling efforts described in the Nutrient Source Assessment (Tetra Tech, Inc., 2003) incorporated a detailed study of the water budget of Canyon Lake and its impact on Lake Elsinore. This effort ultimately used Canyon Lake historical water surface elevation measurements, which display significant seasonal fluctuations (Figure 2-13), to predict flows in the reach of the San Jacinto River downstream of Canyon Lake (measured by USGS gage 11070500, Figure 2-11) and inflows to Lake Elsinore. The historical water surface elevations of Canyon Lake emphasize the flow patterns of the San Jacinto River. The lake fills quickly during the wet season and the water level declines slowly over time during the normal to dry periods.

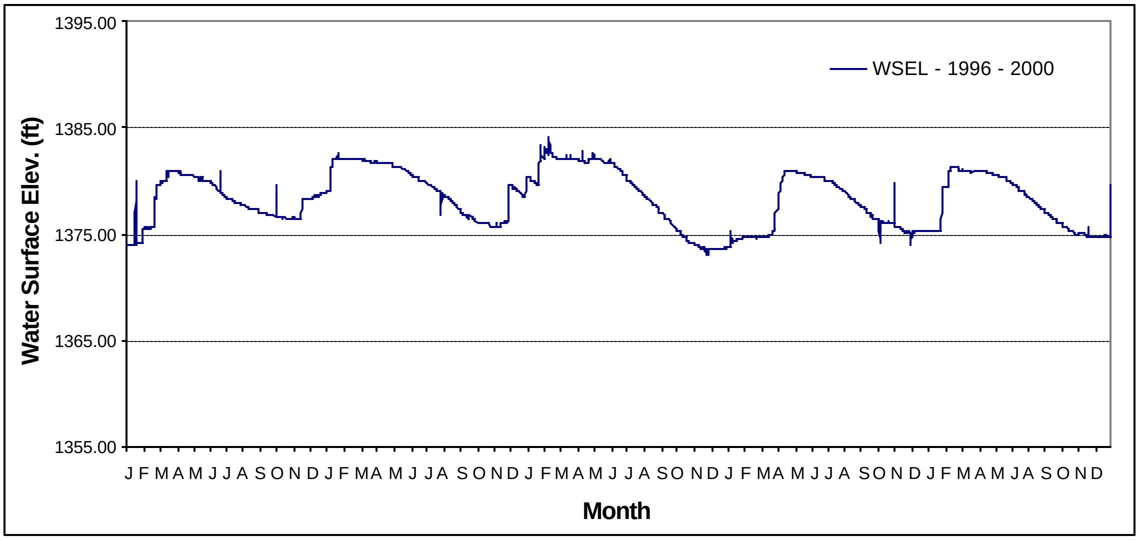

Figure 2-13. Historical Canyon Lake water surface elevations

2.5.7 Lake Elsinore

Lake Elsinore is approximately 3 miles downstream of Canyon Lake at the bottom of the San Jacinto River watershed (Figures 2-11 and 2-14). Surface flow from the San Jacinto River watershed reaches Lake Elsinore only through release, overflow, or seepage from the Canyon Lake dam. Lake Elsinore acts much like a sink, with almost nonexistent outflow. In rare situations, including torrential rains and extended rain periods, the lake overflows into Temescal Creek, which ultimately drains to the Santa Ana River (Santa Ana RWQCB, 1995).

Figure 2-14. Lake Elsinore

2.6 Land Cover and Usage

Hydrology, habitat, and nutrient sources in the watershed are affected by land use and vegetation in the watershed. These characteristics are discussed fully in the following sections.

2.6.1 Land Cover

Annual grasses and small shrubs dominate the natural vegetation in the lowland areas of the San Jacinto River watershed, while the vegetation in the foothills include drought-tolerant evergreen species (Figure 2-15). The mountain ranges consist of coastal sage scrub vegetation with Jeffery and Ponderosa pine trees above 5000 feet. Oak and cottonwood trees are present in both canyons and the riparian corridors within the watershed (RCD, 2002).

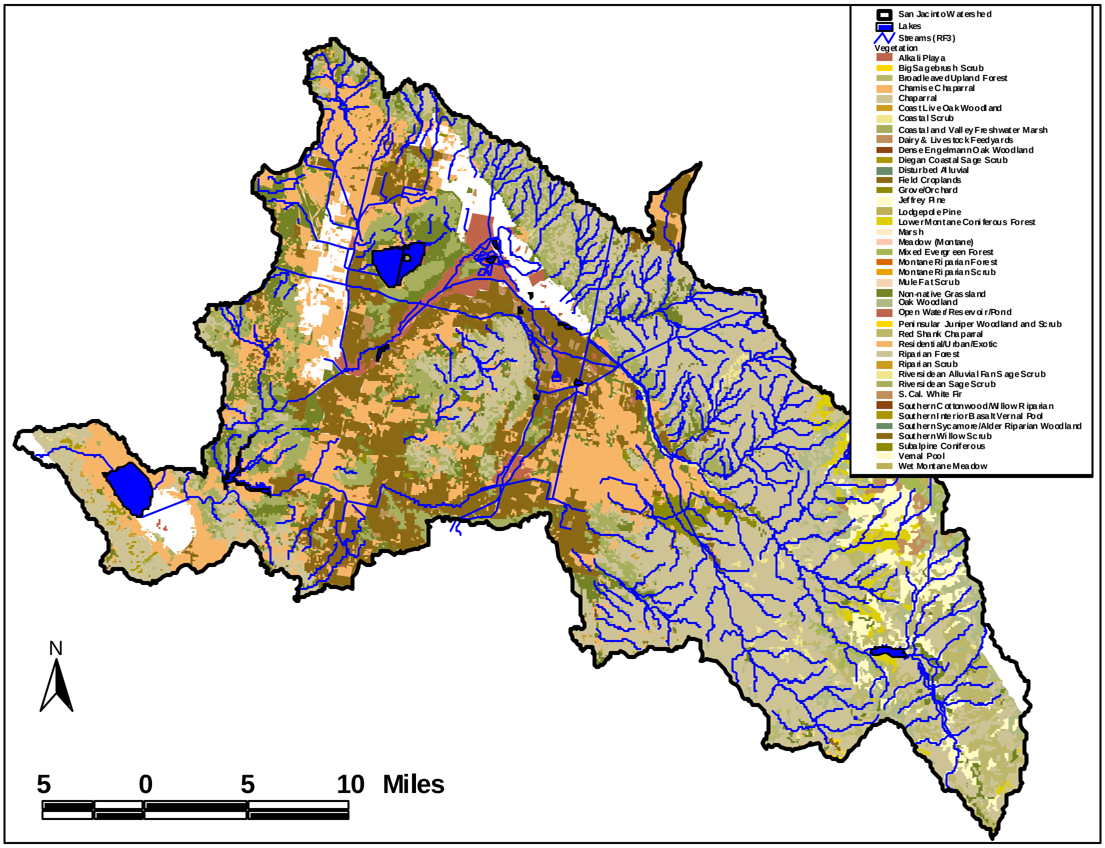

Figure 2-15. The distribution of vegetation types throughout San Jacinto River watershed

Riparian corridors as well as the open space foothills and mountains are important habitat for wildlife in the San Jacinto River watershed. Such habitat supports deer, quail, fox, ground squirrels, and various raptors. In addition, local lakes and reservoirs provide food and habitat for wintering raptors and migrating waterfowl (RCD, 2002). Stephen's kangaroo rat (SKR), which is on the federal endangered species list and the California threatened species list, can also be found in the foothills (U.S. Fish and Wildlife Service, 2003).

2.6.2 Land Use

To assess the land use of the San Jacinto watershed, the USGS Multi-Resolution Land Characteristics (MRLC) 1993 data was combined with supplemental data collected by the Eastern Municipal Water District (EMWD) providing a more detailed coverage of the land use (Figure 2-16) (Tetra Tech, Inc., 2003). Land use in the watershed is predominantly agricultural and residential in the valleys and open in the headwaters. Overall, 73.8 percent of the watershed is open, 18.2 percent is agriculture, and 7.95 percent is urban (Table 2-9).

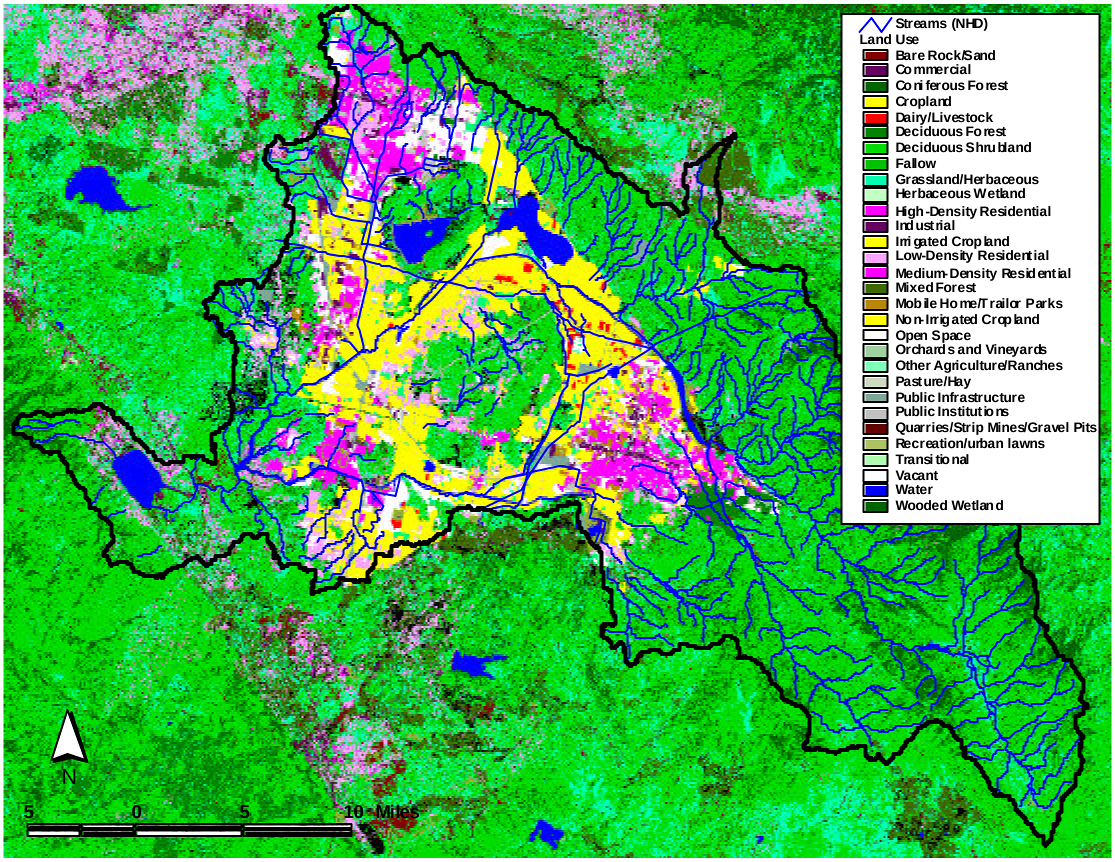

Figure 2-16. Land use in San Jacinto Watershed

Table 2-9. Land use distribution in the San Jacinto River watershed

Land Use Type	Area (acres)	Percent of Watershed
Urban	17,078	3.5%
High-Density Residential	1,998	0.4%
Mobile Home/Trailer Parks	2,231	0.5%
Medium-Density Residential	21,311	4.4%
Low-Density Residential	28,546	5.8%
Cropland	77,065	15.8%
Pasture/Hay/Ranches	10,612	2.2%
Orchards and Vineyards	4,456	0.9%
Dairy/Livestock	1,558	0.3%
Forest/Shrubland/Orchard	306,262	62.8%
Water	12,936	2.7%
Open Space/Bare Rock	4,001	0.8%

2.7 Nutrient Source Overview

Nutrient contributions to the San Jacinto River system are dominated by nonpoint sources. These sources are extremely variable in location and contribution processes, and require detailed analyses for quantification. Nutrient sources are highly influenced by management practices, such as best management practices (BMP's) and land use practices, that can contribute, influence, or inhibit the transport of nutrients from the land surface (e.g., fertilizer application).

In addition to surface transport mechanisms, other potential mechanisms for nutrient loading include discharges from failing septic systems, unimpeded access of cattle to streams, and unsolicited discharges. Although the latter two have not been identified as issues in the San Jacinto River watershed, septic systems are potential sources and will be discussed further in this document.

2.7.1 Agricultural Areas

Potential nutrient sources identified in agricultural areas of the San Jacinto River watershed include cropland, pastureland, and dairies. These sources are typically influenced by management practices specific to each land use.

2.7.1.a Cropland

Stormwater runoff from croplands and resulting nutrient loads due to fertilization are highly influenced by crop type (Figure 2-17). The location and area of croplands (including orchards and vineyards) are available in the MRLC and EMWD land use datasets. However, no comprehensive information regarding the spatial variability of individual crop types is currently available. Common crops in the watershed are grapes, orange trees, turf, and alfalfa. Much of the cropland identified can remain idle and unused for extended time periods.

Fertilizer application in the San Jacinto River watershed can have direct effects on nutrient loading from these areas. Fertilizer applied to cropland accumulates on the land surface where it is available for runoff and delivery to watershed streams during storm events. The amount of nutrient loading from fertilizer application depends on the quantity and frequency of land application, as well as the nutrient content of the fertilizer. Additionally, areas that practice land application of animal manure impact nutrient loading in the watershed as a result of runoff from these areas (Figure 2-18). Manure spreading can potentially contribute large quantities of nutrients to watershed lands and subsequently to receiving waterbodies.

Figure 2-17. Cropland in the San Jacinto River watershed

Figure 2-18. Land application of manure in the San Jacinto River watershed

2.7.1.b Dairies

A large number of dairy facilities, operated as Concentrated Animal Feeding Operations (CAFOs), are located in the middle portion of the San Jacinto River watershed, in close proximity to the river (Figure 2-19). Based on the 1998 EMWD land use data, approximately 1,585 acres are designated as dairy/livestock. Based on data from January 2001, there are 34,327 milking cows; 6,254 dry cows; 16,070 heifers; and 6,121 calves in the San Jacinto River watershed (personal communication with Cindy Li, RWQCB).

Storage facilities that process wastewater from dairy and animal feeding operations must be designed to contain all process-generated wastewater plus the runoff from a 25-year, 24-hour rainfall event (Figure 2-20) (Title 27, Chapter 7, Subchapter 2, Article 1, Section 22562(a), California Code of Regulations and 40 CFR Part 412). Whether current and historical operation and design of these facilities meet this criterion is unknown. During large or frequent storm events, these facilities have the potential to overflow and contribute untreated animal waste to the San Jacinto River. Such spillages would be characteristically high in nutrient concentrations, resulting in significant nutrient loading.

CAFO wastewater storage facilities can also affect nearby streams through contamination of groundwater resulting from infiltration of wastewater. Although no data is currently available to quantify such influences, estimates for infiltration and wastewater concentrations can be made using literature values and model calibration to provide a reasonable estimate of such contributions. Estimates of nutrient loads from CAFOs were provided in the Nutrient Source Assessment and are reported in Section 3.1.1.

Figure 2-19. Dairy feedlot in the San Jacinto River watershed

Figure 2-20. Agricultural BMP in the San Jacinto River watershed

2.7.2 Urban Areas

Urban areas are characterized by unique management practices and surface attributes that must be understood before inferences can be made regarding their respective contributions of nutrients to the San Jacinto River, Canyon Lake, and Lake Elsinore. The following sections discuss several factors that can influence the nutrient loadings from urban areas.

2.7.2.a Population

The population density of an urban area is a good indicator of potential nutrient loading. For different densities, the relative contribution of various nutrient sources (e.g., fertilization of urban lawns; pets) differs. Population densities can be estimated from the MRLC and EMWD land use data; for each specific land use, information regarding the population is often used as criteria for classification. For example, Figure 2-21 depicts a typical urban area in Hemet with land use described by the EMWD dataset. The EMWD land use designated as Low Density Residential (LDR) assumes that 0 to 4 dwelling units (e.g., large lot single-family homes) reside in each acre of area. Likewise, Medium Density Residential (MDR) is defined as an area with a density of greater than 4 but less than 12 units per acre (e.g., small lot single-family homes, apartments). In terms of nutrient loading, relative differences in loadings can often be attributed to the population, with higher loads from more densely populated areas. However, in High Density Residential (HDR) areas, less lawn space and associated fertilizer application could result in less nutrient load than a less populated MDR area.

2.7.2.b Percent Impervious

Urban areas are associated with higher percentages of impervious area resulting from pavement and concrete cover of the land surface. Higher percentages of impervious area result in higher runoff potential due to the reduced ability of water to infiltrate into the ground during rainfall events. As an example, for each urban land use designated in the EMWD land use datasets (Figure 2-21), a percent of impervious area can be assumed (e.g., 90 percent for commercial, 85 percent for industrial). The amount of nutrient loading (export from the land surface) is directly dependent on the volume of available runoff that does not infiltrate.

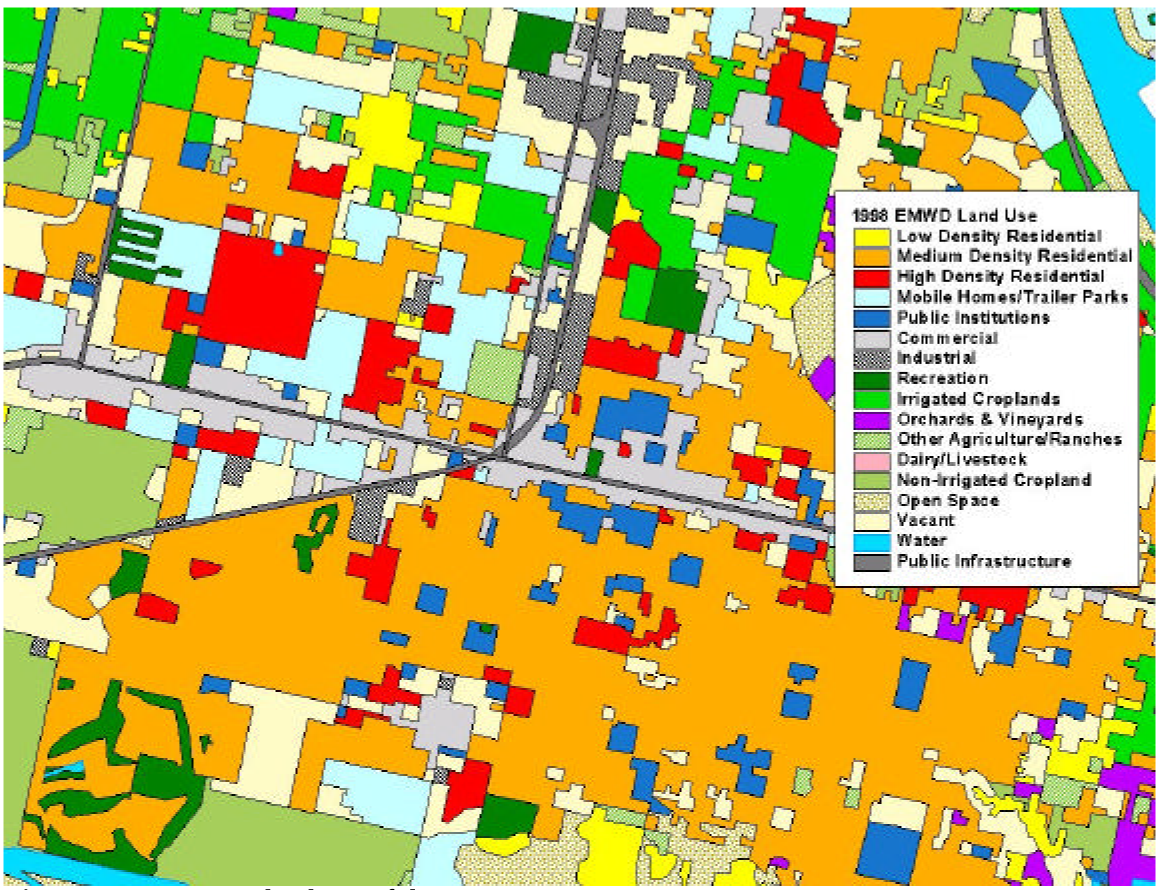

Figure 2-21. EMWD land use of downtown Hemet

2.7.2.c Wastewater Disposal

Although a good portion of the watershed's population is sewered, there are many potential opportunities for contribution of nutrients from human waste to waters of the San Jacinto River watershed. These mechanisms of transport include:

- Direct permitted discharges of treated wastewater to a waterbody
- Unsolicited discharges of untreated wastewater to a waterbody
- Leaking of sewage mains and resulting discharge either directly into a waterbody, or indirectly through groundwater transport
- Groundwater transport of leachate to a waterbody from failed septic systems adjacent to the waterbody

Currently, there are no known direct discharges of wastewater treatment plant effluent to the San Jacinto River, Canyon Lake, or Lake Elsinore. In addition, the impact of unsolicited discharges and leaking sewage mains are not considered an issue in the basin and are not substantiated by any identified datasets. However, septic systems are expected to impact the San Jacinto River watershed, Canyon Lake, and Lake Elsinore. Figure 2-22 shows land parcels in the vicinity of Lake Elsinore and Canyon Lake that use septic systems for wastewater disposal. Several parcels are observed to be relatively close to the shoreline where direct loading of nutrients is possible. Similar analysis of septic system locations throughout the watershed was provided in the Nutrient Source Assessment (Tetra Tech, Inc., 2003). Loading estimates from the Nutrient Source Assessment are reported in Section 3.1.1.

The Clean Lakes Program study of Lake Elsinore estimates an average of 2 to 20 persons per parcel and corresponding wastewater flow of 50 gallons per person per day. The study also assumes that the phosphorus concentration of the untreated domestic sewage was 10 mg/L, assuming no phosphorous removal. Based on these assumptions and an estimate of 350 parcels operating septic systems near the Lake Elsinore shoreline, the total phosphorus loading to Lake Elsinore in 1993 was estimated at 1,900 pounds per year (Black & Veatch, 1994).

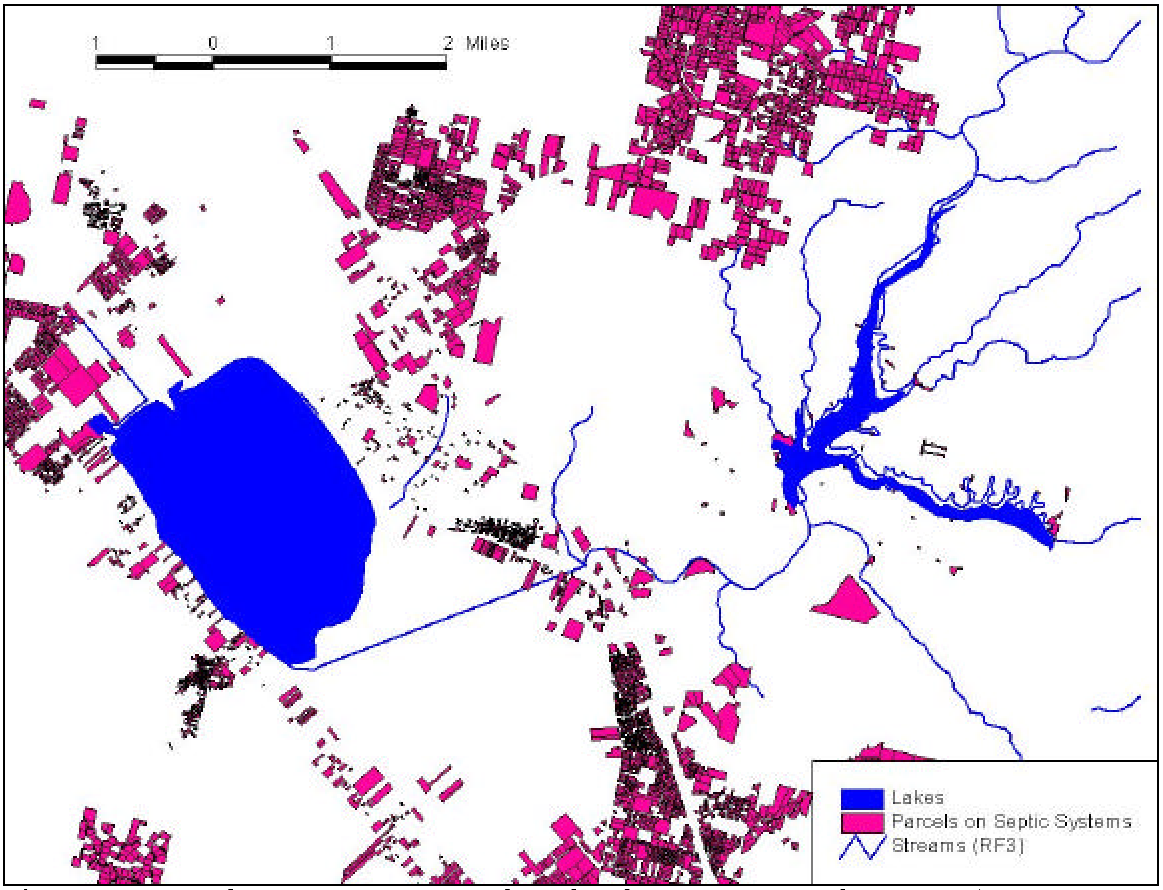

Figure 2-22. Parcels on septic systems in the Lake Elsinore/Canyon Lake vicinity (Source: EVMWD)

2.7.2.d Fertilizer Application

Urban lawns and golf courses are often fertilized to produce vigorous growth. However, fertilizer can cause a considerable buildup of nutrients and additional pollutants on the land surface for subsequent washoff during rainfall events.

3 Pollutant Source Assessment

Several studies have been performed to assess potential sources of nutrients and bacteria to Canyon Lake and Lake Elsinore. To provide the RWQCB guidance in TMDL development, the University of California, Riverside, analyzed potential internal sources and cycling of nutrients and bacteria in Canyon Lake and Lake Elsinore (Anderson, 2001; Anderson et al., 2002; Anderson and Oza, 2003). In 2002, SAWPA coordinated the Nutrient Source Assessment to support management initiatives and development of nutrient TMDL's for the San Jacinto River watershed, specifically, Lake Elsinore and Canyon Lake (Tetra Tech, Inc., 2003). Results of these studies, as well as ongoing work for assessing sources, are discussed in the following sections for both nutrients and bacteria.

3.1 Nutrients

Nutrient contributions to the San Jacinto River system, including Canyon Lake and Lake Elsinore, are dominated by nonpoint sources. These sources are extremely variable in location and contribution processes. Nonpoint sources that contribute loads through surface runoff during rainfall events were predicted using a rainfall/runoff model (Tetra Tech, Inc., 2003). These contributions are highly influenced by management practices, such as BMP's, and land use practices that can contribute to, influence, or inhibit the transport of nutrients from the land surface.

In addition to surface transport mechanisms, other potential mechanisms for nutrient loading include discharges from failed septic systems, unimpeded access of cattle to streams, and unsolicited discharges. Although the latter two have not been identified as issues in the San Jacinto River watershed, failed septic systems have the potential to contribute a significant load of nutrients during wet weather events (Tetra Tech, Inc., 2003).

Once nutrients are delivered to Canyon Lake and Lake Elsinore, they are subject to cycling processes that affect water quality over extended periods. Such processes can have long-term effects as nutrients continue to accumulate in the lake sediments and become available for potential cycling and effects on eutrophic conditions.

3.1.1 <u>Watershed Sources of Nutrients</u>

The Nutrient Source Assessment provides a detailed inventory of the relative nutrient loads to both Canyon Lake and Lake Elsinore from multiple sources throughout the San Jacinto River watershed under various hydrologic conditions. To estimate these nutrient sources and transport to the lakes, a comprehensive modeling system of the watershed was developed. The RWQCB used results of the Nutrient Source Assessment to develop nutrient TMDL's for the lakes. To focus future management efforts and to ensure consistency among the TMDL's and proposed management efforts in the Nutrient Management Plan, the management plan uses the Nutrient Source Assessment as guidance for identifying watershed projects to reduce nutrient loadings (as discussed in Section 4). The following sections summarize the process and results of the Nutrient Source Assessment.

3.1.1.a Analytical Framework

In support of the Nutrient Source Assessment, Tetra Tech, Inc. (2003) developed a modeling system of the San Jacinto River watershed and Canyon Lake. The Loading Simulation Program C++ (LSPC) was used to simulate watershed processes, including hydrology and pollutant accumulation and washoff. For simulation of Canyon Lake and prediction of nutrient loads to Lake Elsinore as a function of overflows of Canyon Lake dam, Tetra Tech, Inc. used a simplified application of the Environmental Fluid Dynamics Code (EFDC). The modeling system was calibrated and validated with instream flow and water quality data collected at various instream stations throughout the watershed from 1991 through 2001, as well as stage data and water quality data collected from four Canyon Lake stations from 1997 through 2000. However, few water quality data were available for a significant wet weather event that resulted in the fill and overflow of Mystic Lake and subsequent transport of nutrients from the upper portions of the San Jacinto River watershed to Canyon Lake and Lake Elsinore. Therefore, the predictive capability of the model during larger storm events was not thoroughly tested.

3.1.1.b Results of the Nutrient Source Assessment

To evaluate nutrient loading characteristics under a variety of hydrologic conditions, the following scenarios were simulated:

- Scenario 1: Mystic Lake and Canyon Lake overflowed (wet year)
- Scenario 2: Canyon Lake overflowed, but Mystic Lake did not (moderately wet year)
- Scenario 3: Neither Mystic Lake nor Canyon Lake overflowed (dry year)

Scenarios 1, 2, and 3 were represented using model results from water years (WY) 1998, 1994, and 2000, respectively (water years extend from October 1 through September 30). The selected model years provided a range of conditions (e.g., extreme wet and dry periods) for evaluating the nutrient load distribution.

The watershed was divided into nine zones for analysis of spatial variability of nutrient sources and transport throughout the watershed. Total phosphorus (TP) and total nitrogen (TN) loads for each zone were estimated from the following sources:

- Cropland
- Dairy/livestock

- Forest
- Urban
- Residential (high-, medium-, and low-density and mobile home/trailer park)
- Open areas
- Orchard/vineyards
- Pasture
- Septic systems
- Canyon Lake load (the load to Lake Elsinore resulting from the overflow of Canyon Lake dam because of upstream wet weather runoff)

Figure 3-1 illustrates the spatial distribution of the zones and their relationship to one another. For the upstream zones (zones 3 through 9), loads represent the total load exiting that zone, including the cumulative loads transported from upstream zones. For zones 1 and 2, loads are reported as contributions to Lake Elsinore and Canyon Lake, respectively. The transport of loads through the zones, and ultimately to Lake Elsinore and Canyon Lake, is influenced by whether Mystic Lake overflows. For the years that Mystic Lake did not overflow (WY 1994 and 2000), only the loads from zones downstream of Mystic Lake contribute loadings to Lake Elsinore and Canyon Lake. For these scenarios, the loads exported from zones 7, 8, and 9 are stored in Mystic Lake and are not exported from zone 7 as Mystic Lake overflow. In addition, the overflow of Canyon Lake affects loads delivered to Lake Elsinore (Zone 1). The Canyon Lake load identified for zone 1 (Lake Elsinore loads) is the load to Lake Elsinore resulting from overflow of the Canyon Lake dam because of upstream wet weather runoff. Total loads for each source, zone, and scenario are presented in Appendices A and B.

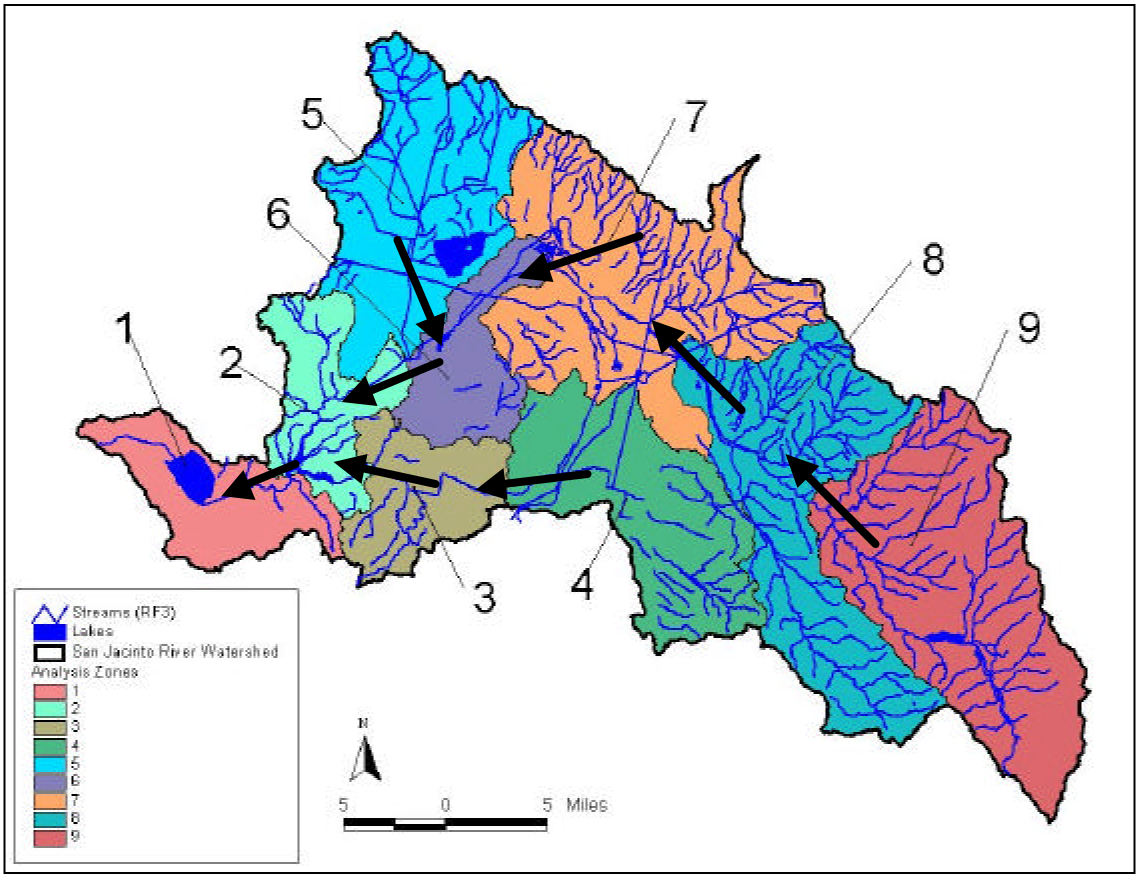

Figure 3-1. Analysis zones for San Jacinto watershed nutrient loads

Results of the Nutrient Source Assessment provide information on the current loads from watershed sources and their relative magnitude—information useful for identifying areas and sources for future management practices. The following discussions provide insight regarding specific sources that can be reduced to substantially decrease overall loads to Canyon Lake and Lake Elsinore.

Cropland – For all scenarios, wet weather runoff from croplands contributed a significant portion of the overall nutrient loads for all zones (see Appendix A). Proportions of nutrient loads to Canyon Lake and Lake Elsinore from croplands for all three scenarios are shown in Table 3-1. For all zones, reductions of nutrients from cropland areas, through either reductions in manure/fertilizer application or use of BMP's that treat runoff from these areas, would result in overall benefits to Canyon Lake and Lake Elsinore.

Table 3-1. Percent of nutrient loads to Canyon Lake and Lake Elsinore from croplands

Nutrient	Total Nitrogen			Total Phosphorus		
Scenario	1 (WY 1998)	2 (WY 1994)	3 (WY 2000)	1 (WY 1998)	2 (WY 1994)	3 (WY 2000)
Canyon Lake	32.7%	33.6%	32.2%	48.5%	48.8%	54.1%
Lake Elsinore	10.0%	20.0%	20.4%	20.7%	36.8%	49.2%

Scenario 1: Mystic Lake and Canyon Lake overflowed (wet year).
Scenario 2: Canyon Lake overflowed but Mystic Lake did not (moderately wet year).
Scenario 3: Neither Mystic Lake nor Canyon Lake overflowed (dry year).

Urban/Residential – For dry years (WY 1994 and 2000), runoff from urban and residential areas contribute a significant portion of the overall nutrient loads exported from zones 4 and 5 and local runoff surrounding Canyon Lake and Lake Elsinore (see Figures A-3 through A-6 of Appendix A). It should be noted that the relative proportion of urban/residential loads is primarily the result of higher flows from these areas resulting from impervious land cover and not necessarily higher proportions of nutrient loads to Canyon Lake and Lake Elsinore from urban/residential runoff (see Section 2.5.2). Urban/residential loads for all three scenarios are shown in Table 3-2. BMP's in these areas, particularly in the cities of Moreno Valley, Hemet, Lake Elsinore, Canyon Lake, Perris, and unincorporated areas at the lower portion of Salt Creek at Canyon Lake (Figure 3-2), could provide substantial reductions in nutrients to the lakes.

Table 3-2. Percent of nutrient loads to Canyon Lake and Lake Elsinore from urban/residential areas

Nutrient	Total Nitrogen			Total Phosphorus		
Scenario	1 (WY 1998)	2 (WY 1994)	3 (WY 2000)	1 (WY 1998)	2 (WY 1994)	3 (WY 2000)
Canyon Lake	14.1%	36.6%	24.8%	9.0%	33.1%	21.4%
Lake Elsinore	4.8%	23.6%	25.7%	4.4%	33.2%	22.0%

Scenario 1: Mystic Lake and Canyon Lake overflowed (wet year).
Scenario 2: Canyon Lake overflowed but Mystic Lake did not (moderately wet year).
Scenario 3: Neither Mystic Lake nor Canyon Lake overflowed (dry year).

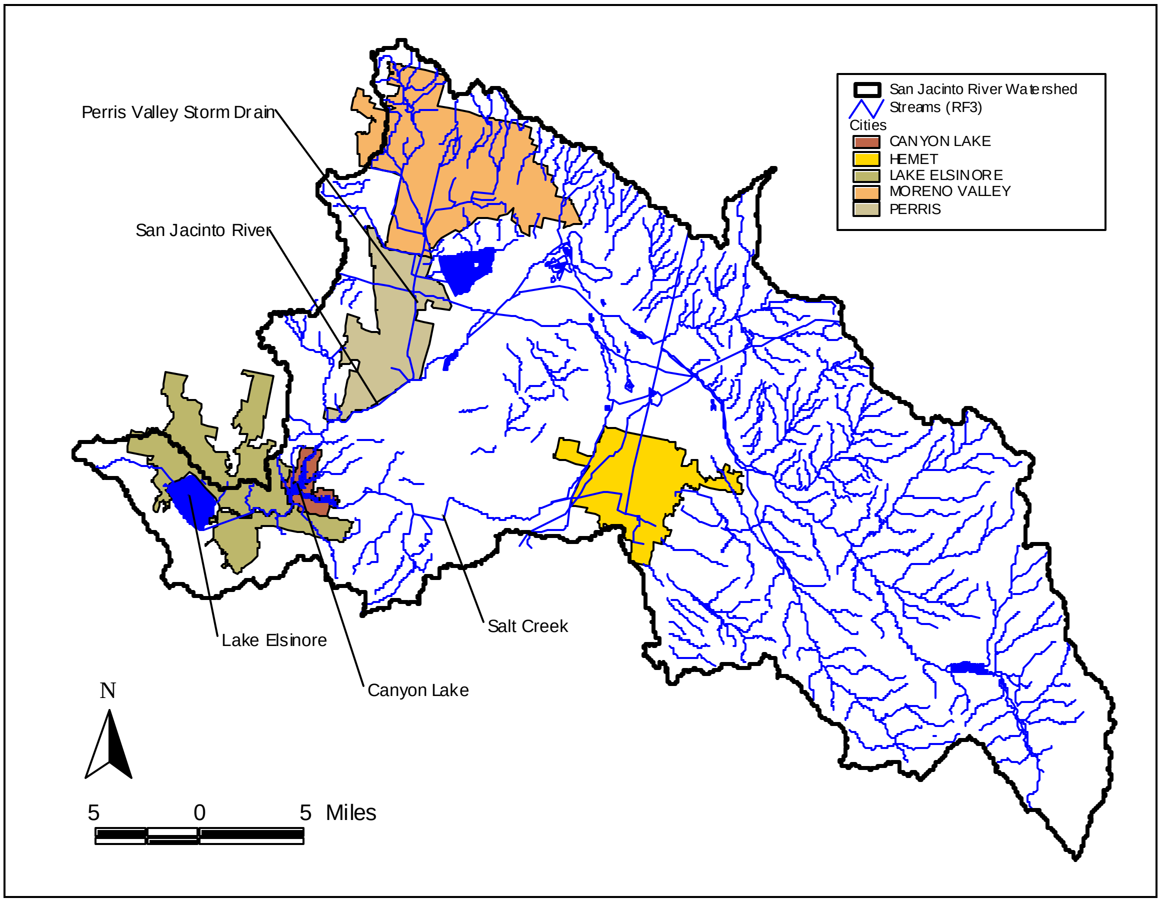

Figure 3-2. Cities in San Jacinto watershed associated with high urban nutrient loads to Canyon Lake and Lake Elsinore

Dairy/Livestock - For very wet conditions when Mystic Lake is full and overflowing, dairy/livestock land uses are relatively large contributors of TN in zones 6 and 7 (see Figures A-1 and A-2 of Appendix A). Proportions of nutrient loads to Canyon Lake and Lake Elsinore from dairies for all three scenarios are shown in Table 3-3. Relative to the proportion of the watershed area used by dairies, percentages reported in Table 3-3 are high compared to the large areas associated with croplands and urban/residential land uses.

Table 3-3. Percent of nutrient loads to Canyon Lake and Lake Elsinore from dairies

Nutrient	Total Nitrogen			Total Phosphorus		
Scenario	1 (WY 1998)	2 (WY 1994)	3 (WY 2000)	1 (WY 1998)	2 (WY 1994)	3 (WY 2000)
Canyon Lake	11.0%	5.7%	4.7%	6.7%	2.0%	1.8%
Lake Elsinore	3.3%	3.3%	2.7%	2.8%	1.4%	1.6%

Scenario 1: Mystic Lake and Canyon Lake overflowed (wet year).
Scenario 2: Canyon Lake overflowed but Mystic Lake did not (moderately wet year).
Scenario 3: Neither Mystic Lake nor Canyon Lake overflowed (dry year).

<u>Failed Septic Systems</u> – For all scenarios, nutrient loads from failed septic systems are estimated to be a significant source of nutrients from populated areas in zones 3, 4, 5, and local areas to Canyon Lake and Lake Elsinore (see Appendix A). Estimated proportions of nutrient loads to Canyon Lake and Lake Elsinore from failed septic systems for all three scenarios are reported in Table 3-4. For most years, the problem areas associated with failed septic systems were identified as local areas to Canyon Lake and Lake Elsinore, specifically an area just north of Canyon Lake known as Quail Valley (Figure 3-3). Because of the local areas' proximity to the lakes, the likelihood is high that nutrients are transported during dry years, as evidenced by the higher proportions shown in Table 3-4 for scenario 3 (typical dry year). Reductions of nutrient loads from failed septic systems can result from public education programs or expansion of sewage collection systems for offsite treatment.

Table 3-4. Percent of nutrient loads to Canyon Lake and Lake Elsinore from failed septic systems

Nutrient	Total Nitrogen			Total Phosphorus		
Scenario	1 (WY 1998)	2 (WY 1994)	3 (WY 2000)	1 (WY 1998)	2 (WY 1994)	3 (WY 2000)
Canyon Lake	25.1%	10.6%	27.4%	6.1%	2.8%	9.5%
Lake Elsinore	8.9%	8.1%	23.5%	2.9%	4.6%	9.1%

Scenario 1: Mystic Lake and Canyon Lake overflowed (wet year).
Scenario 2: Canyon Lake overflowed but Mystic Lake did not (moderately wet year).
Scenario 3: Neither Mystic Lake nor Canyon Lake overflowed (dry year).

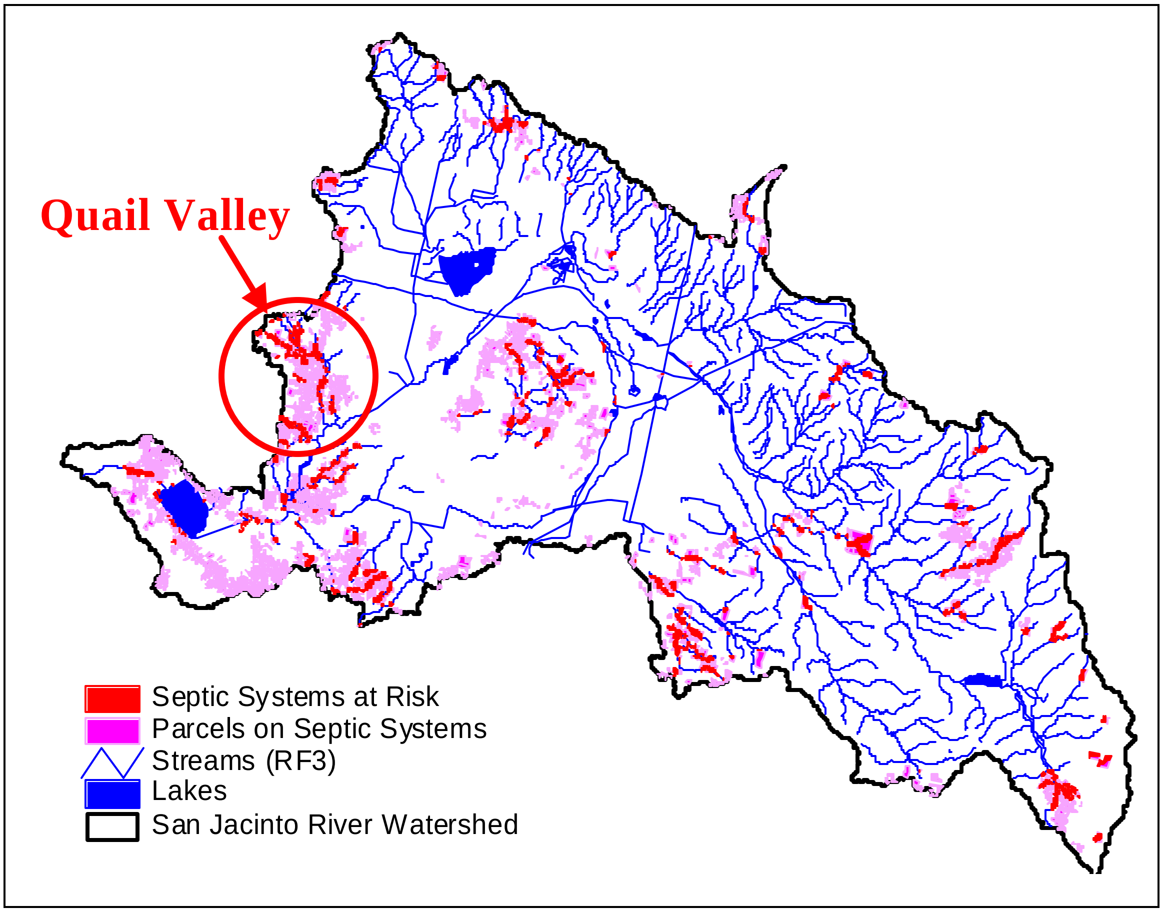

Figure 3-3. Septic systems at risk in the San Jacinto watershed

Forested/Background - It is important to note that although forested (background) sources are reported as the majority of the nutrient loads for zones 8 and 9 during wet periods (see Figures A-1 and A-2 of Appendix A), these loads are primarily the result of large land areas and high stormflows from land uses that are not necessarily due to an active, discernible nutrient source. Moreover, such loads are contained by Mystic Lake under normal flow conditions. No reductions of nutrients from forested/background areas are recommended in the Nutrient Management Plan.

3.1.1.c Model Validation with 2003 Data

For the Nutrient Source Assessment, there were limited data for the range of hydrologic conditions to validate model performance for all three scenarios. Streamflow and water quality data were available throughout the watershed for model calibration and validation during dry conditions, but little or no data were available to validate model predictions during extreme wet events. Such wet events are important to understand, as there exists the potential for transport of water and associated nutrient loads through Mystic Lake from the upper portions of the watershed and to Lake Elsinore from overflow of the Canyon Lake dam.

To provide additional information for model validation, data were collected in spring 2003 for streamflow, instream water quality, and in-lake water quality. However, a wet event meeting the conditions for Mystic Lake to overflow (scenario 1) did not occur. Although additional data for an extreme wet event were not collected, useful information was provided to validate the model for moderate hydrologic conditions. Previously, the only in-lake water quality data for Canyon Lake had been collected in 2000 and 2001, which were dry years when the Canyon Lake dam did not overflow. For 2003, in-lake water quality was available to validate model performance for moderately wet conditions, when Canyon Lake dam overflows but Mystic Lake does not (scenario 2). In addition, flow data were collected at locations not previously monitored, so validation of model-predicted hydrology could be performed at additional locations. Results of the model validation using 2003 data are included in Appendix C.

The 2003 data were useful in overall validation of the watershed and Canyon Lake models, but were not robust enough to support model recalibration given the large amount of long-term data previously used for model calibration and validation for the Nutrient Source Assessment. Instead, model results were compared to 2003 flow and water quality data to qualitatively assess model performance for particular storm conditions, and to identify areas that require further characterization through data collection and model reevaluation in potential future efforts.

Comparison of model results to 2003 data indicates that additional data are necessary to capture the spatial effects of the varying agricultural areas of the watershed. For the watershed model, performance in simulating hydrology and water quality was affected by agricultural areas. Although the model had previously been calibrated and validated to those areas with reasonable success for the Nutrient Source Assessment, conditions in 2003 resulted in poor model performance. Also, impacts seemed to vary depending on location in the watershed. For instance, impacts from agricultural practices seemed to differ between the drainage areas of the Perris Valley Storm Drain and those of Salt Creek. Currently, spatial information regarding crop or management practices in these areas is not available. For this reason, variable impacts cannot be simulated in the current watershed model. In the Nutrient Management Plan an additional study is recommended to collect spatial and temporal information regarding crops and manure and fertilizer application practices in the watershed. These data could be used to provide better resolution of the simulation of these land use practices in the watershed model. In the meantime, current model performance is sufficient for predicting long-term trends in the watershed, as model recalibration, to provide better representation of a single storm event, was not justified.

The lake model used simplified procedures to simulate lake processes. Future projects are planned, however, to update these processes to more detailed, dynamic, multidimensional capabilities. As part of this project, additional data collection is also planned, as a means of providing more representative data of dam overflows, as a function of a rating curve for the dam spillway. This information will be incorporated into the lake model as it is updated. For this reason, the lake model was not recalibrated using 2003 data.

3.1.2 Sources of Nutrients Within Lakes

To support TMDL development by the RWQCB, the University of California, Riverside, performed studies of both Canyon Lake and Lake Elsinore to assess internal cycling of nutrients. The following sections summarize findings from these studies, as well as comparison with results of the Canyon Lake model developed by Tetra Tech, Inc (2003) reported in 3.1.1.

3.1.2.a Canyon Lake

Loads to the Canyon Lake water column from internal sources (e.g., resuspension, atmospheric deposition) were studied by Anderson and Oza (2003) and estimated through field measurements and mass balance calculations for the lake. The internal loads were simulated simplistically through model calibration. Although the model does not provide sufficient resolution for quantification of internal sources of nutrients under various hydrologic conditions, it does provide general insight into the potential loads and magnitudes of internal lake sources to Canyon Lake.

The study of Canyon Lake performed by Anderson and Oza (2003) included:

- Characterization of sediment
- Measurement of nutrient flux rates from the sediment to the water column
- Measurement of the settling rate of particulate-bound nutrients from the water column to the sediments
- Development of an overall nutrient budget for the lake.

Data collection was performed in 2001 and 2002 during a characteristically dry year with limited watershed runoff. The study results indicated that internal nutrient recycling was the greatest source of nutrients over the study period (Anderson and Oza, 2003); however, the results are not representative of loading during a wet year when increased surface runoff would deliver greater watershed loads.

Sediments were classified as sandy sediments (Type I), silt (Type II), and fine, organic sediments (Type III). Release rates of soluble reactive phosphorus (SRP) and ammonium (NH_4-N) from Type I, II, and III soils were determined (Table 3-5). Based on averages of area-assigned release rates for each soil type, flux rates could be estimated for the East Bay and main body of Canyon Lake; they are also listed in Table 3-5. Release rates were comparable to rates determined through calibration of the Canyon Lake model developed by Tetra Tech, Inc. (2003), with total phosphorus and total nitrogen release rates of 20 and 25 mg/m^2/day, respectively.

Table 3-5. Nutrient release from Canyon Lake sediments

Sediment Type	SRP ($mg/m^2/day$)	NH4-N ($mg/m^2/day$)
Type I	6.3	22.7
Type II	15.1	34.8
Type III	6.5	29.8
Lake Section		
Main Body	133	34
East Bay	159	42

Source: Anderson and Oza, 2003.

Settling of particulate-bound nutrients varied by season and depth in the lake. In general, particulate nitrogen sedimentation rates were about four times greater than those for phosphorus. Seasonal trends in rates were not clear, so rates were summarized on an annual basis for general mass balance assumptions. Estimated average annual sedimentation rates of particulate-bound nitrogen and phosphorus varied by location in the lake, and they are listed in Table 3-6 (Anderson and Oza, 2003).

Table 3-6. Particulate nutrient sedimentation to Canyon Lake

Sediment Type	P ($mg/m^2/day$)	N ($mg/m^2/day$)
Main Body	133	34
East Bay	159	42

Source: Anderson and Oza, 2003.

Using the estimated internal cycling release and sedimentation rates in the table above, Anderson and Oza (2003) developed an annual nutrient budget for Canyon Lake (Table 3-7). Estimated inputs to the nutrient budget were determined for watershed runoff, atmospheric deposition, and internal loading. For other nutrient inputs, including local nuisance runoff, resuspension, and other sources not quantified, loads were calculated as the difference between estimated inputs and losses. The only loss quantified was sedimentation. For the 2001–2002 study period, internal nutrient loads greatly exceed external loads. It is important to note that the mass balance below is specific to 2001–2002 when conditions in the watershed were dry. A wet year with increased external loads from the watershed would likely result in a very different mass balance for the lake.

