DRAFT FOR PUBLIC REVIEW AND PEER REVIEW

TMDL Technical Report: Revision to the Lake Elsinore and Canyon Lake Nutrient TMDLs

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Submitted by:

Lake Elsinore and San Jacinto Watersheds Authority (LESJWA) *in collaboration with* the Lake Elsinore and Canyon Lake TMDL Task Force

Prepared by:

CDM Smith *in collaboration with* GEI Consultants, Risk Sciences, University of California Riverside, Wood Environment and Infrastructure and CGRME

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Acronyms

ACOE	Army Corps of Engineers
AFA	*Aphanizomenon flos-aquae*
AFY	Acre-feet/year
AF	Acre-feet
af/d	Acre-feet/day
AgNMP	Agricultural Nutrient Management Plan
AGR	Agriculture Water Supply
AQMP	Air Quality Management Plan
Alum	Aluminum sulfate
AWT	Advanced Wastewater Treatment
BASINS	Better Assessment Science Integrating Point and Non-Point Sources
Basin Plan	Water Quality Control Plan for the Santa Ana River Basin
BMP	Best Management Practice
BOD	Biological Oxygen Demand
°C	Degrees Celsius
C	Concentration
CAEDYM	Computational Aquatic Ecosystem Dynamics Model
CAFO	Concentrated Animal Feeding Operation
CCC	Criterion Continuous Concentration (chronic)
CCHAB	California Cyanobacteria and Harmful Algal Bloom
CDF	Cumulative Distribution Function
CDFG	California Department of Fish and Game
CDWR	California Department of Water Resources
CEDEN	California Environment Data Exchange Network
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CIG	Conservation Innovation Grant (NRCS)
CIMIS	California Irrigation Management Information System
cm	centimeter
CMC	Criterion Maximum Concentration (acute)
C:N	Carbon to Nitrogen Ratio
CNRP	Comprehensive Nutrient Reduction Plan
COD	Chemical Oxygen Demand
Cs	Cesium

CSTR	Continuous Stirred Tank Reactor
CWAD	Conditional Waiver for Agricultural Discharges
CWC	California Water Code
CY	Cubic yards
$	Dollars
DCIA	Directly Connected Impervious Area
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DYRESM	Dynamic Reservoir Simulation Model
EA	Environmental Assessment
EC	Electrical Conductivity
EFDC	Environmental Fluids Dynamic Code
ELCOM	Estuary, Lake and Coastal Ocean Model
EPA	United States Environmental Protection Agency
EMWD	Eastern Municipal Water District
ENR	Engineering News-Record
EVMWD	Elsinore Valley Municipal Water District
°F	Degrees Fahrenheit
ft	Feet or Foot
GHG	Greenhouse Gas Emissions
GWR	Groundwater Recharge
$g/m^2/d$	Grams/square meter/day
HAB	Harmful Algal Bloom
HBI	Hilsenhoff Biotic Index
HOS	Hypolimnetic Oxygenation System
HP	Horsepower
hr	Hour
H_2S	Hydrogen Sulfide
IMP	Imperviousness
IPR	Indirect Potable Reuse
in/yr	Inch/year
IR	Infrared
kg	Kilogram
kg/ac/yr	Kilograms/acre/year
kg/ha	Kilgrams/hectare
$kg/km^2/yr$	Kilograms/square kilometer/year

kg/yr	Kilograms/year
LA	Load Allocation
lb	Pound
lb/ac/yr	Pounds/acre/year
LC_{50}	Lethal Concentration with 50% mortality
LC-MS/MS	Liquid Chromatography coupled with tandem Mass Spectrometry
LEAMS	Lake Elsinore Aeration and Mixing System
LECL Task Force	Lake Elsinore and Canyon Lake Task Force
LEMA	Lake Elsinore Management Authority
LEMP	Lake Elsinore Management Plan
LESJWA	Lake Elsinore and San Jacinto Watersheds Authority
LID	Low Impact Development
LSE	Lake Surface Elevation
LSPC	Loading Simulation Program in C++
m	Meter
MEP	Maximum Extent Practicable
mL	Milliliters
mgd	Million gallons/day
mg/g	Milligrams/gram
mg/L	Milligrams/liter
mg/mL	Milligrams/milliliter
$mg/m^2/d$	Milligrams/square meter/day
mi^2	Square miles
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristics
MRP	Monitoring and Reporting Program
m/s	Meters/second
msl	Mean Sea Level
µg/L	Micrograms/liter
µS/cm	MicroSiemens/centimeter
MS4	Municipal Separate Storm Sewer System
MUN	Municipal and Domestic Water Supply
N	Sample size
NA	Not Available
ND	Non-Detect
nm	Nanometer

NAWQA	National Water Quality Assessment
NH_3	Un-ionized fraction of total ammonia
NH_4	Ionized fraction of total ammonia
NNE	Numeric Nutrient Endpoint
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NSQD	National Stormwater Quality Database
O&M	Operation and Maintenance
OP	Organic Phosphorus
Org/L	Organisms/Liter
Ortho-P	Orthophosphate
OSTDS	Onsite Sanitary Treatment and Disposal Systems (Septic Systems)
PAR	Photosynthetically Active Radiation
PLOAD	Pollutant Loading Estimator
POA	Property Owners Association
ppm	Parts per million
ppt	Parts per thousand
QAPP	Quality Assurance Project Plan
RAA	Reasonable Assurance Analysis
RC	Runoff Coefficient
RCFC&WCD	Riverside County Flood Control and Water Conservation District
REC1	Water Contact Recreation
REC2	Non-Contact Water Recreation
RWRF	Regional Water Reclamation Facility
%RE	Percent Relative Error
Santa Ana Water Board	Santa Ana Regional Water Quality Control Board
SAWPA	Santa Ana Watershed Project Authority
SCAB	South Coast Air Basin
SCAQMD	South Coast Air Quality Management District
SCCWRP	Southern California Coastal Water Research Project
SDR	Sediment Delivery Ratio
SED	Substitute Environmental Document
SLAM	Simplified Lake Analysis Model
SM	Standard Method
SMAV	Species Mean Acute Value
S_{MAX}	Maximum Storage Capacity