Table 3-7. Annual nutrient budget for Canyon Lake

Lake Section	Source/Loss	P (kg/yr)	N (kg/yr)
Main Body	External Load	116	506
	Internal Load	2,685	8,578
	Resuspension/Nuisance Runoff/Unquantified Source	6,461	29,158
	Atmospheric Deposition	144	201
	Sedimentation	-9,406	-38,443
East Bay	External Load	59	179
	Internal Load	1,940	4,971
	Resuspension/Nuisance Runoff/Unquantified Source	4,406	19,140
	Atmospheric Deposition	77	107
	Sedimentation	-6,482	-24,397

Source: Anderson and Oza, 2003.

Anderson and Oza (2003) also developed a steady-state, empirical BATHTUB model (Walker, 1996) of Canyon Lake based on the mass balance assumptions described above. Preliminary investigations using the BATHTUB model determined significant reductions of both nitrogen and phosphorus to improve in-lake water quality.

3.1.2.b Lake Elsinore

To assist the RWQCB in nutrient TMDL development for Lake Elsinore, Anderson (2001) performed a study to assess the internal loading of nutrients to the lake, develop a nutrient budget for the lake, and estimate the lake response resulting from reductions of nutrient inputs. To support this study, data collection of in-lake water quality, soils characterization, nutrient release rates from sediments, and sedimentation rates of particulate nitrogen and phosphorus was performed for 2000 and 2001. However, this study period was specific to typical dry conditions in the region with little surface runoff. Therefore, the results might not indicate conditions during or following rainfall events, when external loads to the lake are greater.

Sediments were classified as sandy sediments (Type I), silt (Type II), and fine, organic sediments (Type III). Release rates of SRP and NH_4-N from each sediment type showed significant seasonal variation (Table 3-8) (Anderson, 2001).

Table 3-8. Nutrient release from Lake Elsinore sediments

Season (6 months)	Sediment Type	SRP (mg/m2/day)	NH4-N (mg/m2/day)
Summer	Type I	1.9	8.0
	Type II	11.0	93.1
	Type III	10.3	91.4
Winter	Type I	0.1	0.1
	Type II	11.8	20.8
	Type III	7.0	25.6

Source: Anderson, 2001.

For each sediment type, flux rates of particulate nitrogen and phosphorus to sediments were measured. No seasonal trends in sedimentation rates were observed, so annual average rates are reported. Sedimentation rates varied depending on type of sediment at each location measured. Table 3-9 lists the sedimentation rates for each soil type (Anderson, 2001).

Table 3-9. Particulate nutrient sedimentation to Lake Elsinore sediments

Sediment Type	P (mg/m2/day)	N (mg/m2/day)
Type I	~0.0	~0.0
Type II	21.3	154.0
Type III	27.7	136.0

Source: Anderson, 2001.

Based on the estimates above, additional estimates of nutrient loads from atmospheric deposition and watershed runoff, and estimated losses of nitrogen due to denitrification, a mass balance of the lake was established by Anderson (2001). Resuspension of nitrogen and phosphorus were calculated through a mass balance of the overall nutrient budgets (Anderson, 2001). The nutrient budget calculated by Anderson (2001) is presented in Table 3-10. It should be noted that this nutrient budget is specific to the study period, which was dry, and is not applicable to other periods of substantial external inputs characteristic of wet conditions.

Table 3-10. Annual nutrient budget for Lake Elsinore

Source/Loss	P (kg/yr)	N (kg/yr)
External Load	626	5,274
Internal Load	33,160	197,370
Resuspension	50,606	269,216
Atmospheric Deposition	108	2,040
Sedimentation	-84,500	-473,900

Source: Anderson, 2001.

The resulting mass balances were used as sources of input for a steady-state, empirical BATHTUB model (Walker, 1986) of the lake to assess the lake response to variations in nutrient loads. The BATHTUB model was used to simulate the lake response to input of recycled water into the lake, and it predicted that limited input of less than a few thousand acre-feet would have a minor impact on in-lake water quality. A larger input of recycled water, however, could have negative impacts. The model also predicted improvements in water quality resulting from management practices that reduce internal nutrient loads, such as lake aeration or addition of alum (Anderson, 2001).

3.2 Bacteria

Canyon Lake is included on the state's section 303(d) list of impaired waters due to bacteria. In support of the RWQCB's effort to develop a bacteria TMDL for the lake, studies for a comprehensive source assessment have been initiated. The following are preliminary results of these studies; the studies are not yet complete. Once the Bacteria Source Assessment is complete for TMDL development, an implementation plan can be developed for management of bacteria sources so that conditions of Canyon Lake are improved. However, specific BMP's outlined in the Nutrient Management Plan (see Section 4) can also potentially provide reductions of bacteria. Verification of these BMP's for control of bacteria sources can be verified with the Bacteria Source Assessment.

3.2.1 Watershed Sources of Bacteria

In 2003, Tetra Tech, Inc., updated the watershed model developed for the Nutrient Source Assessment to simulate two types of indicator bacteria in the watershed (fecal coliform bacteria [FC] and total coliform bacteria [TC]). For model configuration, land use-specific model buildup rates for both TC and FC were obtained from other modeling studies in the region. The buildup rates were originally developed by the Southern California Coastal Water Research Project (SCCWRP) through model calibration to support TMDL development for Santa Monica Bay (Los Angeles RWQCB, 2002). Table 3-11 lists these build-up rates for each land use. Currently, these buildup rates are being used for bacteria TMDL development for the San Gabriel River, Aliso Creek, San Juan Creek, the San Diego River, and multiple beaches in the San Diego region. Use of these calibrated values provides additional confidence in model results because limited bacteria data are currently available for model calibration.

Table 3-11. Land-Use-Specific Buildup Rates for Indicator Bacteria

Land Use	Fecal Coliform (MPN/acre/day)	Total Coliform (MPN/acre/day)
Agriculture	5.00E+10	3.00E+11
High/Medium Density Residential	3.00E+09	6.00E+10
Low Density Residential	6.00E+08	1.50E+10
Open	9.00E+09	8.20E+10
Mixed Urban	6.60E+08	1.20E+10

In 2003, data were collected for TC, FC, enterococcus (ENT), and *Escherichia coli* at six stations on streams and storm drain outfalls in the San Jacinto River watershed. Four of these stations were previously configured for model calibration and validation for the Nutrient Source Assessment (Figure D-1 of Appendix D). The remaining two stations, at storm drains at Fairweather Drive and Roadrunner Park, did not have subwatersheds delineated in the watershed model and subsequently were not used for model calibration. Results of model calibration for TC and FC are shown graphically in Figures D-2 through D-9 of Appendix D. The previously calibrated model buildup rates from the Santa Monica Bay modeling study produced acceptable results compared to the limited bacteria data for the San Jacinto River watershed and the rates were not adjusted further.

Bacteria loads from the watershed were predicted for WY 1994, 1998, and 2001 for analysis of loading conditions resulting from variations in hydrology. Daily loads of FC and TC to Canyon Lake resulting from wet weather runoff for each WY are shown in Figures E-1 through E-6 of Appendix E; annual loads to the lake are listed in Table 3-12.

Table 3-12. Annual Loads (Water Year) of Indicator Bacteria to Canyon Lake

Indicator Bacteria	Loads (MPN/year)		
	WY 1994	WY 1998	WY 2000
Fecal Coliform	2.71E+14	8.85E+14	3.06E+14
Total Coliform	1.44E+15	5.54E+15	1.80E+15

Configuration and calibration of the watershed model is the first phase of ongoing work to develop the bacteria source assessment of the San Jacinto River watershed. Future work will involve validation of the model (if additional data are collected), complete assessment of relative contributions to the overall load from various land uses and watershed sources, and update of the Canyon Lake model for detailed analysis of in-lake bacterial levels and lake response to varying external loading scenarios.

3.2.2 Sources of Bacteria Within Canyon Lake

In 2001 and 2002, Anderson et al. (2002) performed detailed bacteria monitoring at in-lake sites, sites within the watershed, and storm drains discharging directly into Canyon

Lake. Samples were analyzed for FC, TC, ENT, and *E. coli*. The geometric mean of all lake concentrations of FC (858 cfu/100 mL) and TC (8,448 cfu/100 mL) were found to exceed the Basin Plan objectives of log mean FC < 200 organisms/100 mL for water contact recreation (REC-1) and TC < 100 organisms/100mL for municipal and domestic water supply (MUN) (Santa Ana RWQCB, 1995). Additional analysis of data found seasonal, spatial, and depth variations in indicator bacteria levels (Anderson et al., 2002).

In addition to bacteria from wet weather watershed runoff, Anderson et al. (2002) determined that significant sources of bacteria to Canyon Lake during dry periods include bacteria growth within the lake's water column, resuspension of sediments, direct contributions by waterfowl, and nuisance runoff.

4 Nutrient Management Strategy and Recommendations

To remedy observed impairments in the watershed resulting from excess nutrient loads, the Nutrient Management Plan outlines a detailed strategy for nutrient reductions and improvement of the water quality of Lake Elsinore and Canyon Lake. Development of the Nutrient Management Plan included several technical and regulatory considerations, as well as input from watershed stakeholders. The final Nutrient Management Plan consists of a detailed list of nineteen *planned* and *recommended* projects for watershed improvement. Planned projects are those projects already identified and funded to reduce nutrient loads to Lake Elsinore or Canyon Lake, but are still in the planning and early developmental stages. Recommended projects are those projects that require additional study or data for quantifying or refining estimates of source loads or to provide guidance for future management decisions. The final list of projects provides a comprehensive plan to:

- Provide the information necessary for better management of nutrients in the watershed;
- Implement BMP’s to reduce nutrient loads from key sources; and
- Implement BMP’s to improve water quality in Lake Elsinore and Canyon Lake.

Projects are reported in Section 4.2. Sufficient detail for each project is provided to assist stakeholders in project selection.

4.1 Considerations in Strategy Development

Development of a strategy for nutrient management in the San Jacinto River watershed was a multistep process that required assessment of previous studies, input from stakeholders, and modeling analysis. It was determined critical that a Nutrient Management Plan be developed using information and modeling tools utilized for TMDL development so that the recommended strategy is consistent with future goals for the watershed. To guide the decision process for strategy development, an advisory group of LESJWA, consisting of key stakeholders in the watershed, was consulted on a regular basis for input and updates as to the progress of the project. Utilization of previous modeling tools and studies, combined with consultation from local experts and stakeholders for guidance, resulted in development of a strategy based on the best and most complete information available so that solutions to nutrient impairments in the watershed are scientifically sound and justified. The following sections outline key considerations for development of the Nutrient Management Plan.

4.1.1 Nutrient Source Assessment

To provide information for guidance in development of the Nutrient Management Plan, it was essential that all sources of nutrients and hydrologic and hydraulic features in the watershed were understood. Results of this study were reported in Sections 2 and 3. Interpreting results of the Nutrient Source Assessment was necessary for identification of key nutrient sources that require reductions to improve conditions of the watershed. Nutrient sources were categorized by type (e.g., agriculture, urban, failed septics) and location in the watershed, so that specific remedies could be prescribed. Where possible, recommendations in the Nutrient Management Plan referenced results of the Nutrient Source Assessment to provide technical and scientific support. Such detail will assist in final selection of recommended projects by watershed stakeholders and illustrate a firm basis and justification when seeking potential funding opportunities.

4.1.2 Regulatory Drivers

Following completion of the Nutrient Source Assessment, the RWQCB began development of nutrient TMDL's for Lake Elsinore and Canyon Lake. Simultaneously, LESJWA began work on development of a Nutrient Management Plan. However, completion of the Nutrient Management Plan precedes release of the RWQCB's nutrient TMDL's, so consistency with the TMDL's required consultation with RWQCB staff throughout strategy development. Utilizing results of the Nutrient Source Assessment, which was also utilized by the RWQCB for TMDL development, the Nutrient Management Plan was assured to be consistent with these TMDL's. Likewise, the RWQCB is interested in findings of the Nutrient Management Plan for guidance in development of an implementation plan required for the TMDL's. As a result, the Nutrient Management Plan is directly related to RWQCB policy and decisions, with input from RWQCB staff critical in strategy development.

4.1.3 Stakeholder Involvement

The process for developing an effective Nutrient Management Plan required cooperation and utilization of all stakeholders within the watershed. To best receive input from various groups representing unique interests in the watershed, an Advisory Group of the San Jacinto Watershed Council was formed. The Advisory Group met monthly for an 8-month period and reviewed task work products such as existing TMDL data, results of the Nutrient Source Assessment, and results of modeling analyses for input and comment. In these meetings, various modeling scenarios were discussed to provide insight and guidance regarding selection of pollution control measure in the watershed.

During project development, the Advisory Group decided to emphasize efforts less on modeling analysis, and more on identification of key projects to better manage and control nutrients in the watershed. As a result, detailed discussions followed as a way of identifying planned and potential projects in the watershed. To simplify this process, projects were divided into categories specific to the type of project and source of nutrients (see Section 4.2). This categorization encouraged selection of projects to address multiple sources and nutrient reduction techniques, rather than focusing recommendation on a select few sources. Moreover, representative participants of the Advisory Group could focus their input on potential solutions to specific problems, rather than the overwhelming task of figuring out how to remedy the nutrient problem of the entire watershed.

From these discussions, a key list of potential projects was developed and approved by the Advisory Group. Once approved, the remainder of the strategy development process was focused on research and definition of the projects identified. To provide necessary guidance on projects, select stakeholders were contacted on an individual basis so that local expertise could be utilized for development of the projects in the Nutrient Management Plan.

4.2 Nutrient Management Project Recommendations

Results of the Nutrient Source Assessment and input from the RWQCB and stakeholders set the stage for development of the Nutrient Management Plan. At the request of the Advisory Group, recommendations of the Nutrient Management Plan are reported as a list of key projects to address specific nutrient sources and processes in the watershed. This project list can assist stakeholders and the RWQCB in selection of priority projects for development of a comprehensive implementation plan to improve conditions in the watershed and remedy water quality impairments of Lake Elsinore and Canyon Lake.

To guide the process of project identification needed to address multiple nutrient sources and processes in the watershed, projects were identified as Lake Projects or Watershed Projects. For Lake Projects, specific projects were outlined for both Lake Elsinore and Canyon Lake to:

- Collect additional data for guidance in future planning
- Study specific in-lake processes to provide guidance for future planning and BMP design
- Implement BMP's to remedy water quality impairments

Watershed Projects were categorized by specific issues in the watershed, including source of nutrients (i.e., urban, agriculture), physical features (i.e., stream hydraulics, Mystic Lake), data collection, and overall nutrient management (i.e., pollutant trading model). Watershed Projects were identified to:

- Collect additional data for guidance in future planning
- Study nutrient loading characteristics to provide guidance for future planning
- Implement BMP's to reduce nutrient loads from the watershed

The final list includes four projects for Lake Elsinore, four projects for Canyon Lake, and eleven projects specific to the watershed. This results in a total of nineteen projects outlined in the Nutrient Management Plan.

4.2.1 Lake Elsinore and Canyon Lake Projects

Current projects are planned and funded for Canyon Lake and Lake Elsinore to improve in-lake water quality. Additional projects are recommended for both Lake Elsinore and Canyon Lake to provide better understanding of the lakes and implement specific BMP's to improve water quality. The following sections outline these projects.

4.2.1.a Planned Projects for Lake Elsinore and Canyon Lake

Four projects are currently planned by LESJWA for reduction of nutrient levels and improvement of water quality in Lake Elsinore and Canyon Lake. The success of each BMP in improving lake conditions will require assessment before other BMP's are considered. Studies to assess relative impacts of these BMPs are recommended in Section 4.2.1.b. Planned projects include:

1. Lake Elsinore In-Lake Nutrient Treatment
2. Aeration of Lake Elsinore
3. Aeration/Destratification of Canyon Lake
4. Dredging of Canyon Lake

The following are detailed summaries of each project, including the background, goals, overview, schedule, and where available, estimated costs.

Project 1: Lake Elsinore In-Lake Nutrient Treatment

Project Background

Lake Elsinore, the terminal point of the San Jacinto River watershed, has experienced eutrophic conditions due to excess loads of nutrients to the lake. As a result, the lake has been listed as impaired by the RWQCB and required TMDL development (see Sections 2 and 3). Results of the TMDL suggest reductions of external nutrient loads to the lake, however, in-lake nutrient removal is also a potential method to improve lake water quality.

Throughout its history, Lake Elsinore has been susceptible to flooding and drought depending on the climate conditions. The lake loses an average of 14,500 acre-feet (AF) a year to evaporation, dropping the surface level more than 4.5 feet a year. In the last 70 years, average annual inflow to the lake exceeded 14,500 AF only 13 times (LESJWA, 2002c). Management criteria established the objective of a minimum water surface elevation of 1,240 feet above sea level. At the current surface elevation of 1,237 feet, the lake covers 2,896 acres with an average depth of 10 feet and a maximum depth of 14 feet. Current lake volume is 29,800 AF. The lake edges slope gently; so dry years result in extensive zones of unsightly exposed lake bottom sediment and dead vegetation. The fluctuating lake level prevents development of the shoreline, hinders visitor access and excludes natural methods of lake cleanup involving the growth of rooted vegetation in shallow water (LESJWA, 2002c).

A possible alternative to sustain lake levels is through augmentation of lake volume with reclaimed water and pumped groundwater equal to the amount of water that evaporates each year. However, significant amounts of nutrients are added to lake with the addition of recycled water that may cause undesirable effects. Use of recycled water for augmentation of lake volume should not be counterproductive to the nutrient TMDL program. Addition of reclaimed water would require assessment of the RWQCB regarding impacts to TMDLs and minimum nutrient levels of treated effluent. Currently, there are no NPDES permit limitations specific to nutrient concentrations in discharge. To offset the additional nutrient load from recycled water and to prevent further impacts to an already impaired waterbody due to excessive nutrient loads, in-lake nutrient removal has been suggested for study.

Project Goal

LESJWA has initiated a study to determine nutrient removal alternatives that will reduce the nutrient loading that result in water quality impairments of Lake Elsinore. Proposed alternatives are specific to manageable reductions in nutrient loads, rather than source control of nutrients in the watershed as recommended in the TMDL. The final report for the nutrient removal program should provide LESJWA with a program that can be implemented in phases, as funding becomes available, to manage the nutrients in the lake (LESJWA, 2002c).

Project Overview

The present study provides characterization of supplemental water used to augment Lake Elsinore levels, analyzes alternative in-lake treatment options to address nutrient levels in the lake, and provides LESJWA with recommendations for future planning. Upon completion of this study, LESJWA will select a nutrient removal alternative for implementation. To date, LESJWA is in the process of narrowing down potential alternatives for final selection.

Two sources of supplemental water were studied as a potential supply to augment and maintain lake operating levels and achieve water quality goals: groundwater and reclaimed water. Groundwater is available from three existing wells owned and operated by the EVMWD. Reclaimed water is available from two wastewater treatment facilities owned and operated by EVMWD and EMWD.

Thirteen alternative treatment projects have been identified for Lake Elsinore as part of this study. Each of these alternatives was designed to treat the worst-case scenario for the delivery of 13,800 AF of supplemental water provided primarily by reclaimed water. Once the thirteen project alternatives were developed, the construction cost, capital cost, and annual O&M cost for each alternative were estimated. A workshop was conducted with project stakeholders to develop the evaluation criteria categories and assign weighting criteria for primary and secondary evaluation criteria categories. A decision analysis model was then developed to calculate the benefit of each project alternative based on the primary and secondary evaluation criteria and the ranking of the project alternatives against the secondary criteria.

Project 2: Aeration of Lake Elsinore

Project Background

Lake Elsinore is a eutrophic, warm polymictic lake. This means that the lake experiences repeated cycles of water column stratification and destratification during the year, and is without winter ice cover. Its eutrophic condition is sustained by a high rate of nutrient recycling and release from sediments, especially phosphorus that is usually limiting. When dissolved oxygen (DO) at the deep water, mud-water interface approaches or reaches zero, phosphorus is released from the sediments into the water. Researchers studying this lake have found that phosphorus release rates were much greater during summer months than during the winter, and concluded that internal Phosphorus recycling was the primary source of phosphorus maintaining Lake Elsinore in a eutrophic condition (Fast, 2002).

Fish kills are one of the primary concerns at Lake Elsinore; three major fish kills have occurred at Lake Elsinore between 1990 and 1996. One hypothesis for the fish kills is associated with more intense stratification during summer months, followed by DO depletions throughout the water columns as the lake destratified. Fast (2002) suggests that calm weather of one to two weeks' duration during the summer could result in stable thermal stratification and DO depletions to 0 mg/l below 2 to 3 meters depth.

Fish kills at Lake Elsinore were almost certainly caused by DO depletions in virtually all cases, given the time of day when the kills began, and the pattern of fish deaths. When Lake Elsinore stratifies, and DO is depleted in deep waters, fish and other biota are forced into shallow waters. This creates several problems including (Fast, 2002):

- It results in increased predation on larger zooplankton by threadfin shad and young fishes of all species. Large zooplankters graze more efficiently on phytoplankton (algae) then do small zooplankters. This increased predation on large zooplankton reduces grazing on algae, resulting in greater algal densities, greater instabilities in algal populations, and increased likelihood of oxygen depletions that result in fish kills.
- Midges and certain other benthos that can tolerate zero DO for prolonged periods are not fed upon by fishes when DO is low at the mud-water interface. This may result in excessive population increases of these organisms, and nuisance emergence of adult midges that can be very unpleasant for recreationalists.
- Forcing fish into shallow water during deep-water DO depletion increases predation on fishes by piscivorous birds.

Project Goals

The overall objectives of the Lake Elsinore restoration project are to prevent fish kills, reduce algal densities, and improve the recreational and aesthetic uses of Lake Elsinore. According to Fast's (2002) report to LESJWA and SAWPA, there are a number of possible approaches for preventing oxygen depletions in Lake Elsinore. Reducing algal densities, maintaining healthy algae, and preventing prolonged stratification are some of the more important approaches. As discussed previously, transient thermal stratification and DO depletions in bottom waters are responsible for increased phosphorus releases from bottom sediments. If the lake can be artificially mixed or aerated and artificially destratificated, surface waters with high DO can be mixed into deep waters with low DO, preventing DO depletions at the mud-water interface (deep waters), and sediment Phosphorus releases could be reduced along with algal densities. This reduces the likelihood of upwelling toxicants during turnovers, creating better habitat for zooplankton and fish. Decreasing algal densities should reduce the amplitude of daily DO fluctuations and DO depletions, thereby minimizing the likelihood of massive fish kills (Fast, 2002).

The proposed aeration system is intended to shorten the duration of thermal and DO stratification by reducing thermal differences between the lake's surface and bottom, thus allowing wind action to more easily and thoroughly mix the lake. Fast (2002) states that mixing should include much shorter stratification cycles, and overall increased DO throughout the water column.

Based on subsequent discussions with the Technical Advisory Committee on Feb. 26, 2002, this section will only discuss Fast's preferred alternative, which has greater mixing capacity and should be adequate at all lake water volumes. Fast (2002) recommends a destratification system consisting of a combination of axial-flow water pumps and diffuser air lines. Most of the DO additions to deep water are through redistribution of surface waters rather than oxygen absorption from air bubbles. This system, especially the air injection component should be controlled using temperature/DO sensors in the lake and on-shore controllers to reduce energy consumption.

Fast (2002) states that an air injection rate of less than 1.3 SCFM/A would suffice at Lake Elsinore to reduce periods of thermal stratification. The system consists of axial-flow pump systems that push oxygen rich surface waters downward. This can be referred to as top-down mixing. Although the system would reduce the thermal stratification, sufficient quantities of DO will not be added to Lake Elsinore to prevent fish kills during worse case DO depletions.

Project Overview

The aeration/destratification system (Option C) for Lake Elsinore consists of three components; axial-flow water pumps, air injection from diffuser air lines, and a sensor/control system that will automatically determine ON/OFF operations of the water pumps and air injection. The air injection system consists of two compressor sites located on opposite sides of Lake Elsinore. Six diffuser air lines (4,000 feet each) radiate from each compressor site. The axial-flow pumps are clustered in rafts with four pumps per raft and four rafts total. A total of sixteen, 3-HP axial-flow pumps will be used. An underwater cable will deliver electricity to the rafts and pumps. The last component consists of an in-lake temperature and dissolved oxygen (DO) sensors suspended from two rafts near opposite ends of Lake Elsinore. Temperature and DO will be measured at about 15 minute intervals and sent telemetrically to an on-shore computer for data storage and analysis. This data analysis will determine ON/OFF operations of the water pumps and air compressors (Fast, 2002).

Axial-Flow Water Pump Destratification System

This component consists of 16 axial-flow pumps as described above. Each pump would pump >30,000 gpm (>132 AF/d). At greater lake elevations, pumping rates would exceed 8 days, but should still contribute substantially to lake mixing, destratification and aeration of deep waters. Fast (2002) recommends these 16 axial-flow pumps be clustered in rafts of 4 pumps per raft. This would mean 4 rafts in the lake positioned across a centerline stretching from the south east shore. These rafts should consist of a special float such that each axial-flow pump can be inserted or removed from the raft independent of the other pumps and without disrupting operations. This allows for maximum flexibility in operation and maintenance since one or more pumps can be removed and taken to shore for servicing. (Fast, 2002).

The main disadvantage of these axial flow pumps is that they create potential interference with recreational boaters. However, with proper identification this should not pose a major problem. The main advantages of these pumps are that they are simple, easy to maintain and operate, relatively inexpensive to construct or replace, and operate (Fast, 2002).

Air Injection Destratification System

The air injection system for Lake Elsinore consists of air compressors on opposite sides of Lake Elsinore installed in two on-shore buildings. Each compressor would have at least 6 air lines radiating from the shore from each air compressor (Fast, 2002). Fast (2002) states that because of the large electric consumption of this air injections system, it should only be operated when needed. Also, its ON/OFF operation should be controlled using a sensor and controller system described below (Fast, 2002). If the control system is properly designed and operated, and air injection is operated in conjunction with the axial-flow pumps as described above, Fast (2002) believes that operating times for the air injection system could range from 10% to 20% of the time on an annual basis. This is based on observations that bottom DO in Lake Elsinore was depleted or low about one third of the time (Fast, 2002).

The main disadvantage of the air injection system is the cost to run the air compressor. However, this cost could be reduced through an appropriately designed and operated sensor/controller system. The main advantages of air line destratification are that it is simple, easy to service, and has been widely used for a long time (Fast, 2002).

Automated, Programmable Sensor and Control System for both Air Injection and Axial flow Pump Systems

The air compressors should be operated in an ON/OFF mode controlled automatically using an in-lake sensor array and on-shore controllers. The in lake sensors should consist of temperature sensors at about 3-foot intervals from the lake surface to bottom, and a DO probe just above the bottom of the lake. Sensors should be suspended from a raft, with two sets of sensors and two rafts. Data should be collected on an appropriate time interval (e.g. 15 to 30 min.), and sent via wireless transmission to an on-shore computer. Data should be recorded for later interpretations, and it will be used in real time to make decisions about ON/OFF axial-flow pump and compressor operations. Continuous compressor operation could cost $400,000/yr or more. If operation time can be reduced to 20% or less, substantial yearly savings will result (Fast, 2002).

Project Schedule

The project construction will continue, after funding receives approval.

Project Costs

Capital costs for the destratification system is estimated at $1,800,000, with operation and maintenance costs at $150,000 per year. For the aeration system, capital costs are estimated at $1,300,000, with operation and maintenance costs at $100,000 per year (per communication with SAWPA).

Project 3: Aeration/Destratification of Canyon Lake

Project Background

Canyon Lake (Railroad Canyon Reservoir), a drinking water reservoir, lies approximately 75 miles southeast of Los Angeles and approximately 30 miles south of the City of Riverside, California (LESJWA, 2002b). The lake impounds the San Jacinto River, the main water source for both Canyon Lake and Lake Elsinore (Fast, 2002). Canyon Lake is situated upstream of, and on the main inflow into Lake Elsinore. Since dam construction in 1927, Canyon Lake has acted as an interceptor for sediments, containing phosphorus and other nutrients, heavy metals and other constituents that would otherwise flow into Lake Elsinore from the greater San Jacinto River watershed (LESJWA, 2002b).

Canyon Lake is a highly eutrophic lake with dense algal populations and occasional surface scum of mostly blue green algae (cyanobacteria). There is high sediment loading and internal mixing in this reservoir. The water depths in the deeper portions of the lake allow permanent summer thermal stratification; essentially trapping the algae in the deep water, where it consumes dissolved oxygen. Canyon Lake typically stratifies from about late-February/early-March through late-November/early-December each year. Temporary stratification seems to occur even during winter months. However, the lake is usually mixed top to bottom at times during December-February. During thermal stratification, the lake is divided into three depth zones (Fast, 2002).

As a result of dense algal growths, dissolved oxygen (DO) concentrations are often near or above saturation in the epilimnion (well lit surface zone) during daylight hours, while thermocline (transition zone where temperatures decrease rapidly), and hypolimnion (dimly lit or deep water zone) dissolved oxygen (DO) concentrations are typically at or near zero (0.0 mg/l) during most of the stratified period. DO depletions at depth are the result of algae and other organic material settling and consuming oxygen as they decompose, plus sediment respiration. Phosphorus release from sediments under anaerobic (zero DO) conditions may increase eutrophication through internal Phosphorus loading. As a result of the anaerobic (zero DO) thermocline and hypolimnion in Canyon Lake, fish and other biota are often limited to shallow depths of less than 15 feet during stratification (Fast, 2002).

Anaerobic DO results in higher treatment costs in deep water used for drinking water. Other drinking water quality issues are associated with the presence of soluble iron and manganese, high pH and turbidity, taste and odor, and possible blue-green algal toxicity (LESJWA, 2002b). During these times, the water district must use imported or other water (Fast 2002).

Project Goals

LESJWA proposes to implement an in-lake improvement program for Canyon Lake. The purpose of the program is to improve water quality and the long-term sustainability of the lake. The program contains two main elements, the installation and operation of a deep-water aeration system, and sediment removal in the East Bay via dredging. Lake aeration may reduce available Phosphorus (locking P in the sediments) while at the same time reducing nitrogen levels (Fast, 2002). This section will discuss the proposed lake aeration/destratification system. Later sections will discuss sediment removal in the East Bay of Canyon Lake.

Project Overview

The Canyon Lake Improvement Program includes the installation and operation of an in-lake aeration system, which will be located near the dam. The proposed aeration system will consist of two components: (1) air injection from diffuser air lines; and (2) axial flow water pumps. The air injection system consists of one compressor that would be located in the water treatment plant near the dam. This location within the water treatment plant will provide electrical service to the compressor, a secure location, additional sound reduction and an existing air line extending to the lake. A single air line would extend from the compressor to the lake where it would deliver air to two diffuser air lines (1,300 and 3,600 feet long, respectively), and would extend into the lake along the lake bottom (HDR report).

This system will introduce oxygen into the deeper portions of the lake that is used as a potable water source. This oxygenation process will protect and improve the drinking water supply by limiting the internal nutrient loading of the lake. Limiting the overall nutrient loading and increasing the oxygen levels in the lake will reduce the amount of algae, soluble phosphorus, dissolved organic carbon, and other constituents that reduce the drinking water quality of the lake. As such, overall water treatment costs should be substantially reduced (LESJWA, 2002b; HDR, 2002).

A well mixed condition and artificial destratification would be achieved by a combination of air injection and axial-flow water pumps that should maintain aerobic conditions throughout the water column in the main body of Canyon Lake all year. This hybrid destratification system includes two axial-flow water pumps (3-HP each) and 400-SCFM of air injection from two air-line diffusers (Fast, 2002).

Axial-Flow Water Pumps

As stated previously, two axial-flow pumps should be installed in the closed access area near the dam. These pumps should each consist of one six-foot diameter blade operated using a 3-HP gear motor, similar to those described in detail for Lake Elsinore (Fast, 2002).

Fast (2002) recommends an air injection system consisting of a single air compressor of approximately 400 standard cubic feet per minute (SCFM), operating at about 50 psi from two air line defusers extending from their connection near the water treatment plant upstream into Canyon Lake.

Controls and Operations

Fast (2002) also states that manual control of both the axial-flow pumps and air compressors should suffice. The axial-flow pumps should be operated continuously 12 months per year. The air injection system should be operated continuously from March 1 through October 31 during the first year of operation. At the end of first year's operation, limnological data should be evaluated and consideration given to reducing hours of operation schedule for the air injection system (but not axial-flow pumps) during the second year of operation.

Project Schedule

The project schedule will be determined following approval of funding.

Project Costs

Estimated total capital costs for construction and installation of the aeration system (air injection and axial-flow pumps) are estimated at $400,000 (per communication with SAWPA). Estimated yearly energy operating costs are $35,000, including $30,000 for the air injection system and $5,000 for the axial-flow water pumps. This includes 7 months operation for air injection (mid-March through mid-October) and 12 months' operation for the axial flow pumps. During the first two year's operation, however, air injection should extend from early February through November (Fast, 2002). Additional labor costs will be necessary for minor operation, maintenance and repair of the facilities (HDR report).

Project 4: Dredging of Canyon Lake

Project Background

As stated previously, LESJWA proposes to implement an in-lake improvement program for Canyon Lake. The purpose of the program is to improve water quality and the long-term sustainability of the lake. The program contains two main elements, the installation and operation of a deep-water aeration system, and the removal of all or a portion of accumulated sediments in the East Bay of Canyon Lake via dredging (LESWJA, 2002b and HDR, 2002).

Canyon Lake is divided into three sections that are only slightly interconnected. One section of Canyon Lake is East Bay on Salt Creek, connected to the main lake body through a large culvert. This section of the lake is relatively un-connected with the main body of the lake except during high runoff periods (Fast, 2002).

Canyon Lake has acted as an interceptor for sediments. High sediment accumulation in the shallow East Bay has interfered with boating, and contributes to hydrogen sulfide odors and submerged weed growth. It is estimated that the average annual sediment loading to the East Bay is approximately 17,000 cubic yards (cy), (two to three inches per year of deposition per year), which is over 60 times the rate for a normal lake. This translates to minimum average annual phosphorus loading of 17 tons per year. This sedimentation has contributed to a loss of overall reservoir storage capacity, an increase in total nutrient levels in lakebed sediments, a decrease in overall water quality of the lake, and a reduction in the recreational use of the lake due to the raising of the lake bed. Areas in the East Bay that were previously nine feet deep at low water during a survey approximately ten years ago, are now approximately one foot in depth. Estimates have indicated that more than 500,000 cy of sediment have been deposited into the East Bay over this period (LESWJA, 2002a; LESWJA 2002b).

Project Goals

According to LESWJA (2002b), a five-year phased dredging program of the East Bay is recommended to remove the accumulated sediments. Improvements that will result from the dredging program include the following:

- A one time removal of all accumulated sediments in the East Bay;
- Improve overall reservoir storage capacity;
- Improve water quality by reducing the amount of phosphorus-loaded sediment that drives eutrophication and shallow water nutrient mixing;
- Provide future storage space for additional phosphorus-loaded sediment that will enter the East Bay and Canyon Lake in general;
- Improve water quality for Lake Elsinore by providing upstream storage space for phosphorus-loaded sediment;

- Improve recreational opportunities, including boating and swimming, by restoring deeper water.

Project Overview

In order to provide a more accurate estimate of the amount of sediment that must be dredged, LESJWA initiated a lake bottom sediment coring program within a portion of the East Bay. Using a vibratory drilling rig mounted to a boat, core samples were taken from six pre-determined sites in the East Bay. The cores were drilled to a depth that was estimated to have penetrated the original lakebed. Based upon the sediment-coring program, it was determined that the approximate total volume of sediments within the East Bay area is approximately 225,000 cy (337,000 tons) or 140 acre feet (LESJWA, 2002b; HDR, 2002).

The sediment depths at each sample location were compared to newly developed AutoCad topographic maps that illustrate the original lakebed. These new AutoCad maps have been developed using the original, 1926 Railroad Canyon Reservoir survey map as a base. This comparison was used to provide a revised estimate of the amount of sediment that has been deposited in the East Bay. The amount of sediment to be dredged from the East Bay can also be estimated using the core samples and new AutoCad maps (LESJWA, 2002b).

As part of the coring program, a composite sample of each individual core was also analyzed by standard laboratory procedures to evaluate levels of various constituents that could be contained in the sediments. Total soluble phosphorus contained in the sediment samples was non-detectable. None of the 17 CAM metals that were tested exceeded the State of California limits, and options are not constrained by future handling, storage and ultimate disposal of the dredged material (LESJWA, 2002b).

Preliminary plans include the temporary storage of the dredged sediment on parkland that slopes and drains back into the East Bay. Depending on various material factors including density and stability, saturation limits, grain-size distribution (how fast the material will drain), and levels of various constituents as determined by the analytical testing, storage facilities for the dredged sediment can range from a bare ground storage site, to an lined, engineered site. The analyses of the core material will determine the type of storage facility that will be required for the dredged sediment (LESJWA, 2002b).

Temporary storage of material is necessary in order to allow the dredged material to dry out prior to disposal. A dewatering facility would be constructed to remove excess lake water, which would drain back into Canyon Lake. Once the material has dewatered, it would be hauled off-site to be disposed on in a landfill (El Sobrante) (HDR, 2002).

Approvals, Clearances, and Permits

In the HDR (2002) report, there are potential permits and/or clearances that may be required in association with implementation of the dredging program for the East Bay. These include:

- U.S. Army Corps of Engineers – Clean Water Act, Section 404 Permit: Attaining a permit for the removal and temporary placement of fill material within the jurisdictional boundaries of Canyon Lake.
- California Department of Fish and Game – 1600 Series Streambed Alteration Agreement: Attaining a permit for the East Bay sediment dredging as it will disturb the lakebed.
- Santa Ana Regional Water Quality Control Board – Clean Water Act Section 401 Certification: As the program will require a Section 404 permit, a Section 401 Certification will be required from the RWQCB.

Additional permits regarding temporary placement of material from the East Bay sediment dredging may be required from the City of Canyon Lake (HDR, 2002).

Project Schedule

Proposed program implementation would begin with sediment removal. It is anticipated that this project will begin in June 2004 and last roughly 2 years. Upon completion of the sediment removal, the lake aeration system will be placed in the lake, and will begin operation.

Project Costs

It is assumed that based on the amount of material to be removed, approximately 14,000 truckloads would be required. Depending on the method used for dredging, costs would range from $8 per ton to $12 per ton. Total dredge, dewatering, and transport/disposal costs for Canyon Lake is estimated at $2,500,000 (per communication with SAWPA).

4.2.1.b Recommended Projects for Lake Elsinore and Canyon Lake

Four projects are recommended to measure the success of planned projects outlined in the previous section, measure the success of load reduction BMPs implemented in the watershed, and provide a decision tool for testing of alternative BMPs for future planning. These projects are:

5. Water Quality Monitoring at Lake Elsinore
6. Development of a Dynamic Water Quality Model of Lake Elsinore
7. Water Quality Monitoring at Canyon Lake
8. Development of a Dynamic Water Quality Model of Canyon Lake

To provide the necessary data for configuration of water quality modeling tools recommended in Projects 6 and 8, preliminary monitoring work is recommended. Therefore Projects 5 and 7 are recommended as initial projects for overall tracking of lake water quality and success of planned BMPs, with data collection efforts designed to provide helpful information for water quality modeling projects.

The following are detailed summaries of each project, including the background, goals, overview, schedule, and estimated costs.

Project 5: Water Quality Monitoring at Lake Elsinore

Project Background

Collection of water quality data from Lake Elsinore is an important step in providing information regarding the condition of the lake, necessary data for configuration of predictive water quality models of the lake, assessment of the impact of various best management practices that seek to improve in-lake water quality, and a measure of the overall success of the watershed management plan and implementation plans suggested in the nutrient TMDL. To provide this information, continuation of previous water quality monitoring and lab testing are recommended, as well as collection of specific data for assistance in development of a dynamic water quality model of the lake (see Project 6).

Historic water quality monitoring of Lake Elsinore has been performed in the 1980's and early 1990's by SAWPA, Riverside County Health Department, RCFCWCD, EVMWD, RWQCB, and USEPA. Data from these studies have been utilized in determining the condition of the lake resulting from loadings of nutrients, bacteria, and various organic chemicals and metals, as well as lake dissolved oxygen, temperature, pH, and conductivity (Black & Veatch, 1994).

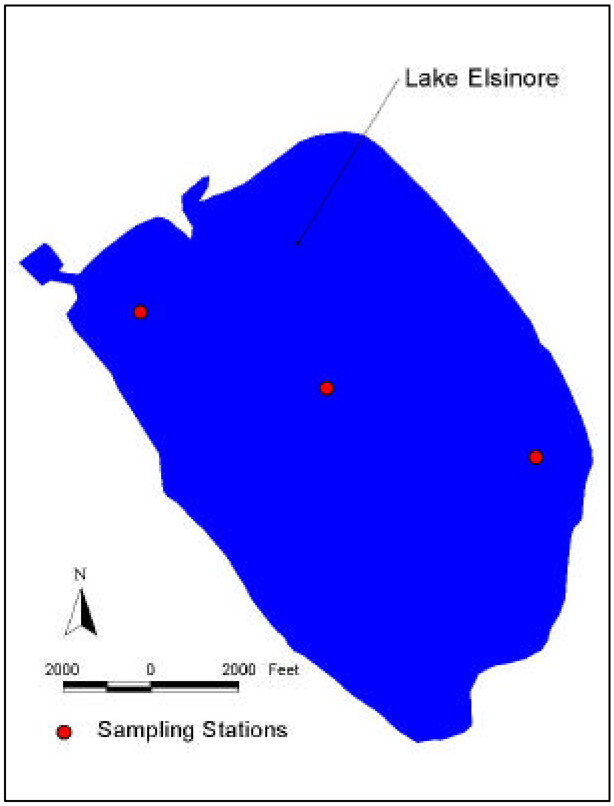

Figure 4-5-1. Lake Elsinore Stations

The University of California, Riverside, has been conducting a water quality and zooplankton monitoring study since June 2002. Results of this study are used to assess the impact of recycled water discharged to the lake.

In 2000, 2001, and 2003, in-lake water quality data was collected at three stations in Lake Elsinore (Figure 4-5-1). These sampling stations have been maintained as part of a TMDL monitoring program of the Santa Ana RWQCB. Data collected from these stations have been utilized for multiple studies involving simplified models of the lake for TMDL projects, as well assessment of in-lake water quality for guidance in future planning and selection of alternative lake management options. Continuation of data collection from these sites will provide useful information regarding variability of in-lake water quality from one year to the next, assess the response of the lake to variable external hydrologic and watershed loading conditions, and provide additional insight regarding internal loading of nutrients within the lake.

At each station, data was collected at three depths: at the surface, at half of the total lake depth, and at the lake bottom. The following constituents were analyzed (depending on station and depth of sample):

- Temperature
- DO
- pH
- Conductivity
- Secchi Depth
- Chlorophyll *a* (at surface)
- Total Nitrogen
- Nitrate
- Nitrite
- Ammonia
- Total Inorganic Nitrogen
- Total Organic Nitrogen
- Total Kjeldahl Nitrogen
- Ortho Phosphate
- Soluble Phosphate
- Total Phosphate
- Hardness
- TDS
- TSS
- Turbidity
- BOD and COD

Project Goals

The years 2000 and 2001 were characteristically dry years, so impacts of nutrient sources to Lake Elsinore resulting from watershed runoff and overflow of Canyon Lake dam were not representative of wet conditions when nutrient transport and resulting impacts to the lake are highest. However, data collected in 2003 captured wet conditions with noticeable overflow of Canyon Lake dam. Although 2003 was a wet year, not enough rainfall resulted in the filling and overflow of Mystic Lake that would result in transport of nutrients from the entire watershed, especially those agricultural areas upstream of Mystic Lake with known sources of nutrients. Therefore, it has yet to be determined what the in-lake response is to critical hydrologic conditions that result in transport of nutrient loads above Mystic Lake to Lake Elsinore resulting from overflow of Canyon Lake dam. To assess this condition and to provide additional data for analyses of in-lake water quality for further study and modeling analysis (see Project 6), continuation of data collection at the three stations in Lake Elsinore is recommended.

Project Overview

In order to support future studies and model development for Lake Elsinore, data collection is recommended for a broader understanding of the physical, chemical and biological processes that exist in Lake Elsinore. The following data collection is suggested for Project 5.

<u>Monitoring of In-Lake Water Quality</u>

A dynamic, 3-dimensional, water quality model of Lake Elsinore is recommended for analysis of in-lake conditions and internal response to variable external loading scenarios (see Project 6). To provide useful information for model configuration, the following additional constituents are recommended for monitoring. These data will assist in configuration of the sediment diagenesis component of the model recommended in Project 6.

- Particulate Organic Carbon
- Dissolved Organic Carbon
- Particulate Organic Phosphorus
- Dissolved Organic Phosphorus
- Particulate Organic Nitrogen
- Dissolved Organic Nitrogen

Assessment of Internal Nutrient Loads to Lake Elsinore

In 2000 and 2001, the University of California, Riverside, performed a study to determine internal loadings of nutrients resulting from sediment flux (Anderson, 2001). Specifically, release rates of ammonia and soluble reactive phosphorus (SRP) from sediments were estimated using both laboratory core flux experiments and *in situ* multi-chamber porewater samplers. Five sites were analyzed with variable depth and relative location considerations. The period of this study was a relatively dry year with minimal external nutrient loading from the local watershed and no loading resulting from overflow of Canyon Lake dam.

To assess the variability of internal loads resulting from differences in external loading conditions and in-lake water quality, a separate study is recommended to correspond with the aforementioned in-lake monitoring also recommended. For this study, core flux experiments of ammonia and SRP are recommended at those locations consistent with the previous study. In addition, analysis of sediment oxygen demand (SOD) is also recommended at these sites. Experiments are recommended at four times throughout the year to capture seasonal variations.

Project Schedule

In-lake monitoring and nutrient flux and SOD studies will be performed for a full year following the start of the project. In-lake monitoring will be performed bi-weekly for the full year of study. Nutrient flux and SOD experiments will be conducted four times throughout the year every 2-4 months corresponding to different seasonal conditions.

Project Cost

Total estimated project cost of the 1-year monitoring project is $200,000. Depending on the number of stations and data selected, this cost can vary.

Project 6: Development of a Dynamic Water Quality Model of Lake Elsinore

Project Background

Lake Elsinore is a dynamic, eutrophic system subject to intensive study and data collection efforts. However, very little is known regarding the hydrodynamics within the lake and the associated dynamic water quality impacts as a function of variable external nutrient loading conditions. Water quality models are useful tools to assist in understanding sources of pollutants within waterbodies and system response to varying environmental conditions. In addition, models can be used to test various BMP's to determine if benefits to in-lake water quality necessitate their implementation. Hence, such models are powerful tools in decision-making and strategy development for lake improvements. Although previous simplified water quality models have been developed for the lake (Anderson, 2001; mass balance model used by Santa Ana RWQCB for TMDL analysis), these applications are limited in their ability to assess spatial and dynamic variability of in-lake water quality resulting from varying hydrologic and nutrient loading characteristics. Moreover, these models provided limited flexibility for testing of alternative model scenarios that result in environmental or nutrient loading conditions that are outside the assumed conditions considered for model configuration.

Several models are available for simulation of lake processes, with model selection often governed by the amount of data available for model configuration and calibration, the pollutant and processes simulated, the geometry of the system, the complexity of the system, and the resolution of model output desired for system analysis.

Project Goals and Overview

For Lake Elsinore, a dynamic model is determined necessary for simulation of lake processes in response to time-variable inputs of nutrients and pathogens under variable environmental conditions (i.e., water surface elevation, temperature). In addition, due to the unique geometry of the lake and the resulting hydrodynamics of the system, a 3-dimensional model was determined necessary to simulate the depth- and spatial-variable kinetic and transport processes involving nutrients and pathogens.

In support of nutrient TMDL development for Canyon Lake and Lake Elsinore, a simplified, 2-dimensional application of the Environmental Fluid Dynamics Code (EFDC) was utilized for simulation of nutrient loads to Lake Elsinore as a function of overflows from Canyon Lake dam (Tetra Tech, Inc, 2003). A future project is proposed (see Project 8) to update this simplified model of Canyon Lake to a fully configured, 3-dimensional, kinetic application for assessment of in-lake response to variable loading and management scenarios. For a dynamic model of Lake Elsinore, a similar EFDC model is proposed.

EFDC is a non-proprietary, comprehensive, 3-dimensional model capable of simulating hydrodynamics, salinity, temperature, suspended sediment, water quality, and the fate of toxic materials. EFDC is a widely accepted model approved and maintained by EPA and included as a component of EPA's TMDL Toolbox. The 3-dimensional EFDC model is capable of simulating 21 water quality parameters including dissolved oxygen, suspended algae (3 groups), various components of carbon, nitrogen, phosphorus and silica cycles, and fecal coliform bacteria. The kinetic processes include use of the Chesapeake Bay three-dimensional water quality model, CE-QUAL.ICM.

Consistency with the Canyon Lake model will capture economies of scale in terms of datasets and assumptions for configuration of a similar model of Lake Elsinore. For example, the Lake Elsinore model can utilize weather data compiled for EFDC input to the Canyon Lake model. In addition, setup of the kinetic processes simulated in the Canyon Lake EFDC model will provide insight into similar assumptions for Lake Elsinore since they are in such close proximity and are influenced by similar environmental conditions.

For model development, additional data collection is proposed and outlined in Project 5. Using these datasets in addition to previously collected data, the EFDC model will be configured and calibrated using the expanded dataset of observed data and load predictions from the Canyon Lake model and a separate, previously developed, watershed model. This process will include hydrodynamic calibration using temperature, water surface, and/or conductivity data, and water quality calibration using depth-variable nutrient and bacteria data at multiple locations in the lake.

The fully configured EFDC model of Lake Elsinore can be used to assess the system response to dynamic variations in nutrient loads resulting from varying hydrologic conditions in the region. Three hydrologic conditions will be tested to assess in-lake water quality as a function of variable nutrient loads and environmental influences that impact the assimilation of such loads in the lake. These three conditions are consistent with the scenarios analyzed in the nutrient source assessment and used for TMDL development, and represent conditions when (1) Mystic Lake and Canyon Lake overflowed, (2) Canyon Lake overflowed but Mystic Lake did not, and (3) neither Mystic Lake nor Canyon Lake overflowed. Nutrient loads to Lake Elsinore for scenarios 1, 2, and 3 will be were represented using watershed model results from water years (WY) 1998, 1994, and 2000, respectively (water years extend from October 1 through September 30).

In addition to the variable hydrologic conditions, the EFDC model can also be utilized to test lake response to various BMP's and reductions in external nutrient loads from the watershed or reductions in internal nutrient loads through treatment options. Such BMP's may include in-lake treatment techniques (see Project 1), lake re-aeration (see Project 2), as well as others considered by managers and decision-makers. Also, load reduction scenarios in the watershed can be tested to assess improvements in the lake.

Project Schedule

Following the data collection prescribed in Project 5, approximately six months is required for project completion. This period provides necessary time for data collection, model configuration, model calibration, public meeting support, as well as development of an updated dynamic model of Canyon Lake (see Project 8) for prediction of loads to Lake Elsinore.

Project Cost

Through utilization of previous and ongoing modeling efforts for Canyon Lake, significant cost is reduced specific to data collection and model configuration. As a result, the cost estimate assumes that EFDC is used as the dynamic model of Lake Elsinore so that data collection efforts and model configuration utilizes previous and continued efforts associated with similar modeling work for Canyon Lake. The estimated project cost is $100,000. However, if the Lake Elsinore modeling project is combined with the proposed modeling project for Canyon Lake (Project 8), through sharing of costs (e.g., expansion of model period for the watershed model, configuration of weather data, public meeting support) the Lake Elsinore modeling portion of the joint project can be reduced.

Project 7: Water Quality Monitoring at Canyon Lake

Project Background

Collection of water quality data from Canyon Lake is an important step in providing information regarding the condition of the lake, necessary data for configuration of predictive water quality models of the lake, assessment of the impact of various best management practices that seek to improve in-lake water quality, and a measure of the overall success of the watershed management plan and implementation plans suggested in the nutrient TMDL. To provide this information, continuation of previous water quality monitoring and lab testing are recommended, as well as collection of specific data for assistance in development of a dynamic water quality model of the lake (see Project 8).

In 2000 and 2001, in-lake water quality data was collected at four stations in Canyon Lake (Figure 4-7-1). In 2003, data was collected at two of these stations. These sampling stations have been maintained as part of a TMDL monitoring program of the Santa Ana RWQCB and are expected to continue as part of the TMDL requirements. Data collected from these stations have been utilized for multiple studies involving simplified models of the lake for TMDL projects, as well assessment of in-lake water quality for guidance in future planning and selection of alternative lake management options. Continuation of data collection from these sites will provide useful information regarding variability of in-lake water quality from one year to the next, assess the response of the lake to variable external hydrologic and watershed loading conditions, and provide additional insight regarding internal loading of nutrients within the lake.