SOD	Sediment Oxygen Demand
SOM	Soil Organic Matter
SRP	Soluble Reactive Phosphorus
SSD	Species Sensitivity Distribution
SSURGO	Soil Survey Geographic Database
SWAMP	Surface Water Ambient Monitoring Program
$t_{1/2}$	Half life
TIN	Total Inorganic Nitrogen
TKN	Total Kjeldahl Nitrogen
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
State Water Board	State Water Resources Control Board
UCR	University of California, Riverside
UIA	Un-ionized Ammonia
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
USLE-M	Modified Universal Soil Loss Equation
UV	Ultraviolet
W/m^2	Watts/square meter
WARM	Warm Freshwater Habitat
WDR	Waste Discharge Requirements
WILD	Wildlife Habitat
WLA	Wasteload Allocation
WQMP	Water Quality Management Plan
WQO	Water Quality Objective
WRCAC	Western Riverside County Agricultural Coalition
WRF	Water Reclamation Facility
WWTP	Wastewater Treatment Plant
yr	Year

Acknowledgments

The Lake Elsinore and Canyon Lake (LECL) Task Force is pleased to have developed this Total Maximum Daily Load (TMDL) Technical Document to support the revision of the 2004-adopted LECL Nutrient TMDLs. The proposed revisions to the existing TMDLs was made possible by a multi-year effort that included collecting and analyzing extensive scientific data, evaluating the findings from project planning/implementation activities and considering the results from watershed and lake water quality modeling. The synthesis of this information, which provided the scientific basis for revising the existing TMDLs, began in December 2015. The outcomes of these efforts are referenced herein and included in the administrative record.

The TMDL revision project was administrated by the Lake Elsinore and San Jacinto Watersheds Project Authority (LESJWA) and overseen by the LECL Task Force. This Task Force, which worked collaboratively with the Santa Ana Regional Water Quality Control Board (Santa Ana Water Board), is comprised of the following entities that work in partnership under a Task Force Agreement:

- California Department of Fish and Game
- California Department of Transportation
- City of Beaumont
- City of Canyon Lake
- City of Hemet
- City of Lake Elsinore
- City of Menifee
- City of Moreno Valley
- City of Murrieta
- City of Perris
- City of Riverside
- City of San Jacinto
- City of Wildomar
- County of Riverside
- Eastern Municipal Water District
- Elsinore Valley Municipal Water District (EVMWD)
- March Joint Powers Authority (JPA)
- Riverside County Flood Control & Water Conservation District (RCFC&WCD)
- United States Air Force (March Air Reserve Base)
- Western Riverside County Agriculture Coalition (WRCAC) (on behalf of the participating Dairy Operators and participating Agricultural Operators in the San Jacinto River Basin)

The TMDL Technical Document was prepared by a project team selected by the LESJWA Board in collaboration with the LECL Task Force. Working with the project team through an open stakeholder process, LESJWA representatives, the Santa Ana Watershed Project Authority (SAWPA), Task Force members and the Santa Ana Water Board provided important contributions to the TMDL Technical Document in the form of technical review, regulatory interpretation, data acquisition, scientific expertise and on-the-ground experience working in the watershed. Project contributions were made by the following:

Santa Ana Watershed Project Authority (SAWPA)

- *Mark Norton* – Task Force Chair, representative to the LESJWA Board
- *Rick Whetsel* – Project Manager and budget oversight for all Task Force activities

- *Dawna Munson* – Administrative support
- *Sara Villa* – Administrative support

Santa Ana Water Board

- *Hope Smythe* – Executive Officer
- *Mark Smythe* – Environmental Program Manager
- *Ken Theisen* – Water Resources Control Engineer
- *Cindy Li* – Senior Engineer Geologist

Technical and Regulatory Project Team

The project team responsible for the development of the TMDL Technical Document was led by the following key personnel:

- *Steven Wolosoff, CDM Smith* – Project Management and Technical Lead
- *Richard Meyerhoff, GEI Consultants, Inc.* - Technical and Regulatory Direction
- *Tim Moore, Risk Sciences* - Facilitation/Regulatory Expertise/Science Advisor

Key contributors to the development of technical analyses and information used to support preparation of the TMDL Technical Document included:

<u>CDM Smith</u>

- *Kathleen Owston* – CEQA analysis
- *Dorothy Meyer* – Technical review for CEQA analysis
- *Jessica Fritsche* – Resource economics expert
- *Zachary Eichenwald* – Implementation, lake and watershed BMP analysis
- *Constantine Karos* – Source assessment, post-processing of models, GIS support
- *Bill Davis*- Economic analysis
- *Bernadette Kolb* - Water quality technical review
- *Dave Jensen* – Project oversight

<u>University of California Riverside</u>

- *Michael Anderson* – Professor of Environmental Chemistry, specializing in applied limnology and lake/reservoir management, surface water quality and modeling, fate of contaminants in soils, sediments and waters, and environmental chemistry. Regional expert on the limnology of Lake Elsinore and Canyon Lake. Developed lake water quality models; prepared linkage analysis, and provided water quality expert technical review

<u>Wood Environment and Infrastructure, Inc.</u>

- *Chris Stransky* – Monitoring, water quality data analysis
- *John Rudolph* – Monitoring, aquatic biology
- *Kevin Stolzenbach* – Water quality data analysis