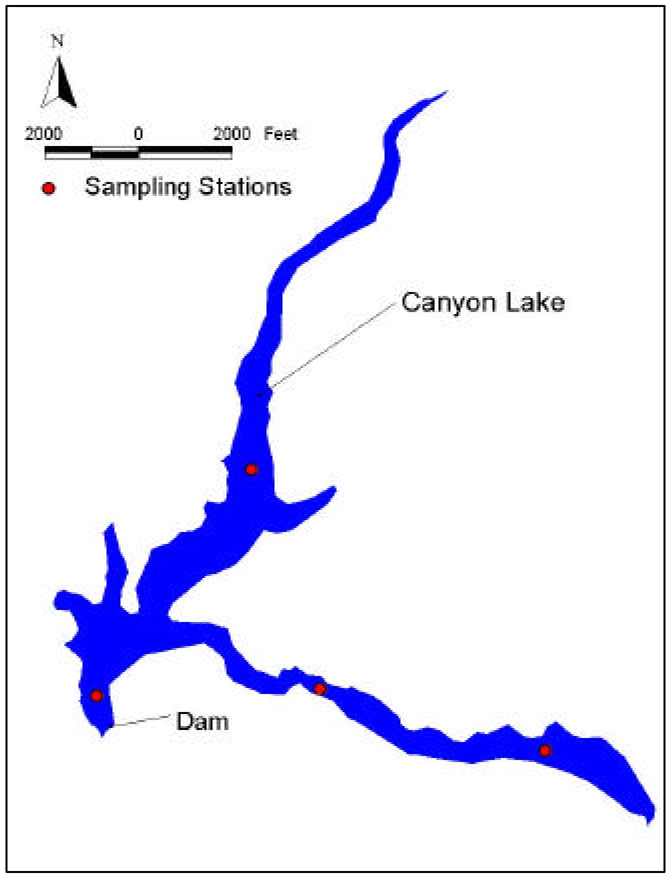

Figure 4-7- 1. Canyon Lake Stations

At each station data was collected at three depths: at the surface, at half of the total lake depth, and at the lake bottom. The following constituents were analyzed (depending on station and depth of sample):

- Temperature
- Dissolved Oxygen
- PH
- Conductivity
- Secchi Depth
- Chlorophyll *a* (at surface)
- Total Nitrogen
- Nitrate
- Nitrite
- Ammonia
- Total Inorganic Nitrogen
- Total Organic Nitrogen
- Total Kjeldahl Nitrogen
- Ortho Phosphate
- Soluble Phosphate
- Total Phosphate
- Hardness
- TDS
- TSS
- Turbidity
- BOD and COD

Project Goals

The years 2000 and 2001 were characteristically dry years, so impacts of nutrient sources to Canyon Lake resulting from watershed runoff were not representative of wet conditions when nutrient transport and resulting impacts to the lake are highest. However, data collected in 2003 captured wet conditions with noticeable overflow of Canyon Lake dam. Although 2003 was a wet year, not enough rainfall resulted in the filling and overflow of Mystic Lake that would result in transport of nutrients from the entire watershed, especially those agricultural areas upstream of Mystic Lake with known sources of nutrients. Therefore, it has yet to be determined what the in-lake response is to critical hydrologic conditions that result in transport of nutrient loads above Mystic Lake to Canyon Lake. To assess this condition and to provide additional data for analyses of in-lake water quality for further study and modeling analysis (see Project 8), continuation of data collection at the four stations in Canyon Lake is recommended.

Project Overview

In order to support future studies and model development for Canyon Lake, data collection is recommended for a broader understanding of the physical, chemical and biological processes that exist in the lake. The following data collection is suggested for Project 7.

<u>Additional Monitoring for Configuration of a Dynamic Water Quality Model</u>

A dynamic, 3-dimensional, water quality model of Canyon Lake is recommended for analysis of in-lake conditions and internal response to variable external loading scenarios (see Project 8). To provide useful information for model configuration, the following additional constituents are recommended for monitoring. These data will assist in configuration of the sediment diagenesis component of the model recommended in Project 8.

- Particulate Organic Carbon
- Dissolved Organic Carbon

- Particulate Organic Phosphorus
- Dissolved Organic Phosphorus
- Particulate Organic Nitrogen
- Dissolved Organic Nitrogen

Additional Studies for Assessment of Internal Nutrient Loads to Lake Elsinore

In 2001 and 2002, the University of California, Riverside, performed a study to determine internal loadings of nutrients resulting from sediment flux (Anderson and Oza, 2003). Specifically, release rates of ammonia, nitrate, and soluble reactive phosphorus (SRP) from sediments were estimated using both laboratory core flux experiments and *in situ* multi-chamber porewater samplers. Seven sites were analyzed with variable depth and relative location considerations. The period of this study was a relatively dry year with minimal external nutrient loading from wet weather runoff.

To assess the variability of internal loads resulting from differences in external loading conditions and in-lake water quality, a separate study is recommended to correspond with the aforementioned in-lake monitoring also recommended. For this study, core flux experiments of ammonia and SRP are recommended at those locations consistent with the previous study. In addition, analysis of sediment oxygen demand (SOD) is also recommended at these sites. Experiments are recommended at four times throughout the year to capture seasonal variations.

Project Schedule

In-lake monitoring and nutrient flux and SOD studies are recommended for a full year following the start of the project. In-lake monitoring should be performed bi-weekly for the full year of study. Nutrient flux and SOD experiments should be conducted four times throughout the year every 2-4 months corresponding to different seasonal conditions.

Project Cost

Total estimated project cost of the 1-year monitoring project is $200,000. Depending on the amount of stations and data selected, this cost can vary.

Project 8: Development of a Dynamic Water Quality Model of Canyon Lake

Project Background

Water quality models are useful tools to assist in understanding sources of pollutants within waterbodies and system response to varying environmental conditions. In addition, models can be used to test various BMP's to determine if benefits to in-lake water quality necessitate their implementation. Hence, such models are powerful tools in decision-making and strategy development for lake improvements.

Several models are available for simulation of lake processes, with model selection often governed by the amount of data available for model configuration and calibration, the pollutant and processes simulated, the geometry of the system, the complexity of the system, and the resolution of model output desired for system analysis.

Project Goals

For Canyon Lake, a dynamic model is determined necessary for simulation of lake processes in response to time-variable inputs of nutrients and pathogens under variable environmental conditions (i.e., water surface elevation, temperature). In addition, due to the unique geometry of the lake and the resulting hydrodynamics of the system, a 3-dimensional model was determined necessary to simulate the depth-variable kinetic and transport processes involving nutrients and pathogens.

Project Overview

In support of nutrient TMDL development for Canyon Lake and Lake Elsinore, a simplified, 2-dimensional application of the Environmental Fluid Dynamics Code (EFDC) was utilized for simulation of nutrient loads to Lake Elsinore as a function of overflows from Canyon Lake dam (Tetra Tech, Inc, 2003). Although the EFDC model was configured using simplified procedures for simulating hydrodynamics and water quality, model selection and development considered the need for flexibility so that model upgrades to a fully-configured, 3-dimensional, kinetic application could be performed in the future with little difficulty.

EFDC is a comprehensive, 3-dimensional model capable of simulating hydrodynamics, salinity, temperature, suspended sediment, water quality, and the fate of toxic materials. EFDC is a widely accepted model approved and maintained by EPA and included as a component of EPA's TMDL Toolbox. The 3-dimensional EFDC model is capable of simulating 21 water quality parameters including dissolved oxygen, suspended algae (3 groups), various components of carbon, nitrogen, phosphorus and silica cycles, and fecal coliform bacteria. The kinetic processes include use of the Chesapeake Bay three-dimensional water quality model, CE-QUAL.ICM.

There are benefits associated with selection of the previously developed, simplified, 2-dimensional EFDC model as the foundation of an expanded 3-dimensional kinetic model of the lake:

- The previous model provides the finite grid necessary for expansion to three dimensions (Figure 4-8-1);
- Boundary conditions of the lake were established in the previous modeling effort (i.e., inflows from a separate watershed model; overflow configuration of the dam);
- Required weather files were developed for the previous modeling study;
- Reduction in project cost through utilization of the previous modeling effort.

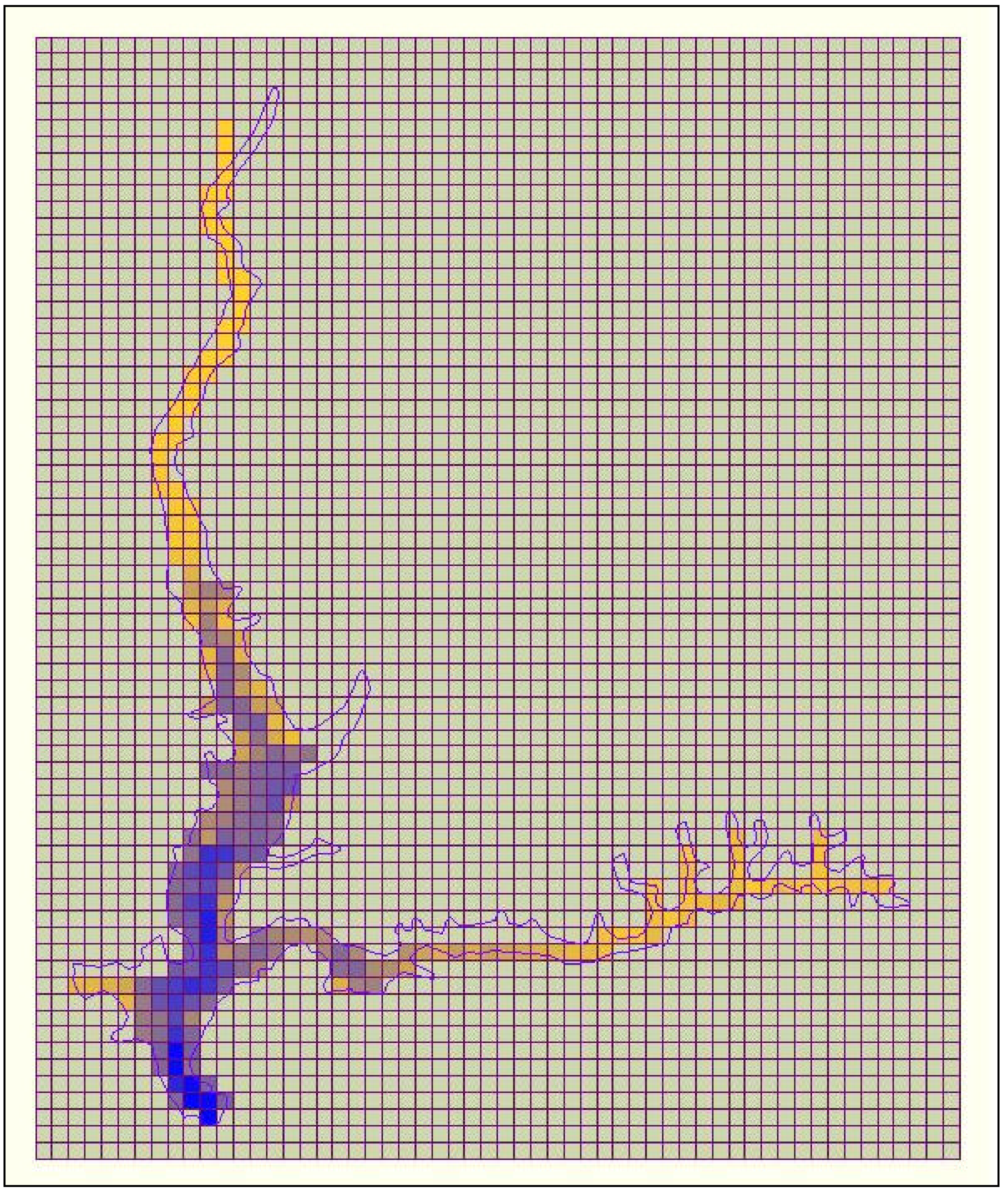

Figure 4-8-1. EFDC Model Segmentation

For model development, additional data collection is proposed and outlined in Project 7. Using these datasets in addition to previously collected data, the model can be reconfigured to three dimensions with kinetic processes simulated using the complete capabilities of EFDC. For inclusion of new data collected as part of Project 7, associated input files and calibration datasets will be expanded to the extended time period of data collection (including expansion of the time period simulated using the watershed model). In addition to nutrients, the model will be configured for simulation of pathogens in support of pathogen TMDL development of the lake.

The fully configured, 3-dimensional EFDC model will be calibrated using the expanded dataset of observed data. This process will include hydrodynamic calibration using temperature, water surface, and/or conductivity data, and water quality calibration using depth-variable nutrient and bacteria data at multiple locations in the lake.

As with the proposed Lake Elsinore model (Project 6), the fully configured EFDC model of Canyon Lake can be used to assess the system response to dynamic variations in nutrient loads resulting from varying hydrologic conditions in the region. Three hydrologic conditions will be tested to assess in-lake water quality as a function of variable nutrient loads and environmental influences that impact the assimilation of such loads in the lake. These three conditions are consistent with the scenarios analyzed in the nutrient source assessment and used for TMDL development, and represent conditions when (1) Mystic Lake and Canyon Lake overflowed, (2) Canyon Lake overflowed but Mystic Lake did not, and (3) neither Mystic Lake nor Canyon Lake overflowed. Nutrient loads to Canyon Lake for scenarios 1, 2, and 3 will be were represented using watershed model results from water years (WY) 1998, 1994, and 2000, respectively (water years extend from October 1 through September 30).

In addition to the variable hydrologic conditions, the EFDC model can also be utilized to test lake response to various BMP's and reductions in external nutrient loads from the watershed. Such BMP's may include re-aeration techniques (see Project 3), testing of reduction in nutrient release from sediment (see Project 4), as well as others considered by managers and decision-makers. Also, load reduction scenarios in the watershed can be tested to assess improvements in the lake.

Project Schedule

Following the data collection prescribed in Project 7, approximately six months is required for project completion. This period provides necessary time for data collection, model configuration, model calibration, and public meeting support.

Project Cost

Through utilization of previous modeling efforts for Canyon Lake, significant cost is reduced specific to data collection and model configuration. As a result, the cost estimate assumes that the previously developed, simplified EFDC model of Canyon Lake is utilized for this modeling project. The estimated project cost is $83,000. However, if the Canyon Lake modeling project is combined with the proposed modeling project of Lake

Elsinore (Project 6), through sharing of costs (e.g., expansion of model period for the watershed model, configuration of weather data, public meeting support) the Canyon Lake modeling portion of the joint project can be reduced.

4.2.2 <u>Watershed Projects</u>

To assist in project identification, Watershed Projects were divided into subcategories specific to sources of nutrients, special issues in the watershed, or additional data collection. As a result, projects were categorized into the following classifications:

- Urban/Residential
- Agricultural
- Special Studies/Long-Term Monitoring and Reporting

The following sections outline the projects identified for each subcategory.

4.2.2.a Urban/Residential

Four projects are recommended to address sources of nutrients from urban areas. These projects are designed to resolve nutrient loading issues specific to urban/residential land uses and failed septic systems identified in the Nutrient Source Assessment (see Section 3.1.1). The following projects are recommended:

9. Structural Urban BMP’s
10. Sewer and Septic Improvements
11. Control of Trash in Stream Channels
12. Interception and Treatment of Nuisance Urban Runoff

The following are detailed summaries of each project, including the background, goals, overview, schedule, and where available, estimated costs.

Project 9: Structural Urban Best Management Plans (BMP's)

Project Background

Urban growth is often characterized by increases in impervious area and surface water runoff. As this runoff washes over land surfaces, it picks up various pollutants including oil, toxic compounds, inorganic and organic chemicals, trash and sediment. The terminal point for such pollutants are receiving waters such as Canyon Lake, Lake Elsinore, and the San Jacinto River. The local jurisdictions in the San Jacinto region are safeguarding these receiving waters through regulation, policies and water runoff treatment technologies. Best Management Practices (BMP's) are treatment technologies that have been shown to effectively manage, prevent, control, remove, reduce and treat runoff before the pollution reaches receiving waters. BMP's include educational programs, operational measures, and engineered environments, technologies and systems. Specific BMP's exist for many sources of pollution, such as urban, agricultural, and industrial land uses and landscaping processes. Urban BMP's have been successfully used to manage the quantity and improve the quality of surface water runoff and, ultimately to protect receiving water bodies.

Site selection for regional urban BMP's is based on several factors. These factors include specific pollutant(s) of concern, site defined constraints, and the relative removal potential of the various BMP's. Consideration of all applicable factors is critical to the appropriate selection of urban BMP's, as described below.

<u>BMP Selection Criteria</u>

A supplemental document to the Riverside County Drainage Area Management Plan (DAMP) identifies post-construction source pollutant prevention and treatment measures. These BMP's can be used by all Riverside County NPDES Co-permittees to prevent or reduce surface water pollution. This document, Supplement A, discusses four broad types of BMP's: detention basins, retention basins/tanks, vegetative controls and source controls. It also addresses the relative effectiveness of BMP's selected for use in the San Jacinto Valley.

Pollution reduction in surface waters is dependent upon controlling the sources of contributing pollution and/or the installation of treatment technologies within the watershed. Source control is an umbrella term that refers to a suite of non-structural BMP's aimed at reducing pollutants before they contaminate receiving waters. Examples of source controls include public awareness programs, employee training, recycling programs, street sweeping, and storm drain maintenance. Source control measures are often preferred to other BMP's because they work to minimize pollution from streets, parking lots, rooftops, lawns, cars, etc. at the source and are generally less expensive to implement.

To supplement source control methods and facilitate additional improvements to water quality, structural BMP's are often necessary. Structural BMP's are physical controls that either capture polluted runoff or allow it to soak back into the ground naturally or act as barriers between polluted runoff and receiving waters. Many structural BMP'S provide additional improvements because they reduce flooding, prevent soil erosion, conserve water, and provide habitat, food, and shelter for wildlife. Detention basins, infiltration trenches, oil/grease separators, and grass swales are just a small subset of the structural BMP's available.

There are important criteria to consider when selecting site specific structural urban BMP's, including: physical and site constraints, drainage area, soil permeability, hydrologic conditions, water quality parameters, removal efficiencies, cost, and maintenance. Supplement A of the DAMP provides a qualitative comparison of effectiveness for seven urban BMP's (infiltration trenches, infiltration basins, porous pavement, sand filters, grassed swales, filter strips, water quality inlets) in seven categories (reliability for pollutant removal, longevity, applicable to most developments, wildlife habitat potential, environmental concerns, comparative cost and special considerations). Each urban BMP has positive and negative attributes associated with it; however, water quality inlets were the only BMP not recommended as a primary BMP option. Riverside County recognizes that unique water quality issues may require additional solutions not contained in the DAMP.

A rating table was developed to quantitatively evaluate common BMP's for effectiveness in an arid environment with low to moderate population densities as found in the San Jacinto Valley. The BMP Rating Guide (Table 1) is based on a similar table in Supplement A of the DAMP. This table includes two urban BMP's, wetlands and wet detention ponds, not discussed in Supplement A. Ratings for the additional BMP's are based on guidance from the EPA (USEPA, 1993). A rating scale from 1 to 5 was applied to the qualitative performance descriptions provided in the DAMP, where 1 indicates poor performance and 5 reflects very good performance. In some instances a range is provided to demonstrate that the rating is site specific. Appendix F provides a description of design and functional qualities of the urban BMP's rated in Table 4-9-1. A description of each column heading is listed following the table.

Table 4-9- 1. BMP Rating Guide for San Jacinto River watershed

Urban BMP Option	Reliability for Pollutant Removal	Percent Total Nitrogen Removal	Percent Total Phosphorous Removal	Longevity	Applicable to Most Development	Wildlife Habitat Potential	Environmental Concerns (Risk to Groundwater 5=none)	Comparative Cost	Special Consideration
Infiltration Trenches	4	55%	60%	1	3	1	4	4	Pretreatment and geotechnical evaluation
Infiltration Basins	4	60%	65%	1	3	2	4	3	60-100% Failure in 5 years makes this impractible
Porous Pavement	5	85%	65%	1	1	1	4	4	Use sparingly due to failure and maintenance needs.
Sand Filters	4	21% *	33% *	4	4	1	4	2	Requires regular maintenance
Grass Swales	3	40%	40%	4	4	1	4	4	Recommended with check dams as one element of a BMP system
Filter Strips	3	40%	40%	3	4	2	4	4	Recommended as one element of a BMP system
Water Quality Inlets	1	5-20%	5%	4	2	1	2	2	Not currently recommended as primary BMP option
Wetlands	4	20%	25%	5	1-3	5	4	3	Requires pooled water to be effective and larger land allotments
Wet Detention Ponds	4	35%	45%	5	1-3	5	4	3	Requires pooled water to be effective and larger land allotments

* Based on USEPA (1999) guidance for sand filters. All other removal percentages based on USEPA (1993).

The *Reliability for Pollutant Removal* field provides a rating for each BMP's' pollutant removal efficiency. Special consideration was given to nitrogen and phosphorous, which are constituents of concern within Canyon Lake and Lake Elsinore. The BMP removal efficiency of these pollutants is explicitly stated in Table 4-9-1 in the "Percent Total Nitrogen Removal" and "Percent Total Phosphorous Removal" columns. The values provided in these columns are based upon EPA guidance on managing sources of nonpoint pollution and sand filter removal rates (USEPA, 1993 and 1998).

The *Percent Total Nitrogen and Phosphorous Removal* field provides total nitrogen and total phosphorous removal efficiencies for each BMP based on EPA guidance for removal rates (USEPA, 1993 and 1998).

The Longevity field provides a rating of the average life span before failure of the BMP. A rating of 5 indicates the average life span of 50 years published for wetlands, wet detention ponds and vegetative filter strips (USEPA, 1993). The ratings step down to 4 for a life span of 20 years and then to 1 for a life span of less than 5 years before prior to failure of the BMP.

The *Applicable to Most Developments* field rates the relative applicability or restrictions of the BMP under urban conditions with low-medium density population and low slopes. The range of values presented for wetlands and wet detention ponds is intended to provide the reader discretion, in case the larger land use requirement is not available. Wetlands or wetponds would best suit residential or commercial areas with land designated for ponds that could easily be retrofitted with native plants and other design features to become wetlands.

Wildlife Habitat Potential refers to the likelihood of plant and animal life to inhabit or use the BMP. The typical wetland freshwater food chain begins with primary producers, plants and algae, and progresses to insects, birds, reptiles, and mammals. Residential and migratory birds are usually the most often observed wildlife group to use a constructed environment. Southern California is an important stop-over and wintering location for several migratory birds and raptors.

The *Environmental Concerns* field refers to potential threats to the environment caused by the BMP and how it manages the pollutants present in the urban runoff. These environmental concerns can include groundwater pollution by infiltration, resuspension of pollutants, thermal pollution, algae blooms, odor, etc. There are only slight risks associated with the majority of the BMP's presented; however, if the groundwater table is very close to an infiltration-based BMP, the risk may be higher. Water Quality Inlets scored poorly in this category because of the potential for resuspension of hydrocarbons and toxics.

Comparative Cost encompasses both construction cost and operation and maintenance costs as reported by EPA (USEPA, 1993). It should be noted that the reference document is a decade old and the costs are outdated. Therefore, these costs should only be used as benchmarks for relative cost comparison.

Special Consideration is a column provided in Supplement A of the DAMP that has been preserved in this analysis to denote BMP specific conditions that should be met.

Comparison of the urban BMP's presented above, established that grassed swales, filter strips, wetlands and wet ponds were the most applicable BMP's for use in the San Jacinto River watershed. In urban settings with small land availability, the grass swale or filter strips provide nitrogen and phosphorous removal, some habitat and aesthetic value, and both the lowest price and risk of failure. If sufficient land area and water are available, then wetland and wet detention ponds offer the best overall pollutant removal rates and also offer wildlife habitat and aesthetic benefits. However, wetlands and wet detention ponds both require standing water and many rivers in the San Jacinto River watershed are dry throughout the summer months and may not be able to maintain standing water year-round.

<u>Modeling Efforts</u>

To expand upon this work and estimate the water quality benefits to BMP installation in the urban areas of the San Jacinto River watershed, Tetra Tech, Inc. simulated the hydrologic and water quality conditions in the watershed under various scenarios. Water quality modeling was performed for a specific area of the watershed, which includes Perris Valley/Moreno Valley in the north and Hemet in the south (see Figure 4-9-1). This modeling effort was specifically designed to quantify the relative nutrient loading to Canyon Lake considering various management scenarios. The calibrated and validated LSPC watershed model developed by Tetra Tech, Inc. for the Lake Elsinore and Canyon Lake Nutrient Source Assessment was utilized to complete this effort. LSPC simulations were performed to imitate management scenarios, including a 20 percent and 40 percent reduction in the nitrogen and phosphorous loadings to urban areas within the Perris Valley/Moreno Valley and Hemet watersheds. These percentages were selected based on reported removal efficiencies for common BMP's (range 5-85% for total nitrogen; 5-65% for total phosphorous) presented in Table 4-9-1 of the BMP Selection Criteria section above.

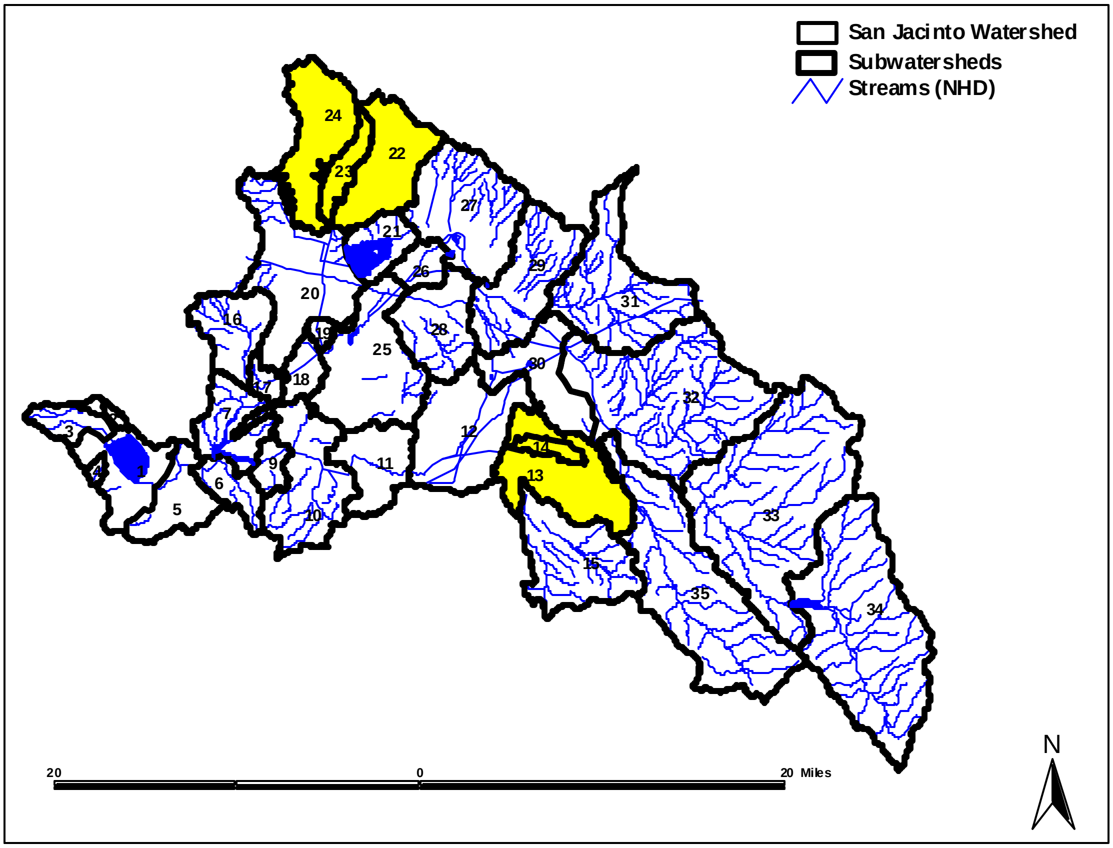

Figure 4-9- 1. The subwatersheds for the BMP modeling in the watershed model

Monthly and annual nutrient loadings to Canyon Lake are summarized below for three water years (WY) over the three different management scenarios. WY 1994 represents an average rainfall year, while WY 1998 represents a wet year (greater than average precipitation) and WY 2000 represents a dry year (less than average precipitation). The first management scenario simulates existing conditions throughout the watershed. The remaining two scenarios consider 20 and 40 percent reductions to the urban loading rate of nitrogen and phosphorous in two highly urbanized regions of the San Jacinto River watershed.

Nitrogen Loads to Canyon Lake

Monthly nitrogen loads to Canyon Lake are presented in Figures 4-9-2 through 4-9-4. These figures illustrate significant seasonal variability between winter and summer for all three water years. The relative reduction in nitrogen loading is also demonstrated in these figures. Based on model predictions, the existing management conditions in the watershed contribute the largest nitrogen loading to Canyon Lake. The 20 percent and 40 percent decrease in urban nitrogen loading result in progressively smaller levels of nitrogen reaching the lake.

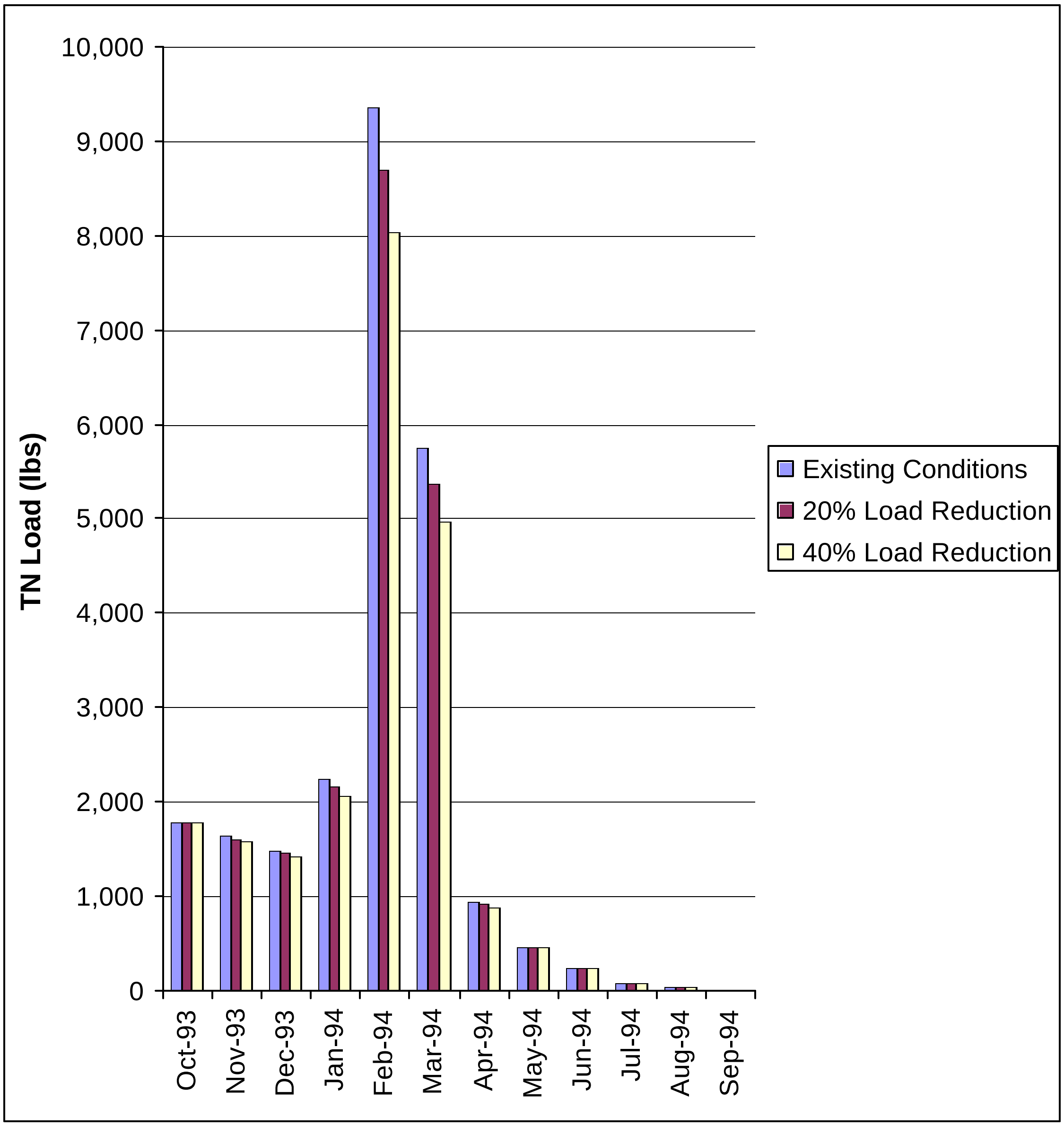

Figure 4-9-2. Comparison of monthly predicted total nitrogen loads to Canyon Lake for varying management scenarios (WY 1994)

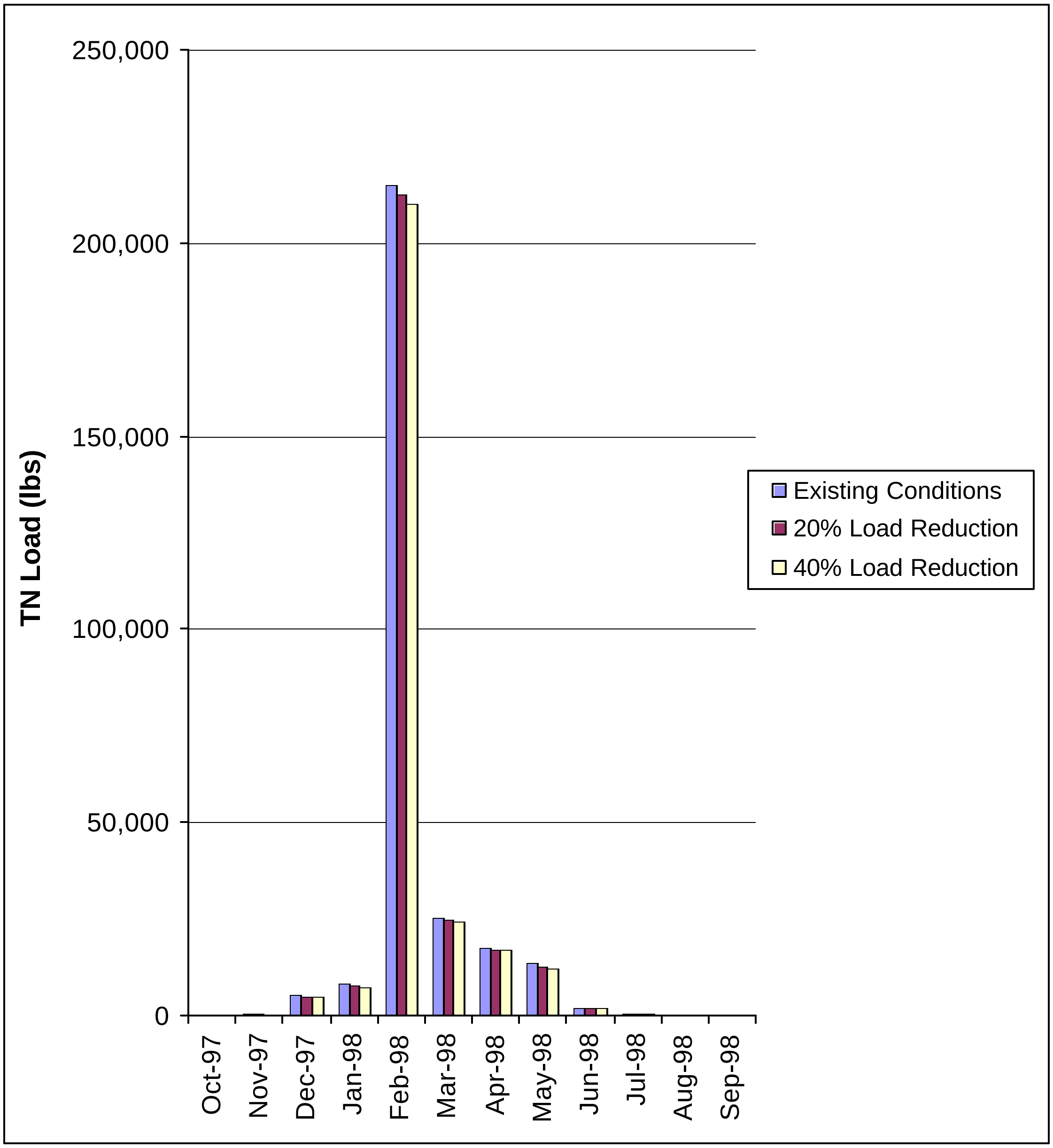

Figure 4-9-3. Comparison of monthly predicted total nitrogen loads to Canyon Lake for varying management scenarios (WY 1998)

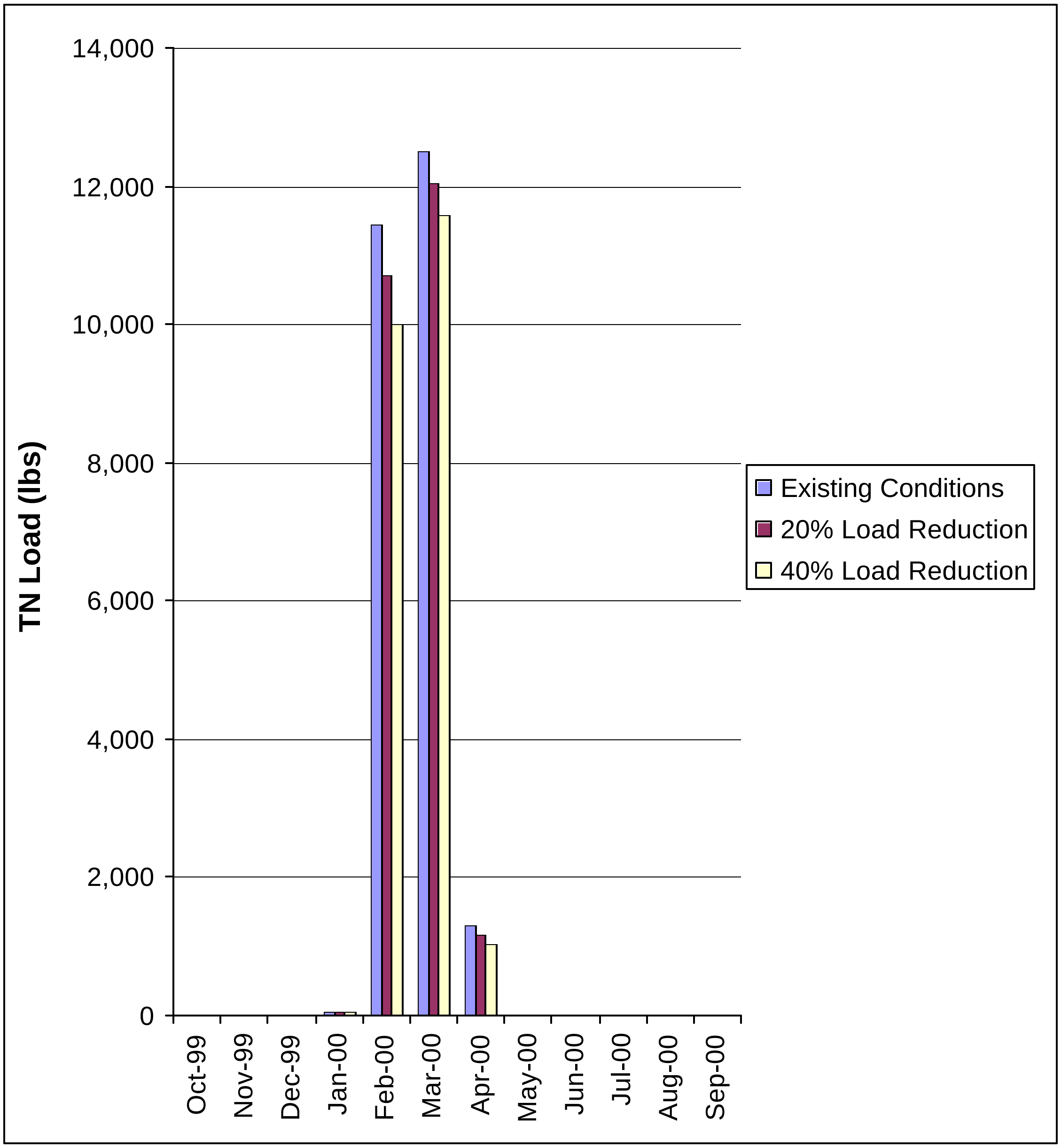

Figure 4-9-4. Comparison of monthly predicted total nitrogen loads to Canyon Lake for varying management scenarios (WY 2000)

In addition to the graphical representation of nitrogen loads presented above, Tables 4-9-2 through 4-9-4 quantify the nutrient reductions to Canyon Lake. These tables provide a comparison between the existing management conditions in the watershed and the two reduced urban loading scenarios. As seen in the tables, both scenarios result in reduced nitrogen loading to Canyon Lake; however, as expected, the 40 percent reduction in urban loadings has a greater impact downstream than the 20 percent reduction.

Table 4-9-2. Relative total nitrogen reduction compared to existing conditions (WY 1994)

Month	20% Load Reduction	40% Load Reduction
Oct-93	0.06%	0.13%
Nov-93	2.08%	4.17%
Dec-93	2.05%	4.09%
Jan-94	3.86%	7.72%
Feb-94	7.09%	14.19%
Mar-94	6.66%	13.32%
Apr-94	3.36%	6.72%
May-94	0.00%	0.00%
Jun-94	0.00%	0.00%
Jul-94	0.00%	0.00%
Aug-94	0.00%	0.00%
Sep-94	0.00%	0.00%
Annual	5.12%	10.23%

Table 4-9-3. Relative total nitrogen reduction compared to existing conditions (WY 1998)

Month	20% Load Reduction	40% Load Reduction
Oct-97	2.83%	5.71%
Nov-97	13.91%	27.82%
Dec-97	5.83%	11.66%
Jan-98	4.53%	9.07%
Feb-98	1.16%	2.33%
Mar-98	1.71%	3.42%
Apr-98	1.20%	2.39%
May-98	4.57%	9.14%
Jun-98	0.00%	0.00%
Jul-98	0.00%	0.00%
Aug-98	7.24%	14.47%
Sep-98	12.99%	25.98%
Annual	1.57%	3.14%

Table 4-9- 4. Relative total nitrogen reduction compared to existing conditions (WY 2000)

Month	20% Load Reduction	40% Load Reduction
Oct-99	0.00%	0.00%
Nov-99	0.00%	0.00%
Dec-99	0.00%	0.00%
Jan-00	9.14%	18.28%
Feb-00	6.26%	12.53%
Mar-00	3.70%	7.40%
Apr-00	11.12%	22.25%
May-00	13.02%	26.07%
Jun-00	0.00%	0.00%
Jul-00	0.00%	0.00%
Aug-00	0.00%	0.00%
Sep-00	3.83%	7.67%
Annual	5.25%	10.51%

As indicated in Table 4-9-3, the reduced nitrogen loading had only a minor impact on the annual total load to Canyon Lake for WY 1998. This water year had extremely high precipitation, resulting in significant nitrogen loading from the upper reaches of the watershed during wet periods. Therefore, during such extreme meteorological events, urban sources of pollution are less significant when compared to the contribution from the remainder of the watershed. Conversely, during average (WY 1994) and low precipitation years (WY 2000), the impact of urban loadings of nitrogen to Canyon Lake is greatly increased. As such, the relative impact of urban management scenarios on annual nitrogen loading to the lake is much greater (as much as 10.5 percent).

Table 4-9-5, which presents annual nitrogen loads to Canyon Lake under the three management scenarios for water years 1994, 1998, and 2000, further illustrates the relative impact of the urban management scenarios. This table also demonstrates the extreme variability in nitrogen loading caused by variation in rainfall amounts (WY 1998 had high rainfall and high nitrogen loading when compared with WY 1994 and 2000).

Table 4-9- 5. Annual total nitrogen loads (in pounds) to Canyon Lake (water years)

WY	Existing Conditions	20% Load Reduction	40% Load Reduction
1994	24,039	22,808	21,578
1998	287,719	283,199	278,680
2000	25,319	23,988	22,658

Phosphorous Loads to Canyon Lake

Similar to the nitrogen loading results, phosphorous loads to Canyon Lake are presented in graphs and tables below. Figures 4-9-5 through 4-9-7 present the monthly loading to the lake. Data are presented for three water years (WY 1994, 1998 and 2000), each of which displays significant variability between winter and summer seasons. The figures also demonstrate the relative reduction in phosphorous loading to Canyon Lake when comparing the three management scenarios: existing conditions, and a 20 percent and 40 percent reduction in urban loading. Based on LSPC model predictions, existing management conditions in the watershed contribute the largest phosphorous loading to Canyon Lake. The 20 percent and 40 percent decrease in urban loading results in progressively lower levels of phosphorous input to the lake.

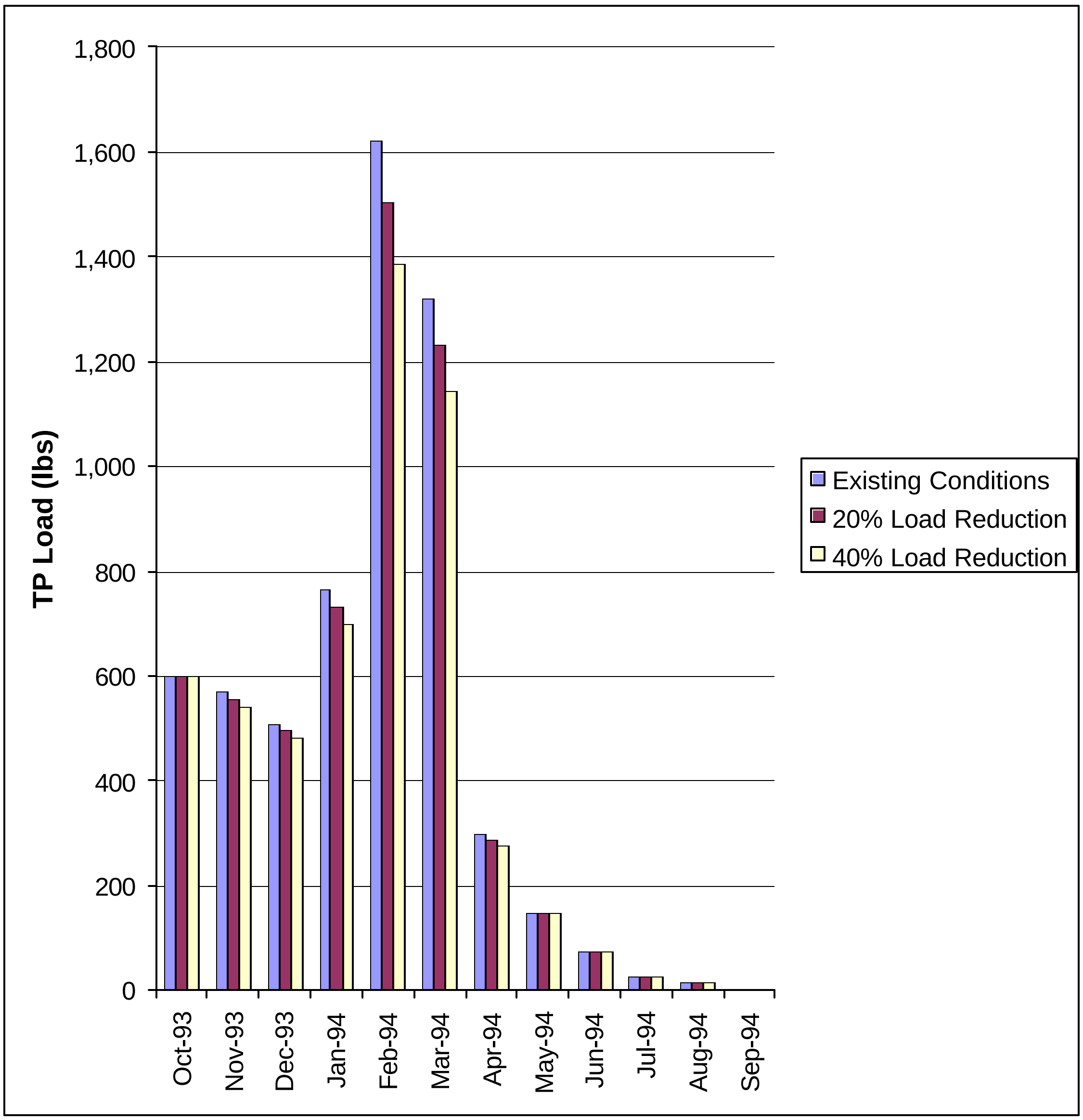

Figure 4-9-5. Comparison of monthly predicted total phosphorous loads to Canyon Lake for varying management scenarios (WY 1994)

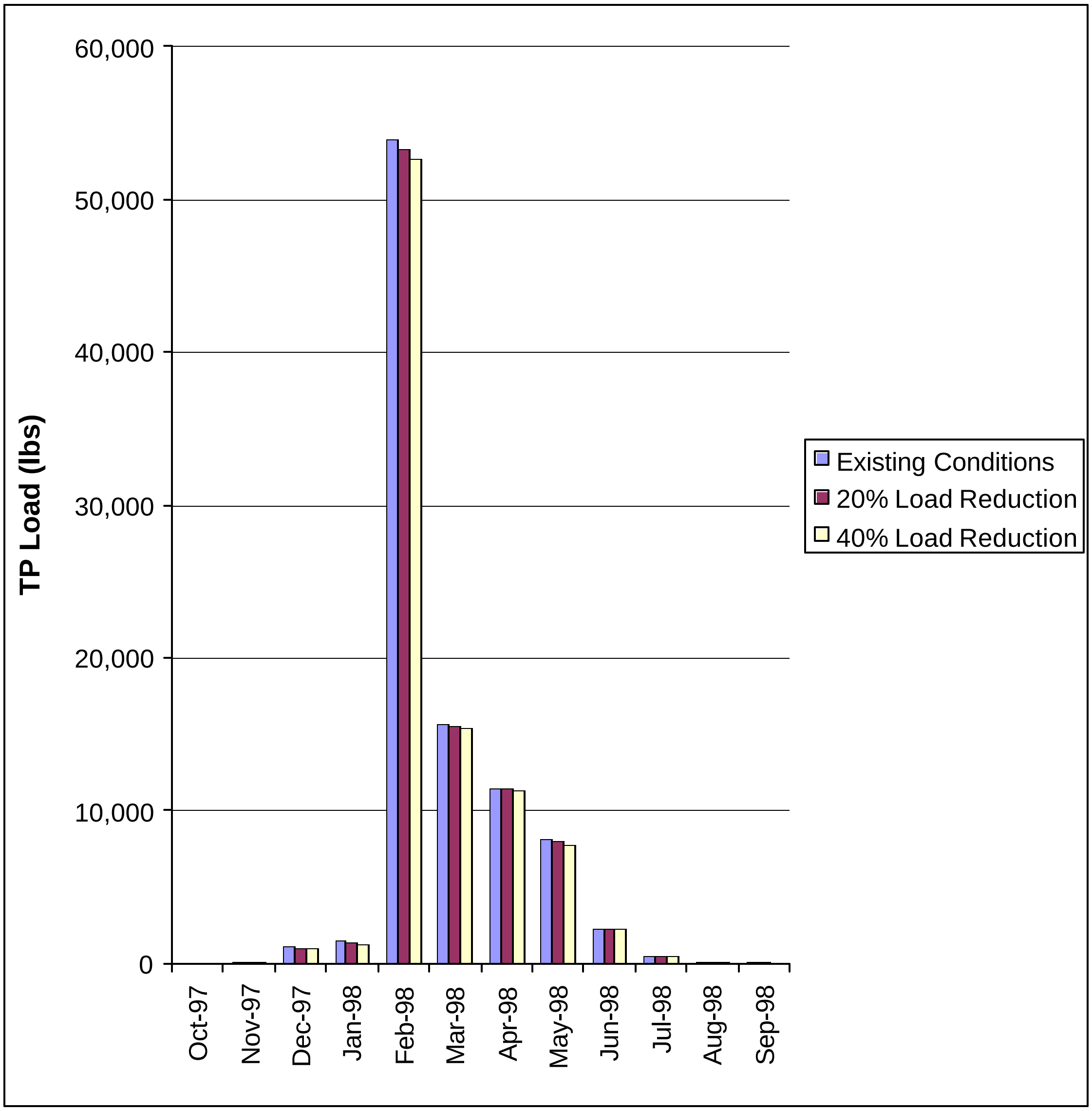

Figure 4-9-6. Comparison of monthly-predicted total phosphorous loads to Canyon Lake for varying management scenarios (WY 1998)

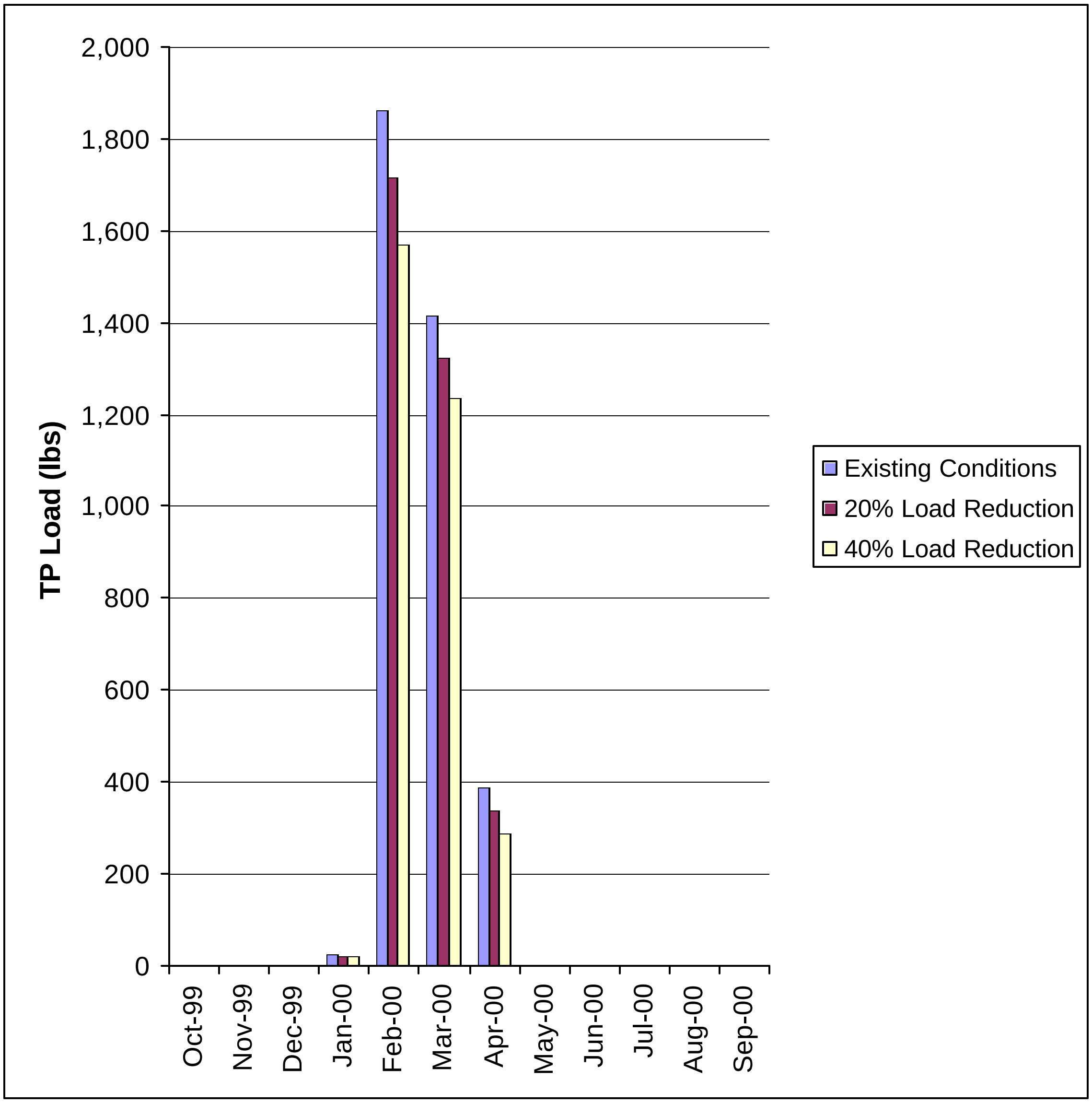

Figure 4-9-7. Comparison of monthly-predicted total phosphorous loads to Canyon Lake for varying management scenarios (WY 2000)

In addition to the graphical representation of phosphorous loads presented above, tables 4-9-6 through 4-9-8 quantify the nutrient reductions to Canyon Lake. These tables provide a comparison between the existing management conditions in the watershed and the two reduced urban loading scenarios. As seen in the tables, both scenarios result in reduced phosphorous loading to Canyon Lake; however, as expected, the 40 percent reduction in urban loadings has a greater impact downstream than the 20 percent reduction.

Table 4-9-6. Relative total phosphorous reduction compared to existing conditions (WY 1994)

Month	20% Load Reduction	40% Load Reduction
Oct-93	0.10%	0.19%
Nov-93	2.61%	5.22%
Dec-93	2.51%	5.03%
Jan-94	4.28%	8.57%
Feb-94	7.26%	14.52%
Mar-94	6.70%	13.39%
Apr-94	3.73%	7.45%
May-94	0.00%	0.00%
Jun-94	0.00%	0.00%
Jul-94	0.00%	0.00%
Aug-94	0.00%	0.00%
Sep-94	0.00%	0.00%
Annual	4.68%	9.36%

Table 4-9-7. Relative total phosphorous reduction compared to existing conditions (WY 1998)

Month	20% Load Reduction	40% Load Reduction
Oct-97	8.24%	16.47%
Nov-97	13.48%	26.96%
Dec-97	5.91%	11.82%
Jan-98	8.37%	16.74%
Feb-98	1.24%	2.49%
Mar-98	0.72%	1.44%
Apr-98	0.39%	0.77%
May-98	2.07%	4.15%
Jun-98	0.00%	0.00%
Jul-98	0.00%	0.00%
Aug-98	8.02%	16.04%
Sep-98	12.85%	25.70%
Annual	1.28%	2.56%

Table 4-9-8. Relative total phosphorous reduction compared to existing conditions (WY 2000)

Month	20% Load Reduction	40% Load Reduction
Oct-99	0.00%	0.00%
Nov-99	0.00%	0.00%
Dec-99	0.00%	0.00%
Jan-00	8.81%	17.62%
Feb-00	7.90%	15.80%
Mar-00	6.23%	12.46%
Apr-00	12.94%	25.88%
May-00	17.97%	35.87%
Jun-00	0.00%	0.00%
Jul-00	0.00%	0.00%
Aug-00	0.00%	0.00%
Sep-00	3.91%	7.87%
Annual	7.80%	15.60%

The reduced phosphorous loading conditions had only a minor impact on the annual load to Canyon Lake for WY 1998 (Table 4-9-7). This water year had extremely high precipitation. During these extreme meteorological events, the upper reaches of the San Jacinto watershed contributed significant phosphorous loading to Canyon Lake. Therefore, during such an extreme water year, urban sources of pollution are less significant when compared to the contribution from the remainder of the watershed. Conversely, during average (WY 1994) and low precipitation years (WY 2000), the impact of urban loadings of phosphorous to Canyon Lake is greatly increased. As such, the relative impact of urban management scenarios on annual phosphorous loading to the lake is much greater (as much as 10.5 percent).

Table 4-9-9, which presents annual phosphorous loads to Canyon Lake under the three management scenarios for water years 1994, 1998, and 2000, further illustrates the relative impact of management decisions. This table also demonstrates the extreme variability in phosphorous loading caused by variation in rainfall amounts. Specifically, WY 1998 had high rainfall and subsequently high phosphorous loading when compared with WY 1994 and 2000.

Table 4-9-9. Annual total phosphorous loads (in pounds) to Canyon Lake (water years)

WY	Existing Conditions	20% Load Reduction	40% Load Reduction
1994	5,951	5,672	5,394
1998	94,865	93,651	92,437
2000	3,690	3,402	3,114

Current Work Conducted by the Riverside County Flood Control and Water Conservation District

The Riverside County Flood Control and Water Conservation District (RCFCWCD) recently contracted with a private consultant to perform a detailed study investigating urban BMP's. This study will identify the pollutants of concern in the Riverside County area and assess specific alternatives to configure or reconfigure open channel segments to include structural BMP's. Several criteria will be used to develop a priority list of the available opportunities. It is expected that the results of this study will provide a recommended implementation plan for specific sites or facilities and will be available in summer 2004.

Project Goals and Overview

The development and first phase of design of the urban BMP's in the Hemet and Moreno Valley will follow the completion of the RCFCWCD feasibility study (Figure 4-9-8).

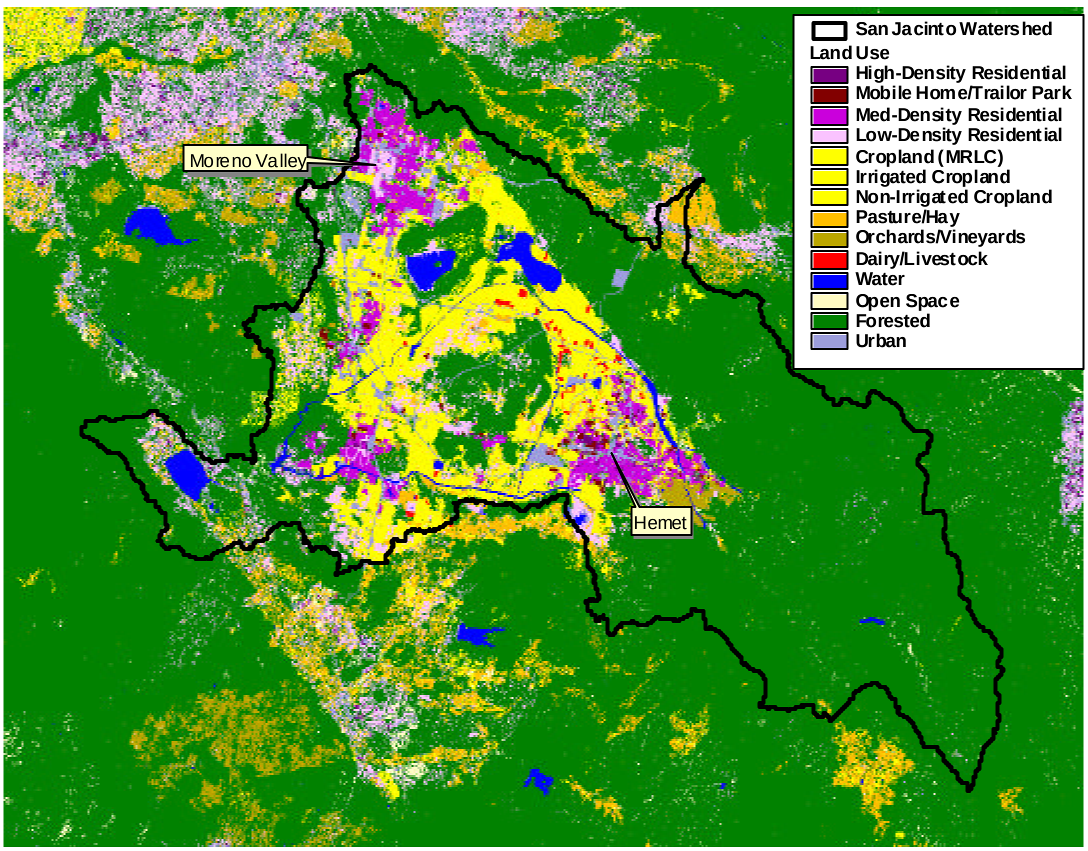

Figure 4-9-8. Targeted Urban BMP areas

The RCFCWCD study described above will identify potential BMP implementation opportunities. It will provide a comparison of the expected removal quantities and the estimated costs of the BMP's, but will not include design plans or the associated overall project construction costs. To expand upon the ongoing RCFCWCD study, a follow-up project is suggested. The recommended project, Project 9, would provide design plans and costs for the BMP's identified in the RCFC study. Specifically, it would develop specific site plans to a 30% level of design and determine the associated project construction costs.

The results of this project would describe a process for reducing nutrients and bacteria from urban areas in Hemet and Perris Valley (see Figure 4-9-8). The relative water quality improvements to Canyon Lake resulting from implementation of such BMP's is provided in the modeling section above. Combining the modeling results with design plans and construction costs is a powerful cost-benefit analysis tool for urban BMP implementation in the San Jacinto River watershed.

Institutional Barriers

Important considerations in the planning and design of urban BMP's are institutional barriers that require cooperation from state, county, and local and municipal entities. Such issues may include land acquisition for sites of BMP construction, cooperation and consistency with the RCFCWCD project planning, cooperation with municipalities where BMP's are recommended, and cooperation with the RWQCB to validate that such BMP measures are considered consistent with TMDL implementation and the California Phase II stormwater management program for municipal storm sewer systems (MS4s), as defined in the *Nonpoint Source Program Strategy and Implementation Plan, 1998-2013 (PROSIP)* (SWRCB, 2000) and the *Draft California Nonpoint Source Program Five-Year Implementation Plan¾July 2003 Through June 2008* (SWRCB, 2003).

Project Schedule

The anticipated start date of the first phase, conceptual design process, could begin in fall 2004, after the results of the RCFCWCD study are available. The first phase is expected to take 4 months and project completion is likely to take an additional 3 months**.**

Project Cost

The cost to develop 30% design plan and construction cost estimates for 3 high priority urban BMP's is approximately $50,000. This assumes that adequate topographic information would be available for the design effort. Second phase completion of the design plans, along with more detailed cost estimates is approximately $60,000. This does not include negotiations for potential rights-of-way that may be required.

Project 10: Sewer and Septic Improvements

Project Background

As stated previously, several studies have been completed to assess potential sources of nutrients and bacteria to Canyon Lake and Lake Elsinore. Nutrient contributions to the San Jacinto River watershed are dominated by non-point sources (Tetra Tech, Inc, 2003).

Land use practices that may contribute and influence the transport of nutrients to Canyon Lake and Lake Elsinore may include discharges from failing septic systems. In the San Jacinto River watershed, failed septic systems can potentially contribute a significant load of nutrients during wet weather events. Nutrient loads from failed septic systems are estimated to be a significant source of nutrients from local areas near Canyon Lake and Lake Elsinore. Due to septic systems proximity to the shoreline where direct loading of nutrients is possible, there is a high likelihood that nutrients are transported from these areas during dry years. For several years, problem areas associated with failed septic systems were identified as areas just north of Canyon Lake known as Quail Valley (see Section 3.1.1.).

Once nutrients are delivered to Canyon Lake and Lake Elsinore, they are subject to cycling processes that impact water quality over extended periods. These processes can have long-term effects as nutrients continue to accumulate in lake sediments for potential internal cycling, and result in eutrophic conditions. Reductions of nutrient loads from failed septic systems can be improved through public education programs or expansion of sewage collection systems for offsite treatment (Tetra Tech, Inc., 2003).

Although a good portion of the watershed's population has sewers, there are many potential opportunities for contribution of nutrients from human waste to waters of the San Jacinto River watershed. Soil and water conditions near shorelines may make septic systems less efficient in treating waste. Otis (1978) states as much as 68% of the total land area of the US has soils unsuitable for septic tank systems (Tsatsaros, 1993). Septic systems with drain fields are a nonpoint source that must be considered, as these systems might not always be effective in trapping and preventing nutrients from entering the lakes via groundwater transport. The general disadvantages of septic systems include the potential for groundwater pollution depending on the soil characteristics and density of systems in a given geographical area, and system overflows and pollution of adjacent water wells and surface watercourses if the systems are not properly maintained.

Septic systems should be located as far from the lakes as possible, the greater the distance between the septic tile field and the water table, the greater the likelihood nutrients will be immobilized and not transported to a surface water via groundwater. Nutrients or biological contaminants encountering soil saturated with water can move greater distances, in some instances as much as several hundred feet (Tsatsaros, 1993).

Most septic systems will fail sometime, and after a while, as long as 20 to 30 years under the best conditions, the soil around the drain field becomes saturated with nutrients making the system unusable, therefore, any additions of nutrients then moves through the drain field into the lake (Tsatsaros, 1993).

The most common on-site system is the septic tank and drain field; the tank provides primary treatment by trapping solids, oil, and grease that could clog in the drain field (EPA 1990). As wastewater flows through the drain field, phosphorus is reduced by adsorption to soil particles, and nitrogen is reduced by biological processes. Some bacteria also convert ammonia nitrogen to nitrate in the drainfield; nitrate moves with the flow eventually entering a lake in the groundwater (USEPA 1990). Many lakeside lots are inappropriate for septic systems, and lake problems have conclusively been associated with septic system failures including unsuitable soils, high water tables, steep slopes, system underdesign, or improper use (USEPA 1990).

The greatest risk of phosphate pollution for lakes comes from surface failing on-site septic systems or from the direct discharge of septic tank effluent into the surface water. The most common reason for early failure of septic systems is improper maintenance by homeowners. When a system is poorly maintained and not pumped out on a regular basis, sludge builds up inside the septic tank, then flows into the adsorption field clogging it beyond repair (Tsatsaros, 1993).

Public Education

Many county health departments and environmental agencies have good reference brochures on function and design of septic systems. These agencies can assist the property owner in evaluating these conditions and selecting the appropriate treatment system. EPA has several publications including the Innovative and Alternative Technology Assessment Manual (USEPA No. 430/9-78-009) (USEPA 1990). Future expansion of sewer collection systems is dependant on the communities needs; in some areas septic systems are more appropriate.

San Francisco Bay Regional Water Quality Control Board (SWRCB) staff engineer Blair Allen co-authored a book on septic systems in 2000. The book is entitled: The Septic System Owner's Manual, by Lloyd Kahn, Blair Allen and Julie Jones, published by Shelter Publications. The book states that in spite of such widespread usage, the average homeowner seems to know little about the basic operation and appropriate maintenance of a septic system. This book describes the conventional gravity-fed septic system, how it works, how it should be maintained, and what to do if things go wrong. There is also basic information on the recent evolution of composting toilets, designs for simple gray water systems, and some typical alternatives to the conventional septic system. There is also a chapter with advice to any community faced with town-wide septic system upgrades, and an illustrated chapter on the history of waterborne waste disposal. This book is a basic manual for the average homeowner, based on conventional septic system practices, providing practical advice on how to keep these systems up and running (SWRCB, 2000).

Riverside County:

Riverside County Community Health Agency, Department of Environmental Health, Land Use Section (www.co.riverside.ca.us**)** facilitates the permitting or certification of subsurface sewage systems. The County has an "Engineering List for Soils Percolation" that lists companies that provide soil percolation studies within Riverside County. The purpose of soil studies is to provide insight on designing sub-surface disposal (septic) systems for repairing existing systems. The County does not endorse any particular company on the list. The county also has a "Soils Information Card" available to help staff research existing data on soils percolation on specific parcels of land. Percolation rates are required for the design of sub-surface disposal systems when sewers are not available in Riverside County.

Orange County:

The County of Orange Planning & Development Services Department**,** Building Permits Services in Santa Ana (http://pdsd.oc.ca.gov**)**, assists permit applicants in providing a uniform approach to percolation testing requirements and design criteria of an on-site sewage system. The County considers these systems to be temporary until a public sanitary sewer becomes available. The Planning and Development Services Department is responsible for the review and approval of all percolation tests for on-site sewage systems, as well as plans for their design.

Future Expansion of Sewage Collection Systems

A sanitary community sewer system installed around Lake Elsinore or Canyon Lake to replace existing septic systems could improve the water quality of the lakes by eliminating septic contamination. However, it may take a number of years (5 or more) for significant improvements to occur in the water quality of the lakes, after the sewer system is installed. There are alternative sewer system designs available that are much more cost effective than conventional systems and can be tied into the public sewer system. These smaller sewers are installed at shallower depths and might work for small communities or individual homeowners when a major municipal or regional facility already exists and has available capacity.

In many communities, small scale treatment is the only feasible approach but site conditions prohibit the use of on-site systems, therefore cluster systems can be used. In this case, wastewater is conveyed by small diameter sewers to a neighborhood drainfield, mound or sand filter. Construction and operating costs for on-site or cluster systems are usually low, and the systems are easy to operate use. The effects are likely to be long lasting, and more cost effective in the long run (USEPA 1990).

Institutional Barriers

Both management options discusses above require involvement of municipal entities and water districts for proper implementation. For public education programs to be successful, involvement of city and county governments are critical to conveying to the public the importance of the issues regarding proper management of septic systems.

Existing public awareness and education programs may be modified to include pertinent information regarding septic systems.

For expansion of existing sewage collection systems, associated costs and benefits would require detailed discussions with municipalities and the water district providing the service. Furthermore, expansion and construction of sewage collection systems would likely require land acquisition for conveyance corridors (i.e., pipelines or lift stations). Substantial future studies are required for full cost estimate, benefit analysis, and planning that include cooperation of citizen groups, municipalities, local and state regulatory agencies, and water districts.

Sources of nutrients from failed septic systems have been identified by the RWQCB in the source assessment for TMDLs of Canyon Lake and Lake Elsinore. For design of a proper implementation plan for TMDLs, the RWQCB relies on cooperation of citizen groups and local agencies for recommendations and input, as described in the *Nonpoint Source Program Strategy and Implementation Plan, 1998-2013 (PROSIP)* (SWRCB, 2000). Without public cooperation, reductions of nutrients from failed septic systems defined by the RWQCB to meet TMDLs cannot be realized.

Project 11: Control of Trash in the San Jacinto River

Project Background

The San Jacinto River has been subject to a large amount of illegal dumping activities that have affected water quality and habitat degradation of sensitive species, as well as contributed to overall degradation of watershed water quality (County of Riverside, 2003). Uncontrolled sources of trash in San Jacinto River and tributaries can potentially flow through the watershed to Canyon Lake and ultimately to Lake Elsinore, both of which are listed as impaired waterbodies on the state's Section 303(d) list. This trash consists of old tires, oil cans, household hazardous wastes, appliances, used baby diapers, refuse, litter, yard waste, dead animal carcasses, and many other items of unknown origin. These materials potentially carry various pollutants and toxics into the river that contribute to the overall loading and resulting impairments of water quality in Lake Elsinore and Canyon Lake (County of Riverside, 2003).

Project Goals and Overview

The County of Riverside, in cooperation with the California Department of Fish and Game, RCFCWCD, the San Jacinto River Watershed Council, SAWPA, and LESJWA, proposes to improve water quality in the San Jacinto River watershed by developing a comprehensive program to provide the following (County of Riverside, 2003):

- Identification sources of pollutants in streams;
- Development of BMP's to control pollutants;
- Control of land use in problem areas to minimize future degradation; and
- Assistance to the RWQCB in TMDL development for Lake Elsinore and Canyon Lake.

Project Overview

The proposed project will provide an overall strategy for management of trash in the San Jacinto River watershed and provide a roadmap for cleanup efforts and future planning. To provide the necessary information for guidance in development of a management plan, the following tasks will be performed (County of Riverside, 2003):

- Cooperation with stakeholders to develop a management practices strategy to identify components of a comprehensive cleanup and monitoring program;
- Designation of a prioritized demonstration area to assess effectiveness of management practices where illegal dumping activities are prevalent;
- Organization of community cleanup events of the demonstration area to promote public outreach and education and provide the basis of a cleanup program that can be continued in the future;
- Monitoring of the demonstration area, following cleanup efforts and management practices, to assess effectiveness of programs in improving water quality;

- Land acquisition of high-priority areas for reduction of illegal dumping activities and provision of habitat conservation areas.

Results of the tasks outlined above will provide the basis for development of an overall watershed management plan, including identification of target areas and necessary BMP's to improve watershed conditions.

Institutional Barriers

Cooperation of RCFCWCD with local and state regulatory agencies and the public are key to project success. Land acquisition of high-priority areas will require cooperation with existing landowners. Furthermore, nutrient sources that are identified in trash in the stream channel will require estimation and coordination with the RWQCB if such sources are to be incorporated within implementation plans for nutrient TMDLs for Canyon Lake and Lake Elsinore; in current TMDLs, nutrient sources from trash are not identified as a source to the lakes

Project Schedule

The County of Riverside, in cooperation with the California Department of Fish and Game, RCFCWCD, San Jacinto River Watershed Council, SAWPA, and LESJWA, have submitted their full concept proposal to the State Water Resource Control Board for review. If awarded, anticipated start date is October 2004 with a completion date of March 2007 (County of Riverside, 2003).

Project Costs

The projected budget for the San Jacinto Watershed Improvement and Protection Program is $6,139,000. This project cost includes the acquisition of approximately 300 acres or riparian land for habitat protection (County of Riverside, 2003). A Proposition 13 grant application for partial project funding was submitted to the State Water Resources Control Board by the RCFCWCD in October 2003.

Project 12: Interception and Treatment of Nuisance Urban Runoff

Project Background

Nuisance flows from urban areas are considered to be an active source of pollutants to both Lake Elsinore and Canyon Lake. Such flows, characteristic of dry periods, derive from common urban practices such as lawn irrigation, car washing, etc., and result in transport of relatively high concentrations of bacteria. Nutrients are also likely transported from these areas through lawn fertilization. Quantification of these sources is often difficult due to the temporal variability associated with magnitudes of urban runoff and water quality. For instance, one resident may start a lawn sprinkler system in the morning, which washes into the street and eventually reaches the gutter. Pet waste and fertilizer in the yard are also washed into the gutter, carrying high concentration of bacteria and nutrients. Later, the sprinkler system stops, but a neighbor starts washing his car with rinse water flowing to the same gutter. As a result of these multiple sources, flow out of this gutter into a lake is intermediate and does not flow at a constant rate. Also, the water quality changes as the source of flow changes.

The ideal method for control of nuisance urban runoff is at the source, however, it is not feasible to attempt to control an entire community's water usage and wastage. Therefore, structural BMP's are often employed to either treat the water onsite prior to discharge to the receiving water, or intercept and divert runoff to an offsite, existing sewage treatment facility. Both technologies have proven to be successful in reducing nuisance urban runoff impacts to waterbodies.

In 1991, the City of San Diego constructed an interceptor system to reduce nonpoint source pollution to Mission Bay, an important recreational area of San Diego (City of San Diego, 2002). This system intercepts and diverts dry weather flows in storm drains to a wastewater treatment plant. During wet weather, the interceptor system is opened to allow stormflows to bypass the system and flow directly to the bay. A similar system has recently been implemented by the South Orange County Wastewater Authority (SOCWA) for treatment of nuisance flows in coastal areas of southern Orange County to reduce beach closures due to high bacteria levels and provide compliance to stormwater NPDES permits (Schmidtbauer, 2003). Larger scale implementation has been very successful for large urban areas of Los Angeles to improve water quality at Santa Monica beaches (Salgaonkar et al., 2003). For other communities, such as the City of Encinitas (specifically Moonlight Beach), other BMP's were selected to remedy problems resulting from urban nuisance runoff due to high costs of pumping to existing sewage treatment plants in the area. For Moonlight Beach, UV disinfection facilities were designed specifically for treatment of urban runoff (Rasmus and Weldon, 2003).

Project Goals and Overview

A study is recommended to assess the flows and water quality associated with nuisance urban runoff to Lake Elsinore and Canyon Lake and analyze management options to reduce pollutant loads. This study will include the following components:

- Characterization of nuisance urban runoff
- Assessment of impacts to Lake Elsinore and Canyon Lake
- Review of BMP technologies
- Recommend BMP's for Canyon Lake and Lake Elsinore

Each task is dependent upon available funding, but should at minimum include details outlined in the following sections.

Characterization of Nuisance Urban Runoff

Limited data is currently available for characterization of dry flows from nuisance urban runoff and associated water quality for both Lake Elsinore and Canyon Lake. Likely, additional data collection will be required for assessment of average conditions. For this data collection, a survey is recommended to identify which storm drains typically discharge nuisance flows. Once located, a sampling effort can be undertaken to measure flows and water quality from these storm drains. These data can be utilized for characterization of pollutant loads to the lakes for assessment of lake impacts. Similar studies have been performed in the region to analyze nuisance flows for development of nutrient and bacteria TMDL's (e.g., Los Angeles River, San Gabriel River).

Assessment of Impacts to Lake Elsinore and Canyon Lake

Utilizing results of the characterization study outlined above, annual loads of nutrients and bacteria can be estimated for the lakes. These loads can be compared with predictions of other sources of nutrients and bacteria identified in separate studies (Anderson, 2001; Anderson and Oza, 2003; Anderson et al., 2003; Tetra Tech, Inc, 2003) to determine relative impacts to the lakes. If loads are significant, specific BMP's will be required to reduce impacts.

Review of BMP Technologies

A review of BMP technologies for treatment or reduction of nuisance urban runoff is recommended to provide necessary information to define options for selection of BMP's for the San Jacinto River watershed. This review will include an assessment of relative success and costs of alternative BMP's so that proper selection can be made.

Recommend BMP's for Canyon Lake and Lake Elsinore

Based on the review of BMP's described above, recommendations will be made for BMP's for Lake Elsinore and Canyon Lake. The recommended BMP's will consider such factors as cost, benefits to the lakes, and degree of pollutant load reductions required. Recommendations of this study may be utilized by stakeholders in the watershed for selection and design of BMP's.

Project Schedule

At least 6 months are required to complete the study once initial data collection tasks are performed.

Project Cost

The overall cost of the project consists of a characterization study and associated monitoring and lab work. This task is dependent upon the total number of storm drains determined to require sampling in the initial survey. Other impacts to cost are the number of water quality parameters requiring analysis. Therefore, the estimated cost for this study is based on conservative assumptions of number of storm drains sampled. Total project cost is therefore estimated to be $150,000. This cost can be refined through prioritization of the monitoring program.

4.2.2.b Agriculture

Four projects are recommended to address nutrient loads from agricultural areas. These projects are designed to resolve nutrient loading issues specific to cropland and dairy land uses identified in the Nutrient Source Assessment (see Section 3.1.1). These projects are consistent with USEPA's guidance for identification and implementation of agricultural BMPs (USEPA, 2003e). Recommended projects to provide reductions of nutrient loads from croplands include: source-based controls and management of nutrient application to crops; and edge-of-field controls through riparian buffers and improved riparian vegetation adjacent to croplands. Additionally, flooding of agricultural areas has been observed to be a significant problem for extreme storm events, so a study is recommended to quantify nutrient loads from flooded areas. For dairies, a regional organic digester is recommended to improve the overall management of manure in the watershed. The following projects are recommended:

13. Riparian Habitat Restoration and Development of Agricultural Buffers
14. Determination of Crop-Specific Agronomic Rates for Guidance in Fertilizer and Manure Application Management
15. Assessment of Nutrient Loads to the San Jacinto Watershed as a Result of Flooding in Agricultural Areas
16. Regional Organic Waste Digester

The following are detailed summaries of each project, including the background, goals, overview, schedule, and where available, estimated costs.

Project 13: Riparian Habitat Restoration and Development of Agricultural Buffers

Project Background

Agriculture is the leading industry within Riverside County and the San Jacinto River watershed in particular. Much of the valley area of the watershed is devoted to agricultural cropland and grassland. Agricultural irrigation and urban development has lowered the groundwater table and therefore reduced the available water within the root zone of riparian plants. The streams draining into Canyon Lake are intermittent with sandy soils, wide stable banks, and sparse to moderate vegetative cover. Natural vegetation is predominantly winter annual grasses, weeds, and shrubs. Canyons and riparian areas produce oak and cottonwood trees. Important wildlife habitat occurs throughout the area particularly along riparian corridors and brush covered foothills and mountains. Lakes and reservoirs support wintering raptors and thousands of migrating waterfowl. Chaparral and upland habitat support deer, quail, fox, ground squirrels, and numerous raptors. Stephen's kangaroo rat can be found in the foothills.

Riparian habitat serves as a buffer zone between agricultural areas and sensitive receiving waters. Riparian areas support a variety of plant life that helps to provide treatment of runoff from these areas. Restored riparian areas can be constructed as local retention/detention basins to capture flows resulting from urban runoff from upstream areas (i.e., Moreno Valley, Hemet, and San Jacinto) and local runoff from agricultural areas. This will aid in runoff control by reducing the volume of runoff through processes of infiltration. Also, improved buffer areas along streambanks can provide control of sediment eroded from agricultural areas that are high in nutrient content. Runoff quality will also be improved through mechanisms of sorption, filtration, biological uptake, ion exchange, volatilization, and sedimentation. Infiltration of runoff has the additional benefit of recharging groundwater within the proximity of the riparian area. Control of sediment and associated nutrients through riparian habitat buffers are consistent with management measures recommended in the *Nonpoint Source Program Strategy and Implementation Plan, 1998-2013 (PROSIP)* (SWRCB, 2000).

The riparian ecosystem is defined as the zone of direct interaction between the terrestrial and stream ecosystems. This interaction includes two major components: (1) shading by trees and shrubs which regulates light availability for primary production and heat transfer to the stream and (2) biological and chemical cycling between surface water, groundwater and terrestrial vegetation. Dissolved oxygen is another component of importance. Shading and reduced heat transfer maintains a higher level of dissolved oxygen in a waterbody that is critical for a waterbody to sustain fish. Terrestrial vegetation is a source of fine litter, an insect's food resource, and coarse litter (large woody debris) that creates habitat structure and also affects the retention of dissolved oxygen and particulate organic matter. Riparian areas are critical components for survival of wildlife species that depend upon the food, habitat, and microclimate found in riparian zones. Restoration of the riparian buffer along streams and lakes is intended to alleviate historical impacts made to riparian ecosystems as a result of development of the floodplains and protect against further degradation associated with urban development within the watershed. Restoration goals include improving water quality and the structure and function of the native riparian habitat for wildlife, especially migratory birds.

Project Goals and Overview

A field survey by Tetra Tech staff was conducted in September 2003 to visually inspect the stream channels and corridors to assess the conditions of the stream and determine the necessity and feasibility of improvement projects. For each stream corridor identified for improvements, locations are noted below that would benefit from further study to assess the appropriateness of channel restoration opportunities. A summary of these locations and the existing features are presented in Table 4-13-1.

Table 4-13-1. Summary of Stream Conditions at Observed Locations

Location	Existing Features along Stream Channel
Salt Creek	
Goetz Rd	Vegetation
Antelope Rd	Standing Water, Vegetation
Winchester Rd	Standing Water, Vegetation
Linderberger	Vegetation with Large Shrubs
Perris Valley Drain	
Rider St	Minimal Vegetation
Orange St	Standing Water, Vegetation
San Jacinto Ave	Limited Vegetation
Nuevo Road	Standing Water, Vegetation
San Jacinto River	
Goetz Rd	Limited Vegetation
12th Street	Limited Vegetation
Nuevo Rd	Occasional Tree Coverage
Ramona Expressway	Occasional Tree Coverage

For each stream corridor, a separate project is outlined to allow phasing of the combined effort for planning purposes. As a result the restoration studies for Salt Creek, Perris Valley Storm Drain, and the San Jacinto River are separated in the Projects 13A, 13B, and 13C, respectively.

<u>Project 13A: Salt Creek</u>

The majority of Salt Creek, from Canyon Lake at Goetz Road to Winchester Road, would be suitable for riparian habitat restoration. Much of the creek, though dry, supports limited vegetation along the riparian corridor. There are current plans of the RCFCWCD to improve the Salt Creek channel through the Winchester area upstream of Lindenberger Road. The proposed design is an earthen channel with very mild side slopes. The side slopes would be hydro-seeded with native vegetation. The RCFCWCD investigated the possibility of developing a mitigation bank along the channel alignment but decided not to pursue it. No environmental concerns were cited for this decision. It is likely that the banks and areas adjacent to the improved channel would be appropriate for riparian habitat restoration. Therefore this site is recommended for further investigation of restoration opportunities.

Two locations have standing water that may be supportive of a wetland ecosystem. The first location on Salt Creek with standing water is at Winchester Road (Figure 4-13-1). If observed standing water is indicative of year round water availability, then it is likely that vegetation could be sustained over the hot, dry summer months. The second location was within a residential area, the Menifee Lakes Country Club, where it appears the streambed was ponded into three ponds in series for aesthetic purposes. Outflow from these ponds could be used to create a flow-through wetland just upstream of Antelope Road (Figure 4-13-2). There are reeds and other wetland plants already established at this site, indicating suitable wetland habitat.

Figure 4-13-1. Salt Creek at Winchester Road (looking upstream)

Figure 4-13 2. Salt Creek at Antelope Road (looking upstream)

Riparian and wetland restoration improvements could reduce the nutrient loads to Canyon Lake and subsequently Lake Elsinore through buffers along streams in agricultural areas and detention/retention of urban watershed runoff. Upstream of the locations observed in the San Jacinto Valley are the cities of Perris and Hemet. Flow from these urban centers contributes to urban runoff above the locations identified as suitable for restoration efforts. There is significant agricultural land use along Salt Creek. In addition to contaminants from the urban areas, agricultural areas contribute a significant amount of nutrients either during irrigation or storm events. Riparian and wetland restoration adjacent to the creek would act as an agricultural buffer and reduce the amount of nutrients discharged into the creek.

The RCFCWCD flood control project along Salt Creek extends from Lindenberger Avenue through the Winchester area, as shown in Figure 4-13-3. It has been designed with mild side slopes with the intent of providing vegetation. Utilizing this basic framework, more intensive habitat restoration could be developed, either along the banks/overbanks or in designated pockets along the creek's reach. These design decisions will depend on topography, availability of rights-of-way, and the potential for local water diversions. To provide better understanding the system and recommend additional restoration work, the following studies should be implemented in a single project:

- Water Supply: Study would evaluate the expected amount of flow that is available to support restoration. The water supply could include urban runoff, storm flows, groundwater or subsurface flow, or domestic sources.

- Vegetation Plan: To complement the hydro-seeding that is planned, study of the types of vegetation that could provide more variety of habitats would be performed. The recommended vegetation plan would be dependent on the determined water availability.
- Hydraulic Study: Based on the requirement to convey the 100-year flood, study to determine if any stream sections have excess capacity and if so how much additional vegetation could be supported without interfering with the flood control aspects.
- Land Ownership: Determine the land ownership adjacent to the channel right-of-way. Public lands may provide opportunity for off-line restoration opportunities.
- Conceptual Plan: Based on the results of the preceding studies, conceptual plans for restoration opportunities along Salt Creek would be developed. The plans would include a typical cross section and plan view and would identify the recommended vegetation plan.

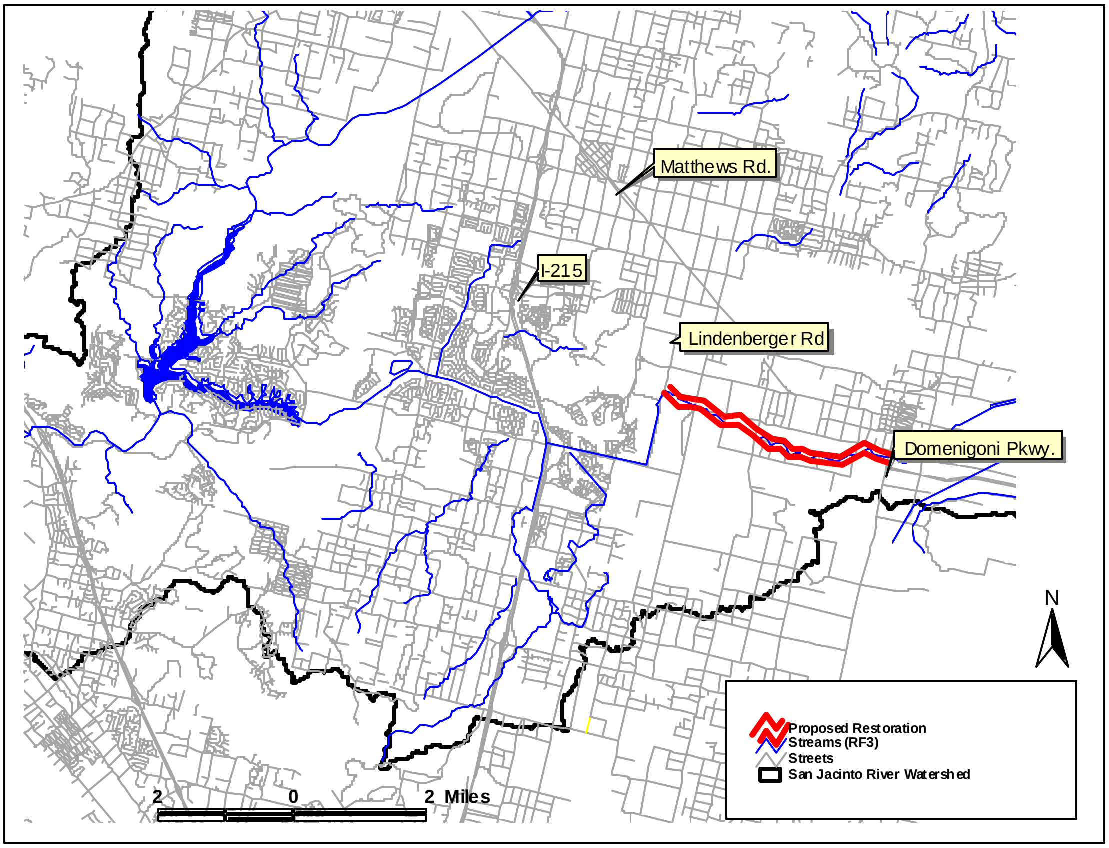

Figure 4-13-3. Location of Salt Creek channel improvements and proposed restoration

Project 13B: Perris Valley Storm Drain

The Perris Valley Storm Drain extends from above Rider Street to the San Jacinto River confluence. Riparian restoration along the stream corridor in the predominantly agricultural area downstream of Perris is recommended. The extent of opens space and the potential for nutrient removal and habitat creation are high. The stream corridor appears suitable for habitat restoration given the existing plant life, soil, open space and presence of water. The creek bed has both dry and wet sections. Dry reaches are located upstream and downstream of Rider St, and at San Jacinto Avenue (Figure 4-13-4). Several small pools of standing water are located downstream of Orange Street (Figure 4-13-5).

The Perris Valley Storm Drain channel segment between Nuevo Rd and San Jacinto Avenue has the largest volume of standing water (Figure 4-13-6). This water may be dry weather flow from the nearby urban areas, and represents a potential water source for habitat creation. The standing water seen downstream of the Nuevo Road disappears within approximately 200 yards. Downstream of Nuevo Road, a large pool is present that suggests a likely spot for a wet detention pond or wetland habitat restoration project. This assumes that the standing water is persistent over a reasonable length of time. The continued availability of the water will require further investigation.

Figure 4-13-4. Perris Valley Drain at Rider Street (looking downstream)

Figure 4-13-5. Perris Valley Storm Drain at Orange Street (looking downstream)

Figure 4-13-6. Perris Valley Drain at Nuevo Road (looking downstream)

The RCFCWCD has a conceptual plan to deepen and widen the Perris Valley Storm Drain in order to provide adequate storm flow conveyance. A constraint to this design is the proximity of the aqueduct. There is little clearance between the two conveyance systems. Once this design issue is resolved, it may be possible to include a riparian habitat restoration element into the Perris Valley Storm Drain project. Restoration along Perris Valley Storm Drain would help mitigate the pollutant loading from both the urban areas and the agricultural areas. These buffered areas would reduce the loading of pollutants, particularly nutrients, to the river and to the downstream lakes.

The RCFCWCD flood control project along Perris Valley Storm Drain will likely extend from the confluence with the San Jacinto River to Ramona Expressway, as shown in Figure 4-13-7. No design has been completed for this project. It is recommended that the planning phase of a restoration project be completed in conjunction with the RCFCWCD design efforts. The design work completed by the RCFCWCD should be used to identify sections of the storm drain where either additional conveyance is recommended or the right-of-way allows for a channel design that exceeds the flood control requirement to contain the 100-year flood. Areas of excess capacity provide opportunities for restoration improvements, either along the conveyance or in designated pockets along the drain's reach. These design decisions will depend on topography, availability of rights-of-way, and the potential for local/standing water or diversions.

It is recommended that an investigation take place that considers the RCFCWCD plans for the storm drain and the opportunities for additional riparian restoration. Selecting appropriate locations for restoration and defining the type of restoration will require the following studies to be performed:

- <u>Water Supply:</u> Study to determine the expected amount of flow that is available to support restoration. The water supply could include urban runoff, storm flows, groundwater or subsurface flow, or domestic sources.
- <u>Hydraulic Study:</u> Based on the requirement to convey the 100-year flood, determine if any drain sections that have excess capacity, and if so, how much vegetation could be supported without interfering with conveyance.
- <u>Vegetation Plan:</u> Study to determine the types of vegetation that would provide the optimal habitat for the area. The recommended vegetation plan would be dependent on the determined water availability.
- <u>Land Ownership:</u> Determine the land ownership adjacent to the channel right-of-way. Public lands may provide opportunity for off-line restoration opportunities.

From the results of the tasks described above, specific site locations would be selected for channel restoration. The selected sites could range from a few focused locations to the entire length of the storm drain. Once the site selection has been made the following task would be required:

- Conceptual Plans: Develop conceptual plans for restoration opportunities along Perris Valley Storm Drain. The plans would include a typical cross section and plan view and would identify the recommended vegetation plan.

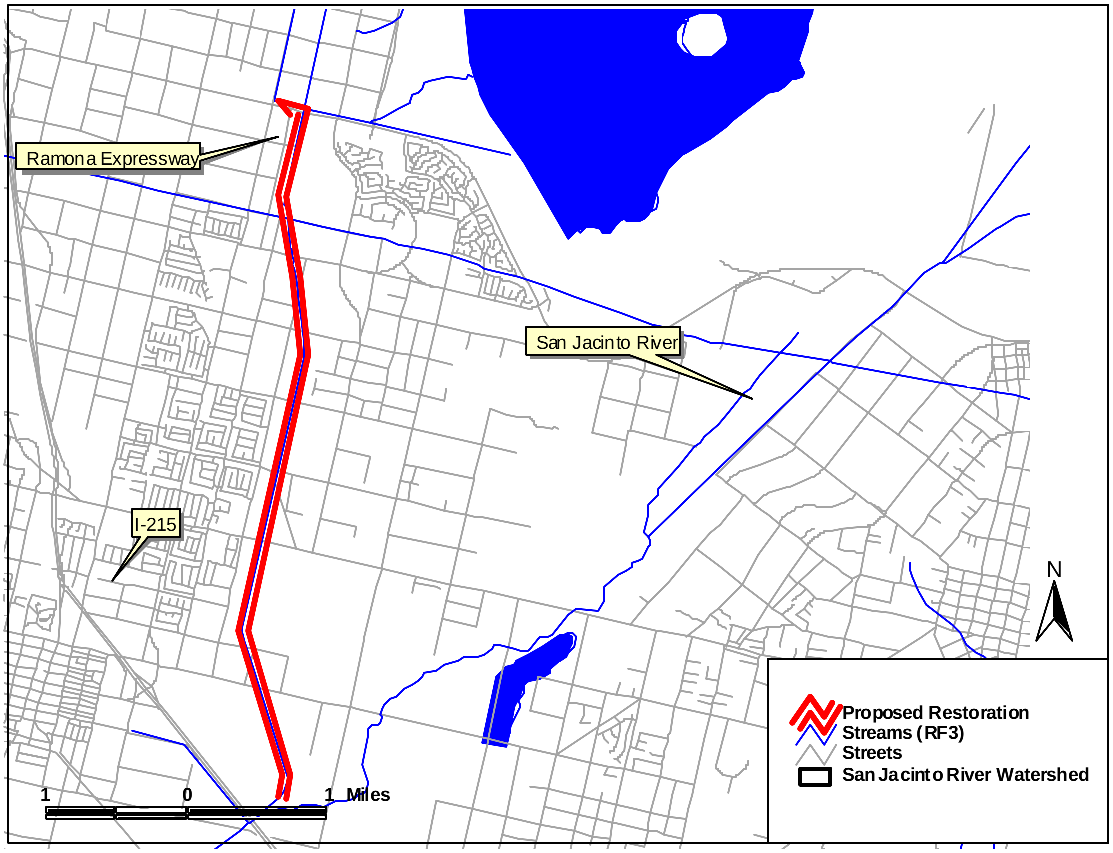

Figure 4-13-7. Location of proposed Perris Valley Storm Drain channel improvements and proposed restoration

Project 13C: San Jacinto River

Locations along the San Jacinto River appear suitable for habitat restoration given that there are trees and other plant life, soil, and open space. Agricultural land uses exist adjacent to the river almost the entire length of the study area. The river reaches examined are located at the edge of Nuevo and Perris residential development, between Goetz Road and the Ramona Expressway. The creek bed was dry in all places, although plant life is supported in many locations. The reach between Nuevo Road and the Ramona Expressway (Figure 4-13-8) is lined with occasional trees and appears to sustain riparian plant life. The downstream reach of the San Jacinto River at Nuevo Road has a dense covering of grass, indicating to some extent water availability (Figure 4-13-9). The Eastern Municipal Water District (EMWD) percolation ponds are located just upstream of San Jacinto Avenue; these ponds had a dense green grass covering (Figure 4-13-10). The river reach downstream of San Jacinto Avenue appears to have some available water due to the plant coverage; however standing water is not evident.

Figure 4-13-8. San Jacinto River at 12th Street (looking upstream)

Figure 4-13-9. San Jacinto River at Nuevo Road (looking downstream)

Figure 4-13-10. EMWD Percolation Ponds

There is currently a management plan under development for the San Jacinto River along the entire study reach from Ramona Freeway to Canyon Lake. The plan is being developed by the local landowners and will conform to the requirements of the Multiple Species Habitat Conservation Plan (MSHCP, 2003). No details regarding the possible riparian restoration elements of that plan are currently available. For future project planning, it is recommended that involvement with the landowners group be maintained in order to provide input regarding riparian habitat opportunities that are available. It is possible that the recommended plan will include levees along the river in order to reclaim a portion of the existing floodplain for development. Between the levees land would be set aside for flood control purposes but could also be used for restoration purposes. These levees would likely become part of the RCFCWCD flood control facilities and a maintenance plan would be developed. Currently the San Jacinto River from Canyon Lake to the Ramona Expressway is strictly a natural system with no maintenance plan.

The proposed project area is shown in Figure 4-13-11. The recommendation for riparian enhancement/restoration is based on the assumption that landowners adjacent to the river will restrict any development within the defined riparian area. If that occurs this area could behave as a buffer for both urban and agricultural runoff. It is recommended that involvement with the landowner group be maintained in order to provide input regarding riparian habitat opportunities as part of the landowner plan. Potential buffer areas would be identified in association with the following investigations:

- Water Supply: Study to determine the extent of water that will be available to support any riparian enhancements.
- Vegetation Plan: Study to determine a riparian planting scheme in order to provide the types of vegetation to supplement existing vegetation for optimal habitat considering water availability.

These investigations would include coordination and cooperation with landowners and stakeholders in the vicinity of the project area or impacted by the results of the study.

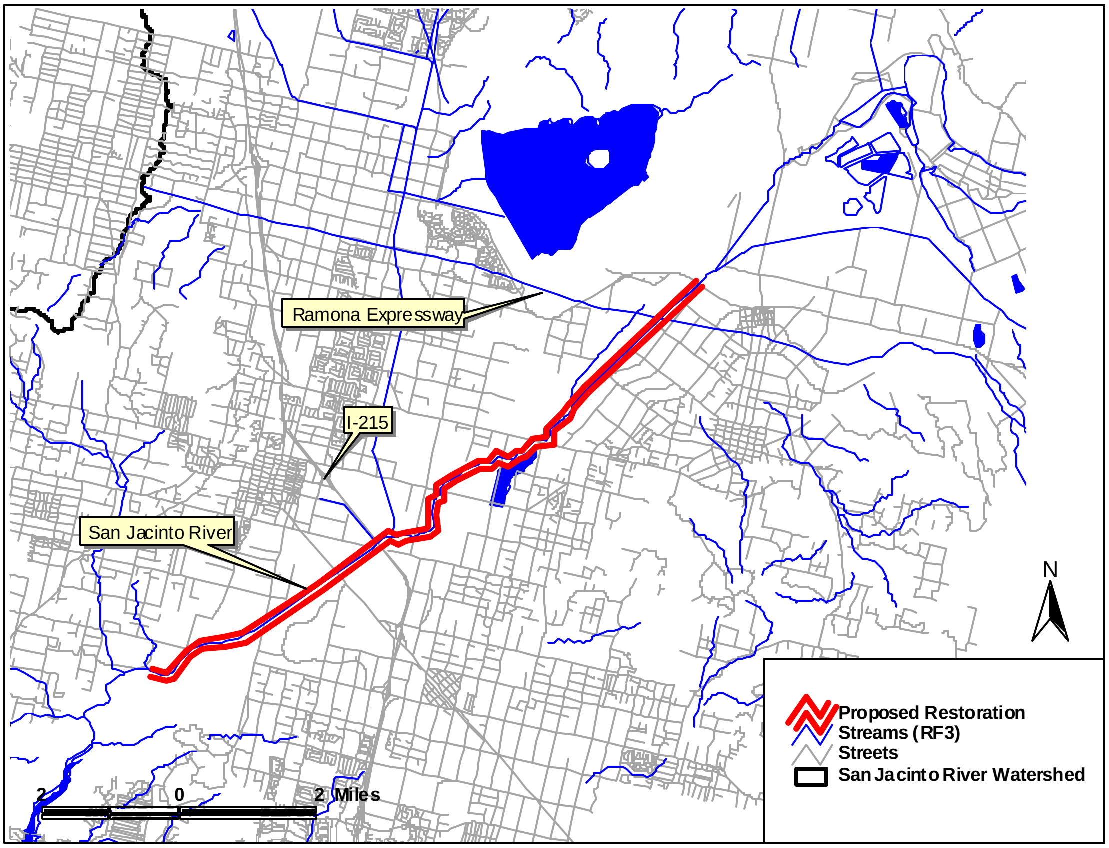

Figure 4-13-11. Location of San Jacinto River channel improvements and proposed restoration

Institutional Barriers

Important considerations in the planning and design of riparian habitat restoration projects are institutional barriers that require cooperation from state, county, and local and municipal entities. Such issues may include land acquisition for sites of BMP construction, cooperation and consistency with the RCFCWCD project planning, cooperation with municipalities where restoration work is recommended, and cooperation with the RWQCB to validate that such BMP measures are considered consistent with TMDL implementation plans, as recommended in the *Nonpoint Source Program Strategy and Implementation Plan, 1998-2013 (PROSIP)* (SWRCB, 2000) and the *Draft California Nonpoint Source Program Five-Year Implementation Plan ¾ July 2003 Through June 2008* (SWRCB, 2003).

Project Schedule

Project 13A: Salt Creek

Design plans for the Salt Creek RCFCWCD project are available; therefore, Project 13A could begin immediately. It is anticipated that the 5 tasks identified above will require approximately 10 months to complete, including coordination with affected agencies.

Project 13B: Perris Valley Storm Drain

Project 13B must be developed in conjunction with the development of the RCFCWCD improvements to the Perris Valley Storm Drain, and is therefore dependent on the RCFCWCD schedule.

Project 13C: San Jacinto River

The schedule for this project is highly dependent on the plan that will be developed by the landowners. The landowner plan must be more fully developed before any further plans can be made regarding riparian habitat enhancement.

Project Cost

Project 13A: Salt Creek

The cost for completing the 5 tasks and development of the conceptual plan associated with Project 13A is approximately $80,000. Coordination and issue resolution with RCFC would represent an additional cost.

Project 13B: Perris Valley Storm Drain

The cost for completing the 5 tasks associated with Project 13B is approximately $100,000.

Project 13C: San Jacinto River

The cost for completing the water supply study and the enhancement plan is approximately $60,000. The enhancement plan will include typical cross sections of the area and details regarding the planting to be accomplished.

Project 14: Determination of Crop-Specific Agronomic Rates for Guidance in Fertilizer and Manure Application Management

Project Background

Agricultural area, specifically croplands, dominate the sources of nutrients in the San Jacinto River watershed (see Section 3.1.1.b). Sources of nutrients from cropland areas result from fertilization and manure spreading practices. During a rainfall event, nutrients that accumulate on the land surface wash off and are transported to Canyon Lake and Lake Elsinore. However, little information is currently available regarding management practices and spatial and temporal variability of agricultural practices in the watershed.