<u>CG Resource Management and Engineering</u>

- *Cynthia Gabaldon*- Natural history, administrative record

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- Other Agency Representatives – Ankita Vyas (representing Caltrans); Nancy Horton (Canyon Lake POA); Rae Beimer (representing the Cities of Canyon Lake and Moreno Valley); Daniel Cortese (City of Hemet); Nicole Dailey, Rita Thompson and Pat Kilroy (City of Lake Elsinore); Tad Nakatani (City Menifee); Cynthia Gabaldon (representing the City of Perris); Mike Roberts (City of Riverside); Lynn Merrill (representing the City of San Jacinto); Rachel Johnson (Farm Bureau); Lauren Sotelo (March JPA); Scott Bruckner and Steve Horn (Riverside County)
- Alta Environmental – Garth Englehorn
- Tetra Tech, Inc. – Prepared the 2010 TMDL Model Update
- Alex Horne Associates – Alex Horne
- Southern California Coastal Water Research Project – Meredith Howard

Project information is managed by SAWPA and can be found at http://www.sawpa.org/task-forces/lake-elsinore-canyon-lake-tmdl-task-force/#tmdl-update

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Executive Summary

Lake Elsinore and Canyon Lake are located in western Riverside County of southern California. Lake Elsinore is a natural waterbody and Canyon Lake is a man-made reservoir that was created when the San Jacinto River was dammed in 1928. Both lakes are characterized by highly unusual hydrology and relatively poor water quality.

Lake Elsinore is a large (≈3,000 acres), relatively shallow (≈20 feet), and located in an area with a hot dry climate (< 12 inches rain/year). As a result, each year nearly four billion gallons of water evaporate causing the lake level to drop by about 4 feet. Average precipitation is not sufficient to make up for such losses and during prolonged droughts Lake Elsinore sometimes dries up completely. Historical records indicate this occurs every 50-60 years and lasts 2-3 years until heavy rains associated with "El Niño" winters refill the lake. The last time this happened was about 60 years ago in the late 1950s (**Figure ES-1**).

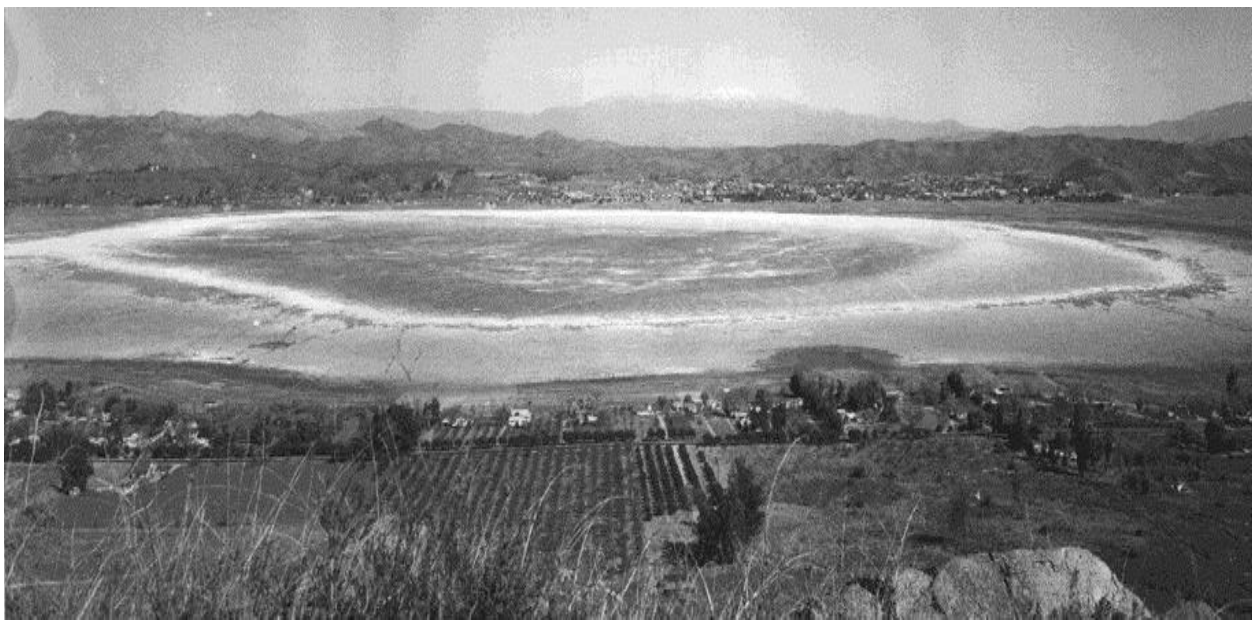

Figure ES-1. Lake Elsinore Evaporated (circa 1956)

Canyon Lake is unusual in that it is very small (< 450 acres) compared to the size of the watershed (> 450,000 acres) which drains into it. This 1,000-to-1 ratio, coupled with the highly variable natural precipitation in the area, poses an extreme challenge to lake management. More than half the water flowing into Canyon Lake in any given 10-year period occurs during just one El Niño winter. At these times, the cumulative volume of runoff can exceed the total storage capacity of Canyon Lake by 500-600%.

The large volume of runoff also brings with it a large amount of nitrogen and phosphorus (aka "nutrients") that washes off the landscape. Over time, the nutrients also build up in the lake bottom sediments. The high nutrient concentrations stimulate excess algae growth and contribute to water quality problems in both lakes. In addition to interfering with recreational uses, too much algae can cause major fish kills by reducing the amount of dissolved oxygen in the water. For these reasons the Santa Ana Regional Water Quality Control Board (Santa Ana Water Board) established special regulatory requirements to restore water quality in both lakes.

In 2004, the Santa Ana Water Board adopted Total Maximum Daily Loads (TMDL) to control the amount of nitrogen and phosphorus flowing into Canyon Lake and Lake Elsinore from the surrounding watershed. The TMDLs imposed strict conditions that are enforced through permits issued under the federal Clean Water Act and the California Water Code. Stakeholders throughout the region formed a joint Lake Elsinore and Canyon Lake TMDL Task Force ("LECL Task Force") to implement water quality improvement projects in both lakes. These efforts have been underway for nearly 15 years and have achieved considerable success.

Since 2004, internal and external nutrient loads to the two lakes have been reduced by more than 30%. As a result, Canyon Lake began meeting the Santa Ana Water Board's algae targets five years ahead of the TMDL deadline and water clarity has increased by nearly 100%. Water quality in Lake Elsinore is also substantially better due largely to the addition of nearly 2 billion gallons per year of highly treated recycled water to the lake. Without this supplemental water, authorized under the TMDL, the recent severe drought would otherwise have caused Lake Elsinore to dry up completely in mid-2014. Instead, in late 2018, the lake remained about 10 feet deep and algae concentrations were less than half the level expected to occur without the supplemental water.

In addition to investing millions of dollars to implement projects and monitor improvements in water quality, the LECL Task Force has also continued to conduct new scientific studies in both lakes. These studies were designed to better understand how hydrology and biology interact to affect the aquatic ecosystem. This information has been essential to develop more effective implementation programs and, if necessary, to update the 2004-adopted TMDLs.

Periodic review and reassessment is a normal part of every TMDL but is especially important in this case. Although the TMDLs were based on the best available scientific information in 2004, the lack of adequate long-term data and sophisticated computer software made it difficult to accurately model water quality conditions in both lakes. For example, the watershed models used to estimate external nutrient loads flowing in stormwater were not well calibrated for the extremely wet winters when most of that runoff occurs. In addition, relatively simple models, which assumed water levels never changed, were used to predict the effects on water quality in both lakes. These and other limitations were well-documented at the time and it was accepted that the TMDLs would be updated when better information and analytical tools became available. In late 2015, as part of the Triennial Review Process, the Santa Ana Water Board determined that the time had come to revisit and revise the TMDLs. The LECL Task Force began working on the project shortly thereafter.

This TMDL Technical Report, Revision to the Lake Elsinore and Canyon Lake Nutrient TMDLs, represents the culmination of a three-year collaboration between the LECL Task Force and the Santa Ana Water Board staff to assemble and analyze the vast amount of new data collected over the last 15 years. In addition, state-of-the-art computer simulation tools were used to develop more accurate and reliable water quality models for both lakes. Modern software can now handle numerous dynamic variables and it is no longer necessary to rely on the simplifying assumptions used previously. Some of the generic literature values used to prepare the 2004 TMDL can now be replaced with site-specific data for Canyon Lake and Lake Elsinore. **Table ES-1** identifies the numerous key elements that were updated in the course of reviewing and revising the existing TMDLs.

Table ES-1. Comparison of Key Differences Between the Current and Proposed TMDLs

Key Element	2004 TMDLs (Current)	2018 TMDLs (Proposed)
Precipitation & Runoff Hydrology	3 years: Low, Med. &High	Full 100-year Range
Lake Water Quality Models	Simple, Static	Complex, Dynamic
Natural, Pre-Development Loads	Partially Considered	Fully Integrated in Analysis
Natural Reference Condition for Lakes	Not Known; Insufficient Data	Defined Full Dynamic Range
In-Lake Algae Targets	Single Generic Value	Site-Specific Range of Values
Salinity Effects on Zooplankton	Not Evaluated	Fully Considered
EPA's 2013 Ammonia Criteria	Did Not Exist in 2004	Fully Considered
Mystic Lake Storage & Overflow	Inaccurately Specified	More Accurate Estimates
Nutrient Cycling in Sediment	Overestimated Decay Rate	More Accurate Estimates
Land Use Activities	Obsolete Zoning Maps	Recent Aerial Surveys
Nutrient Loads from Ag. Runoff	Generic Literature Values	Estimated from Local Data
Load Allocation Methodology	Mass-based Only	Mass & Concentration-based
Final Load & Wasteload Allocations	Overestimated; Less Stringent	More Stringent
Canyon Lake: Main Body v. East Bay	One Combined TMDL	Two Separate TMDLs
Water Quality Monitoring	Field Sampling Only	Added Satellite Surveillance
Discharge Prohibition in CAFO Permit	Not Included	Included
Retention Requirements in MS4 Permit	Did Not Exist in 2004	Included
Conditional Waiver for Ag. Discharges	Did Not Exist in 2004	Included
Statewide Septic System Policy	Did Not Exist in 2004	Included
EPA's Highest Attainable Use Concept	Did not Exist in 2004	Described as Managed Lakes
Net Effects of Recycled Water	Estimated	Demonstrated
Aeration Effectiveness for N Reduction	Unknown	Quantified Empirically
Cyanotoxins from Blue-Green Algae	Not Considered	Included
Compliance via Offsets	Implicitly Allowed	Explicitly Authorized

Perhaps the single most significant improvement between the 2004 TMDLs and the proposed revisions is that the latter fully recognizes and accounts for the highly variable nature of precipitation in the San Jacinto River watershed and the extreme effects this has on nutrient loading, water levels and water quality in both lakes. As a result, the revised TMDLs acknowledge that a single, literature-based algae target is inappropriate because the irregular hydrology associated with long-term weather cycles effectively prevented either lake from consistently meeting such a target even under natural, pre-development conditions.

The Water Quality Control Plan for the Santa Ana Region ("Basin Plan") states that: "waste discharges shall not contribute to excessive algal growth in inland surface receiving waters." Excessive algal growth is anything beyond what would have occurred naturally, in the absence of anthropogenic discharges, under similar meteorological conditions. The revised TMDLs propose to evaluate attainment of the water quality objective by comparing the frequency, duration and magnitude of modern-day algae blooms to the range of concentrations expected in the natural reference condition. The target range for this natural reference condition has been precisely defined in the revised TMDLs.

The recommended range for Canyon Lake does not differ markedly from the algae response targets established by the 2004 TMDL. Recent water quality monitoring data indicate that algae concentrations are already in or near compliance with both the current TMDLs and proposed revisions. It will be necessary to maintain the current level of effort focused on controlling nutrient loads in order to preserve this significant improvement in water quality.