During validation of the watershed model (utilized for the Nutrient Source Assessment) to 2003 water quality data (Appendix C), deviation of model predictions from observed data suggested misrepresentation of nutrient loads resulting from agricultural runoff. Although the model was previously calibrated and validated to ten years of data, the model had difficulty predicting water quality for two storm events in 2003 for areas with substantial amounts of croplands. For the Nutrient Source Assessment, accumulation rates of phosphorus (21 lbs/acre/yr) and nitrogen (105 lbs/acre/yr) were assumed constant for all croplands based on spatial land use data (see Section 2.4.2). This estimate assumed 12 dry tons/acre of manure applied annually. Land use data provided no information regarding crop types and variability of management practices such as fertilizer/manure application rates. As a result, nutrient load estimates from specific croplands may be improved since uniform rates of nutrient accumulation for all croplands are unlikely. Furthermore, these rates were assumed uniform throughout the year, when seasonal variability is likely due to crop rotation or other agronomic considerations.

Project Goals

To refine predictions of nutrient loads from specific croplands in the watershed, a survey of the spatial distributions of specific crops and associated fertilizer/manure application rates would be useful. If specific croplands vary significantly in fertilizer/manure application than other areas with similar crops, then this information would provide additional detail in assessment of the overall nutrient budget. To provide additional guidance, agronomic rates for nutrients can be estimated for each crop type to determine if existing practices result in application of higher quantities of nutrients than can be assimilated by those crops. Results of analyses can be utilized to determine an optimal system for management of nutrients from croplands in the watershed.

The prediction of crop-specific agronomic rates for nutrients are independent of the source of the nutrient applied. Different sources include manure, industrial fertilizer, and recycled water. The goal of this study is to determine the maximum load of nutrients that can be assimilated by each crop type. This information can support future management of nutrients in agricultural areas in the watershed, including the budgeting of collective loads associated with application of either manure, industrial fertilizer, or recycled water.

It should be noted that currently there are no minimum requirements regarding effluent nutrient concentration in recycled water, as defined in NPDES discharge permits. Nutrient loads associated with recycled water are also defined by the *volume* applied to watershed areas. For future analyses that compare existing loading rates to agronomic rates, decision-makers can consider impacts of recycled water (including NPDES requirements) relative to other sources of nutrients (i.e., manure and fertilizer) for guidance regarding management of nutrients in agricultural areas.

Project Overview

The recommended study will include three major tasks outlined in the following sections.

<u>Data Collection</u>

A study is recommended to collect the following information:

- Spatial inventory (GIS) of crop distributions in the watershed; if crops are rotated throughout the year, each crop and associated season will be included in the inventory.
- Estimation of seasonal nutrient application rates for each crop type. For both fertilizer and manure, content will be assessed to determine quantities of nitrogen and phosphorus. If management of specific farms varies significantly for identical crop types, nutrient application rates will be estimated and catalogued separately for each farm so that spatial variability in the watershed will be representative of such conditions.
- Estimation of agronomic rates associated with each crop type for both nitrogen and phosphorus.

<u>Development of Nutrient Budget and Nutrient Management Plan for Croplands</u>

Based on the data collected above, an assessment can be performed to compare estimates of existing nutrient loading rates for specific crops with estimated agronomic rates. Results of this assessment can be used as guidance for local farmers in determining necessary loading rates for manure or fertilizer application. If existing practices result in excess nutrients from over-fertilization, such loading rates can be reduced. Reduction of these loads will reduce nutrients available for wash-off and delivery to Canyon Lake and Lake Elsinore during wet weather. Proper management of manure/fertilizer application in croplands will likely result in drastic improvements in overall nutrient loads to the lakes. Although many farms in the watershed already exercise proper management practices for manure/fertilizer application, other farms are believed to grossly over-apply manure to lands which ultimately result in delivery of excess nutrients to the lakes. Results of this study would provide guidance for management of these problem areas.

<u>Reconfiguration and Recalibration of the Watershed Model</u>

Quantification of nutrient accumulation rates, dependent on area in the watershed and crop type, would provide better resolution for the watershed model (Tetra Tech, Inc.,

2003) should the model be updated in the future. Projects 6 and 8 recommend future modeling of Lake Elsinore and Canyon Lake that would require update of the watershed model for simulation of boundary conditions for the lake. If sufficient data is available from the study proposed herein, the watershed model can be refined to include spatial variability of specific crops and associated nutrient management practices. Updates would require recalibration of the watershed model, so the scope and costs outlined in Projects 6 and 8 would likely require expansion should the results from the above study be incorporated into the model. As a result, the cost estimate for Project 17 below does not include cost associated with modeling tasks. If possible, such work should be included during planned updates so the lake models proposed in Projects 6 and 8 can be calibrated using boundary conditions defined by the reconfigured watershed model. This would avoid any duplication of calibration efforts in the future.

Project Schedule

Once started, the duration of the project is estimated to be one year. So that results of this study can be utilized for potential model updates, the start date should begin at least a year prior to modeling projects. This project could be on schedule with the monitoring projects (Projects 5, 7, and 19) since results from these tasks will also be utilized for model development.

Project Cost

Total estimated cost of the project is $120,000, and includes all data collection efforts mentioned above. Costs may vary depending on the detail of data collected. Such detail can be refined depending on the amount of funding available to complete the project.

Project 15: Assessment of Nutrient Loads to the San Jacinto Watershed as a Result of Flooding in Agricultural Areas

Project Background

Flooding of agricultural areas is a major potential source of nutrients during large storm events. Such an event occurred in 1993 with significant agricultural area flooded in the San Jacinto River floodplain. Agricultural areas have high nutrient deposits on the land surface due to manure or fertilizer application to crops or detention of manure from dairies. As flooding occurs, these areas are submerged and nutrients are carried in flows to downstream areas (Figure 4-15-1). Nutrient loads carried from flooded areas are transported to Canyon Lake and Lake Elsinore, where they contribute to in-lake biological problems over extended periods through recycling processes (Section 3.1.2).

The Nutrient Source Assessment was unable to estimate loads attributed to flooding since such processes are not simulated in currently available watershed models and no other data was available for quantification of these loads during 1993. Furthermore, the Riverside County Flood Control and Water Conservation District (RCFCWCD) has plans for modifications of existing levees to redefine the floodplain in problem areas, so quantification of loads from flooding of 1993 would not provide information regarding potential nutrient loads resulting from future floods. As a result, it is recommended that a model be developed to predict nutrient loads as a function of increasing water levels and associated expansion of the channel width as the floodplain is inundated with floodwater.

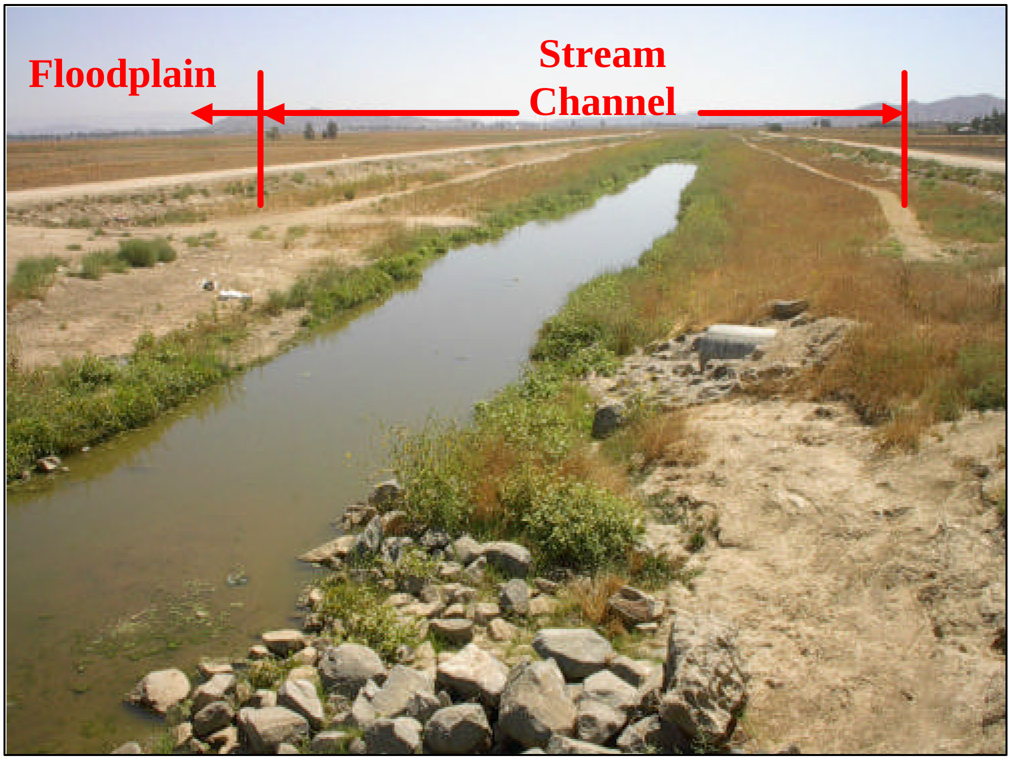

Figure 4-15-1. Example stream channel and floodplain

Project Goals and Overview

The recommended study will provide nutrient estimates for the existing floodplain and the changed floodplain resulting from proposed redesign of the levee system by the RCFCWCD. To complete the nutrient load estimates, the following tasks are recommended:

- Floodplain analysis: Assessment of the existing floodplain and the proposed future floodplain by the RCFCWCD using all models or information used in floodplain analysis.
- Nutrient Source Analysis: Assessment of nutrient sources in the existing and RCFCWCD proposed floodplain, with consideration given to elevation and susceptibility to flooding.
- Nutrient Transport Estimates: Estimate of nutrient transport from sources as a function of flooding
- Nutrient Loading Curves: Development of loading curves for nutrients as a function of depth of the stream channel for major segments of the San Jacinto River.

Results of this study will provide information regarding nutrient loads to Lake Elsinore and Canyon Lake during torrential storm events. This information would be very useful in overall management of nutrients in the watershed and impacts on the lakes. The RWQCB can use the results of the study to revisit the Lake Elsinore and Canyon Lake

TMDL's if it is determined that flooding conditions are common enough to require their inclusion in the TMDL's and necessitate specific load allocations to ensure improvement of water quality of the lakes. Also, conclusions from the study can provide guidance to the RCFCWCD for future planning and management options.

Floodplain Analysis

For analysis of the existing floodplain, a HEC-RAS model of the San Jacinto River floodplain was prepared for the RCFCWCD (WEST Consultants, Inc., 2001). Using this model, the floodplain and depth of flow can be estimated for various storm events (e.g., 10-year storm, 25-year storm, 50-year storm).

For the RCFCWCD's proposed future floodplain, either the existing HEC-RAS model can be updated, or a separate analysis can be performed to estimate the extent of flooded area as a function of storm magnitudes consistent with the study of existing conditions discussed above.

Nutrient Source Analysis

Using land use data and other sources of information regarding agricultural practices in the floodplain, the sources of nutrients in the watershed that are available for transport during flood events can be assessed. Such sources include croplands where manure or fertilizer are collected on the land surface and are available for transport as these areas are submerged. Storage facilities for dairy wastewater, designed to contain all process-generated wastewater plus the runoff from a 25-year, 24-hour rainfall event (Title 27, Chapter 7, Subchapter 2, Article 1, Section 22562(a), California Code of Regulations and 40 CFR Part 412), can potentially overflow or flood during storm events greater than a 25-year storm. If these facilities are mismanaged or if they provide limited volume for containment of runoff, the likelihood of system overflows are increased.

Nutrient Transport Estimates

Based on information regarding the extent of floodplain and location of sources of nutrients within the area, nutrient loads can be estimated for each storm event assessed in the floodplain analysis. Sources of nutrients in the floodplain can be washed downstream as these areas are submerged. The amount of nutrients transported from these sources during such events can be estimated.

Nutrient load estimates specific to storm events will be determined for key stream segments of the San Jacinto River and Perris Valley Storm Drain determined to have problematic flooding occurrences. Channel segmentation will be based on stream hydraulic features and analysis of nutrient sources within the floodplain.

Nutrient Loading Curves

To report nutrient loads for each stream segment, loading curves can be provided to allow prediction of loads as a function of different storm magnitudes. Figure 4-15-2 shows an example of a loading curve for a specific stream segment; storm magnitudes for the loading curve are expressed as return periods (e.g., 25-year storm is a storm likely to occur once every 25 years). For this study, loading curves will be provided for both total nitrogen and total phosphorus for each stream segment studied.

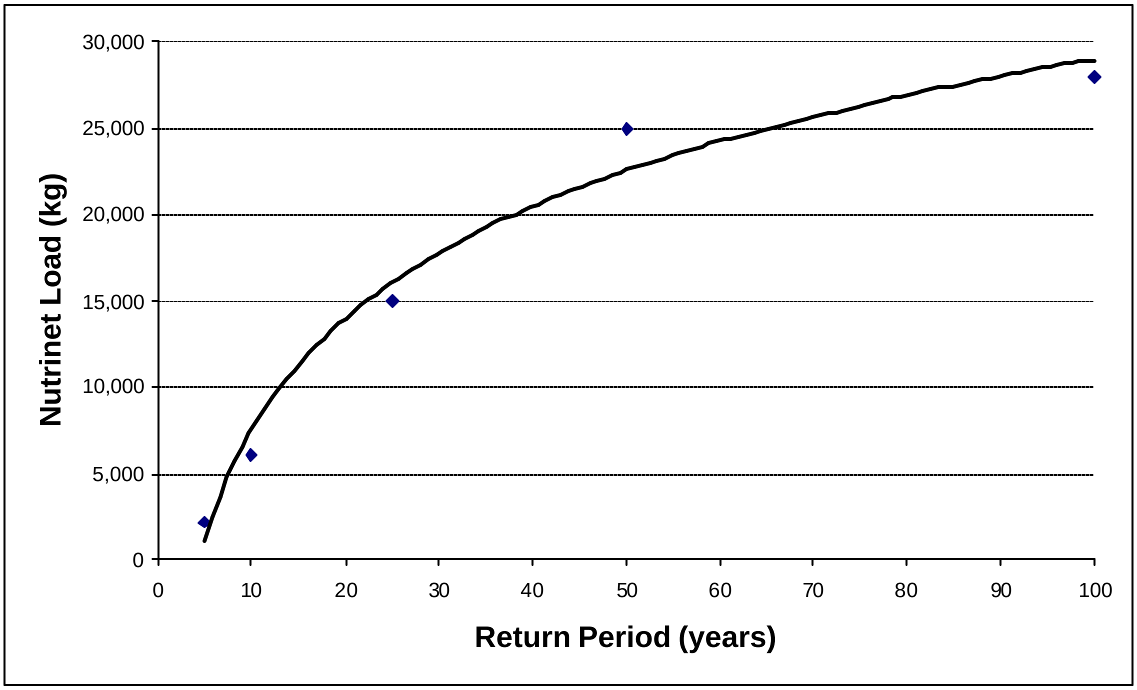

Figure 4-15-2. Example Nutrient Loading Curve

Project Schedule

Once started, the project is estimated to last 1 year. The TMDL's for Lake Elsinore and Canyon Lake have less stringent in-lake water quality targets during the interim period, and more stringent targets in the long term. The interim period allows time for additional studies and data collection to determine if the TMDL needs revision before the more stringent targets are applied. This study is designed to address data gaps for assessment of extreme loading conditions to determine if such conditions require consideration in TMDL revisions.

Project Cost

Total estimated cost of the project is $200,000, which includes all data collection efforts mentioned above. Costs may vary depending on the detail of data collected. Such detail can be refined depending on the amount of funding available to complete the project.

Project 16: Regional Organic Waste Digester

Project Background

The concept of farm-scale anaerobic digestion for treatment of livestock wastewater has been of interest in the United States for over 20 years. In the United States, livestock wastewater digestion systems were initially installed to control odors and little more. Interest in anaerobic digesters has increased dramatically over the past several years, however, due to the following (USEPA, 2003d):

- Technology has become more dependable
- Farm owners have become more aware of environmental quality awareness by farm owners
- Funding at the state and federal levels have increased assisting in cost share in the development of these systems
- New state energy policies to expand growth in reliable renewable energy and green power markets have emerged

Anaerobic digesters use anaerobic bacteria to break down solids, followed by methane bacteria to breakdown compounds created by the anaerobes. By-products of anaerobic digestion are liquid effluent and methane gas. The effluent can be used as a fertilizer that is more biologically stable than raw wastewater (Moser, 2003). Methane gas can be utilized as an alternative energy source. There are several different types of systems utilized by the agricultural industry for anaerobic digestion: covered lagoons, completely mixed digesters, and plug flow digesters.

Over the last 20 years, there have been two anaerobic digesters of particular interest to farms in the United States. In the 1970's, due to rising prices of fuel, generation of methane biogas was seen as an alternative energy source with a potential for lucrative returns to small farmers. Programs supporting research and implementation received federal and state funding until the programs were cut in the early 1980's. The basic systems designed in the 1980's were successful and are still applicable today. A resurgence of interest occurred during the Clinton Administration. The Climate Change Action Plan, released in 1993, supported voluntary pollution prevention programs to stabilize greenhouse gases (Riggle,2003). One of the major outcomes of this plan was the creation of the AgStar program within the USEPA and the US Department of Agriculture (in cooperation with the US Department of Energy). The AgStar program provides information, tools, and training to assist farmers in making informed decisions about methane recovery on their farms. AgStar has also helped support regional anaerobic digesters, such as the MEAD program in Tillamook, Oregon, where cow manure from more than 40 farms is collected (USEPA, 2003d).

Farm-scale digesters have several environmental benefits. Digester systems can reduce risks of surface water contamination with harmful pathogens through source control

(Moser, 2003). Digester systems can also reduce nutrient loading into receiving water bodies, which in turn reduces algal blooms and improves water quality. Using the effluent as a fertilizer would also reduce the amount of total nitrogen leeched into the watershed because the effluent contains a higher percentage of ammonia, which can be managed more efficiently (Moser, 2003).

Locally, Synagro's Agribusiness Services Group provided anaerobic digester technology to the Inland Empire Utilities Agency (IEUA) for the treatment of dairy cow manure in the Chino Basin. This project represents a public-private partnership between IEUA, the Milk Producers Council, and Synagro to demonstrate effective manure management. A plug flow digestion system was designed for the Chino Basin. Plug flow digestion is a relatively simple and proven technology that has been improved by years of research and full-scale operations dealing specifically with cow manure treatment. This type of system is not recommended for treatment of swine manure. For the Chino digester, approximately 30 percent of the biogas will be used to generate electricity using four Capstone microturbines to run the digester equipment, substantially reducing operating costs. The remaining gas will be sent to two Waukesha generators to power an off-site groundwater desalting facility. The cost of this project was estimated at $20 million (Synagro, 2003).

Project Goals

Development of a regional digester for the San Jacinto River watershed would require interest and cooperation from various stakeholders in the region. The benefits of such a system are obvious: improved disposal processes for dairy waste and opportunity for secondary energy production. The costs of the system, however, are large relative to alternative measures in the watershed to manage nutrients. A feasibility study would assist stakeholders in making an informed decision regarding the necessity of a regional digester for the San Jacinto River watershed.

Project Overview

A feasibility study is recommended to assess the cost and benefits of a regional organic waste digester for the San Jacinto River watershed. Such a study would assess necessary capacity, location, system designs, and benefits. Assessment of benefits will consider both primary benefits (potential improved management of nutrients associated with manure) and secondary benefits (energy source from biogas) to the watershed. Negative aspects of such a system will also be characterized. Results of this study will provide stakeholders necessary information regarding options for management of manure and associated nutrients in the watershed.

Project Schedule

The recommended study would last 6 months.

Project Cost

The total project cost of the feasibility study is estimated to be $30,000.

4.2.2.c Special Studies/Long-Term Monitoring and Reporting

Three projects are recommended to address special issues in the watershed and provide additional data for future project development and watershed planning. The following projects are recommended:

17. Development of a Pollutant Trading Model
18. Data Collection for Mystic Lake to Support Development of Future Projects
19. Continued Monitoring of Streamflow and Water Quality Throughout the Watershed

The following are detailed summaries of each project, including the background, goals, overview, schedule, and where available, estimated costs.

Project 17: Development of a Pollutant Trading Model

Project Background

Water quality pollutant trading is a market-based, voluntary tool designed for pollutant trading among and between point and nonpoint sources to improve and preserve water quality. Under an agreement involving several sources in a watershed, trading allows one source to meet its regulatory obligations by using pollutant reductions created by another source that has lower pollution control costs (USEPA, 2003a). This trading approach allows various sources within a watershed to act in a partnership to resolve common water quality problems.

On January 13, 2003, USEPA issued a Water Quality Trading Policy to provide guidance to States and others on how pollutant trading can occur under the Clean Water Act (CWA) and its implementing regulations. USEPA Office of Water (www.epa.gov/owow/watershed/trading.htm) funds several trading projects across the country, and is currently investigating non-traditional pollutant trades and/or multiple environmental benefits from trading. USEPA is working with States and others to develop implementation documents discussing specific approaches to permitting, nonpoint source accountability, and stakeholder involvement in the trading process (WEF, 2002).

USEPA's policy supports trading of nutrients (e.g. total phosphorus, total nitrogen) and sediment load reductions. USEPA recognizes the environmental potential for other water quality constituents besides nutrients and sediment, but believes these trades warrant further study (USEPA, 2003a).

There has to be strong incentives and drivers behind decisions to explore pollutant trading in communities; without public concern and pressure to find solutions to water quality impairments, pollutant trading may not be a successful tool. Implementation of a pollutant-trading tool could trigger cost effective pollutant reductions in a non-traditional manner, and may provide flexibility in the Clean Water Act (WEF, 2002).

Project Goals and Overview

In order for water quality trade to take place, a pollution reduction "credit" would have to be created. USEPA's water quality trading policy states that sources should reduce pollution loads beyond the level required by the most stringent water quality based requirements in order to create a pollution reduction "credit" that can be traded. For example, a landowner or farmer in the San Jacinto River watershed could create credits by changing farming practices and planting shrubs and trees next to a stream. A municipal wastewater treatment plant then could use these credits to meet water quality limits in its permit (USEPA, 2003b).

A pollutant trading model within the San Jacinto River watershed could provide a vehicle that would establish incentives for voluntary reduction, address watershed-based initiatives, and facilitate the implementation of TMDL's. Such a model would be developed in cooperation with the RWQCB and stakeholders in the San Jacinto River watershed. The model would be linked with ongoing TMDL efforts and would provide planning level estimates for treatment costs, pollutant load reductions, and proposed institutional arrangements for successfully implementing a trading program. Candidate project sites for implementation of the trading model in future phases of a trading program could include Lake Elsinore, Canyon Lake, Mystic Lake, and agricultural and urban/residential areas along the San Jacinto River.

USEPA Region 10 recently developed the Water Quality Trading Assessment Handbook (http://yosemite.epa.gov/R10/OI.NSF/). This handbook could help stakeholders in the San Jacinto River watershed evaluate whether this trading tool is right for this watershed, and if it should be pursued. The handbook guides readers through an informal assessment of trading opportunities, and looks at environmental, economic, and technical factors in a watershed that influence the ability to create a water quality trading market (USEPA, 2003c).

Project Schedule

Once initiated, development of a pollutant trading model will require approximately one year for completion.

Project Cost

USEPA is currently providing more than $800,000 in fiscal year 2002 for technical and other support for eleven trading projects around the country (USEPA, 2003b). Estimated cost of the trading project in the San Jacinto River watershed would most likely range between $75,000 and $250,000.

Project 18: Data Collection for Mystic Lake to Support Development of Future Projects

Project Background

Although much data has been collected throughout the watershed to assist in understanding hydrology and water quality, very little information is available regarding the influence of Mystic Lake on these processes. Located in the central part of the San Jacinto River, this lake provides substantial storage of water from upper portions of the watershed and only overflows during extreme storm events (see Section 2.5.4). No data have been collected to define the storage of the lake and hydraulic influence on San Jacinto River flows, and water quality processes within the lake are also unknown. For the Nutrient Source Assessment (Tetra Tech, Inc., 2003), loads predicted during wet conditions of 1998, when Mystic Lake overflowed to the lower San Jacinto River and Canyon Lake, were uncertain due to lack of data for such events to validate predictions (see Section 3.1.1). Assumptions used for the Nutrient Source Assessment to define Mystic Lake were based on limited data to represent the physical, chemical, and biological processes in the lake.

The RWQCB used the results of the Nutrient Source Assessment in developing TMDL's for Lake Elsinore and Canyon Lake. These TMDL's are designed with nutrient load reductions over an interim period with less-stringent water quality goals to provide sufficient opportunity for additional data collection prior to implementation of more-stringent goals for the lakes. This interim period provides much needed time for collecting data to validate the assumptions of the Nutrient Source Assessment, allow refinement of predictions through reconfiguration and recalibration of modeling tools, and provides necessary assurance that TMDL's are protective of the lakes.

Mystic Lake is also a source of debate regarding various projects proposed by stakeholders in the watershed. One suggested project is to use stored water in Mystic Lake as a viable source for augmentation of Lake Elsinore's volume. Another option is to use the Mystic Lake area as natural habitat, maintained using effluent flows from local wastewater treatment facilities. Regardless of the project suggested, none could be assessed without sufficient information pertaining to available storage and physical characteristics of the lake, water quality and associated biological and chemical processes in the lake, and additional sources of pollutants in the lake.

Project Goals

A study is recommended to collect various data to define the physical and water quality processes of Mystic Lake. Data will be utilized by both regulatory agencies and stakeholders to determine overall management plans for the lake and watershed so that goals for the watershed can be ascertained. As with previous monitoring projects in the watershed, data collection efforts would encourage cooperation from the RWQCB, SAWPA, LESJWA, RCFCWCD, and volunteers to ensure project success.

Project Overview

The recommended study would focus on the following data sets for collection:

- Lake bathymetry
- Inflow and outflow hydraulics
- In-lake water quality

The following sections provide detail regarding data sets suggested for collection. Obviously, the robustness of these data sets would be determined by the available project budget.

Lake Bathymetry

The only data available to define lake bathymetry is the USGS topography of the area and descriptions from local experts. These data are very limited and do not provide confident predictions of Mystic Lake's capacity. To fully understand the available volume of the lake and the potential storage for San Jacinto River flow, a survey of the lake bottom is recommended. This information can be assessed to determine an overall stage versus storage curve, a tool often used by engineers and hydrologists to understand lake hydraulics and simulate storage and detention time.

Inflow and Outflow Hydraulics

The linkage of Mystic Lake to the San Jacinto River is uncertain, and field survey is required to provide necessary information. Upstream of Mystic Lake, the river can take one or two pathways depending on the water surface elevation of the streamflow. One pathway is the historic riverbed that leads directly into Mystic Lake. The second pathway is a diversion channel constructed by local farmers to divert flows around the Mystic Lake area. This diversion channel, however, is believed to be heavily silted which restricts flow through the channel under most flow conditions. During increasingly wet events when streamflows rise, whether the path of the flow is through Mystic Lake, the diversion channel, or both is uncertain. A survey of this area would provide much needed information for definition of flows either through or around Mystic Lake.

The return flow from the lake (or overflow) to the San Jacinto River once Mystic Lake is filled is not understood. During large storm events, significant flows entering Canyon Lake are from Mystic Lake storage. The mechanism for conveyance of such flows, however, is not known. Field surveys of this area would be extremely useful so future predictions of Mystic Lake outflows can be more easily determined. Data may be assessed to develop a rating curve to define Mystic Lake outflow as a function of water surface elevations.

Additional study of the soil compositions and properties would be performed for estimation of lake bed infiltration rates. Estimates of lake infiltration, in combination with estimations of lake inflow and outflow, will provide information for quantification of an overall water budget for the lake.

In-Lake Water Quality

The standing pool of water in Mystic Lake varies and is dominated by previous wet or dry conditions in the watershed. The lake is often dry, but once filled it has been known to sustain a substantial volume over an extended period. During such periods of substantial lake volume, in-lake water quality data would be very useful to assess lake conditions and determine potential impacts on Lake Elsinore and Canyon Lake if Mystic Lake overflowed. If projects are planned that recommend pumping and possible treatment of Mystic Lake water as a potential source for other uses, information regarding in-lake water quality is necessary to assess the ability of the source water to meet the criteria for those uses. Moreover, if treatment of the Mystic Lake water is recommended prior to use, water quality data would be useful to define the level of treatment required. Data collection is suggested at three locations throughout the lake (e.g., inlet, middle, and outlet of lake) is suggested. The amount of data collected at each location would be determined by the budget available. The minimum amount of data would be a single grab sample at each location with measurements of nutrient concentrations at mid-depth. More samples would provide better indication of water quality trends in the lake.

Information regarding in-lake water quality can be combined with estimates of the water budget for assessment of the overall nutrient budget of Mystic Lake.

Project Schedule

Ideally, data collection for Mystic Lake would follow a wet period sufficient to provide a substantial volume in the lake for study. Assessment of inflow and outflow hydraulics would also benefit from observing periods when such flows occur. However, in the absence of such conditions, survey information would suffice. To increase the likelihood of data collection during wet conditions, data collection efforts are recommended for two wet seasons. If a wet event that results in the flow conditions mentioned has not occurred by the end of the second wet season, data collection will focus on survey information on dry channels and Mystic Lake bathymetry. If a wet event does occur, this information can be accompanied by flow measurements and water quality data.

Project Cost

The project cost will depend on the available budget for prioritization and selection of critical data sets. Likewise, the budget will define the robustness of the data sets will be defined by the budget. As a result, an overall estimated budget is only a starting point for discussion and should not be measured against the budgets of other candidate projects unless consideration is given to adjusting the cost by refining the data sets and details of the study. Moreover, datasets can be eliminated based on the judgment of decision-makers. The overall estimated project cost is $250,000.

Project 19: Continued Monitoring of Streamflow and Water Quality Throughout the Watershed

Project Background

Data collection throughout the watershed has provided vital understanding of the hydrologic and water quality processes of the San Jacinto River and its tributaries. Such information also provides much insight regarding flows and pollutant loads to Canyon Lake and Lake Elsinore. As new BMP's are implemented in the watershed to improve water quality conditions as the result of TMDL's and watershed plans designed by SAWPA, LESJWA, RCFCWCD and the RWQCB, continued data collection will provide tracking of improvements realized. Several planned projects in the watershed would also benefit from continued data collection so that the watershed processes are fully defined and project designs are appropriate. Continued modeling of the watershed, whether for flood analysis or water quality simulations, would also require additional data to ensure proper model configuration and calibration to observed conditions. The availability of streamflow and water quality for data throughout the watershed is critical to ensuring continued success of watershed plans and initiatives.

Project Overview

Continued data collection of streamflow and water quality at previously monitored instream locations, through cooperation of SAWPA, LESJWA, RCFCWCD, USGS, and the RWQCB, is recommended. Consistency with previous monitoring stations will provide expansion of existing datasets for specific segments of streams. Figures 4-19-1 and 4-19-2 show locations of previously monitored streamflow and water quality stations. Additional streamflow data are also available at some water quality monitoring stations for limited periods.

Project Schedule

Continuation of watershed monitoring is recommended for an indefinite period, and termination of such work is strongly discouraged.

Project Cost

The project cost is depends on the number of stations selected for continued monitoring. The cost of collecting water quality data is also contingent on the number of parameters tested. Annual cost is estimated to be $250,000, but it can be modified based on aforementioned considerations.

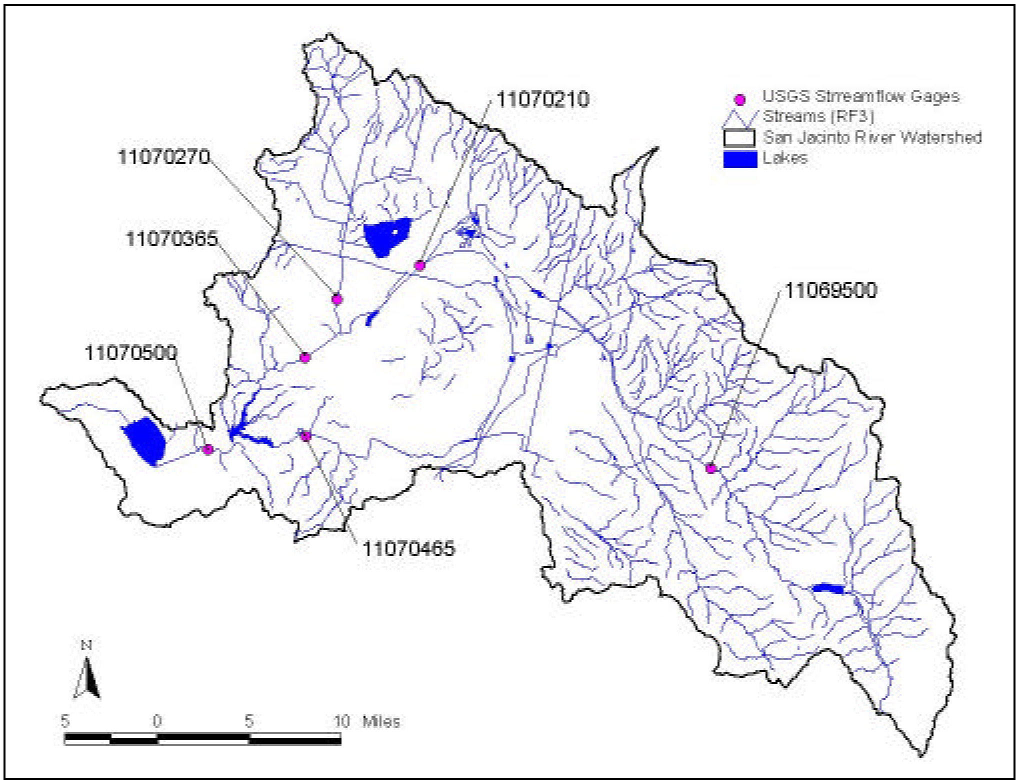

Figure 4-19-1. USGS streamflow gage stations

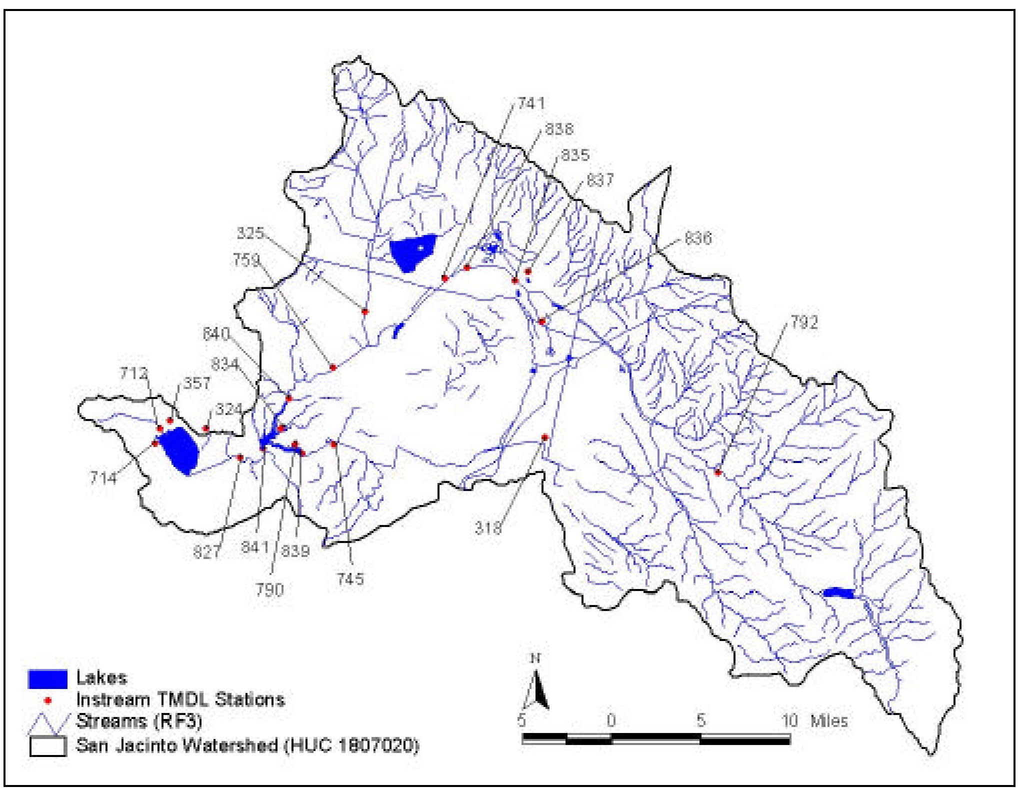

Figure 4-19-2. Water quality stations

5 Considerations for Future Planning

Nineteen specific projects are outlined in the Nutrient Management Plan to provide information for better management of nutrients in the watershed, or suggest BMP's to reduce nutrient loads or improve water quality of Lake Elsinore and Canyon Lake. There is no prioritization of the projects, as all are deemed valuable and address issues that are diverse and not necessarily comparable using a single prioritization scheme. Rather, the Nutrient Management Plan provides a holistic look at projects deemed important to improving water quality and reducing nutrients in the San Jacinto River watershed. The following sections discuss relative benefits of projects and the next steps for watershed planning and project implementation.

5.1 Benefits of Planned and Recommended Projects

In this section, the projects are presented on a common system for comparison of relative benefits and specific issues addressed. Each project was examined relative to key benefits that are considered important factors in development of a comprehensive Nutrient Management Plan. These benefits include: pollutant load control, habitat protection, aesthetic value, lake water quality, lake water quantity, TMDL development, and TMDL implementation and/or BMP's. Projects outlined in the Nutrient Management Plan are listed in Table 5-1 with designated benefits marked with "X." Tables 5-2 through 5-8 provide more-detailed discussion of the specific issues addressed by each project relative to the benefits identified.

Tables 5-1 through 5-8 categorically describe how each project addresses issues that impact multiple benefits that are determined important criteria for future watershed planning. Based on specific issue requiring implementation measures, planners and decision-makers can reference these tables for a quick survey of projects, with additional information for each project provided in Section 4 for further review.

Table 5-1. Benefits of Projects Outlined in the Nutrient Management Plan

Project No.	Project Name	Pollutant Load Control (Table F-1)	Habitat Protection (Table F-2)	Aesthetic Value (Table F-3)	Lake Water Quality (Table F-4)	Lake Water Quantity (Table F-5)	Addresses TMDL Development (Table F-6)	Addresses TMDL Implementation & BMPs (Table F-7)
1	Lake Elsinore In-Lake Nutrient Treatment	X	X	X	X	X		
2	Lake Elsinore Aeration	X	X	X	X			X
3	Canyon Lake Aeration/ Destratification	X	X	X	X			X
4	Canyon Lake Dredging	X	X	X	X	X		X
5	Lake Elsinore Water Quality Monitoring				X	X	X	X
6	Development of a Dynamic Water Quality Model of Lake Elsinore				X	X	X	X
7	Canyon Lake Water Quality Monitoring				X	X	X	X
8	Development of a Dynamic Water Quality Model of Canyon Lake				X	X	X	X
9	Structural Urban BMPs	X			X			X
10	Sewer and Septic Improvements	X			X			X
11	Control of Trash in Stream Channels	X	X	X	X			
12	Interception and Treatment of Nuisance Urban Runoff	X			X			X
13	Riparian Habitat Restoration and Development of Agricultural Buffers	X	X	X	X			X
14	Determination of Crop-Specific Agronomic Rates for Guidance in Fertilizer and Manure Application Management	X			X		X	X
15	Assessment of Nutrient Loads to the San Jacinto Watershed as a Result of Flooding in Agricultural Areas	X			X		X	X
16	Regional Organic Waste Digester	X			X			X
17	Development of a Pollutant Trading Model							X
18	Data Collection for Mystic Lake to Support Development of Future Projects		X		X		X	
19	Continued Monitoring of Streamflow and Water Quality Throughout the Watershed				X		X	X

Table 5-2. Pollutant Load Control Addressed by Projects

Project No.	Project Name	Nutrient Source Addressed				
		In-lake/ Sediment Release	Urban Runoff	Agricultural Runoff	Dairies	Septics
1	Lake Elsinore In-Lake Nutrient Treatment	• Reduce impacts to in-lake nutrient concentration associated with import of recycled water • Reduce nutrient release from sediments				
2	Lake Elsinore Aeration	• Reduce release of nutrients from sediments				
3	Canyon Lake Aeration/Destratification	• Reduce release of nutrients from sediments				
4	Canyon Lake Dredging	• Reduce release of nutrients from sediments				
9	Structural Urban BMPs		• Reduce nutrient loads from urban runoff through detention and/or treatment			
10	Sewer and Septic Improvements					• Public awareness program to reduce failure rates of septic systems • Expansion of sewage collection system and elimination of septic systems
11	Control of Trash in Stream Channels		• Reduce instream sources of nutrients and bacteria			

Project No.	Project Name	Nutrient Source Addressed				
		In-lake/ Sediment Release	Urban Runoff	Agricultural Runoff	Dairies	Septics
12	Interception and Treatment of Nuisance Urban Runoff		• Reduce nutrient loads during dry weather conditions through interception of nuisance urban runoff			
13	Riparian Habitat Restoration and Development of Agricultural Buffers			• Reduce nutrient loads from agricultural runoff through filtering of natural riparian buffer zones		
14	Determination of Crop-Specific Agronomic Rates for Guidance in Fertilizer and Manure Application Management			• Provide guidance regarding proper management of manure and fertilizer application for specific crops • Provide information regarding variations in practices throughout the watershed		
15	Assessment of Nutrient Loads to the San Jacinto Watershed as a Result of Flooding in Agricultural Areas			• Provide assessment of nutrient loads during extreme wet events		
16	Regional Organic Waste Digester			• Improve condition of dairy waste prior to application to croplands	• Provide improved management of disposal of dairy waste	

Table 5-3. Habitat Protection Addressed by Projects

Project No.	Project Name	Habitat Protection
1	Lake Elsinore In-Lake Nutrient Treatment	• Provide treatment/removal of nutrient load associated with reclaimed water used for lake volume augmentation. Augmentation of lake volume provided to sustain water surface elevation and protect shoreline and lake habitat areas.
2	Lake Elsinore Aeration	• Provide direct source of dissolved oxygen to prevent fish kills • Reduce predation on larger zooplankton by threadfin shad and young fishes of all species, and therefore increase grazing on algae. Grazing on algae would provide better stability of algal densities and reduce associated oxygen depletions resulting in fish kills. • Increase in dissolved oxygen at the mud-water interface will improve feeding of benthic organisms, thereby preventing the emergence of nuisance emergence of benthic species. • Improve deep-water dissolved oxygen to prevent forcing of fish populations to shallow water where predation of piscivorous birds is common.
3	Canyon Lake Aeration/Destratification	• Provide direct source of dissolved oxygen to prevent fish kills • Reduce algal densities in the lake and thereby reduce the occurrence oxygen depletion resulting from algal respiration and prevent fish kills. • Improve deep-water dissolved oxygen to prevent forcing of fish populations to shallow water where predation of piscivorous birds is common.
4	Canyon Lake Dredging	• Reduce nutrient loads to the lake by providing upstream storage of phosphorus-loaded sediment, thereby improving in-lake water quality and protecting fish populations.
11	Control of Trash in Stream Channels	• Provide land acquisition of high-priority areas for reduction of illegal dumping activities and provision of habitat conservation areas.
13	Riparian Habitat Restoration and Development of Agricultural Buffers	• Restore the riparian habitat along the San Jacinto River, Salt Creek, and the Perris Valley Storm Drain, through provision of improved terrestrial vegetation and habitat structure for native wildlife.

Table 5-4. Aesthetic Value Addressed by Projects

Project No.	Project Name	Aesthetic Value
1	Lake Elsinore In-Lake Nutrient Treatment	• Provide treatment/removal of nutrient load associated with reclaimed water used for lake volume augmentation. Augmentation of lake volume provided to sustain water surface elevation and improve recreational and aesthetic value of the lake and shoreline.
2	Lake Elsinore Aeration	• Reduce the occurrence of fish kills and associated nuisances • Reduce nuisance algal densities that are unpleasant to recreationalists • Reduce the emergence of nuisance benthic organisms that can be unpleasant to recreationalists
3	Canyon Lake Aeration/Destratification	• Reduce the occurrence of fish kills and associated nuisances • Reduce nuisance algal densities that are unpleasant to recreationalists • Reduce the emergence of nuisance benthic organisms that can be unpleasant to recreationalists
4	Canyon Lake Dredging	• Improve recreational opportunities, including boating and swimming, by restoring deeper water • Reduce nutrient loads to the lake by providing upstream storage of phosphorus-loaded sediment, thereby improving in-lake water quality and reducing nuisance algal densities unpleasant to recreationalists.
11	Control of Trash in Stream Channels	• Reduce illegal trash dumping activities and thereby improve the aesthetics and pleasantness of the San Jacinto River
13	Riparian Habitat Restoration and Development of Agricultural Buffers	• Improve natural habitat for support of native wildlife and promote increased recreational use of stream corridors through establishment of hiking/biking trails and other viewing areas.

Table 5-5. Benefits to Lake Water Quality Addressed by Projects

Project No.	Project Name	Benefit to Lake Water Quality
1	Lake Elsinore In-Lake Nutrient Treatment	• Reduce in-lake nutrient concentrations and improve water quality
2	Lake Elsinore Aeration	• Improve oxygen levels at lake bottom • Reduce the release of nutrients from lake sediments • Improve the overall water quality of the lake through reduction of algal densities and eutrophic processes
3	Canyon Lake Aeration/Destratification	• Improve oxygen levels at lake bottom • Reduce the release of nutrients from lake sediments • Improve the overall water quality of the lake through reduction of algal densities and eutrophic processes
4	Canyon Lake Dredging	• Reduce the release of nutrients from lake sediments • Reduce nutrient loads to the lake by providing upstream storage of phosphorus-loaded sediment • Improve in-lake water quality and reduce algal densities and eutrophic processes
5	Lake Elsinore Water Quality Monitoring	• Provide tracking of lake improvements and impacts of alternative management solutions to guide future planning • Provide information for development of additional predictive modeling tools for assessment of lake water quality under varying conditions
6	Development of a Dynamic Water Quality Model of Lake Elsinore	• Provide prediction of lake water quality under various conditions • Assess the effectiveness of various best management practices for guidance in future planning of water quality improvement strategies • Provide additional resolution of in-lake water quality predictions as a result of critical loading conditions for refinement of the nutrient TMDL
7	Canyon Lake Water Quality Monitoring	• Provide tracking of lake improvements and impacts of alternative management solutions to guide future planning • Provide information for development of additional predictive modeling tools for assessment of lake water quality under varying conditions
8	Development of a Dynamic Water Quality Model of Canyon Lake	• Provide prediction of lake water quality under various conditions • Assess the effectiveness of various best management practices for guidance in future planning of water quality improvement strategies • Provide additional resolution of in-lake water quality predictions as a result of

Project No.	Project Name	Benefit to Lake Water Quality
		critical loading conditions for refinement of the nutrient TMDL
9	Structural Urban BMPs	• Reduce the nutrient and bacteria load to the lakes associated with urban
10	Sewer and Septic Improvements	• Reduce the nutrient and bacteria load to the lakes associated with the failure of septic systems
11	Control of Trash in Stream Channels	• Reduce the nutrient and bacteria load to the lakes associated with trash in the stream channel
12	Interception and Treatment of Nuisance Urban Runoff	• Reduce the nutrient and bacteria load to the lakes associated with nuisance urban runoff during dry weather conditions
13	Riparian Habitat Restoration and Development of Agricultural Buffers	• Reduce the nutrient load to the lakes associated with agricultural runoff
14	Determination of Crop-Specific Agronomic Rates for Guidance in Fertilizer and Manure Application Management	• Reduce the nutrient load to the lakes associated with agricultural runoff
15	Assessment of Nutrient Loads to the San Jacinto Watershed as a Result of Flooding in Agricultural Areas	• Provide guidance for future planning regarding the nutrient load to the lakes associated with flooding of agricultural areas
16	Regional Organic Waste Digester	• Reduce the nutrient load to the lakes associated with agricultural runoff
18	Data Collection for Mystic Lake to Support Development of Future Projects	• Provide information regarding impact of Mystic Lake on nutrient loading to the lakes • Provide additional resolution of in-lake water quality predictions as a result of critical loading conditions for refinement of the nutrient TMDL
19	Continued Monitoring of Streamflow and Water Quality Throughout the Watershed	• Provide tracking of lake improvements and impacts of alternative management solutions to guide future planning • Provide information for development of additional predictive modeling tools for assessment of lake water quality under varying conditions • Provide additional resolution of in-lake water quality predictions as a result of critical loading conditions for refinement of the nutrient TMDL

Table 5-6. Benefits to Lake Water Quantity Addressed by Projects

Project No.	Project Name	Lake Water Quantity
1	Lake Elsinore In-Lake Nutrient Treatment	• Provide treatment/removal of nutrient load associated with reclaimed water used for lake volume augmentation. Augmentation of lake volume provided to sustain water surface elevation and protect shoreline and lake habitat areas.
4	Canyon Lake Dredging	• Improve overall lake storage capacity
5	Lake Elsinore Water Quality Monitoring	• Provide information regarding lake water quality under variable conditions and lake volume • Provide information for development of additional predictive modeling tools for assessment of lake water quality under varying conditions
6	Development of a Dynamic Water Quality Model of Lake Elsinore	• Provide a predictive modeling tool for assessment of lake water quality under varying conditions. Model scenarios can include assessment of conditions at varying lake volumes.
7	Canyon Lake Water Quality Monitoring	• Provide information regarding lake water quality under variable conditions and lake volume • Provide information for development of additional predictive modeling tools for assessment of lake water quality under varying conditions
8	Development of a Dynamic Water Quality Model of Canyon Lake	• Provide a predictive modeling tool for assessment of lake water quality under varying conditions. Model scenarios can include assessment of conditions at varying lake volumes.

Table 5-7. Issues for TMDL Development Addressed by Projects

Project No.	Project Name	Addresses TMDL Development
5	Lake Elsinore Water Quality Monitoring	• Provide data to support development and potential refinement of nutrient and bacteria TMDLs
6	Development of a Dynamic Water Quality Model of Lake Elsinore	• Provide an improved predictive modeling tool to support development and potential refinement of nutrient and bacteria TMDLs
7	Canyon Lake Water Quality Monitoring	• Provide data to support development and potential refinement of nutrient and bacteria TMDLs
8	Development of a Dynamic Water Quality Model of Canyon Lake	• Provide an improved predictive modeling tool to support development and potential refinement of nutrient and bacteria TMDLs
14	Determination of Crop-Specific Agronomic Rates for Guidance in Fertilizer and Manure Application Management	• Provide additional data to support model updates and potential refinement of the nutrient TMDL
15	Assessment of Nutrient Loads to the San Jacinto Watershed as a Result of Flooding in Agricultural Areas	• Provide additional data to support model updates and potential refinement of the nutrient TMDL
18	Data Collection for Mystic Lake to Support Development of Future Projects	• Provide additional data to support model updates and development and potential refinement of the bacteria and nutrient TMDLs
19	Continued Monitoring of Streamflow and Water Quality Throughout the Watershed	• Provide data to support development and potential refinement of nutrient and bacteria TMDLs

Table 5-8. TMDL Implementation and Best Management Practices Addressed by Projects

Project No.	Project Name	Addresses TMDL Implementation & BMPs
2	Lake Elsinore Aeration	• Reduce the release of nutrients from lake sediments • Improve the overall water quality of the lake through reduction of algal densities and eutrophic processes
3	Canyon Lake Aeration/Destratification	• Reduce the release of nutrients from lake sediments • Improve the overall water quality of the lake through reduction of algal densities and eutrophic processes
4	Canyon Lake Dredging	• Reduce the release of nutrients from lake sediments • Reduce nutrient loads to the lake by providing upstream storage of phosphorus-loaded sediment • Improve in-lake water quality and reduce algal densities and eutrophic processes
5	Lake Elsinore Water Quality Monitoring	• Provide tracking of lake improvements and impacts of alternative management solutions to guide future planning • Provide information for development of an improved predictive modeling tool necessary for assessment of impacts on lake water quality resulting from alternative best management plan scenarios
6	Development of a Dynamic Water Quality Model of Lake Elsinore	• Provide an improved predictive modeling tool necessary for assessment of impacts on lake water quality resulting from alternative best management plan scenarios
7	Canyon Lake Water Quality Monitoring	• Provide tracking of lake improvements and impacts of alternative management solutions to guide future planning • Provide information for development of an additional predictive modeling tool for assessment of impacts on lake water quality resulting from alternative best management plan scenarios
8	Development of a Dynamic Water Quality Model of Canyon Lake	• Provide an improved predictive modeling tool necessary for assessment of impacts on lake water quality resulting from alternative best management plan scenarios
9	Structural Urban BMPs	• Provide necessary nutrient and bacteria load reductions to meet TMDL wasteload allocations to urban runoff

Project No.	Project Name	Addresses TMDL Implementation & BMPs
10	Sewer and Septic Improvements	• Provide necessary nutrient and bacteria load reductions to meet TMDL load allocations to septic systems
12	Interception and Treatment of Nuisance Urban Runoff	• Provide necessary nutrient and bacteria load reductions to meet TMDL wasteload allocations to urban runoff
13	Riparian Habitat Restoration and Development of Agricultural Buffers	• Provide necessary nutrient and bacteria load reductions to meet TMDL load allocations to agricultural runoff
14	Determination of Crop-Specific Agronomic Rates for Guidance in Fertilizer and Manure Application Management	• Provide information to guide strategy development for TMDL implementation • Provide necessary nutrient and bacteria load reductions to meet TMDL load allocations to agricultural runoff
15	Assessment of Nutrient Loads to the San Jacinto Watershed as a Result of Flooding in Agricultural Areas	• Provide information to guide strategy development for TMDL implementation
16	Regional Organic Waste Digester	• Provide information to guide strategy development for TMDL implementation • Provide necessary nutrient load reductions to meet TMDL load allocations to agricultural runoff and dairies
17	Development of a Pollutant Trading Model	• Provide information to guide strategy development for TMDL implementation
19	Continued Monitoring of Streamflow and Water Quality Throughout the Watershed	• Provide tracking of lake improvements and impacts of alternative best management plans to guide future planning • Provide information for development of an improved predictive modeling tool necessary for assessment of impacts on lake water quality resulting from alternative best management plan scenarios

Five nutrient sources are addressed in Table 5-2 regarding Pollutant Load Control: in-lake/sediment release, urban runoff, agricultural runoff, dairies, and septics. Pollutant load control can be achieved by various means, including: instream source reduction, in-lake source reduction, public awareness programs, detention and/or treatment of runoff, provision of natural riparian buffer zones, manure and fertilizer application management, and collection of information to allow improved management of nutrients in the watershed.

Benefits to Habitat Protection are addressed in six projects (Table 5-3) - four in-lake projects and two watershed projects. Examples of habitat protection include: protection of lake shoreline and habitat areas, provision of direct source of dissolved oxygen to the lakes to prevent fish kills, reduction of algal densities in the lakes, reduction of predation on larger zooplankton in the lakes, land acquisition of high-priority problem areas, and restoration of riparian habitat.

Benefits to Aesthetic Value are addressed by six projects (Table 5-4) - four in-lake projects and two watershed projects. Examples of aesthetic value include: reduction of the occurrence of fish kills, reduction of algal densities that are unpleasant to recreationalists, reduction of the emergence of nuisance benthic organisms, augmentation of lake volume to sustain water surface elevation and improve recreational and aesthetic value of the lake and shoreline, reduction of illegal trash dumping, and improvement of natural habitat for support of native wildlife and promotion of increased recreational use of stream corridors.

Benefits to Lake Water Quality are addressed by eighteen projects (Table 5-5) - eight in-lake projects and ten watershed projects. Examples of Lake Water Quality benefits include: reduction of nutrient release from lake sediments, reduction of algal densities, reduction of in-lake nutrients, assessment of the effectiveness of BMP's for future planning efforts, reduction of nutrient loads to the lakes associated with agricultural runoff, provision of information for Mystic Lake regarding nutrient loading, and reduction of nutrients loads to the lakes associated with nuisance urban runoff.

Benefits to Lake Water Quantity are addressed in six in-lake projects (Table 5-6). Lake Water Quantity benefits include: improvement of overall lake storage capacity, provision of additional predictive modeling tools for assessment of lake volume impacts, and treatment/removal of nutrient loads associated with reclaimed water used for Lake Elsinore volume augmentation.

Eight projects address issues specific to TMDL Development (Table 5-7) - four in-lake projects and four watershed projects. These issues include collection of additional data and development of improved predictive modeling tools to support development and refinement of nutrient and bacteria TMDLs.

Sixteen projects address TMDL Implementation and BMPs (Table 5-8) - seven in-lake projects and nine watershed projects. Issues specific to TMDL Implementation and BMPs include: reduction of nutrient release from lake sediments, improvement of overall lake water quality through reduction of algal densities and eutrophic processes, provision of improved predictive modeling tools to test BMP effectiveness, provision of necessary nutrient and bacteria load reductions to meet TMDL wasteload allocations for urban runoff, septics, and agricultural runoff, and provision of information to guide strategy development for TMDL implementation.

5.2 Implementation and Funding

Regardless of the detail and effort put forth in the development of a Nutrient Management Plan, watershed improvements will not be realized until the plan is properly implemented. There are many examples of watershed groups that developed plans, yet failed to successfully implement them in their watersheds. Coordination and cooperation among watershed partners are essential for successful implementation. Potential participants need to receive clear messages regarding the proposed efforts, including descriptions of their purpose and benefits.

The implementation process can proceed in many different ways. Several watersheds have created implementation teams; others have used existing committees and stakeholder groups. Fortunately for the San Jacinto River watershed, entities such as SAWPA, LESJWA, and an active Watershed Council encourage stakeholder involvement and pursuit of funding opportunities in the watershed.

In developing a strategy for implementation of the projects outlined in the Nutrient Management Plan, funding is key to success. The primary state and federal grant vehicles for current and future funding are: Proposition 13, Proposition 40, Proposition 50, and Clean Water Act Section 319(h). The SWRCB recently completed a consolidated grant proposal/approval process that provides multiple funding sources through a single grant process. These grants are specific to projects related to nonpoint source pollution control, watershed protection, and drinking water protection. Some of the projects recommended in the Nutrient Management Plan have already been submitted as proposals through this process. The programs included in this process are as follows:

- Proposition 13 Nonpoint Source Pollution Control Program
- Proposition 13 Coastal Nonpoint Source Pollution Control Program
- Proposition 13 Watershed Protection Program
- Proposition 13 CALFED Drinking Water Quality Program
- Proposition 13 CALFED Watershed Program
- Proposition 50 CALFED Watershed Program
- Proposition 50 CALFED Drinking Water Quality Program
- Clean Water Act Section 319(h) Nonpoint Source Implementation Program

The Proposition 40 program includes the California Clean Water, Clear Air, Safe Neighborhood Parks, and Coastal Protection Bond Act of 2002. To date, no funding has been generated through Proposition 40, but it is expected to be a valuable funding source over the next few years.

In addition to the state and federal sources mentioned previously, funding is also available from other federal and local sources. USEPA has several water quality grants listed on its website (www.epa.gov/water/funding.html), including: Beach Act Grants, Wetland Program Development Grants, Clean Water Act Section 106 Water Pollution Control Program Grants, and Clean Water Act Section 104(b)(3) Water Quality Cooperative Agreements. The U. S. Army Corps of Engineers and the U.S. Bureau of Reclamation also have funding programs available to address water issues, including funds for planning and construction projects. Smaller entities with non-profit status can take advantage of a variety of smaller grants available, such as the Metropolitan Water District's Community Partnership Program.

SAWPA and LESJWA has provided a tremendous amount of technical information and progress obtaining Proposition 13 funding for Lake Elsinore and Canyon Lake projects. Because of their commitment and success in obtaining funding for projects in the watershed, projects in the planned stages are moving forward. All lake and watershed projects recommended in the Nutrient Management Plan are currently either in the process of obtaining funding or are new recommendations. To ensure that all planned and recommended projects are eventually implemented, wherever possible the watershed strategy should:

- Maintain momentum on existing LESJWA projects
- Group projects together for potential cost benefits
- Divide projects into phases to allow best use of available funds in stages
- Encourage interagency cooperation and teaming
- Seek funding opportunities aggressively
- Promote stakeholder involvement
- Work closely with the RWQCB to determine which projects will address TMDL implementation

Maintaining the existing momentum of current LESJWA projects is important to the continued success of watershed management initiatives. Planned projects for Lake Elsinore and Canyon Lake have partial funding from Proposition 13, while most recommended lake and watershed projects are still in developmental, early stages and are currently not funded. Continued funding of projects in the watershed is contingent on proper and successful utilization of previous funds used to support implementation measures.

Grouping of projects is also important in realizing cost reductions. For example, combining Project 6 and 8 into a single project has cost savings benefits. Both are dynamic water quality models - one for Lake Elsinore and one for Canyon Lake.

Through sharing of tasks associated with model development, cost reductions can be achieved.

Understanding the various projects and planning the projects in phases will also assist in overcoming funding challenges. For example Project 1, In-Lake Nutrient Treatment for Lake Elsinore, consists of multiple complex facility components. By reviewing projects and understanding funding constraints, various elements of construction of these facilities can be considered in phases to match available funding opportunities and future planning.

5.3 Beyond Nutrients and Pathogens

The Nutrient Management Plan for the San Jacinto River watershed is an excellent beginning for watershed planning and restoration of Lake Elsinore and Canyon Lake. The plan was developed to respond to nutrient impairments of the lakes and resulting TMDL development that requires nutrient load reductions for multiple sources in the watershed. As the RWQCB continues with development of a bacteria TMDL for Canyon Lake and sedimentation, toxicity, and organic enrichment TMDL's for Lake Elsinore, assessment of additional pollutant sources from the watershed will need to be considered.

Preliminary work has been done for the Bacteria Source Assessment and thus the foundation for the development of the bacteria TMDL for Canyon Lake. The Bacteria Source Assessment is not complete, however, and requires additional data collection, model development, and study. As a result, a bacteria management plan is not included in this report. Once guidance is provided through completion of the Bacteria Source Assessment and TMDL development, information will be available to determine a strategy for reducing bacteria loads in the watershed to improve water quality of Canyon Lake. Similar work will need to be performed as impairments to Lake Elsinore from other pollutants are addressed through TMDL development.

Ultimately, a holistic San Jacinto Watershed Management Plan that capitalizes on the findings of these separate pollutant management plans provides the RWQCB and stakeholders a roadmap for improving the water quality and health of Lake Elsinore, Canyon Lake, and the San Jacinto River and tributaries will be developed. Development of the Watershed Management Plan will require cooperation with other planning agencies in the watershed and consistency with all project plans to ensure a comprehensive management strategy for the watershed and a unified approach for future project planning, funding, and implementation.

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Appendix A- Results of the Lake Elsinore/Canyon Lake Nutrient Source Assessment

Figure A-1

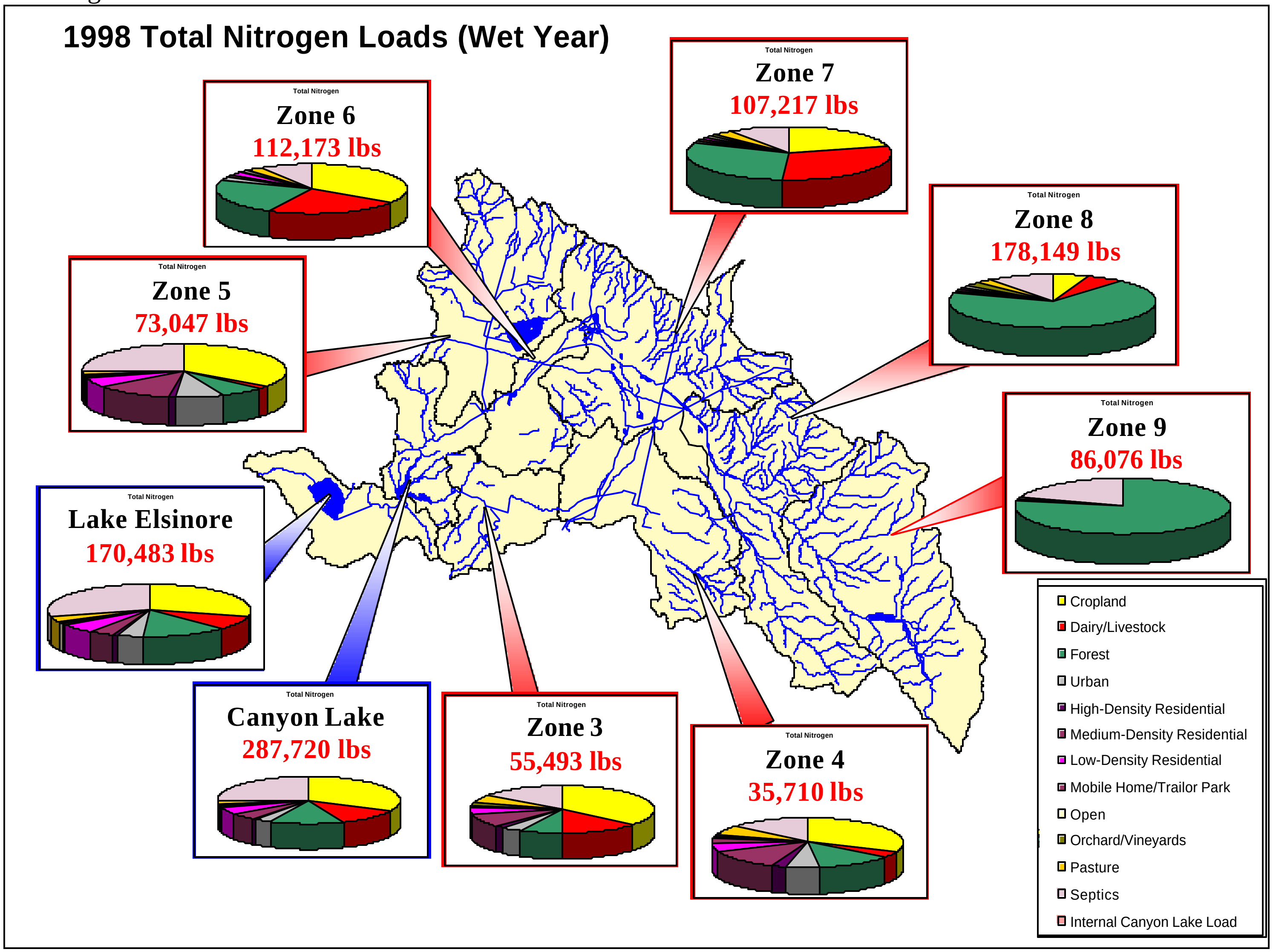
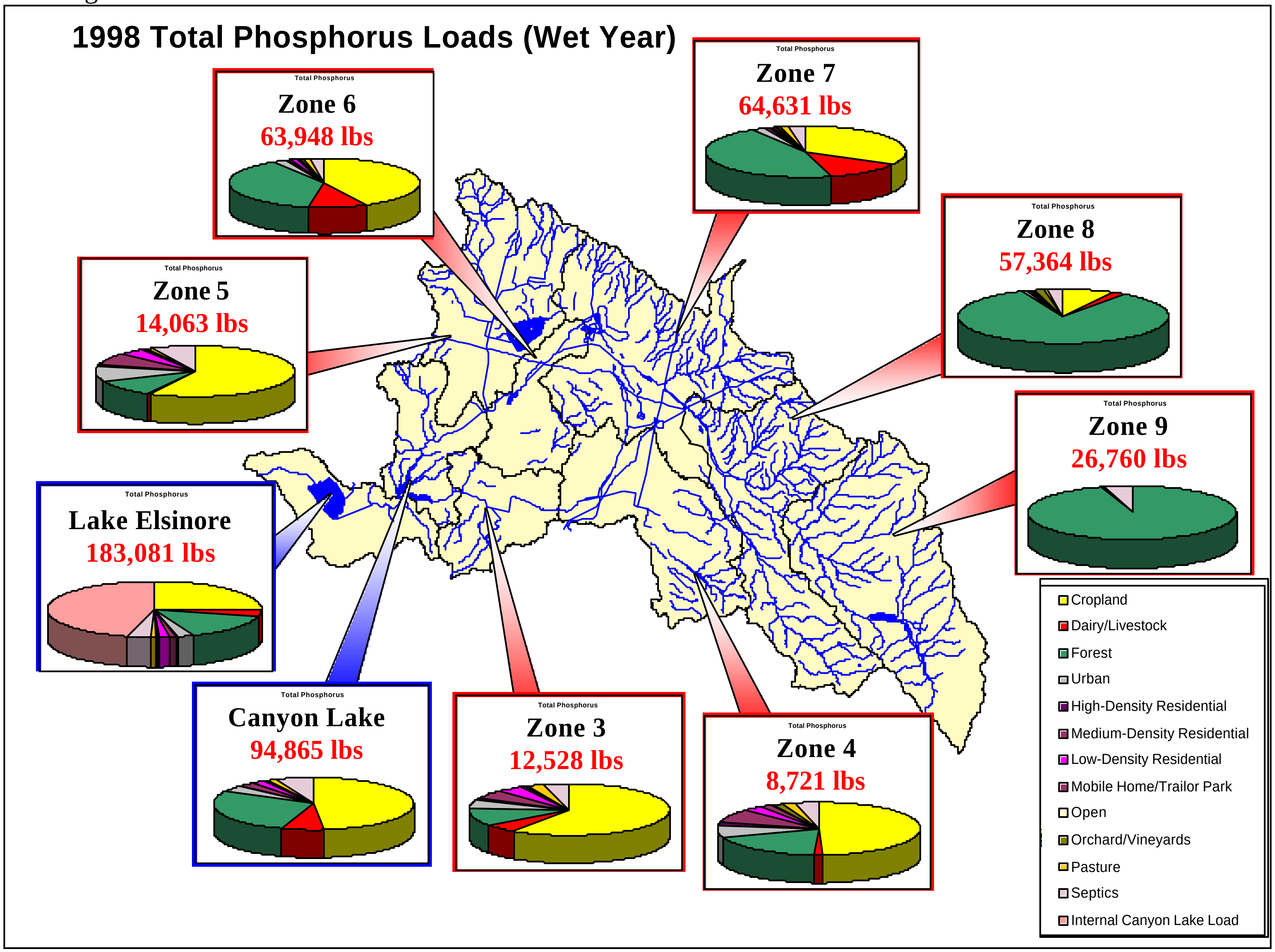
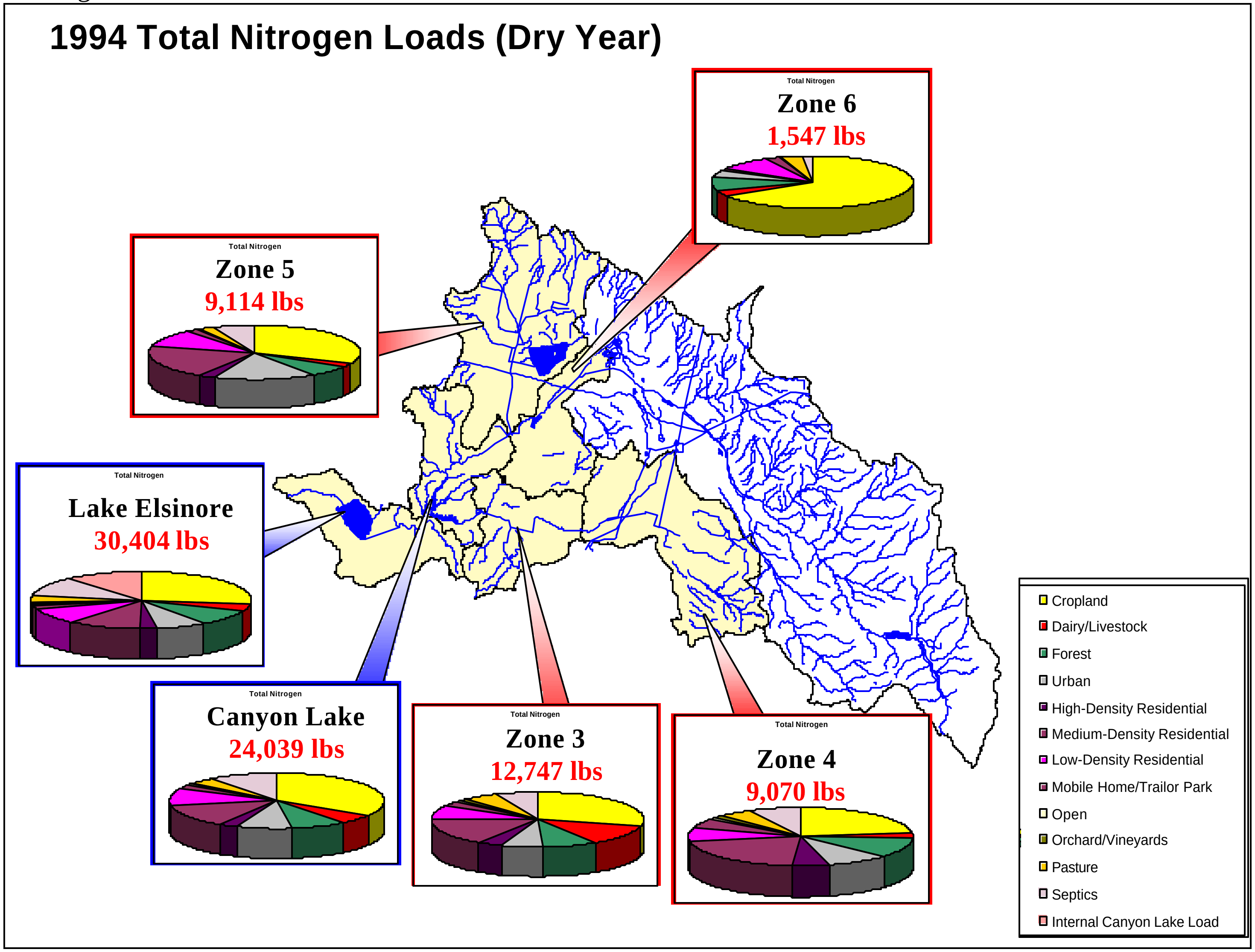

1998 Total Nitrogen Loads (Wet Year)
Total Nitrogen
Zone 6
112,173 lbs
Total Nitrogen
Zone 7
107,217 lbs
Total Nitrogen
Zone 8
178,149 lbs
Total Nitrogen
Zone 5
73,047 lbs
Total Nitrogen
Zone 9
86,076 lbs
Total Nitrogen
Lake Elsinore
170,483 lbs
Total Nitrogen
Canyon Lake
287,720 lbs
Total Nitrogen
Zone 3
55,493 lbs
Total Nitrogen
Zone 4
35,710 lbs
Cropland
Dairy/Livestock
Forest
Urban
High-Density Residential
Medium-Density Residential
Low-Density Residential
Mobile Home/Trailor Park
Open
Orchard/Vineyards
Pasture
Septics
Internal Canyon Lake Load

Figure A-2



1998 Total Phosphorus Loads (Wet Year)
Total Phosphorus
Zone 6
63,948 lbs
Total Phosphorus
Zone 7
64,631 lbs
Total Phosphorus
Zone 8
57,364 lbs
Total Phosphorus
Zone 5
14,063 lbs
Total Phosphorus
Zone 9
26,760 lbs
Total Phosphorus
Lake Elsinore
183,081 lbs
Total Phosphorus
Canyon Lake
94,865 lbs
Total Phosphorus
Zone 3
12,528 lbs
Total Phosphorus
Zone 4
8,721 lbs
Cropland
Dairy/Livestock
Forest
Urban
High-Density Residential
Medium-Density Residential
Low-Density Residential
Mobile Home/Trailor Park
Open
Orchard/Vineyards
Pasture
Septics
Internal Canyon Lake Load

Figure A-3



1994 Total Nitrogen Loads (Dry Year)
Total Nitrogen
Zone 6
1,547 lbs
Total Nitrogen
Zone 5
9,114 lbs
Total Nitrogen
Lake Elsinore
30,404 lbs
Total Nitrogen
Canyon Lake
24,039 lbs
Total Nitrogen
Zone 3
12,747 lbs
Total Nitrogen
Zone 4
9,070 lbs
Cropland
Dairy/Livestock
Forest
Urban
High-Density Residential
Medium-Density Residential
Low-Density Residential
Mobile Home/Trailor Park
Open
Orchard/Vineyards
Pasture
Septics
Internal Canyon Lake Load

Figure A-4

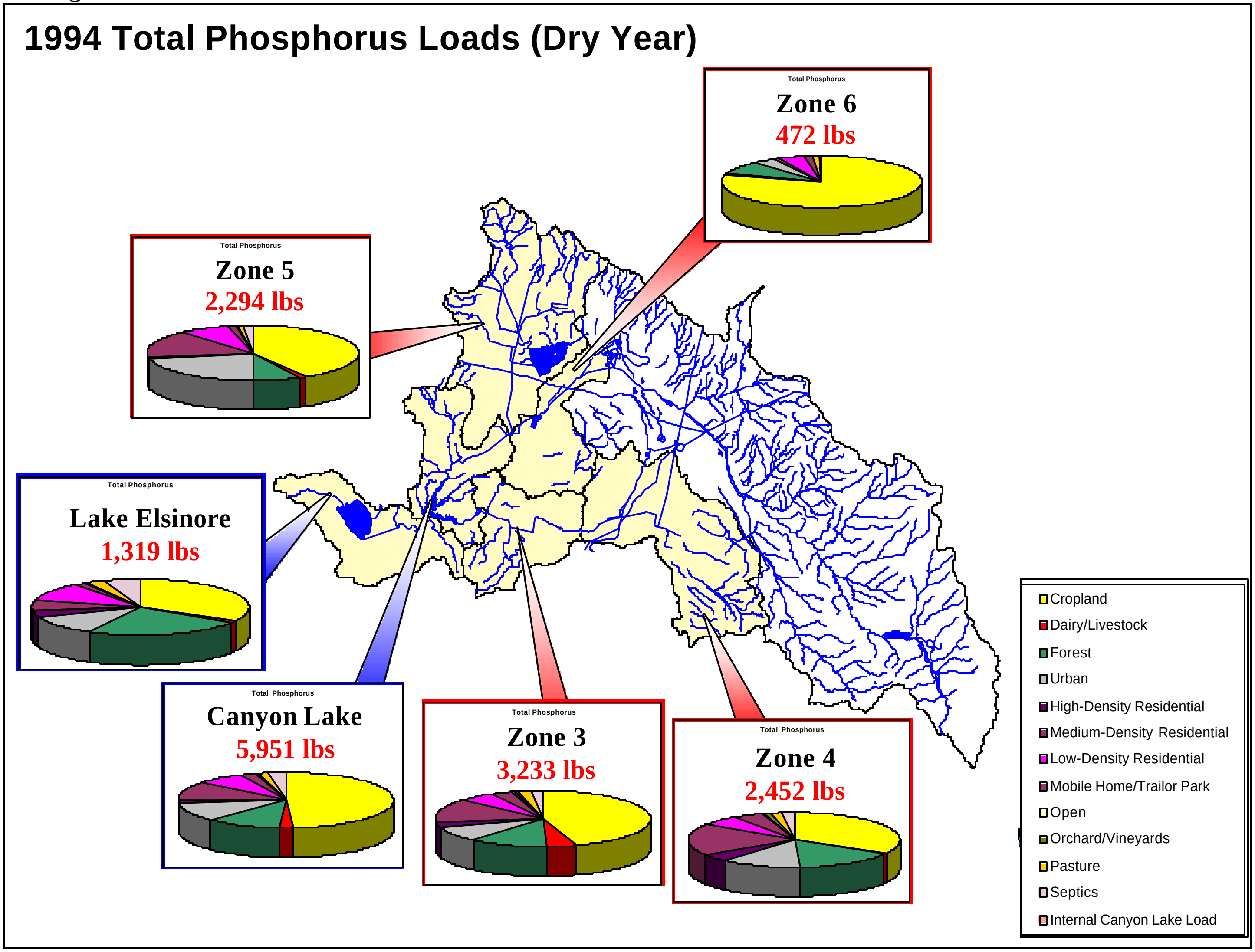

1994 Total Phosphorus Loads (Dry Year)
Total Phosphorus
Zone 6
472 lbs
Total Phosphorus
Zone 5
2,294 lbs
Total Phosphorus
Lake Elsinore
1,319 lbs
Total Phosphorus
Canyon Lake
5,951 lbs
Total Phosphorus
Zone 3
3,233 lbs
Total Phosphorus
Zone 4
2,452 lbs
Cropland
Dairy/Livestock
Forest
Urban
High-Density Residential
Medium-Density Residential
Low-Density Residential
Mobile Home/Trailor Park
Open
Orchard/Vineyards
Pasture
Septics
Internal Canyon Lake Load

Figure A-5

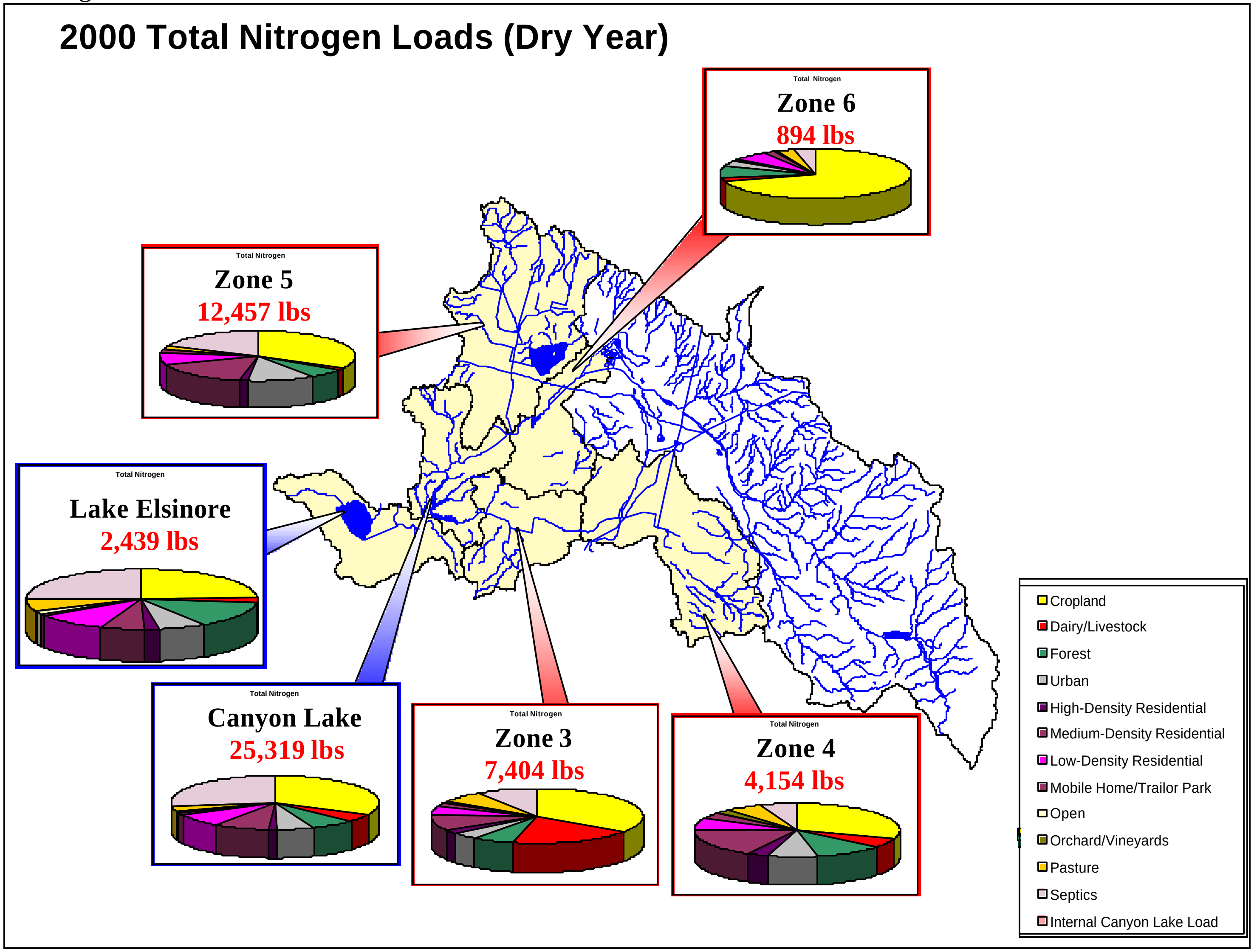
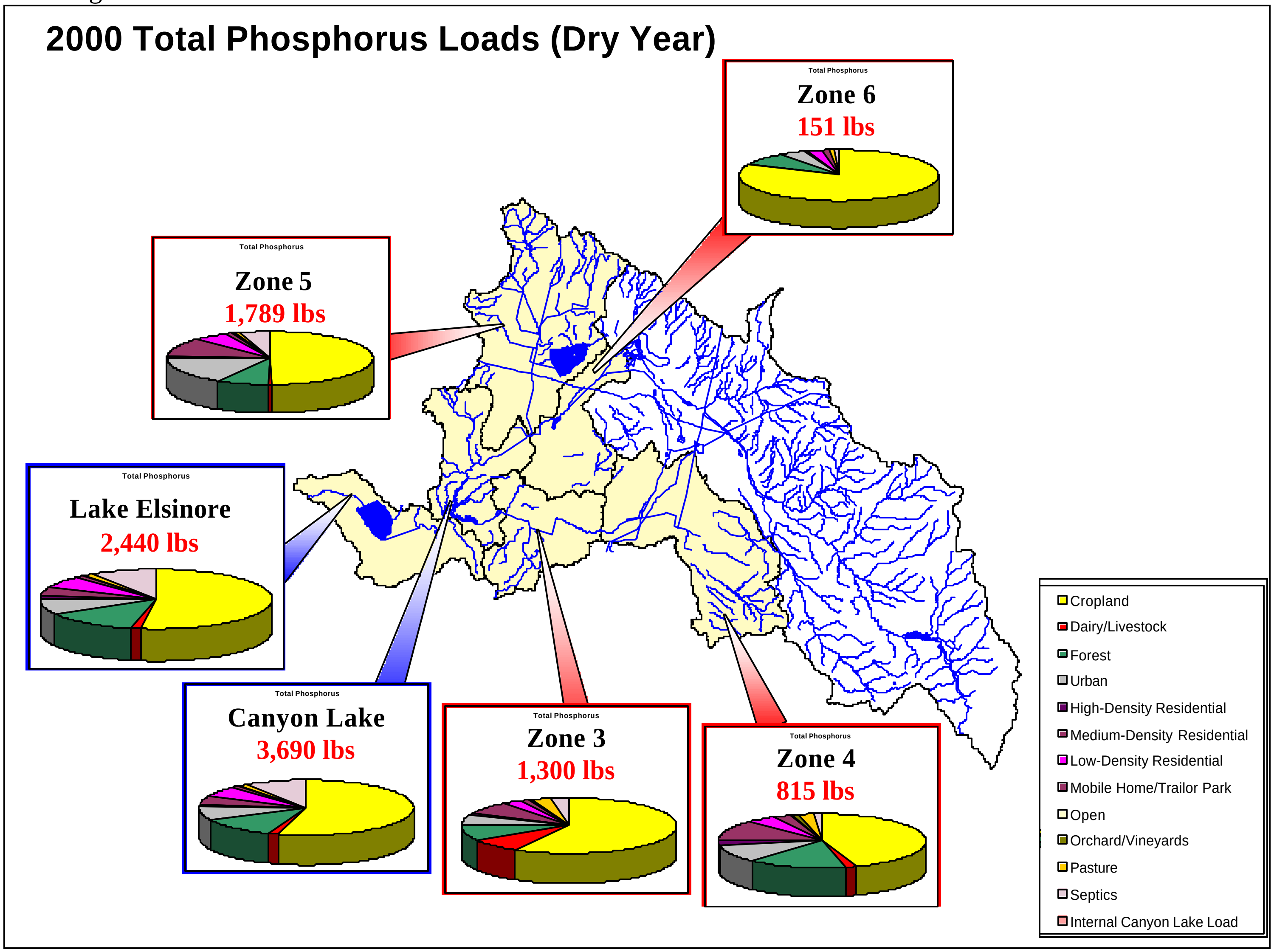

2000 Total Nitrogen Loads (Dry Year)
Total Nitrogen
Zone 6
894 lbs
Total Nitrogen
Zone 5
12,457 lbs
Total Nitrogen
Lake Elsinore
2,439 lbs
Total Nitrogen
Canyon Lake
25,319 lbs
Total Nitrogen
Zone 3
7,404 lbs
Total Nitrogen
Zone 4
4,154 lbs
Cropland
Dairy/Livestock
Forest
Urban
High-Density Residential
Medium-Density Residential
Low-Density Residential
Mobile Home/Trailor Park
Open
Orchard/Vineyards
Pasture
Septics
Internal Canyon Lake Load

Figure A-6


2000 Total Phosphorus Loads (Dry Year)
Total Phosphorus
Zone 6
151 lbs
Total Phosphorus
Zone 5
1,789 lbs
Total Phosphorus
Lake Elsinore
2,440 lbs
Total Phosphorus
Canyon Lake
3,690 lbs
Total Phosphorus
Zone 3
1,300 lbs
Total Phosphorus
Zone 4
815 lbs
Cropland
Dairy/Livestock
Forest
Urban
High-Density Residential
Medium-Density Residential
Low-Density Residential
Mobile Home/Trailor Park
Open
Orchard/Vineyards
Pasture
Septics
Internal Canyon Lake Load

Appendix B - Results of lake Elsinore/Canyon Lake Nutrient Source Assessment in Tabular Form.

Table B-1 Total nitrogen loads (lbs) for Scenario 1 – both Mystic Lake and Canyon Lake overflowed (WY 1998)

Landuse	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
Cropland	95,178	94,192	20,029	11,161	25,463	38,688	21,674	10,458	56
Dairy/Livestock	31,613	31,613	7,705	1,407	1,530	25,948	33,068	10,269	0
Forest	41,766	37,065	4,198	4,558	5,035	26,157	31,839	122,166	67,613
Urban	11,254	9,931	2,025	1,996	5,564	2,185	1,596	715	88
High-Density Residential	2,783	1,859	875	955	658	193	225	265	46
Medium-Density Residential	14,043	14,043	4,719	4,692	8,875	1,128	1,299	2,736	0
Low-Density Residential	15,698	12,366	2,776	1,963	4,380	2,702	1,196	759	108
Mobile Home/Trailor Park	2,227	2,227	837	1,065	565	630	474	969	0
Open	2,199	1,717	196	232	554	828	937	3,301	1,087
Orchard/Vineyards	1,535	1,512	552	772	324	651	802	3,629	5
Pasture	11,344	8,907	3,371	2,150	1,624	3,538	3,477	3,986	223
Septics	84,492	72,288	8,209	4,758	18,475	9,524	10,630	18,895	16,851
Canyon Lake Load	638,500								
Total	952,632	287,720	55,493	35,710	73,047	112,173	107,217	178,149	86,076

Table B-2 Total phosphorus loads (lbs) for Scenario 1 – both Mystic Lake and Canyon Lake overflowed (WY 1998)

Landuse	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
Cropland	46,350	45,977	7,403	4,300	8,046	27,443	21,807	4,540	23
Dairy/Livestock	6,337	6,337	689	126	113	6,317	7,744	1,034	0
Forest	28,131	26,426	1,415	1,638	1,488	24,430	29,328	47,917	25,386
Urban	4,214	3,674	701	680	1,377	1,565	1,375	448	53
High-Density Residential	462	304	127	144	82	72	84	36	6
Medium-Density Residential	2,198	2,198	708	717	1,172	420	487	415	0
Low-Density Residential	2,492	1,982	425	278	487	707	437	108	14
Mobile Home/Trailor Park	406	406	121	164	72	188	170	130	0
Open	214	179	12	15	31	132	153	228	71
Orchard/Vineyards	438	433	92	140	49	314	379	734	1
Pasture	1,420	1,187	301	197	124	765	827	407	21
Septics	6,578	5,761	536	320	1,022	1,595	1,840	1,366	1,186
Canyon Lake Load	124,658								
Total	223,896	94,865	12,528	8,721	14,063	63,948	64,631	57,364	26,760

Table B-3 Total nitrogen loads (lbs) for Scenario 2 –Canyon Lake overflowed (WY 1994)

Landuse	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
Cropland	8,191	8,086	3,677	2,034	2,913	1,025	0	377	1
Dairy/Livestock	1,370	1,370	1,513	278	206	57	0	1,295	0
Forest	2,737	2,043	1,071	1,018	581	122	0	11,290	7,317
Urban	2,231	2,013	818	839	1,414	66	0	102	12
High-Density Residential	795	640	483	467	223	3	0	48	9
Medium-Density Residential	3,229	3,229	2,079	1,891	1,844	15	0	492	0
Low-Density Residential	2,799	2,294	941	728	888	137	0	126	16
Mobile Home/Trailor Park	624	624	447	479	172	36	0	213	0
Open	203	128	46	47	63	7	0	356	120
Orchard/Vineyards	155	152	137	159	34	3	0	467	1
Pasture	1,300	915	736	454	183	54	0	476	23
Septics	3,335	2,546	800	678	594	24	0	778	1,210
Canyon Lake Load	13,953								
Total	40,922	24,039	12,747	9,070	9,114	1,547	0	16,020	8,708

Table B-4 Total phosphorus loads (lbs) for Scenario 2 – Canyon Lake overflowed (WY 1994)

Landuse	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
Cropland	640	2,901	1,453	806	957	371	0	133	0
Dairy/Livestock	24	117	142	25	16	5	0	105	0
Forest	359	685	382	373	177	41	0	3,402	1,881
Urban	202	649	274	302	480	18	0	21	2
High-Density Residential	49	118	100	105	39	0	0	7	1
Medium-Density Residential	132	633	456	453	367	3	0	74	0
Low-Density Residential	170	452	184	156	172	21	0	15	2
Mobile Home/Trailor Park	25	119	95	111	30	6	0	30	0
Open	5	7	3	3	3	0	0	19	5
Orchard/Vineyards	6	25	24	29	5	0	0	76	0
Pasture	46	78	68	42	14	5	0	39	1
Septics	81	166	54	47	34	1	0	39	58
Canyon Lake Load	0								
Total	1,740	5,951	3,233	2,452	2,294	472	0	3,960	1,950

Table B-5 Total nitrogen loads (lbs) for Scenario 3 – neither Mystic Lake nor Canyon Lake overflowed (WY 2000)

Landuse	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
Cropland	352	8,161	2,568	1,261	4,077	621	0	138	0
Dairy/Livestock	47	1,197	1,411	229	240	30	0	672	0
Forest	292	1,764	469	463	731	64	0	6,199	3,708
Urban	107	1,499	291	311	1,377	35	0	66	6
High-Density Residential	47	335	157	148	168	1	0	37	4
Medium-Density Residential	86	2,177	724	698	2,056	6	0	353	0
Low-Density Residential	189	1,914	377	279	990	55	0	77	9
Mobile Home/Trailor Park	14	347	138	178	155	16	0	137	0
Open	29	121	19	22	78	4	0	202	64
Orchard/Vineyards	5	97	46	73	55	1	0	309	0
Pasture	150	779	499	253	265	28	0	286	12
Septics	405	6,929	705	238	2,266	32	0	450	619
Canyon Lake Load	0								
Total	1,722	25,319	7,404	4,154	12,457	894	0	8,925	4,423

Table B-6 Total phosphorus loads (lbs) for Scenario 3 – neither Mystic Lake nor Canyon Lake overflowed (WY 2000)

Landuse	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
Cropland	503	1,998	760	363	889	123	0	41	0
Dairy/Livestock	16	65	102	15	12	1	0	46	0
Forest	161	426	119	124	148	12	0	1,601	796
Urban	85	296	72	87	289	6	0	10	1
High-Density Residential	13	36	20	21	16	0	0	5	0
Medium-Density Residential	48	195	90	102	210	1	0	43	0
Low-Density Residential	70	226	43	39	102	4	0	8	1
Mobile Home/Trailor Park	9	38	16	24	15	1	0	17	0
Open	2	5	1	1	3	0	0	9	2
Orchard/Vineyards	3	10	5	10	6	0	0	42	0
Pasture	19	45	35	17	14	1	0	20	1
Septics	93	351	37	12	86	1	0	20	25
Canyon Lake Load	0								
Total	1,022	3,690	1,300	815	1,789	151	0	1,862	826

Appendix C - San Jacinto Modeling System Validation

C. San Jacinto Modeling System Validation

In support of the Lake Elsinore and Canyon Lake Nutrient Source Assessment, Tetra Tech developed a modeling system of the San Jacinto River watershed and Canyon Lake. To summarize nutrient loading characteristics under a variety of hydrologic conditions, the following scenarios were simulated: (1) Mystic Lake and Canyon Lake overflowed, (2) Canyon Lake overflowed but Mystic Lake did not, and (3) neither Mystic Lake nor Canyon Lake overflowed. However, there was limited data for the range of hydrologic conditions to verify model performance for all three scenarios. Streamflow and water quality data were available throughout the watershed for model calibration and validation during dry conditions, but little or no data was available to verify model predictions during extreme wet events. Such wet events are important to understand due to the potential for transport of water and associated nutrient loads through Mystic Lake from the upper portions of the watershed, and to Lake Elsinore from overflow of Canyon Lake dam.

To provide additional information for model validation, data was collected in Spring 2003 for streamflow, instream water quality, and in-lake water quality. However, a wet event meeting the conditions for Mystic Lake to overflow (scenario 1) did not occur. Although additional data for an extreme wet event was not collected, useful information was provided for moderate hydrologic conditions that justified utilization for model validation. Previously, the only in-lake water quality data for Canyon Lake was collected in 2000 and 2001, which were dry years when the Canyon Lake dam did not overflow. For 2003, in-lake water quality was available to validate model performance for moderate wet conditions when Canyon Lake dam overflows, but Mystic Lake did not (scenario 2). In addition, flow data was collected at locations not previously monitored, so validation of model-predicted hydrology could be performed at additional locations not previously calibrated.

The modeling system can be divided into two components representative of the processes essential for accurately modeling nutrient loading and internal mass balances of the lakes. The first component of the modeling system consists of a watershed model that predicts stormwater runoff and transport of nutrients as a result of rainfall events (and direct, non-storm loadings to waterbodies). It was beneficial for the selected watershed model to also include predictive capability for pathogens (which are targeted for future TMDL development). The second component includes a simplified dynamic model of Canyon Lake to predict the response and mass balance of nutrients within the water column for Canyon Lake and to provide time-series output for assessment of loadings to Lake Elsinore.

C.1 Watershed Model Validation

Model validation to 2003 data considered hydrology and water quality of the watershed model at various locations throughout the watershed where data were collected.

C.1.1 Watershed Model Hydrology Validation

Hydrology validation of the watershed model to 2003 data was performed for all five USGS streamflow gages that were used for initial calibration/validation and reported in the Nutrient Source Assessment (Tetra Tech, Inc, 2003). Although USGS station 11070500 was not used to calibrate the watershed model, it was used to validate the prediction of outflow from the Canyon Lake model. In addition to these previously calibrated gages, data was collected in 2003 at a highly urban watershed in Hemet (TMDL Station 318) and three contributing watersheds of Lake Elsinore (TMDL Stations 357, 712, and 714). These additional stations provided much insight regarding model performance. Table C-1 lists the streamflow gages used for calibration/validation reported in the Nutrient Source Assessment, as well those used for validation to 2003 data. Station locations are shown in Figure C-1.

Table C-1 Streamflow Gages Used for Hydrology Calibration and Validation

RWQCB TMDL Station	USGS Station Number	Station Name	Historical Record	Nutrient Source Assessment Calibration Period	Nutrient Source Assessment Validation Period	2003 Validation Period
792	11069500	San Jacinto River near San Jacinto	10/1/1920 - 9/30/1991; 10/1/1996 - 9/30/2001	10/1/1996 - 9/30/2001	10/1/1990 - 9/30/1991	10/1/2002 - 3/31/2003
325	11070270	Perris Valley Storm Drain at Nuevo Rd. near Perris	10/1/1969 - 9/30/1997; 10/1/1998 - 2/14/2001	1/1/1991 - 9/30/1997	10/1/1998 - 2/14/2001	10/1/2002 - 3/31/2003
827	11070500	San Jacinto River near Elsinore	1/1/1916 - present	none (influenced by Canyon Lake overflow)	10/1/1997 - 9/30/1998 (lake model validation)	10/1/2002 - 3/31/2003 (lake model validation)
745	11070475	Salt Creek at Murrieta Rd.	10/1/1969 - 9/30/1978; 8/25/2000 - 9/30/2001	none (insufficient period of record)	10/1/2001 - 6/29/2001	10/1/2002 - 3/31/2003
759	11070375	San Jacinto River at Goetz Rd.	10/1/2000 - 9/30/2001	none (insufficient period of record)	10/1/2001 - 6/29/2001	10/1/2002 - 3/31/2003
741	11070210	San Jacinto River at Romona Exp.	10/1/2000 - 9/30/2001	none (insufficient period of record)	10/1/2001 - 6/29/2001	10/1/2002 - 3/31/2003
318	--	Hemet NPDES	10/1/01 - 5/31/03	data not available	data not available	10/1/2002 - 3/31/2003
357	--	Four Corners NPDES	3/8/02 - 5/31/03	data not available	data not available	10/1/2002 - 3/31/2003
712	--	Leach Cyn ChanOutlet	10/14/02 - 6/10/03	data not available	data not available	10/1/2002 - 3/31/2003
714	--	Ortega Cyn Chan	10/1/01 - 6/9/03	data not available	data not available	10/1/2002 - 3/31/2003

Results of watershed model validation to streamflow data collected at the above stations are shown in Figures C-2 through C-10. It is important to note that although in some cases validation did not match observed flows, the 2003 validation period was confined to a few storms. For the initial calibration and validation performed in model development for the Nutrient Source Assessment, watershed model performance was assessed over a ten-year period with variable hydrologic conditions and storm magnitudes. The following is a brief discussion of the streamflow validation results for each TMDL station.

Station 792 – This station is located in the headwater portion of the watershed where flows terminated in Mystic Lake with no overflow and transport of associated nutrients to Canyon Lake. Overall, flows were over-predicted (Figure C-3). However, deviation from observed data associated with a few storms did not justify recalibration of the model due to acceptable calibration/validation over the previous 10-year period (see the Nutrient Source Assessment).

Station 325 – This station, located on Perris Valley Storm Drain, was a critical point used for calibration of urban model parameters for the Nutrient Source Assessment. For 2003, the model consistently under-predicted three stormflows in February and March (Figure C-4). However, the model was proven to accurately predict 2003 flows from a dominantly urban watershed in the Hemet area (see Station 318). Moreover, previous long-term calibration/validation showed acceptable results through comparison to long-term trends and statistics determined from observed data (see the Nutrient Source Assessment). Under-prediction of flows could be the result of several factors, including the presence of localized storm events in the vicinity of the rain gage (rain data is used to drive the watershed model) not representative of the contributing watershed to the station location, or variability in agricultural practices and impact on runoff (all agricultural areas in the watershed are subject to a single set of hydrologic model parameters). Validation to downstream Station 759, located on the San Jacinto River just above Canyon Lake, showed accurate representation of 2003 stormflows. Due to the fact that the majority of flows in the San Jacinto River are from the Perris Valley Storm Drain, and the magnitude of flows from Perris Valley were observed at Station 325 to exceed downstream flows at Station 759 (see Figures C-3 and C-5), the flows observed at station 325 are questionable. Since 2003 validation showed under-prediction of only three stormflows, this did not provide sufficient indication that model recalibration was warranted, especially due to previous success in calibration/validation to long-term data.

Station 745 – Located on Salt Creek just above Canyon Lake, this gage was previously used for model validation, but too little data was previously available for model calibration for the Nutrient Source Assessment. For validation to 2003 data, the model over-predicted streamflows resulting from three storms (Figure C-5). As with station 325, the error observed is not believed to be a result of inaccurate representation of urban runoff due to acceptable validation to Station 318. Deviation from observed results are believed to result from localized storm events that were not representative of conditions across the entire Salt Creek watershed. Variability in agricultural practices (i.e., crops or irrigation practices impacting the storage and runoff of stormflows) was also likely influential in over-prediction of flows. Such variability potentially resulted in under-prediction of stormflows at Station 325.

Station 759 – Located on the San Jacinto River just above Canyon Lake, this station represents the majority of flow to Canyon Lake. Therefore, acceptable validation of streamflows at this station is important in assessing the capability of the model in predicting nutrient loads to the lake. As shown in Figure C-5, the model was shown to predict flows at this station reasonably well.

Station 741 – This station is located on the San Jacinto River below Mystic Lake. Although Mystic Lake did not overflow in 2003, the model inaccurately predicted overflow. This was likely due to underestimation of the volume of Mystic Lake, essentially limiting the available storage in the lake. Since the original estimate of the Mystic Lake volume was based on very rough data, under-sizing of the lake was not unlikely. Therefore, adjustments to lake volume were made until model-predicted overflow of the lake was prevented in 2003. The resulting volume of Mystic Lake was exactly twice the assumed volume in the Nutrient Source Assessment.

The remaining flows predicted by the model at Station 741 were the result of localized runoff downstream of Mystic Lake. Following reconfiguration of Mystic Lake, validation was performed (Figure C-6). The model over-predicted flows in 2003 associated with two storm events. Since acceptable previous validation was performed on data from 2001, and 2003 validation was confined to a few storm events, no recalibration of watershed modeling parameters was justified.

Station 318 – This station is located at a primarily urban watershed, and provides much insight into the ability of the model to predict urban runoff. For model validation, this station is ideal since no flow data has been previously available for hydrology calibration or validation. As shown in Figure C-7, the model predicted flows reasonably well.

Station 357 – This station provides flows at a location in the vicinity of Lake Elsinore where flow data was not previously available for model calibration or validation. Therefore, this station provides insight into the model's predictive capability for estimation of runoff to Lake Elsinore. As shown in Figure C-8, the model predicted flows reasonably well. For the last storm, no rainfall was recorded at the rain gage, which suggests either a localized rainfall event was not recorded at the location of the rain gage, or an error occurred with the rain gage. As a result, the model predicted no streamflow for the last storm.

Station 712 – Located in the local area of Lake Elsinore, no data was previously available for model calibration or validation at this station for the Nutrient Source Assessment. The model was shown to have some deviation from observed flows, but overall did reasonably well in comparison to observed data (see Figure C-9). As with Station 357, the last storm was missed due to unrecorded rainfall.

Station 714 – Also located in the vicinity of Lake Elsinore, flows from this watershed were minor. The model consistently under-predicted flows at this station, but relative error was minor (see Figure C-10; note the scale of the flow axis when making comparisons).

In summary, results of model validation to 2003 data provided reasonable assurance of model performance in predicting hydrology of the San Jacinto River watershed. Although some deviation was noted from observed flows, this difference did not justify recalibration of watershed hydrologic processes. However, hydraulic assumptions regarding Mystic Lake volume required reconfiguration so that downstream flow predictions could be refined. This resulted in twice the assumed volume of Mystic Lake originally simulated for the Nutrient Source Assessment.