Despite significant efforts to achieve large reductions in internal and external nutrient loads to Lake Elsinore, the lake is unlikely to comply with the final algae target of 25 micrograms-per-liter by the end of 2020 as required by the 2004 TMDL. Detailed analysis, completed as part of the TMDL update, shows that Lake Elsinore met this target less than 20% of the time under the natural reference condition. Close inspection of the linkage analysis in the 2004 TMDL also reveals that full compliance with the approved load allocations and wasteload allocations, in that TMDL, was likely to result in an average algae concentration that was nearly three times higher than the final target. New modeling results indicate that, in the time before humans colonized the watershed, algae concentrations in Lake Elsinore were more than double the current TMDL target about 60% of the time.

The revised TMDL recommends a new target that is based on the range of algae concentrations that Lake Elsinore is actually able to achieve under the natural, pre-development reference condition. The numeric compliance threshold applicable in any given year can be calculated based on lake elevation and the current position in the long-term weather cycle (drought v. El Niño).

As with Canyon Lake, it will be necessary to maintain the current level of effort focused on controlling nutrient loads in order to preserve the improvements in water quality already achieved in Lake Elsinore. Additional efforts will also be needed in order to ensure that the frequency, duration and magnitude of algae blooms in the Lake do not exceed that which would have occurred under the natural, pre-development reference condition.

Although the revised algae targets for Lake Elsinore are somewhat higher than those established in the 2004 TMDL, the new nutrient load reductions required to attain the revised targets are more stringent than the current TMDL. This outcome is largely due to the fact that the model used to develop the 2004 TMDL was never accurately calibrated for the high volume of stormwater runoff expected to reach Lake Elsinore during extremely wet winters. As a result, the previously approved load allocations and wasteload allocations were computed based on incomplete data. This problem has been corrected in the revised TMDL.

The revised TMDL explicitly reaffirms the Santa Ana Water Board's prior commitment that encourages stakeholders to implement in-lake remediation projects, as a means of achieving the algae targets through an approved offset program, where it can be shown that such an approach will result in better water quality sooner than could otherwise be achieved by relying solely on traditional source control measures to demonstrate compliance with the new load allocations and wasteload allocations. In addition, focusing exclusively on pollution prevention may inadvertently encourage wider implementation of large-scale volume reduction Best Management Practices that decrease the amount of nutrients at the expense of also diverting much needed runoff from the lakes. The revised TMDL continues to endorse the adoption of innovative compliance strategies that avoids such unintended consequences while still achieving the desired outcomes.

Because the proposed revisions impose more stringent obligations on stakeholders throughout the watershed, it is appropriate to establish a new schedule to achieve compliance with those requirements. Recent reanalysis of all available data confirms one of the key findings in the 2004 TMDL: 85% of the total nutrient load in Lake Elsinore continues to originate from the lake bottom sediments. Consequently, it may take several decades for these nutrients to cycle-out even after external loads are brought into compliance in the near-term.

The revised TMDLs recognize these facts and requires stakeholders to implement the nutrient control programs over the next ten years but allows at least ten additional years to allow these programs to achieve their full effect on the lakes. The dischargers have earned this consideration by virtue of the good faith demonstrated in implementing the requirements of the current 2004-adopted TMDLs and the significant improvements in water quality achieved as a result of these efforts.

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Section 1

Introduction

Lake Elsinore first appeared on California's 303(d) list of impaired waterbodies in 1994. Canyon Lake was added to that list in 1998. The lakes were deemed to be impaired by low dissolved oxygen (DO) levels and excess algae growth. Elevated nutrient concentrations (e.g., phosphorus and nitrogen) were cited as the primary cause of poor water quality in both lakes.

The Santa Ana Regional Water Quality Control Board (Santa Ana Water Board) adopted a Total Maximum Daily Loads (TMDL) for nutrient discharges to Lake Elsinore and Canyon lake in 2004 (Santa Ana Water Board 2004a). The TMDLs became effective when the United States Environmental Protection Agency (EPA) gave it final approval on September 30, 2005. The scientific data and analysis used to justify the TMDLs is summarized in a detailed technical support document prepared by the Santa Water Board staff (Santa Ana Water Board 2004b).

The TMDLs specified numeric targets for DO, chlorophyll-*a*, ammonia, Total Phosphorus (TP) and Total Nitrogen (TN) concentrations in both lakes. It also established Load Allocations (LA) and Wasteload Allocations (WLA) to govern the discharge of excess nutrients from non-point sources and point sources, respectively. The TMDLs include a detailed Implementation Plan which describes a variety of activities that must be undertaken to meet water quality standards in Lake Elsinore and Canyon Lake. In the decade following EPA's approval, stakeholders throughout the watershed initiated a large number of programs and projects to comply with the requirements set forth in the Implementation Plan for the TMDLs.

- From 2002-2008, fisheries management was implemented as a means of enhancing water quality in the lake. Carp were periodically removed to reduce the impact of their feeding behavior of rooting through the sediments which increases turbidity and enhances the release of nutrients from the lake sediments. An assessment of the program in 2008 showed significant reductions in carp (City of Lake Elsinore 2008).

- In 2005, the stakeholders formed the Lake Elsinore and Canyon Lake TMDL Task Force (LECL Task Force) to coordinate and share the cost of all implementation efforts. The LECL Task Force is comprised of all the dischargers identified in the TMDLs, including: Municipal Separate Storm Sewer System (MS4) permittees, wastewater treatment plants, agricultural operators, concentrated animal feeding operations (dairies), and a number of other state, federal, or tribal agencies that own land or operate facilities that discharge in the watershed.

- In 2006, the LECL Task Force developed and submitted a water quality monitoring program for both lakes and the major tributary streams (LESJWA 2006). This plan was approved by the Santa Ana Water Board on March 3, 2006 (Santa Ana Water Board 2006a).