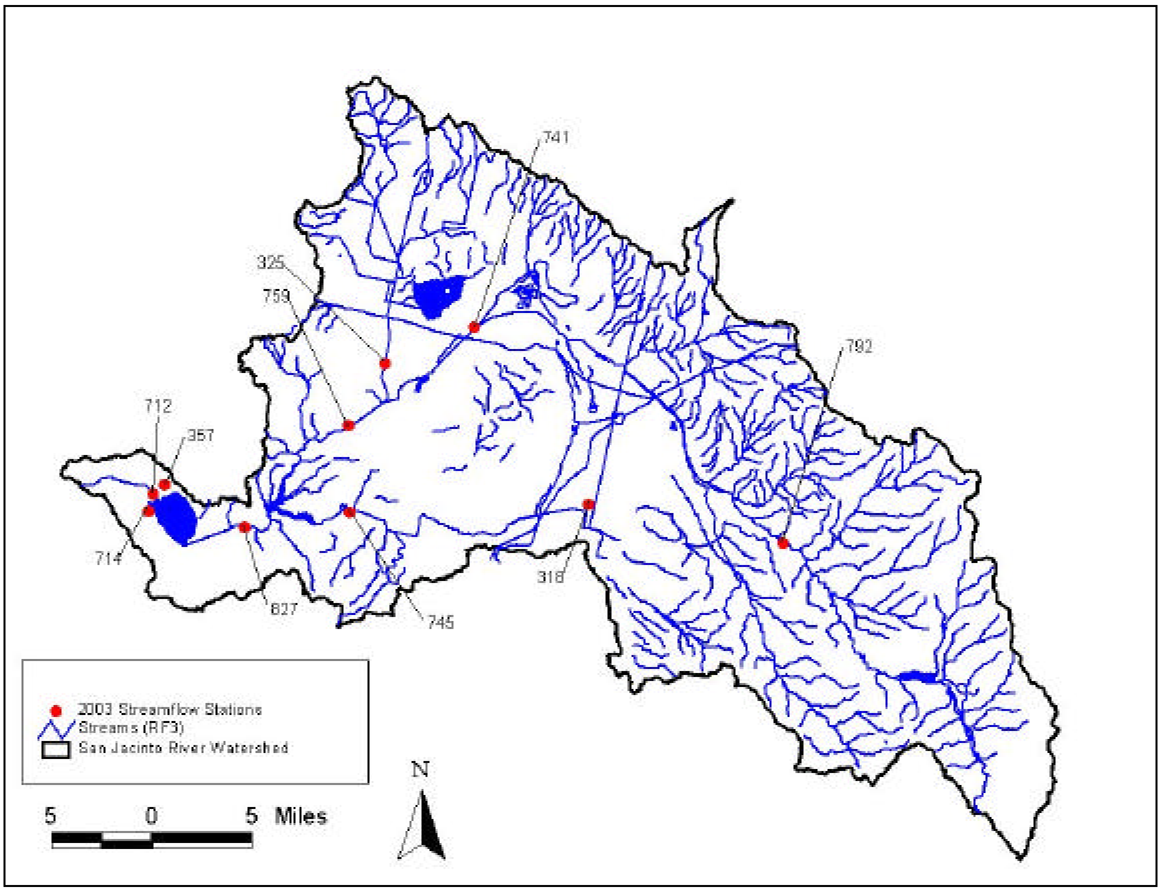


Figure C-2. 2003 Streamflow Gage Locations

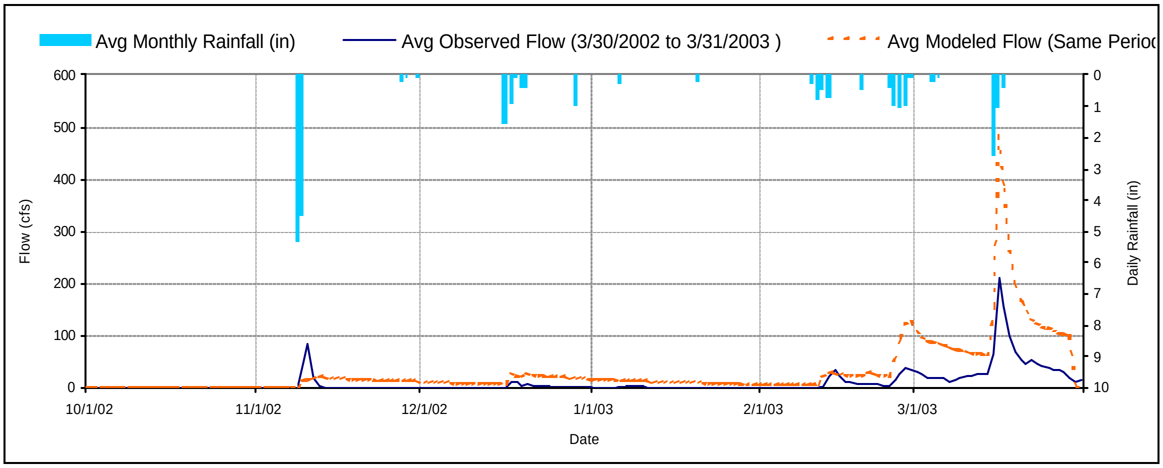


Figure C-3. Validation to TMDL Station 792

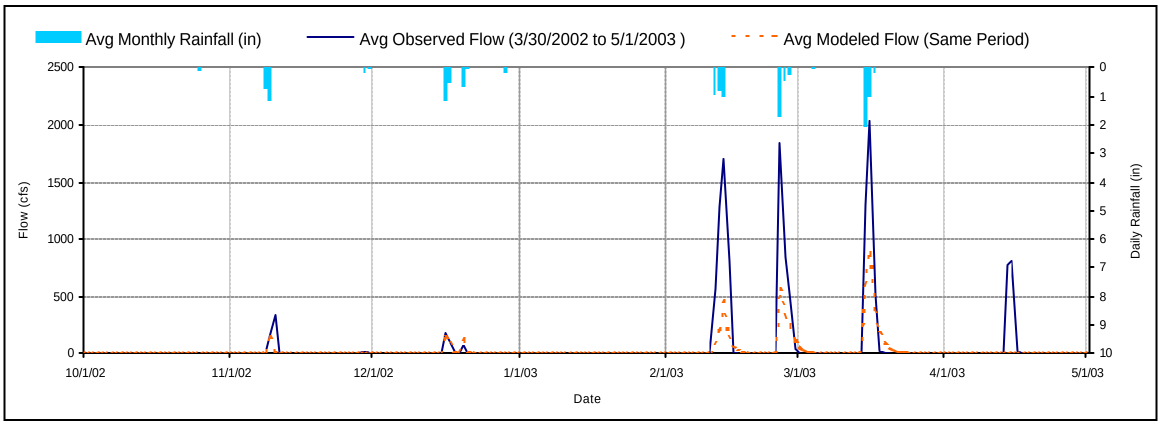


Figure C-4. Validation to TMDL Station 325

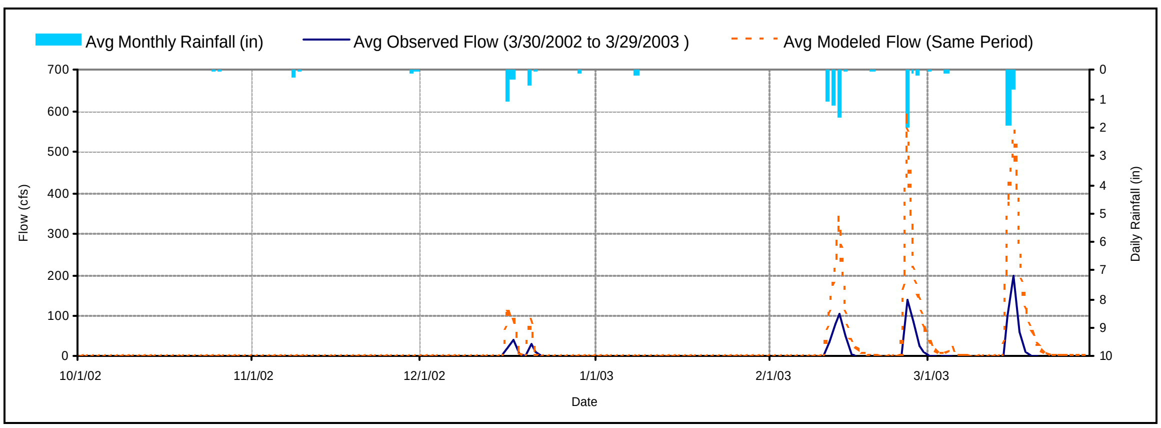


Figure C-5. Validation to TMDL Station 745

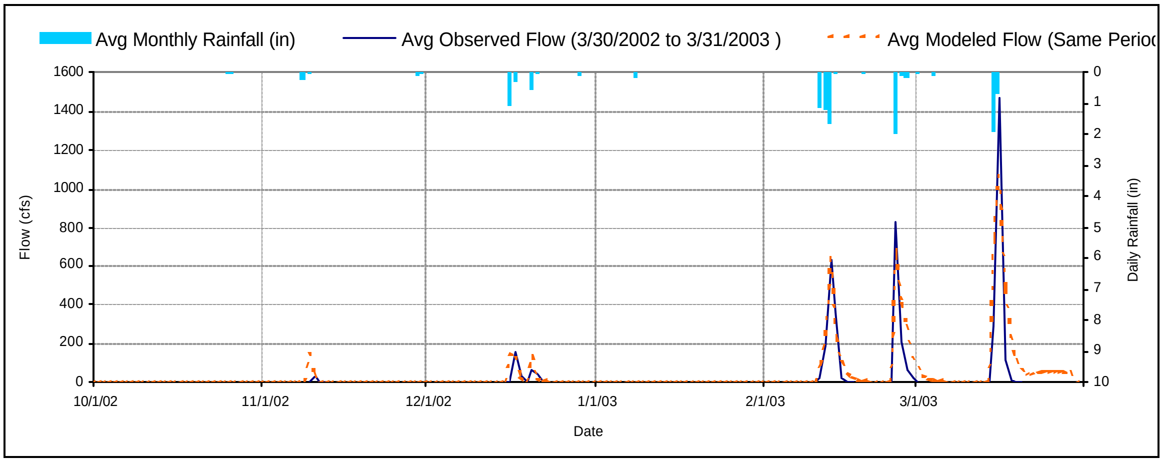


Figure C-6. Validation to TMDL Station 759

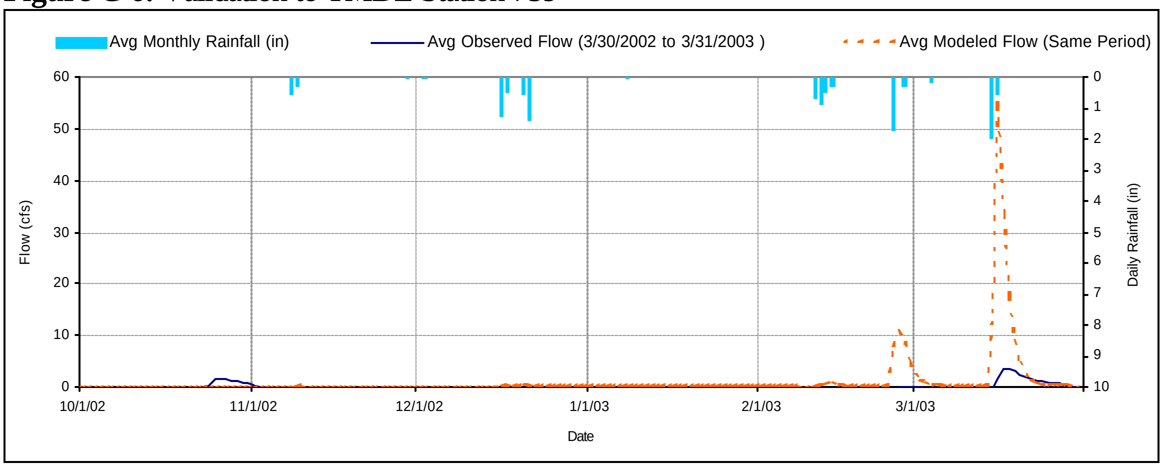


Figure C-7. Validation to TMDL Station 741

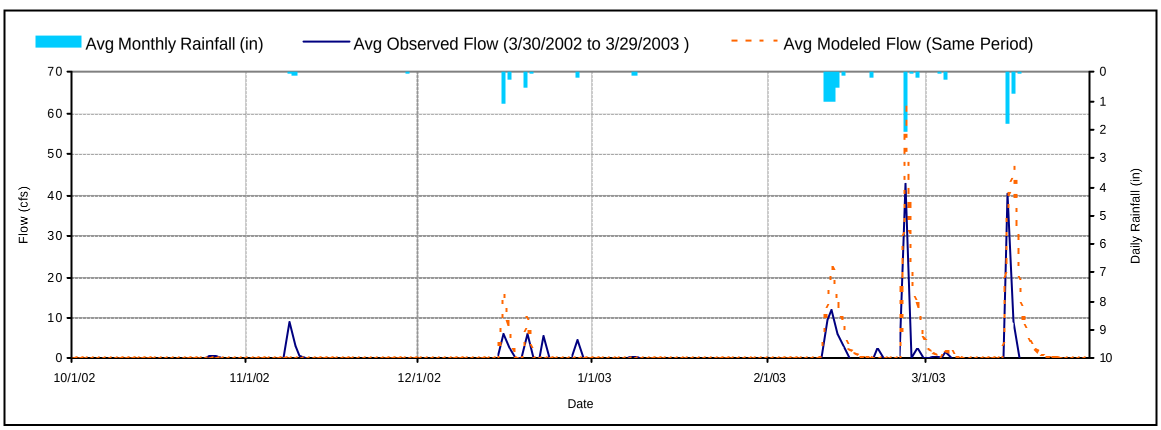


Figure C-8. Validation to TMDL Station 318

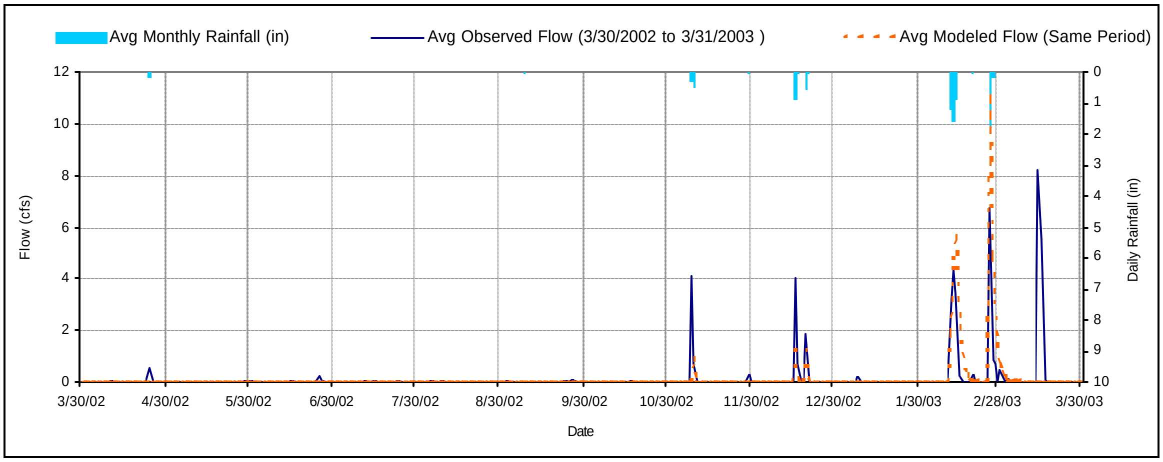


Figure C-9. Validation to TMDL Station 357

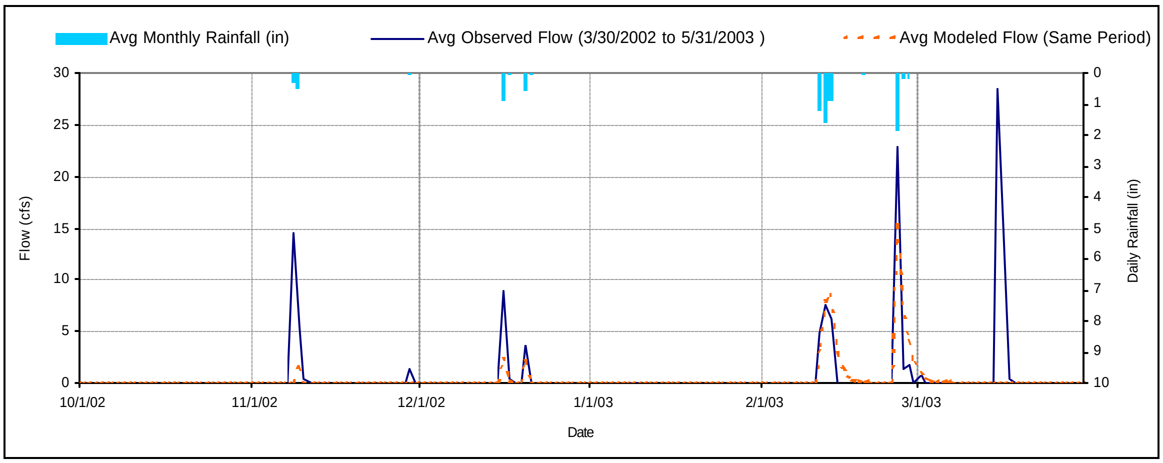


Figure C-10. Validation to TMDL Station 712

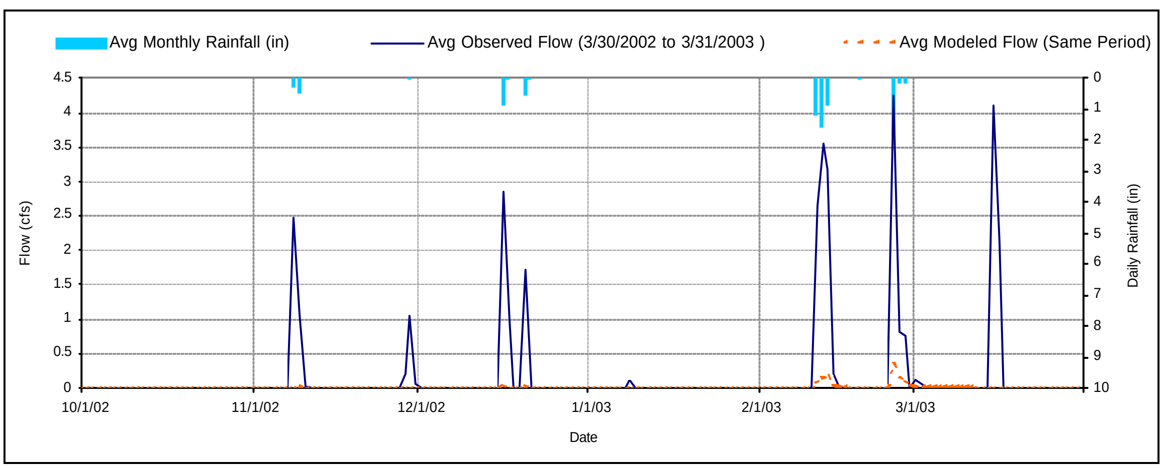


Figure C-11. Validation to TMDL Station 714

C.1.2 Watershed Model Water Quality Validation

Watershed model water quality validation to observed 2003 data was performed at multiple stations where previous calibration and validation were performed for the Nutrient Source Assessment (Table C-2). Validation was performed for total nitrogen (TN) and total phosphorus (TP). Graphical results of water quality validations are provided in Figures C-11 through C-26. 2003 water quality data was limited to two storms in February. For some stations, the model under-predicted instream nutrient concentrations. However, this deviance from observed data did not justify model recalibration since 2003 was limited to two storms, and original model calibration and validation extended over a 9-year period. Below are brief discussions of water quality validation results at each station.

Table C-2. Streamflow Gages Used for Water Quality Calibration and Validation

Station Number	Station Name	Period of Record	Nutrient Source Assessment Calibration Period	Nutrient Source Assessment Validation Period	2003 Validation Period
318	Hemet NPDES	12/15/1992 -2/28/2001	1/11/2001 - 2/28/2001	6/1/1993 - 2/15/1998	2/1/2003 - 3/1/2003
325	Perris Ch @ Nuevo Rd	2/12/2000 - 6/19/2001	1/11/2001 - 6/19/2001	2/12/2000 - 8/22/2000	2/1/2003 - 3/1/2003
357	Four Corners NPDES	1/3/1992 - 2/25/2001	2/3/1998 - 2/25/2001	1/3/1992 - 12/16/1997	2/1/2003 - 3/1/2003
712	Leach Cyn ChanOutlet	1/3/1992 - 2/13/2001	1/11/2001 - 2/13/2001	none	2/1/2003 - 3/1/2003
714	Ortega Cyn Chan	1/3/1992 - 2/13/2001	1/11/2001 - 2/13/2001	none	2/1/2003 - 3/1/2003
745	Salt Creek @ Mur Rd	1/11/2001 - 3/3/2001	1/11/2001 - 3/3/2001	none	2/1/2003 - 3/1/2003
759	S.JacintoRiv@GoetzRd	2/21/1996 - 3/2/2001	1/11/2001 - 3/2/2001	none	2/1/2003 - 3/1/2003
792	S.Jac.Riv @ Cranston	8/17/1995 - 4/17/2001	1/14/1998 - 4/17/2001	8/17/1995 - 9/24/1997	2/1/2003 - 3/1/2003
834	Cyn Lk@ Sierra Park	1/11/2001 - 3/2/2001	1/11/2001 - 3/2/2001	none	2/1/2003 - 3/1/2003

Station 792 – This station, located at the headwaters of the San Jacinto River, is highly impacted by groundwater water quality. The model over-predicted TN for the first storm, but under-predicted the peak TN concentration of the second storm (Figure C-11). For TP, the model predicted the two storms reasonably well (Figure C-12).

Station 325 – The model under-predicted both TP and TN for both storms (Figures C-13 and C-14). Located at the bottom of the Perris Valley Storm Drain, this station is impacted heavily by both urban and agricultural runoff. The model was shown to predict urban runoff reasonably well from analysis of a predominately urban watershed (see Station 318; Figures C-19 and C-20). Therefore, deviance from observed data was likely related to under-prediction of stormflows or misrepresentation of agricultural areas. Under-prediction of two storm events did not justify model recalibration due to previous acceptable calibration and validation over 2 wet periods. However, results do suggest that additional information regarding variation of agricultural practices could provide better resolution of agricultural impacts on instream water quality and quantity.

Station 745 – Located at the bottom of Salt Creek, water quality is impacted by both urban and agricultural runoff. The model under-predicted TP and TN concentrations for both storms of 2003 (Figures C-15 and C-16). At Station 318 (Figures C-19 and C-20) the model was shown to perform well at predicting urban runoff water quality, therefore deviance in model-predicted water quality at Station 745 is determined to result from simulation of agricultural practices. However, previous acceptable calibration to storms of 2001 suggest that agricultural practices likely vary from one year to the next. Further study of spatial and temporal variation of agricultural practices could improve understanding of influences on water quality in this area.

Station 759 – Under-prediction of both TP and TN at this station is the result of flows from Perris Valley Storm Drain, which was shown to under-predict concentrations at Station 325 (Figures C-17 and C-18).

Station 318 – Located at the bottom of a predominately urban area, the model performed well at predicting both TN and TP concentrations (Figures C-19 and C-20). This provided confidence in simulation of urban runoff water quality in other areas of heterogeneous land use.

Station 357 - An urban drainage area in the vicinity of Lake Elsinore, the model did reasonably well at predicting TP and TN concentrations (Figures C-21 and C-22).

Station 712 – Also located in the Lake Elsinore area with heterogeneous land use, the model did reasonably well at predicting TP and TN concentrations, although data was limited to a single storm event (Figures C-23 and C-24).

Station 714 – The model under-predicted both TN and TP concentrations for a single storm event of 2003 (Figures C-25 and C-26). The model also under-predicted nutrient concentrations in the previous calibration to 2001 data. As stated in the Nutrient Source Assessment, under-prediction of water quality at this location is likely the result of either a misrepresentation of land use for the watershed or possible influence of an unknown source of nutrients upstream of the station that cannot be accounted for through land use representation.

In summary, resolution of model performance for validation to 2003 conditions was limited due to sparse data confined to two storm events occurring in February. Although the model consistently under-predicted nutrient concentrations at areas influenced by agricultural land use practices, sufficient data was not available to justify model recalibration. To better assess model performance under a variety of storms (i.e., wet year that Mystic Lake fills and overflows to the lower portion of the watershed) and seasons, additional data collection is recommended. Also, variation of both hydrology and water quality is believed to result from variation of agricultural practices specific to different crops and irrigation practices. An additional study will be recommended in the San Jacinto River Watershed Management Plan to collect information regarding spatial variation of agricultural practices within the watershed so that better resolution of such variability can be provided in future model updates, and guidance can be provided regarding overall management of nutrients in the watershed associated with fertilizer and manure application.

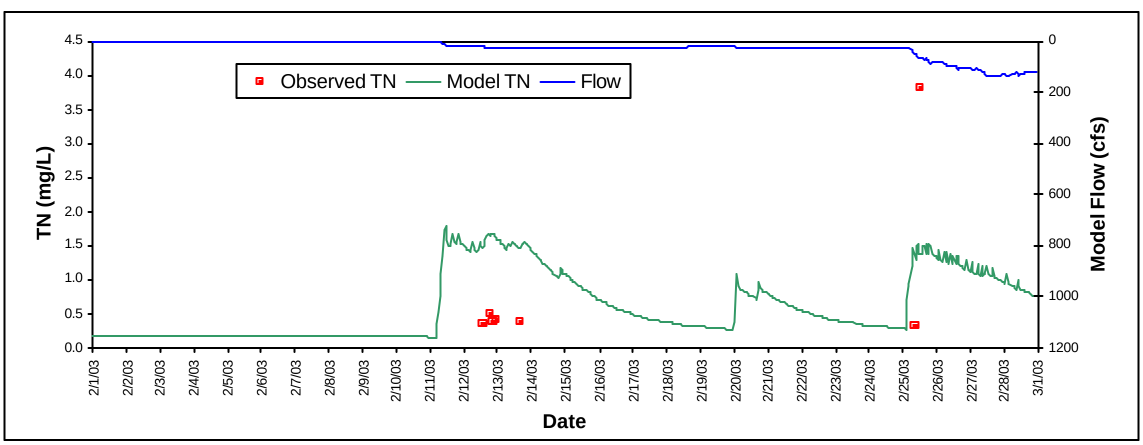


Figure C-12. Validation of Total Nitrogen Concentrations at TMDL Station 792

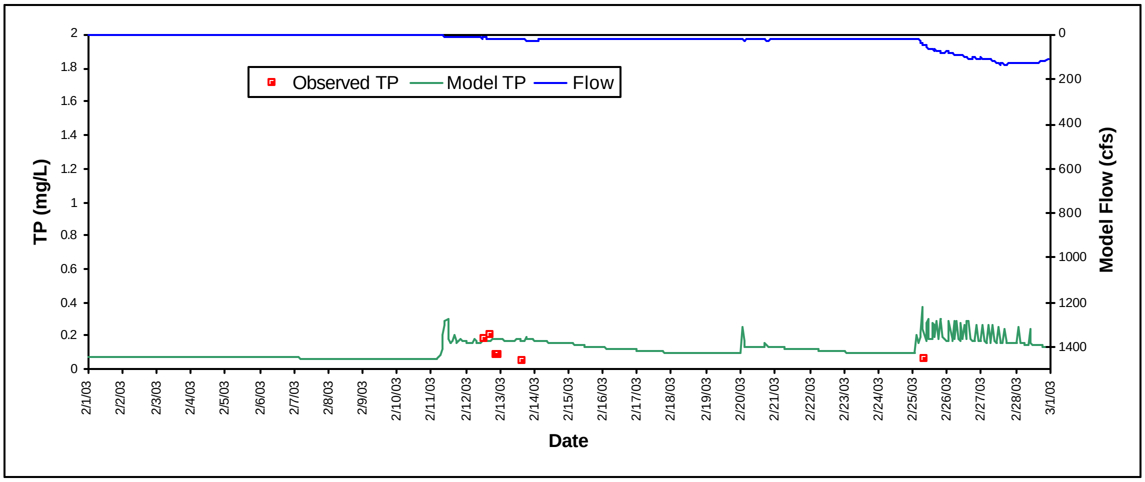


Figure C-13. Validation of Total Phosphorus Concentrations at TMDL Station 792

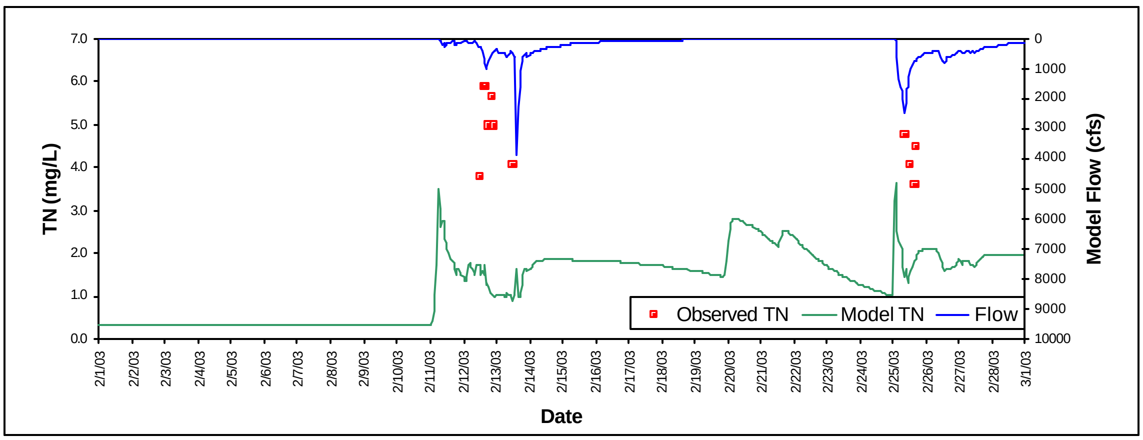


Figure C-14. Validation of Total Nitrogen Concentrations at TMDL Station 325

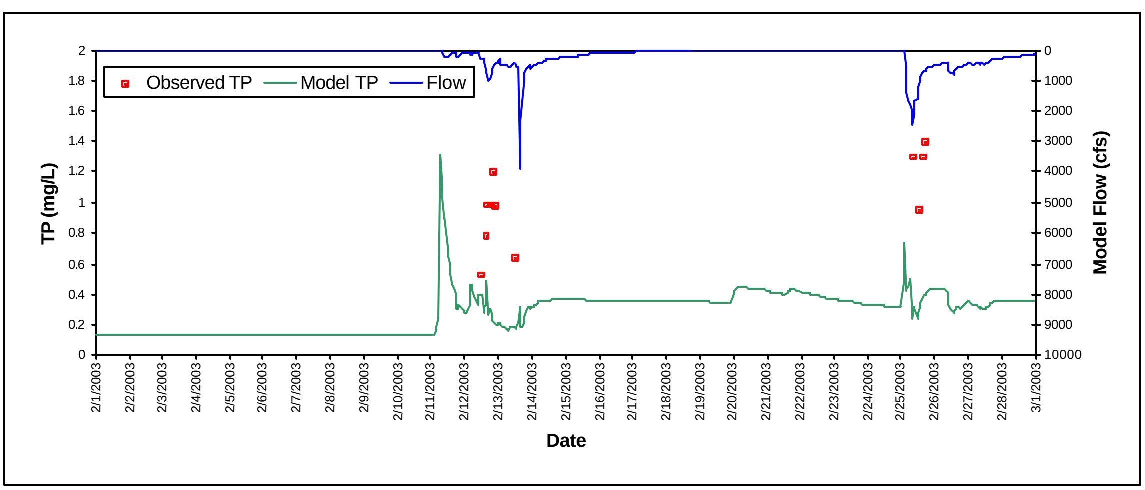


Figure C-15. Validation of Total Nitrogen Concentrations at TMDL Station 325

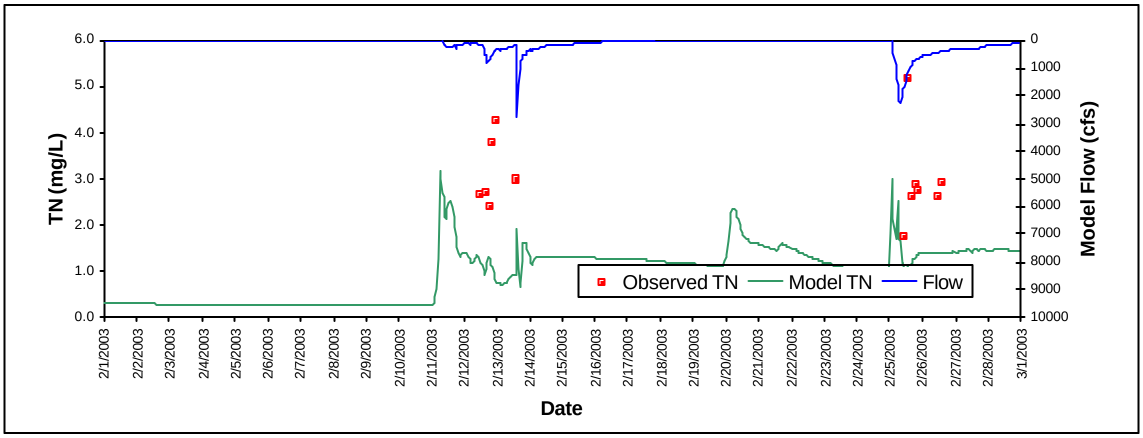


Figure C-16. Validation of Total Nitrogen Concentrations at TMDL Station 745

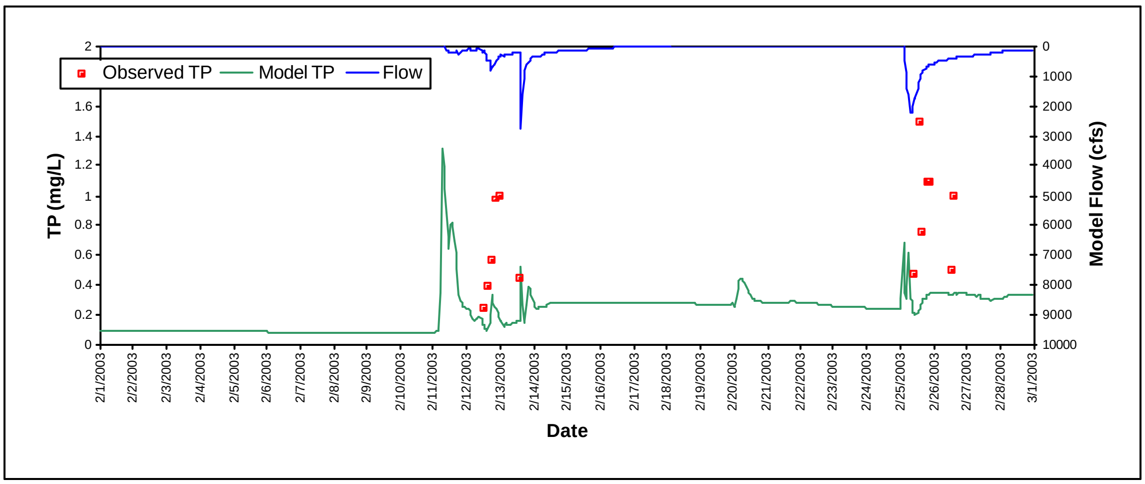


Figure C-17. Validation of Total Phosphorus Concentrations at TMDL Station 745

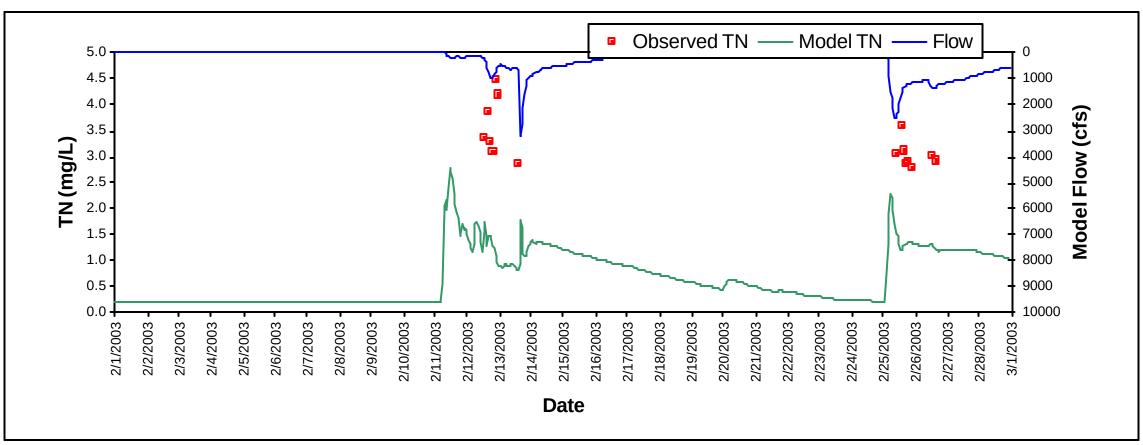


Figure C-18. Validation of Total Nitrogen Concentrations at TMDL Station 759

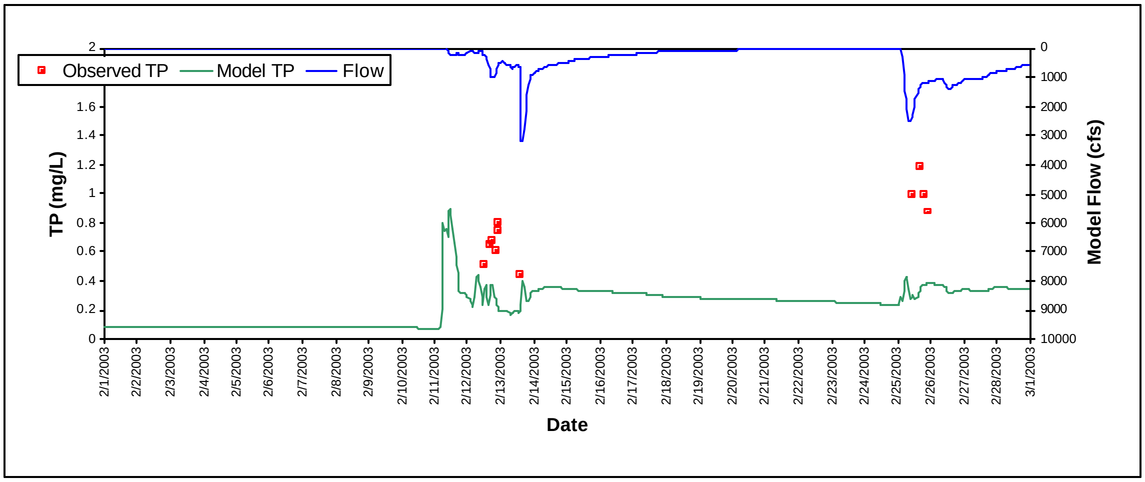


Figure C-19. Validation of Total Phosphorus Concentrations at TMDL Station 759

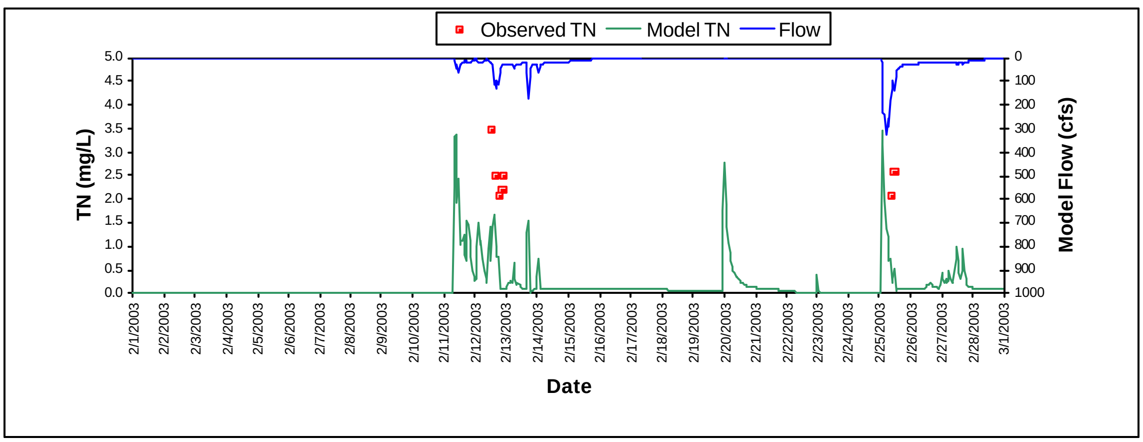


Figure C-20. Validation of Total Nitrogen Concentrations at TMDL Station 318

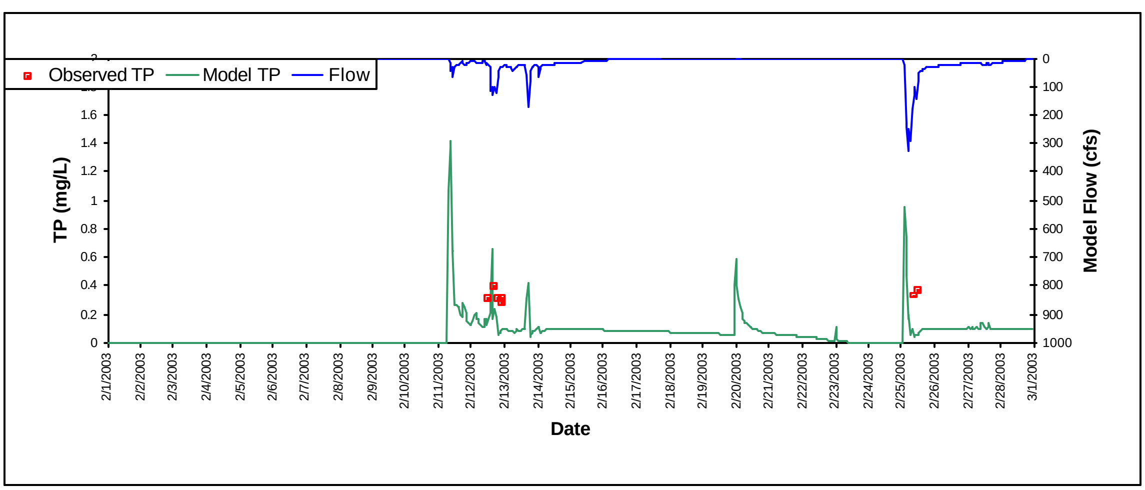


Figure C-21. Validation of Total Phosphorus Concentrations at TMDL Station 318

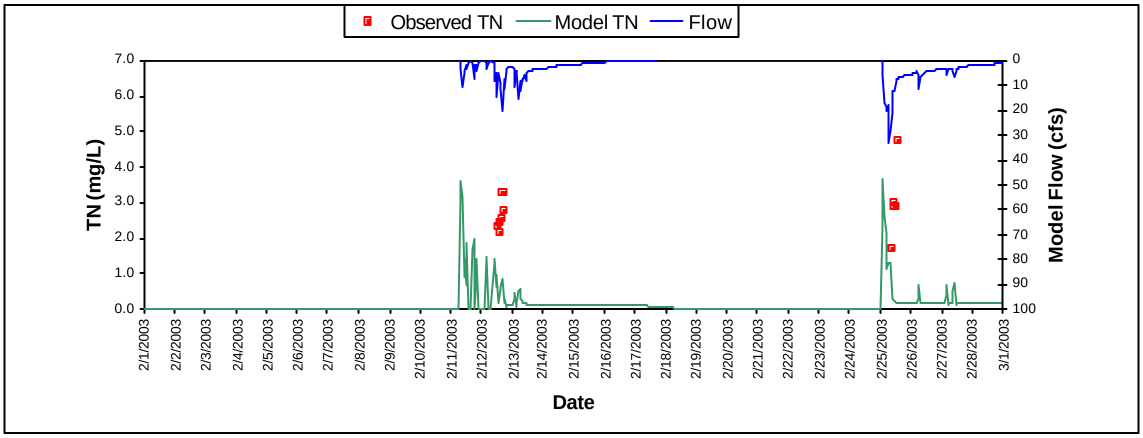


Figure C-22. Validation of Total Nitrogen Concentrations at TMDL Station 357

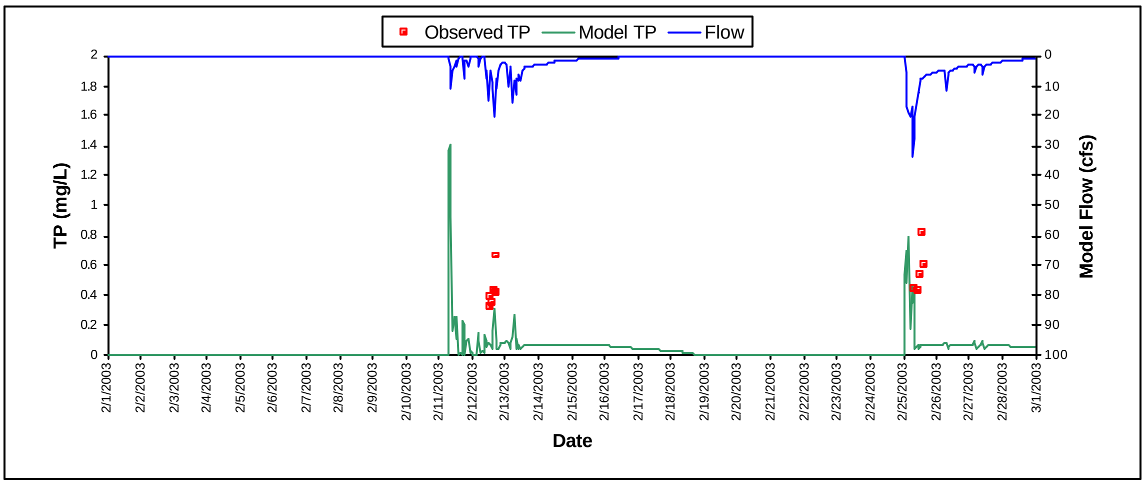


Figure C-23. Validation of Total Phosphorus Concentrations at TMDL Station 357

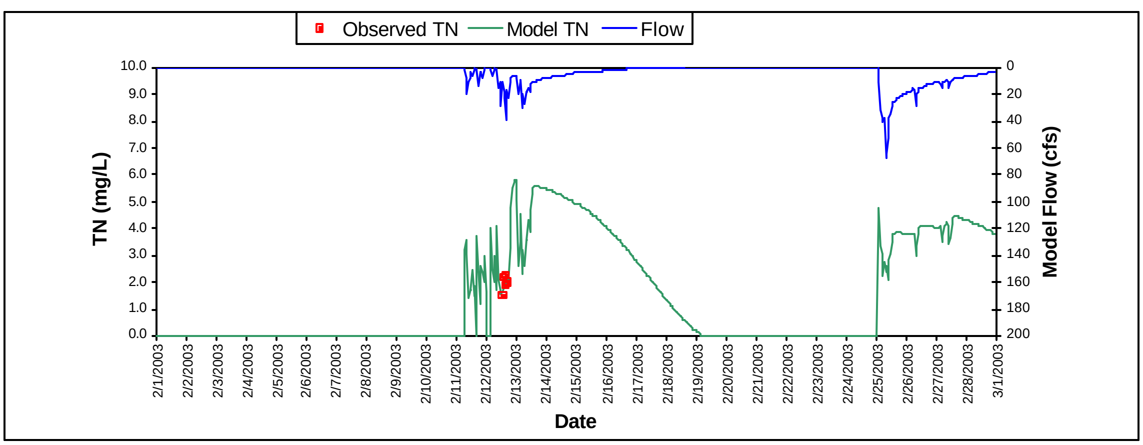


Figure C-24. Validation of Total Nitrogen Concentrations at TMDL Station 712

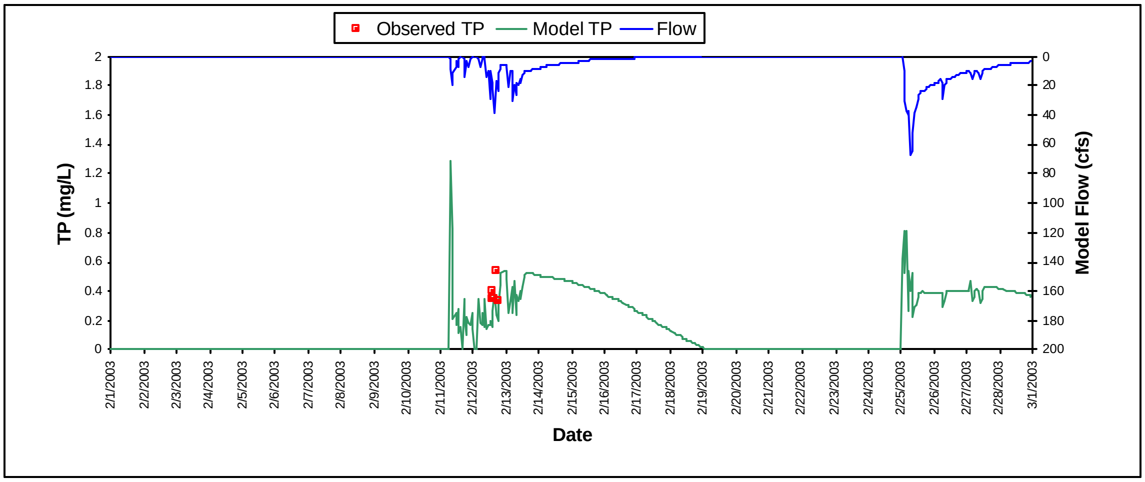


Figure C-25. Validation of Total Phosphorus Concentrations at TMDL Station 712

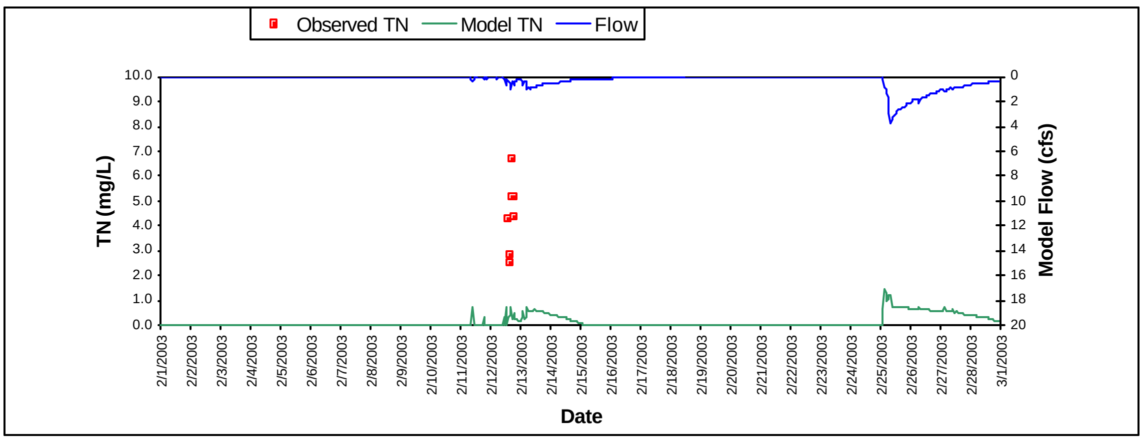


Figure C-26. Validation of Total Nitrogen Concentrations at TMDL Station 714

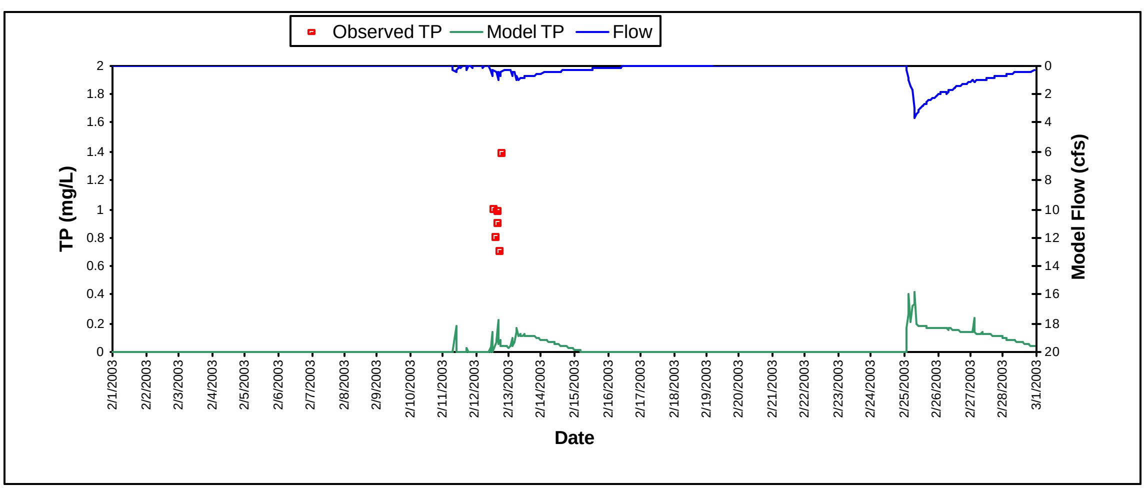


Figure C-27. Validation of Total Phosphorus Concentrations at TMDL Station 714

C.2 Canyon Lake Model Validation

For the Canyon Lake model, validation to 2003 data was performed for water surface elevation, overflow of Canyon Lake dam, and in-lake and outflow water quality. Fortunately, storm events in 2003 resulted in the fill and overflow of Canyon Lake dam so that prediction of such overflows could be validated. However, the Riverside County Flood Control and Water Conservation District (RCFC) has raised questions regarding the validity of USGS flow data collected downstream of the dam. Furthermore, the RCFC discovered that the rating curve of the dam overflow used for model configuration is specific to large flood events and is not valid for typical dam overflows. A correct rating curve to describe typical dam overflows is currently unavailable. As a result, accurate simulation of lake volume and overflow to Lake Elsinore is questionable. Moreover, inaccurate simulation of lake volume has impacts on simulation of in-lake water quality. As a result, future model upgrades are likely as additional data becomes available.