- In 2007, the LECL Task Force developed and submitted a Sediment Nutrient Reduction Plan for Lake Elsinore (LECL Task Force 2007), which was subsequently approved by the Santa Ana Water Board (Santa Ana Water Board 2007a).

- In 2008, the Lake Elsinore Aeration and Mixing System (LEAMS) project, designed to improve water quality in Lake Elsinore, began full-time operation.

- In 2010, the Santa Ana Water Board reauthorized the National Pollutant Discharge Elimination System (NPDES) permit governing stormwater discharges in Riverside County (Santa Ana Water Board 2010). That permit obligated the MS4 permittees to comply with the nutrient TMDLs and required them to develop a Comprehensive Nutrient Reduction Plan (CNRP) for Lake Elsinore and Canyon Lake. The CNRP was prepared and submitted in 2012 and the Santa Ana Water Board approved it in 2013 (RCFC&WCD 2013; Santa Ana Water Board 2013a). Since then, the permittees have been actively implementing the CNRP.

- In 2013, the Western Riverside County Agricultural Coalition (WRCAC) submitted a final Agricultural Nutrient Management Plan (AgNMP) for agricultural operators in the watershed (WRCAC 2013a).

- In recent years the LECL Task Force has initiated a large-scale alum application program in Canyon Lake. Aluminum sulfate ("alum") binds with phosphorus thereby preventing excess algae growth in the lake. As of February 2018, 1,520 metric tons of alum have been applied and an estimated 4,000 kilograms (kg) (8,800 pounds [lb]) of phosphorus have been neutralized in Canyon Lake. Water quality has improved significantly since the program began.

The LECL Task Force has supported a large number of supplemental scientific studies in the ten years since the TMDLs were first approved. These studies were designed to aid the stakeholders in selecting the most effective and efficient management strategies to control nutrient loads in both lakes. The special studies were also intended to support necessary revisions to the TMDLs as better information became available.

In 2010, the LECL Task Force contracted with Tetra Tech, Inc. to update the runoff models used to estimate nutrient loads to both lakes (LESJWA 2010). This same firm also developed the original watershed model that the Santa Ana Water Board relied on to support and justify the nutrient TMDLs. Among the key improvements was a more accurate characterization of storage capacity in the Mystic Lake area and a more precise description of how rainfall and runoff vary in the region. At the Task Force's direction, LESJWA also developed a spreadsheet tool that could be used to estimate changes in nutrient loading based on changes in land use throughout the watershed.

Beginning in 2011, the LECL Task Force contracted with Dr. Michael Anderson at the University of California, Riverside (UCR) to develop more sophisticated dynamic models to predict water quality in both lakes. The Canyon Lake model was completed in 2012 and was instrumental in selecting alum applications as the most cost-effective nutrient control strategy for that lake (Anderson 2012a). The new water quality model for Lake Elsinore was just recently completed (Anderson 2016a). These models are designed to estimate the concentration of key water quality parameters under natural, pre-development conditions. The models are also used to predict how various nutrient management strategies will affect water quality and the time required to meet the response targets specified in the TMDLs. Among Dr. Anderson's many key findings are the following:

(1) Nutrients cycle in the lakes far longer and decay much slower than previously thought. This finding suggests that the previous water quality models may have underestimated the level of effort and length of time required to attain the water column targets for nitrogen and phosphorus specified in the current TMDLs.

(2) Canyon Lake is unlikely to achieve the current response targets for DO or Chlorophyll-*a* even after the stakeholders achieve compliance with the LA and WLA specified in the TMDLs. This is principally due to nutrient loads contributed by the lake-bottom sediments.

(3) Naturally-elevated salinity concentrations inhibit the zooplankton populations needed to constrain algae growth in Lake Elsinore. The interactions between salinity, biology and water quality were not considered when the current TMDL targets were originally developed.

(4) The strong asymmetric pattern of precipitation and drought in the watershed indicate that the lakes would not be able to consistently comply with the current TMDL response targets under natural, pre-development conditions.

(5) The natural hydrology of Lake Elsinore has been significantly altered by the construction of a large levee designed to reduce its size by 50% and by the addition of more than 50,000 acre-feet of reclaimed water to the lake. Both projects are intended to protect aquatic habitat and recreational uses by ensuring that the lake no longer dries up as it did during periodic droughts of the past. However, keeping the lake wet also alters some of the natural "reset" mechanisms that once governed water quality conditions in Lake Elsinore.

Dr. Anderson's findings indicate that important elements of the original TMDLs, including the water quality targets and the WLAs/LAs, must be revisited to ensure that they are appropriate and achievable. It is also necessary to update the technical analysis to reflect current land use conditions which have changed significantly since the original TMDLs were developed. Finally, the TMDLs should be revised to account for the large nutrient load reductions that have resulted from Best Management Practice (BMP) implementation, low-impact development (LID) requirements, restrictions on dairy discharges, changes in certain water quality standards (e.g., ammonia), and the in-lake remediation projects that have occurred over the last 10 years.

None of these findings are intended to imply that the original TMDLs were deficient or defective. It was not; it was based on the best data available at the time. Today, however, we know a great deal more about how the lakes actually work than we did just a decade ago. For example, we know considerably more about which nutrient control strategies are most effective at improving water quality. We also know that many critical factors (especially source loads from changing land use) are now quite different from what was assumed when the TMDLs were first approved.

According to EPA, updating the TMDLs to reflect all of this new information will "facilitate better watershed planning and adaptive implementation" (EPA 2012). In fact, the Santa Ana Water Board believed that regular review and revision is so critical to ultimate success that it adopted an Implementation Plan specifying that the TMDLs be "re-evaluated at least once every three years to determine the need for modifying the load allocations, numeric targets or implementation schedule" (Santa Ana Water Board 2004a; see Task #14 on page 21 of 22). Doing so provides reasonable assurance of continued progress toward attainment of water quality standards and protection of beneficial uses in Lake Elsinore and Canyon Lake.

Section 2

Problem Statement

The purpose of the Problem Statement is to provide the foundation or basis for the development of a TMDL. The statement typically includes an assessment of current water quality conditions and the basis for the identified impairments of the waterbodies of concern for which a TMDL is deemed necessary. This Problem Statement provides not only the information used to adopt the original nutrient TMDL for Lake Elsinore and Canyon Lake (**Figures 2-1** and **2-2**) but also provides an overview of the substantial body of data and information that has been generated since adoption of the 2004 TMDLs. This collective body of information provides the basis for revising the existing TMDLs.

Figure 2-1. Sunrise on Lake Elsinore, 2016 (Source: Wood Environment and Infrastructure Solutions, Inc.)

2.1 Regulatory Background

This section summarizes the basis for the adoption of the 2004 TMDLs for Lake Elsinore and Canyon Lake and planned revision of these TMDLs.

2.1.1 Beneficial Uses and Water Quality Objectives

Chapters 2 and 3 of the Water Quality Control Plan for the Santa Ana River Basin (Basin Plan; Santa Ana Water Board 2016, as amended) establish the beneficial uses and water quality objectives (WQO), respectively, applicable to Lake Elsinore and Canyon Lake. **Figure 2-3** provides an illustration of the geographic location of these waterbodies within the San Jacinto River watershed. **Table 2-1** summarizes each waterbody's beneficial uses and the numeric and narrative WQOs relevant to nutrients and related constituents. These objectives provide the basis for assessing the impairment status of each lake.

Figure 2-2. Canyon Lake Reservoir, 2016 (Source: Wood Environment and Infrastructure Solutions, Inc.)

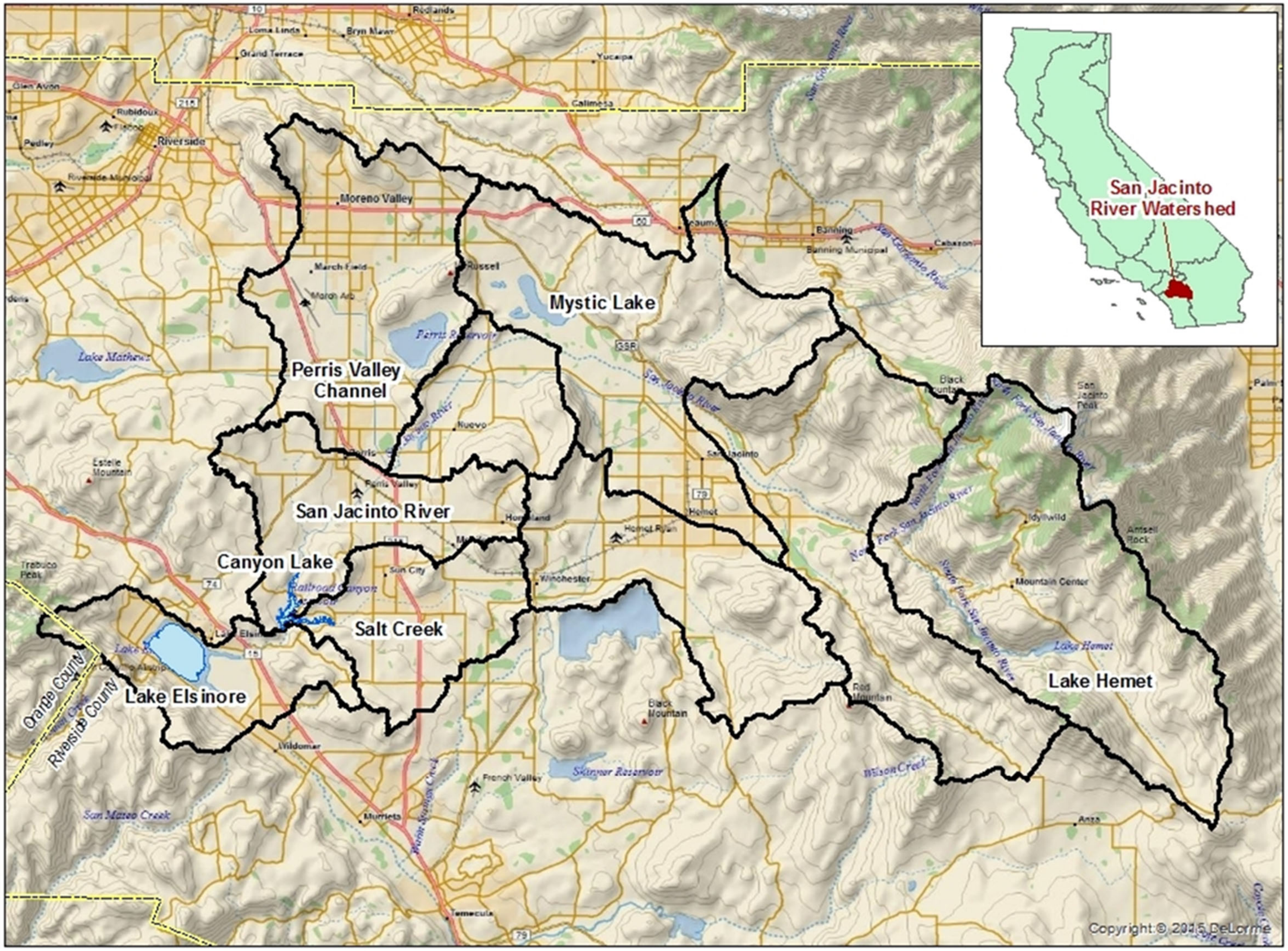

Figure 2-3. San Jacinto River Watershed with Key Subwatersheds Highlighted

CDM Smith

Table 2-1. Lake Elsinore and Canyon Lake Beneficial Uses and Water Quality Objectives (Santa Ana Water Board 2016, as amended)