C.2.1 Canyon Lake Model Hydraulic Validation

Hydraulic validation of the Canyon Lake model to 2003 data involved comparison of model verses observed water surface elevations and flows downstream of the dam as shown in Figures C-27 and C-28, respectively. Both the lake volume and lake outflows are contingent upon the simulated watershed flows from the watershed model. For the comparison of lake outflows to observed streamflows at Station 827 (see Figure C-1), localized watershed runoff estimates from the watershed model were added to dam overflows for representation of local runoff upstream of the station.

The model over-predicted water surface elevations following a storm event in December. Water surface elevations within this range were very sensitive to inflows, and since inflows were predicted from a separate watershed model (slightly over-predicted flows for the December storm), discrepancy in lake model results may result from propagation of watershed model errors.

Outflows from Canyon Lake (plus downstream local runoff predictions from the watershed model) matched periods of stormflows observed at Station 827. However, the model over-predicted the first overflow of 2003. This over-prediction was likely due to the over-prediction of the Canyon Lake water surface elevation resulting from the earlier wet weather event occurring in December. Also, as mentioned before, the rating curve used for estimation of dam overflows was determined inaccurate, which likely resulted in error in all dam overflow predictions.

In summary, the hydraulics and associated volume predictions of the Canyon Lake model are questionable given recent discoveries regarding assumptions used for original model configuration and resulting calibration. As a result, additional studies are planned to collect more accurate information to support future model upgrades. Currently, the RWQCB, in cooperation with SAWPA and LESJWA, is planning future projects to support upgrades of the lake model to a more-detailed, dynamic model.

C.2.2 Canyon Lake Water Quality Validation

Water quality validation was performed using depth-averaged lake data collected on two sampling dates of 2003. Validation was performed for total phosphate (TPO4) and TN (Figures C-29 and C-30). The model performed reasonably well at predicting in-lake TPO4 concentrations. For TN, the model varied from depth-averages. This discrepancy can result from several factors including under- or over-prediction of watershed TN loads, inaccurate simulation of lake volume (resulting form either the error associated with dam overflows or propagated watershed model error), or limited predictive capability of the model which assumes no vertical stratification of water quality. Likely, model error is associated with a combination of these factors.

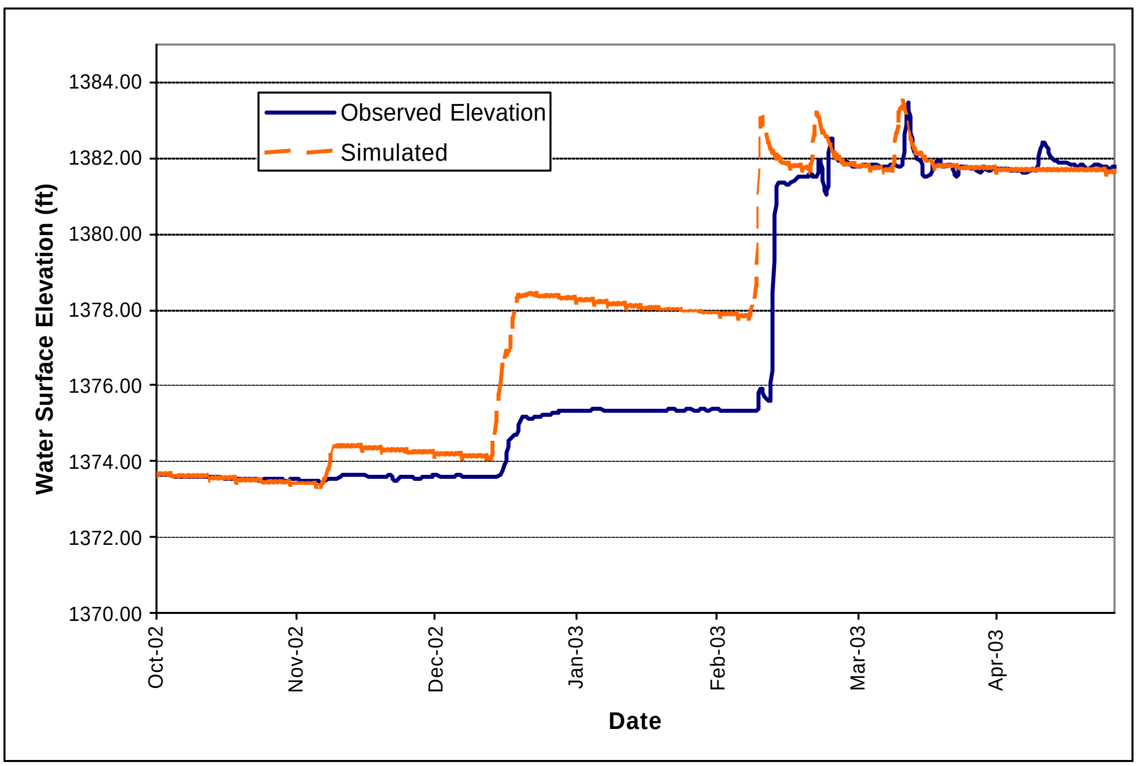


Figure C-28. Canyon Lake Model Validation - Water Surface Elevation

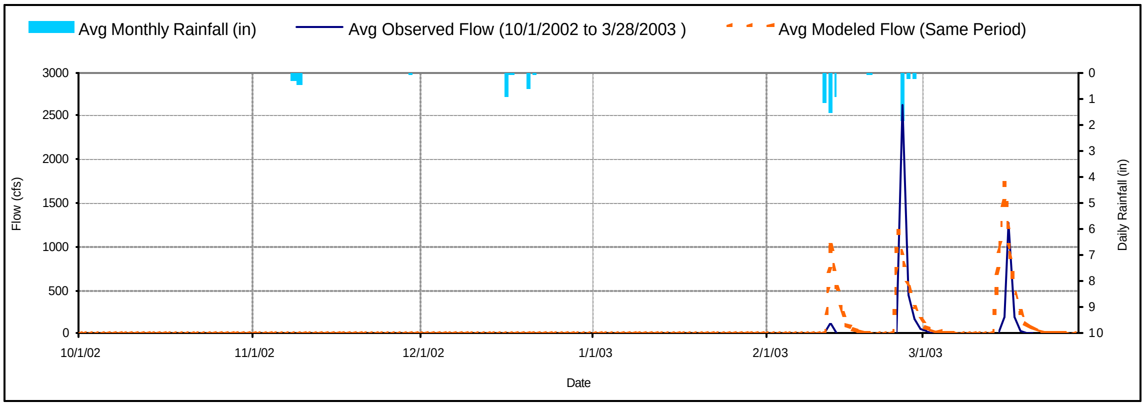


Figure C-29. Validation of Streamflows at Station 827 (Downstream of Canyon Lake Dam)

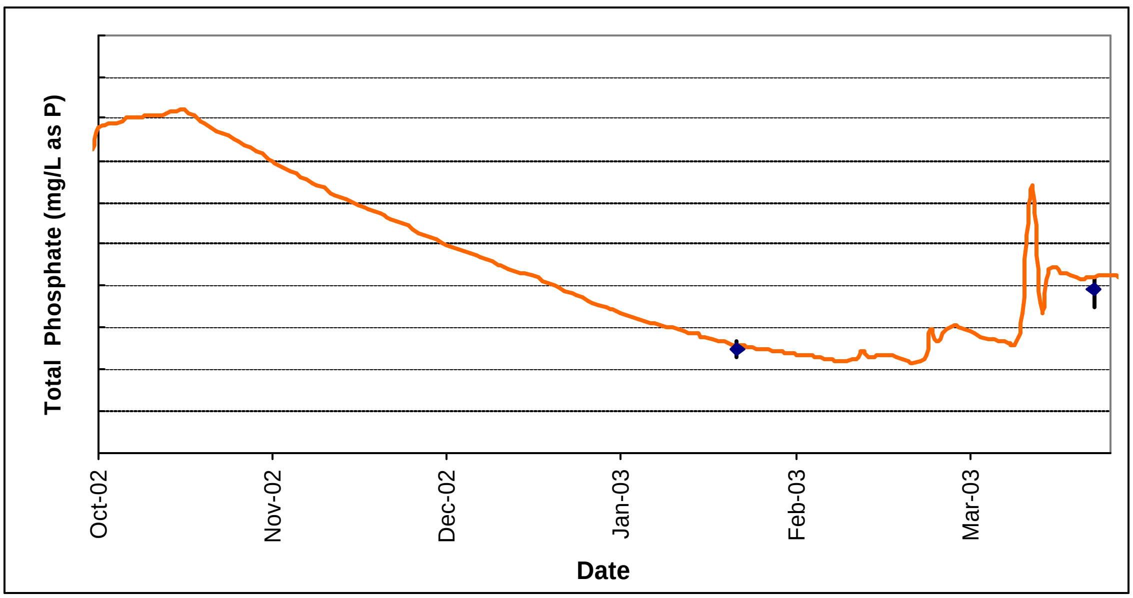


Figure C-30. Total Phosphate Validation for Canyon Lake Model (bars represent range of observed data at varying depths)

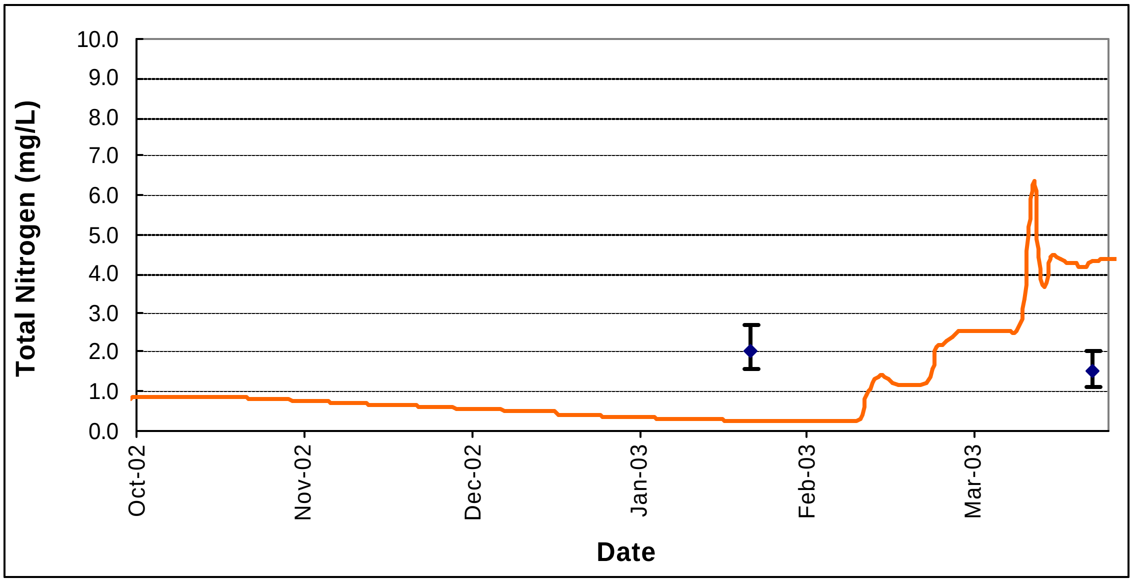


Figure C-31. Total Nitrogen Validation for Canyon Lake Model (bars represent range of observed data at varying depths)

C.3 Conclusions

Originally, data collection and model validation was contingent on collection of wet weather data during a rainfall event that resulted in the fill and overflow of Mystic Lake, since no water quality data was available in the watershed during such an event. Such an event did not occur. However, a wet weather event did occur that resulted in the overflow of Canyon Lake dam. This data was sufficient in overall validation of the watershed and Canyon Lake model, but was not robust enough to justify model recalibration given the large amount long-term data previously used for model calibration and validation for the Nutrient Source Assessment. As a result, comparisons of model results were made to observed streamflows and instream and in-lake water quality to assess model performance.

For the watershed model, performance in simulating hydrology and water quality are impacted by agricultural areas. Although the model was previously calibrated and validated to these areas with reasonable success for the Nutrient Source Assessment, conditions in 2003 resulted in model error. Also, these impacts seem to vary depending on location in the watershed. For instance, impacts from agricultural practices seem to differ between drainage areas of the Perris Valley Storm Drain drainage and Salt Creek. Currently, there is no spatial information available regarding crop or management practices in these areas, so such variable impacts cannot be simulated in the watershed model. An additional study is recommended in the San Jacinto Watershed Management Plan to collect spatial and temporal information regarding crops, manure and fertilizer application practices in the watershed. These data could be used to provide better resolution of the simulation of these land use practices in the watershed model. In the meantime, model performance in predicting long-term trends in the watershed are required, and model recalibration is not justified to provide better representation of a single storm event.

The lake model was based on several assumptions so that processes could be simulated using simplified procedures. However, future projects are planned to update these processes to more-detailed, dynamic, multi-dimensional capabilities. As part of this project, additional data collection is also planned to collect more representative data regarding dam overflows as a function of a rating curve for the dam spillway. This information will be incorporated into the lake model as the model is updated. Therefore, no recalibration of the lake model was performed as a result of comparison and validation to 2003 data since model hydraulic assumptions are already considered questionable and will be remedied in future model upgrades.

Appendix D- San Jacinto Watershed Model Bacteria Calibration

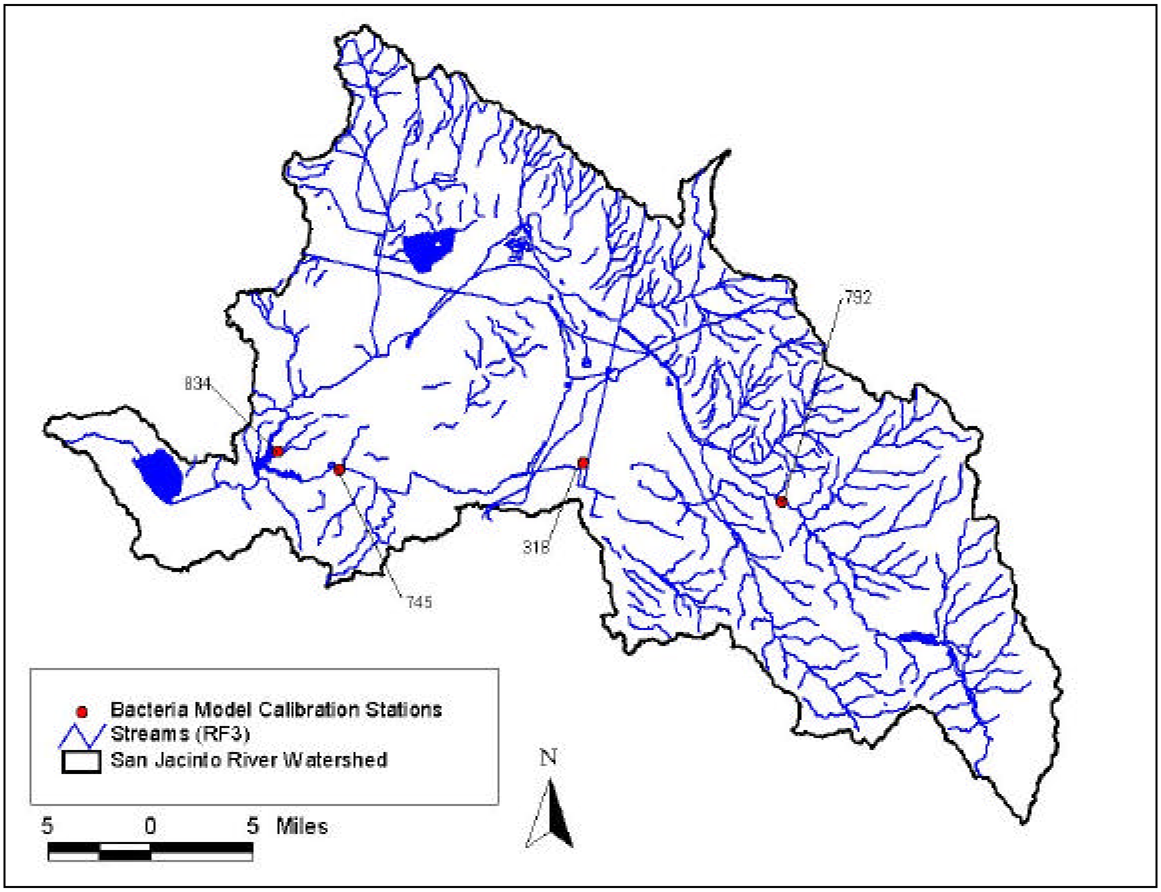


Figure D-1. Stations Used for Watershed Model Calibration for Bacteria

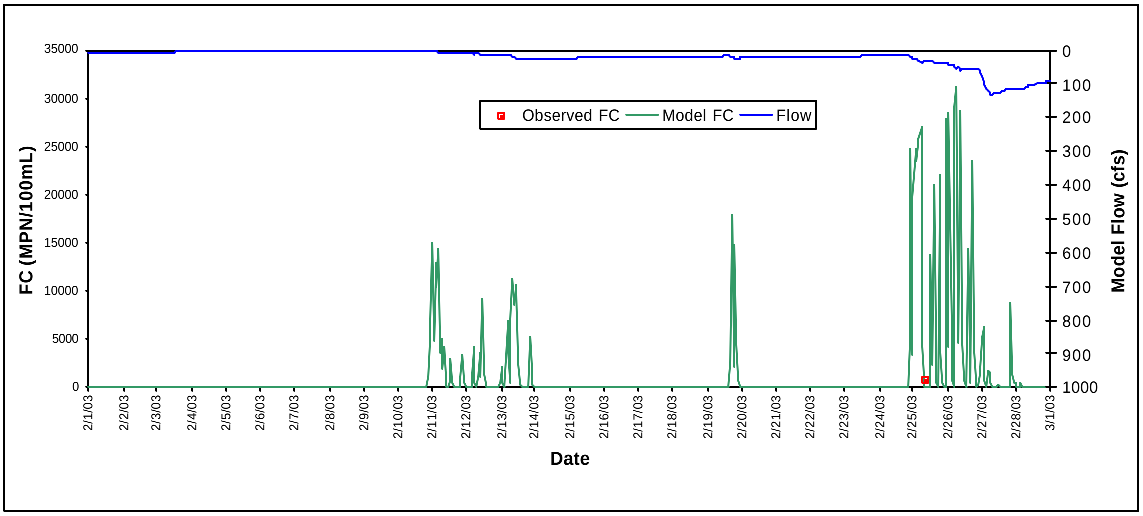


Figure D-2. Calibration to Fecal Coliform Levels at Station 792

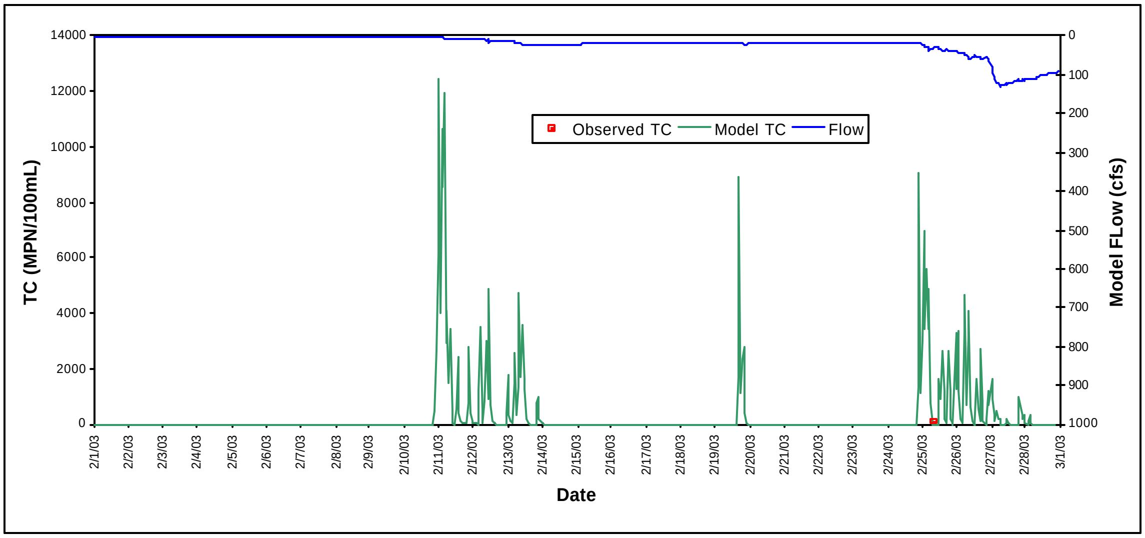


Figure D-3. Calibration to Total Coliform Levels at Station 792

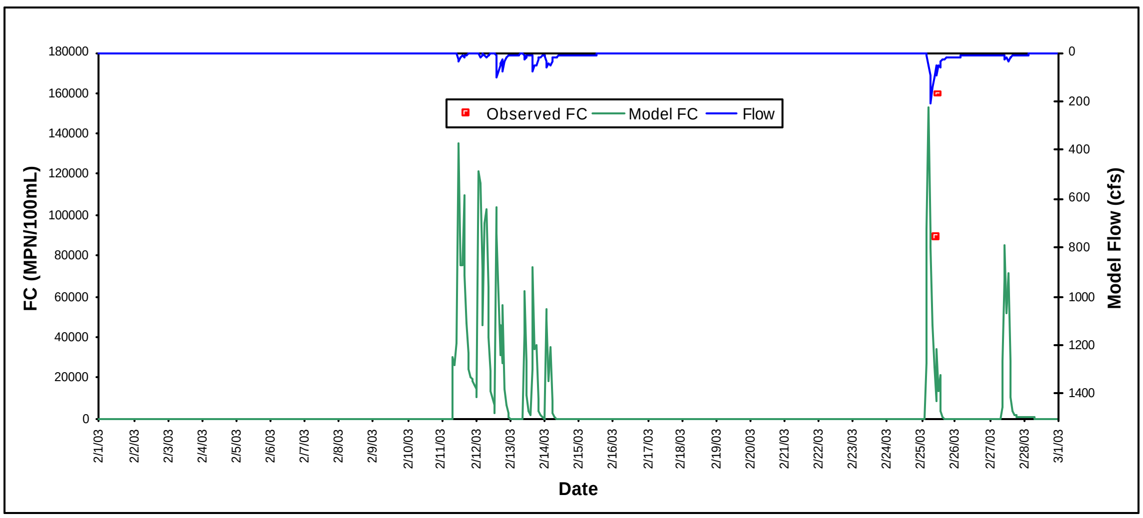


Figure D-4. Calibration of Fecal Coliform Levels at Station 318

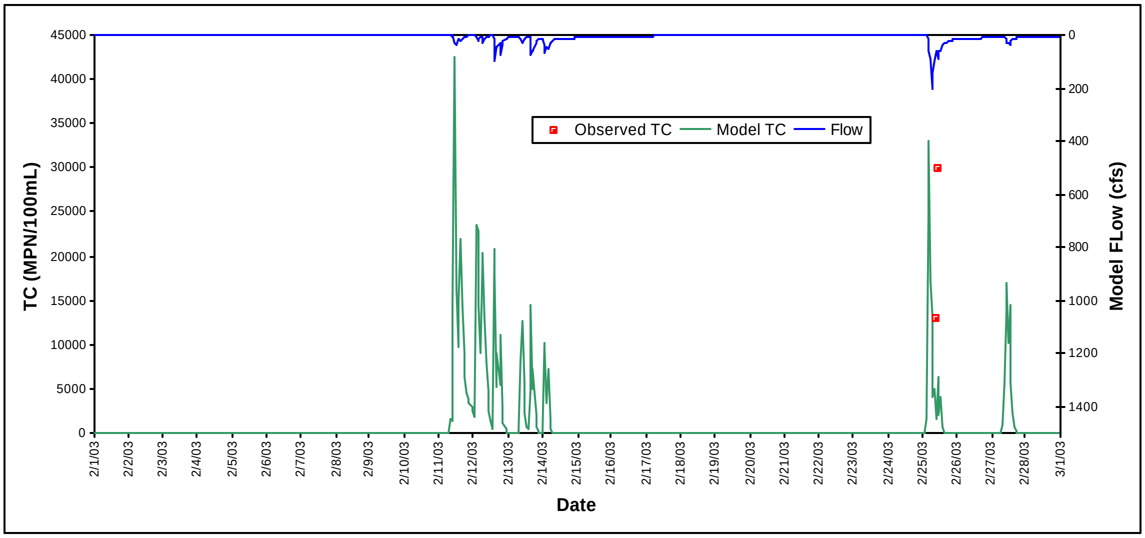


Figure D-5. Calibration of Fecal Coliform Levels at Station 318

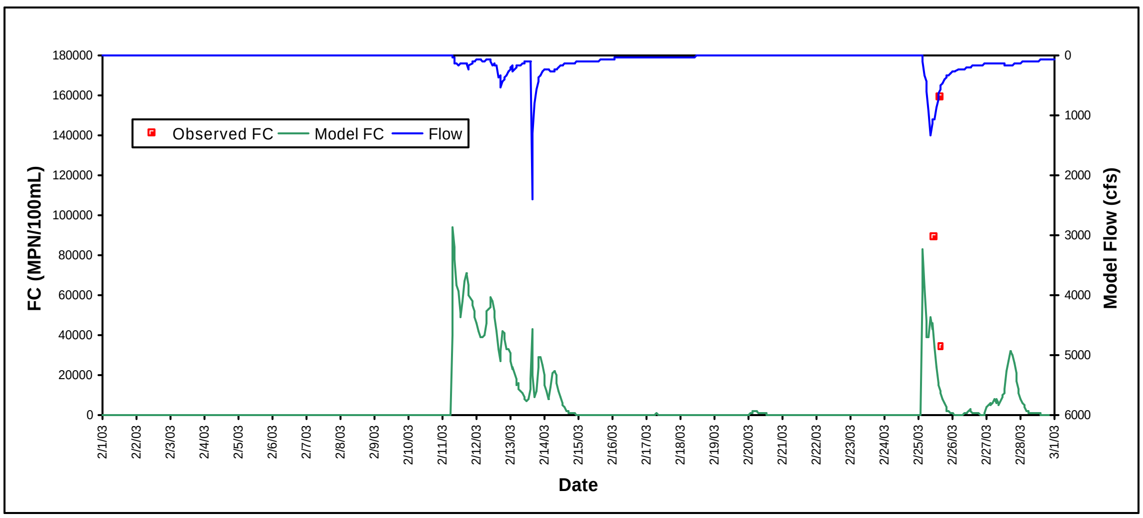


Figure D-6. Calibration of Fecal Coliform Levels at Station 745

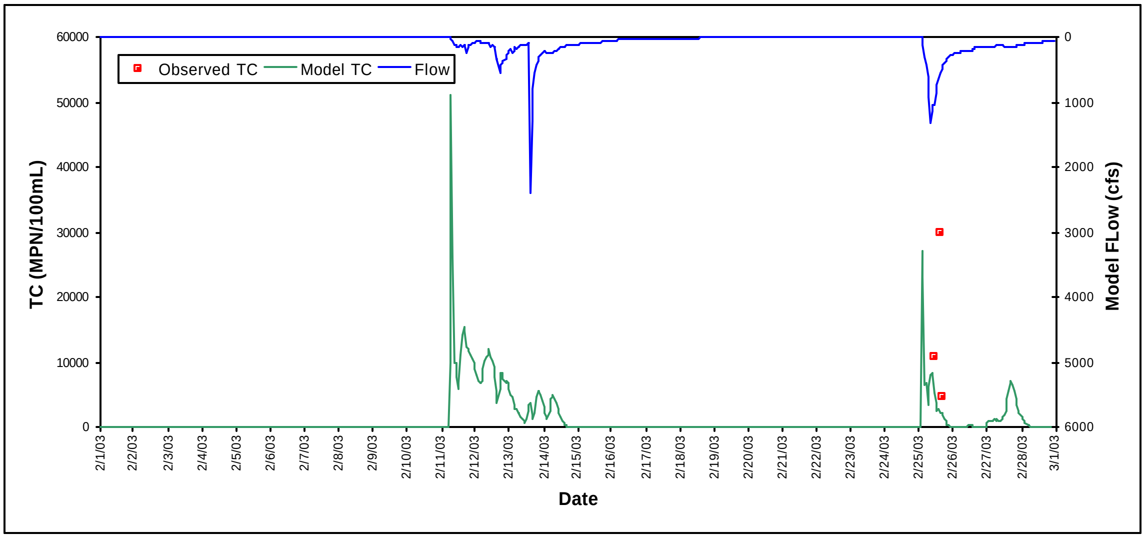


Figure D-7. Calibration of Total Coliform Levels at Station 745

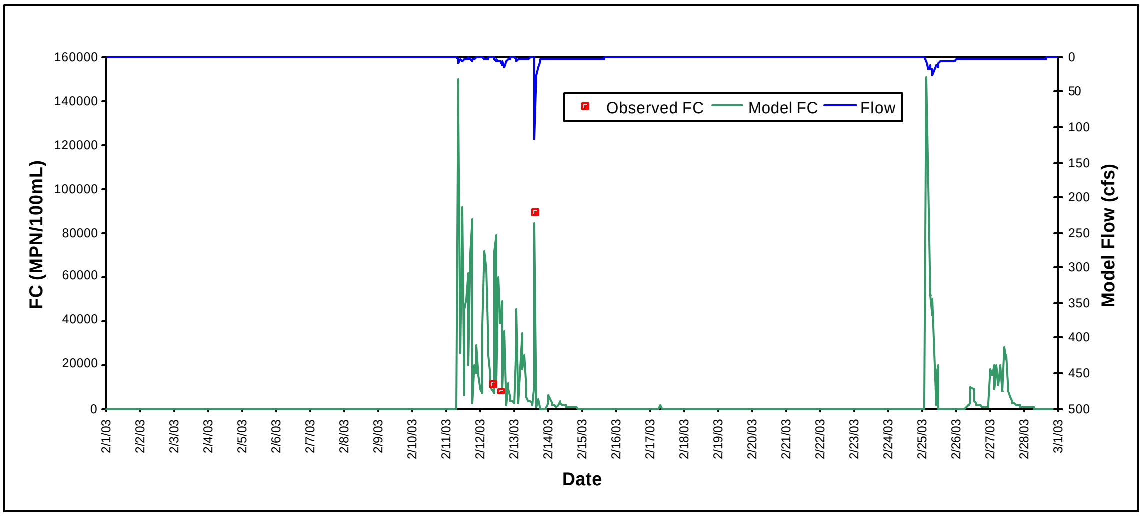


Figure D-8. Calibration of Fecal Coliform Levels at Station 834

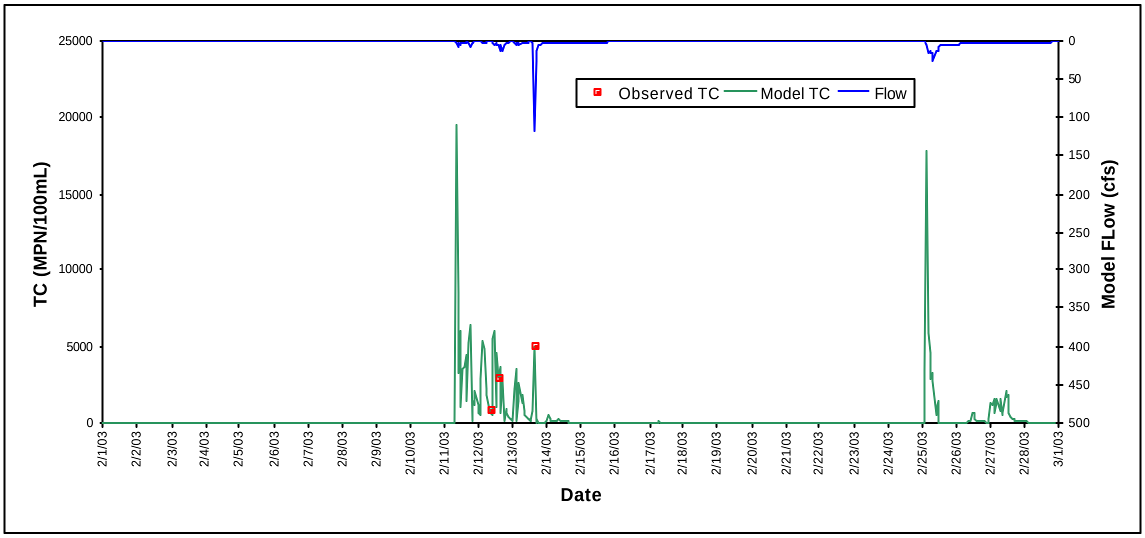


Figure D-9. Calibration of Total Coliform Levels at Station 834

Appendix E – Daily Model-Predicted Indicator Bacteria Loads to Canyon Lake

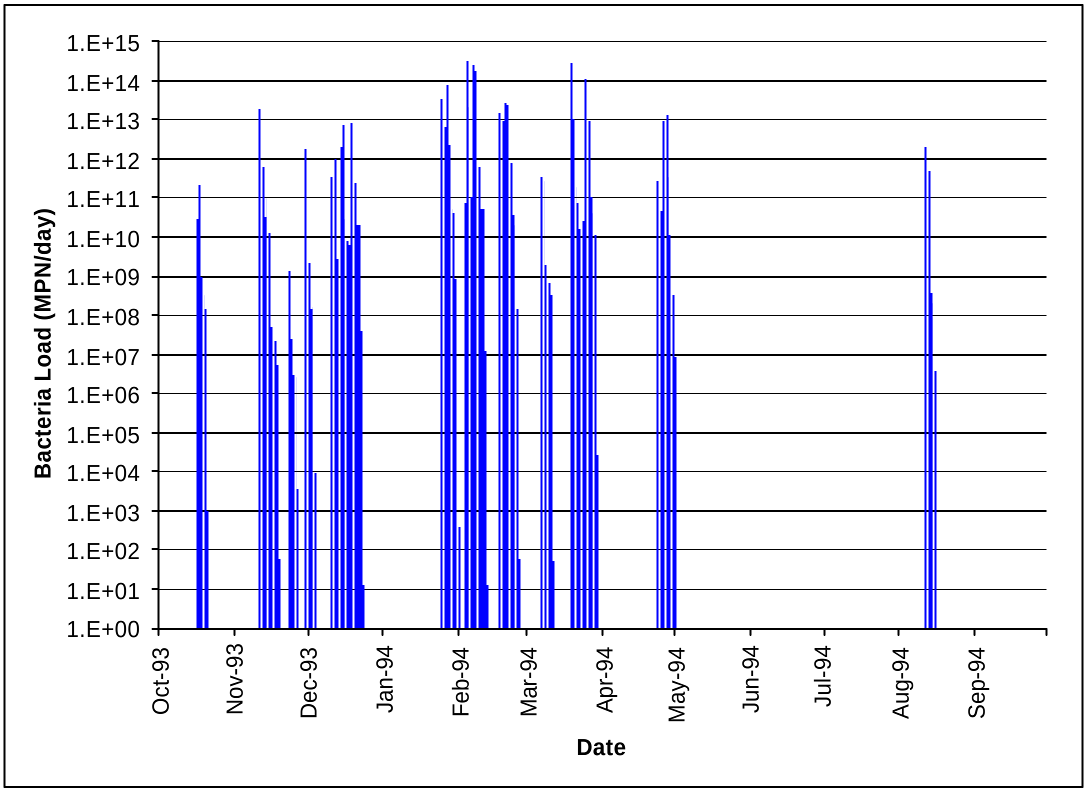


Figure E-1. Total Coliform Loads to Canyon Lake in WY 1994

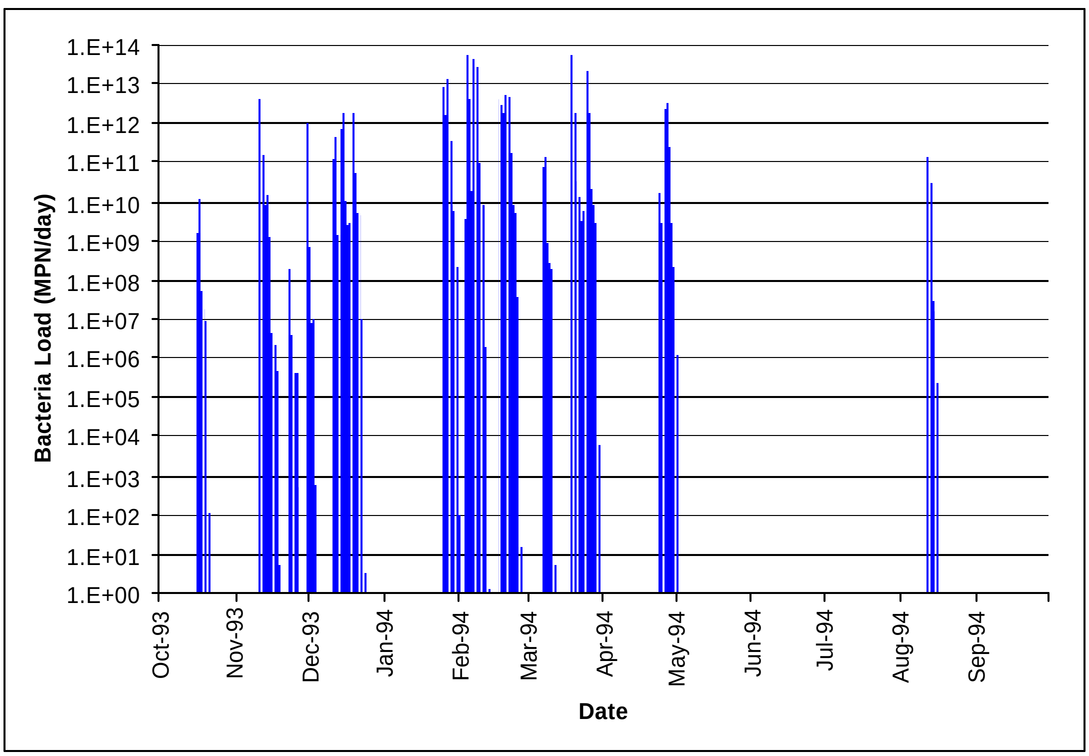


Figure E-2. Fecal Coliform Loads to Canyon Lake in WY 1994

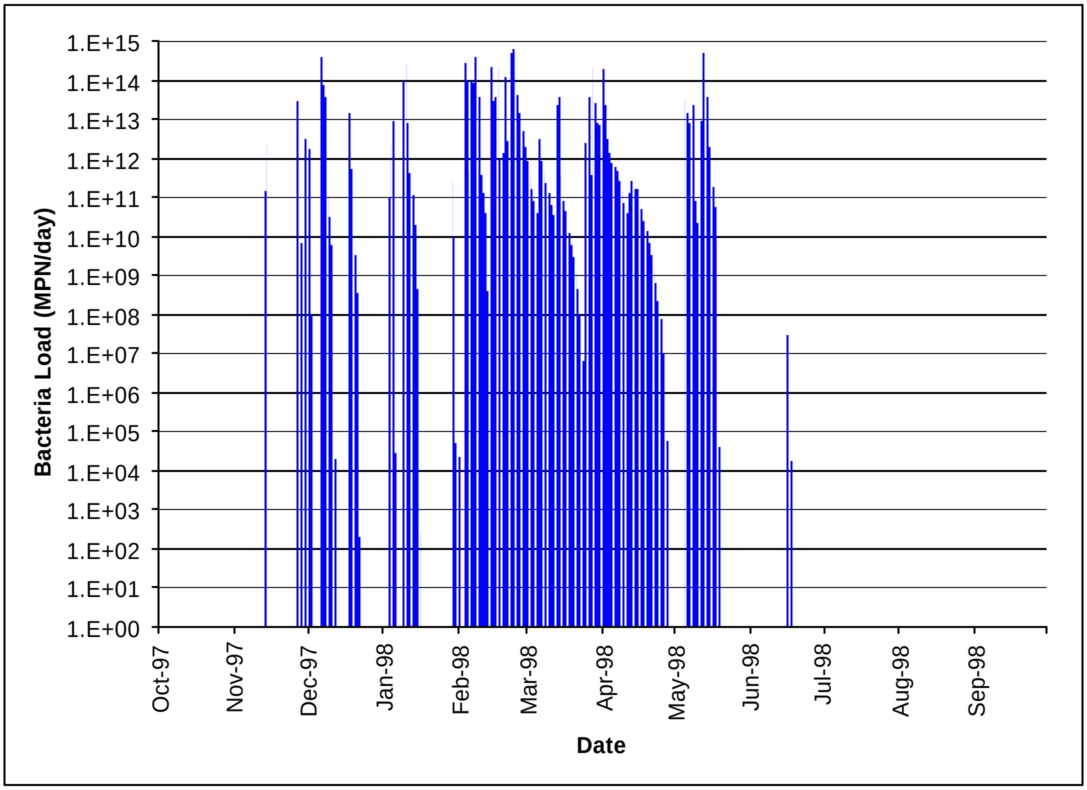


Figure E-3. Total Coliform Loads to Canyon Lake in WY 1998

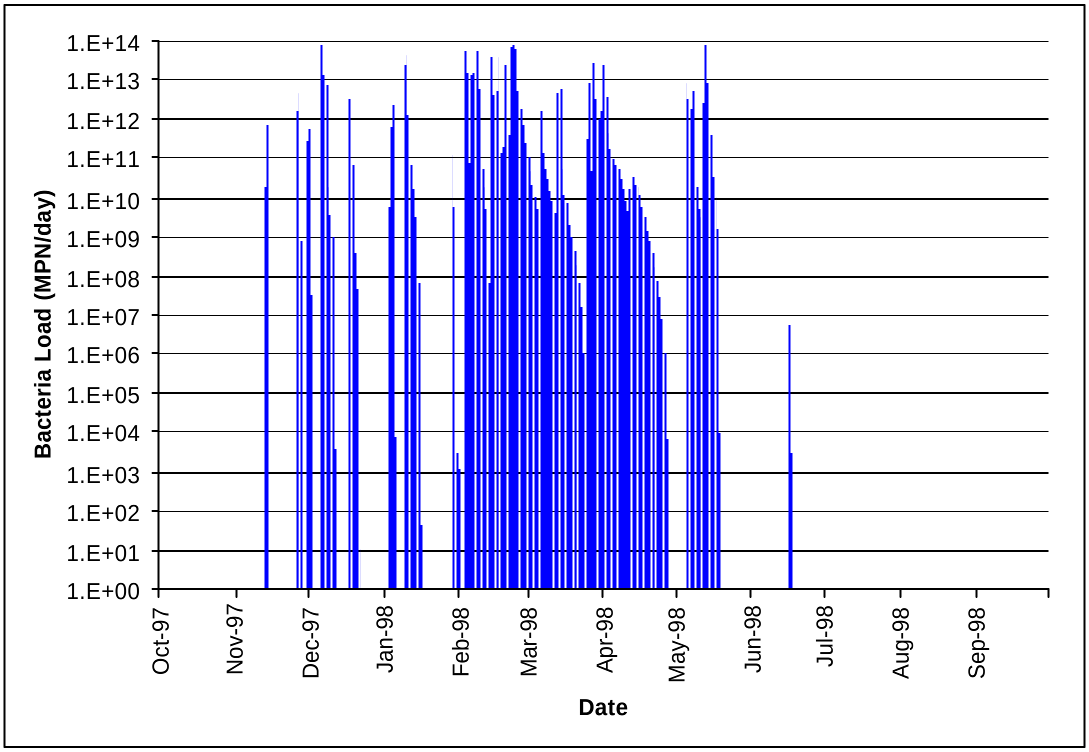


Figure E-4. Fecal Coliform Loads to Canyon Lake in WY 1998

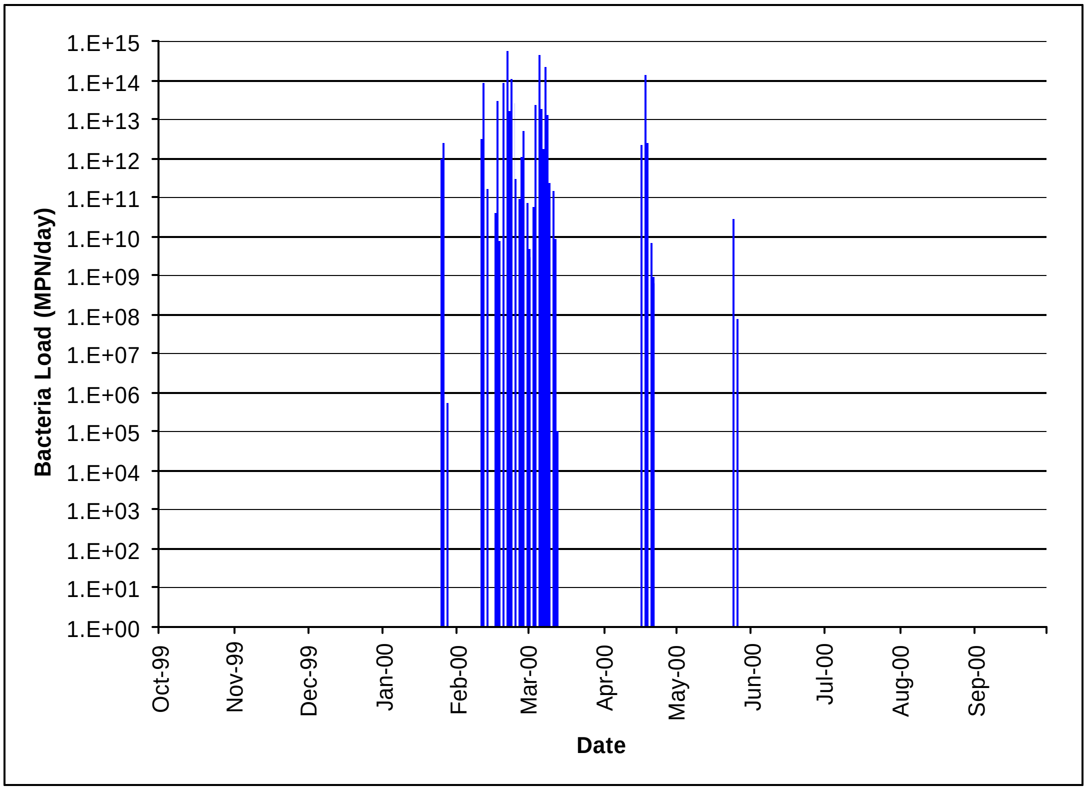


Figure E-5. Total Coliform Loads to Canyon Lake in WY 2000

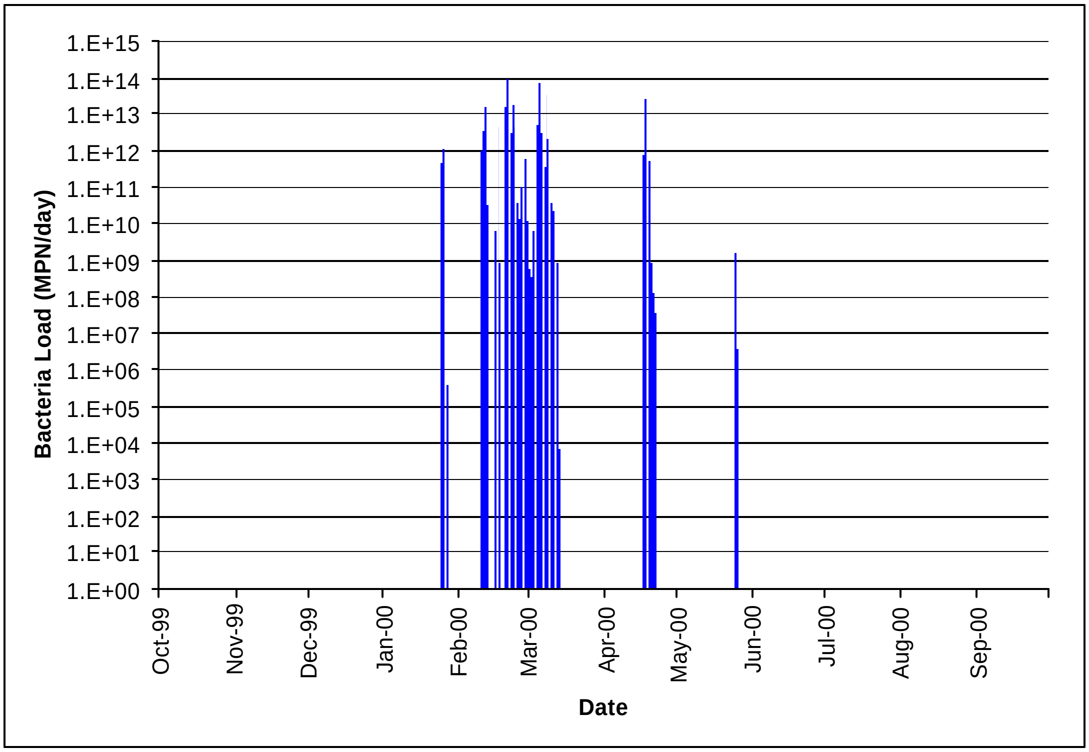


Figure E-6. Fecal Coliform Loads to Canyon Lake in WY 2000

Appendix F - Description of Selected Urban BMPs

For the purpose of this document the descriptions and definitions provided are consistent with the ASCE National Stormwater BMP Database.

Infiltration An infiltration BMP is designed to capture stormwater runoff and retain the water until it infiltrates into the ground. Infiltration of stormwater has both advantages and disadvantages. The primary advantage is the control of water quantity and water quality as a result of limited discharge. This reduces the volume of water discharged to receiving waters from storm events as well as the pollutants transported to the streams and lakes. Infiltration system size depends on the size of the contributing area, can be designed to capture and hold water over a period of several hours or even days. The secondary benefit of infiltration systems is groundwater recharge. The disadvantage of these systems is the potential for groundwater contamination by pollution carried by the stormwater.

Infiltration Basins
Infiltration basins are almost always placed off-line, and are designed to only intercept a certain volume of runoff. A basin planted along the lining can help to prevent migration of pollutants and the roots of the vegetation can increase the permeability of the soils, enhancing the basin function. The basins should be designed to infiltrate surface water runoff within 72 hours to prevent odor problems and mosquito breeding.

Infiltration Trench
An infiltration trench (or well) is typically lined with gravel and is designed to infiltrate as much diverted stormwater runoff as possible during the first flush of the storm. Because they are smaller than an infiltration basin they are often used in combination with another BMP such as a detention pond. Infiltration trenches and wells can be used effectively in smaller spaces to remove pollutants from surface water runoff.

Porous Pavement
Porous pavement allows rainwater or runoff to infiltrate in to the ground through a permeable layer. These surfaces can include porous asphalt, porous concrete, perforated concrete block, cobble or brick pavers with porous joints or thick plastic reinforced turf. Porous pavement systems are typically used in areas without traffic or heavy equipment, such as residential driveways and streets. This system functions best when the pore spaces are kept free of sediment by vacuuming or spray washing the surface. Performance has varied regionally and is most likely due to contractor experience with installation and proper design and maintenance.

Retention Systems
Retention systems are designed to capture a given volume and hold that volume until the next runoff event displaces it in part or completely. Retention systems provide both water quantity and quality control. Sedimentation is the main mechanism for water quality improvements. Additional pollution removal mechanisms can be taken advantage of if the systems retains a permanent pool of water and is vegetated such as; filtration of

suspended solids by vegetation, infiltration, biological conversion and uptake of organic and inorganic chemical compounds, sorption, and volatilization of organic compounds.

Wet Ponds

Wet ponds, also known as retention ponds, are designed to retain a permanent pool of water and provide extra capacity above the pool level that may be displaced during storm events. When properly designed and maintained, wet ponds are very effective BMPs in providing both water quality improvements and water quantity control. Wet ponds also provide aquatic and terrestrial habitat for plants and animals, which in turn is considered an aesthetic bonus.

Constructed wetlands

Constructed wetlands incorporate the natural functions of wetlands to aid in removal of pollutants from stormwater. Although the construction of wetlands is somewhat similar to retention ponds, particular care must be paid to the water balance throughout the seasons to sustain aquatic vegetation and the removal of coarse sediments in stormwater that can degrade the performance of the system. Two types of constructed wetlands, wetland basins and channels, are design modifications to better suit site specifics of available land, flow rate, and some seasonal variation. Wetland channels are often densely vegetated and designed to convey runoff at a rate less than 2 feet/second at a 2-year peak flow. Wetland basins may or may not sustain a permanent pool of water. If a pool is sustained, it is covered with emergent vegetation. Otherwise, the soils must retain water to support a ‘meadow’ of plants that are tolerant of periodic inundation.

Filtration Systems

Filtration systems use various media such as sand, gravel, peat, or compost/mulch to remove a portion of pollution constituents found in stormwater. Filters are typically placed offline and their designs are numerous. A wide variety of pollutant-specific proprietary filters are available. Most filters offer water quality improvements and if combined with a water storage basin, can offer additional water quantity control. Most filter life spans are improved if there exists a forebay or pre-settling chamber to remove coarse sediment.

Sand Filters

Sand filters can be built above and below ground, however the above ground variety are the suggested technology for the San Jacinto Valley given the availability of open space. The simple surface sand filter is an old technology that has been upgraded into two basins in series to improve the filter life. Runoff first flows into a coarse sediment settling basin and then into the filter basin. The filter basin consists of sand over gravel and a perforated pipe to capture the treated water. The surface can be planted with grasses to improve water quality treatment. Filters with an organic media component are useful in areas where additional nutrient or metal removal is desirable due to the adsorption, ion-exchange and biofilm uptake.

Vegetated Systems (Biofilters)

Vegetated systems such as grass filter strips and vegetated swales are used to convey and treat storm water flows. These BMPs are alternatives to the traditional curb-and-gutter stormwater system. The advantages of biofilters are reduced water speed, some degree of treatment, storage and infiltration of runoff prior to discharge to a receiving waterbody or storm sewer system.

Filter Strips

Biofilter strips are densely vegetated, with grass or native vegetation, and uniformly graded areas that typically intercept runoff from parking lots, roofs, highways and other impervious surfaces. These biofilters are often used as a pre-treatment component in combination with other BMPs such as riparian buffers, filters or bioretention systems.

Swales

Vegetated swales are broad, shallow channels with dense vegetation lining the sides and channel bottom. Swales differ from filter strips in size. Swales are larger versions of the filter strips and may offer greater treatment and control of stormwater runoff volume. Vegetative swales can be either wet or dry to best match the site characteristics.