Lake	Constituent	Relevant Water Quality Objectives
Lake Elsinore • Warm Freshwater Aquatic Habitat – (WARM) • Water Contact Recreation (REC1) • Non-Contact Recreation (REC2) • Wildlife Habitat (WILD)	Total Inorganic Nitrogen (TIN)[1]	1.5 milligrams/liter (mg/L)
	Algae	Waste discharges shall not contribute to excessive algal growth in receiving waters
	Un-ionized Ammonia (UIA)[2]	• Acute (1-hour) Objective = 0.822 [0.87/FT/FPH/2] • Chronic (4-day) UIA-N Objective = 0.822 [0.87/FT/FPH/RATIO]
	Dissolved Oxygen	DO content of surface waters shall not be depressed below 5 mg/L for waters designated WARM
	Total Dissolved Solids (TDS)	2,000 mg/L TDS
Canyon Lake • Municipal and Domestic Water Supply (MUN) • Agriculture Water Supply (AGR) • Groundwater Recharge (GWR) • Water Contact Recreation (REC1) • Non-Contact Recreation (REC2) • Warm Freshwater Aquatic Habitat (WARM) • Wildlife Habitat (WILD)	Total Inorganic Nitrogen (TIN)[1]	8 mg/L
	Algae	Waste discharges shall not contribute to excessive algal growth in receiving waters
	Un-ionized Ammonia (UIA)[2]	• Acute (1-hour) Objective = 0.822 [0.87/FT/FPH/2] • Chronic (4-day) UIA-N Objective = 0.822 [0.87/FT/FPH/RATIO]
	Dissolved Oxygen	DO content of surface waters shall not be depressed below 5 mg/L for waters designated WARM

[1] TIN is the sum of nitrate, nitrite and ammonia forms of nitrogen. The TIN WQO was established based on the TIN historical average in the lake prior to 1975.
[2] See page 4-8 of the Basin Plan for formulas for "FT", "FPH", and "RATIO" relevant to pH and water temperature

2.1.2 Basis for Adoption of 2004 Nutrient TMDLs

2.1.2.1 Lake Elsinore

The Santa Ana Water Board first listed Lake Elsinore as impaired in 1994, based on an historical record of periodic fish kills and excessive algae blooms in the lake since the early 20th century. The lake remains listed as impaired on the most recent EPA-approved impaired waters or 303(d) List for the region (State Water Board 2017a; EPA 2018) for toxicity, nutrients, and organic enrichment/low DO. Uses impaired include warm freshwater habitat (WARM), water contact recreation (REC1) and non-water contact recreation (REC2). Based on these impairments, the Santa Ana Water Board developed a nutrient-based TMDL. During TMDL development, the first Problem Statement developed in 2000 identified hypereutrophication as the most significant water quality problem affecting Lake Elsinore (Santa Ana Water Board 2000). In 2004, a final Problem Statement was developed that included information from the 2000 Problem Statement and findings from a number of newly completed studies as referenced in the document (Santa Ana Water Board 2004b). These findings provided additional information with regards to the basis for impairment. Specifically, hypereutrophic conditions arise due to nutrient enrichment (phosphorus and nitrogen) resulting in high algal productivity (mostly planktonic algae). Algae respiration and decay depletes available water column oxygen, resulting in adverse effects on aquatic biota, including fish. In 2004, the Problem Statement documented what was known with regards to reported algal blooms and fish kills, which have been documented since early last century (Section 2.2.2.4 below provides additional information regarding the fish kill data record). The decay of dead algae and fish also produces offensive odors and an unsightly lakeshore, adversely affecting use of the lake for recreational purposes. In addition, massive populations of algal cells in the water column cause high turbidity in the lake, making the water an uninviting murky green color at times.

2.1.2.2 Canyon Lake

Canyon Lake is located approximately five miles upstream of Lake Elsinore. The lake was created as a result of the construction of Railroad Canyon Dam in 1928. Only during wet years does Canyon Lake overflow and send water downstream to Lake Elsinore. Concerns regarding water quality were identified in the latter part of the 1990s, in particular concerns regarding periodic algal blooms and fish kills, but neither as significant as occur in Lake Elsinore. However, the water quality concerns were sufficient for the Santa Ana Water Board to place Canyon Lake on the 303(d) List in 1998 and a TMDL was adopted in 2004.[1]

The 2004 TMDL for Canyon Lake was developed in coordination with the Lake Elsinore nutrient TMDL. An initial Problem Statement specific to Canyon Lake was drafted in 2001 (Santa Ana Water Board 2001). This Problem Statement documented that the beneficial uses of the lake were impaired because of excess phosphorus and nitrogen. Subsequently, a revised Problem Statement was prepared in 2004 based on completion of a number of studies that provided additional understanding regarding water quality concerns in Canyon Lake (Santa Ana Water Board 2004b).

2.1.2.3 2004 TMDL Adoption

In June of 2004 the Santa Ana Water Board released for public comment the *Lake Elsinore and Canyon Lake Nutrient Total Maximum Daily Loads* which established numeric targets for both lakes (**Table 2-2**) (Santa Ana Water Board 2004b). Based on the outcomes of public workshops held in June and September 2004, a formal resolution to adopt the TMDLs was put forward for Board approval. The TMDLs, which included WLAs and LAs in kilograms/year (kg/yr) for Lake Elsinore and Canyon Lake (**Tables 2-3 and 2-4**), were adopted on December 20, 2004 (Santa Ana Water Board 2004a). The State Water Resources Control Board (State Water Board) approved the TMDLs on May 19, 2005 (State Water Board 2005); Office of Administrative Law approved it on July 26, 2005, and the EPA approved the TMDLs on September 30, 2005.

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[1] The 2014/2016 California Integrated Report moved Canyon Lake from Category 5 (impaired waters requiring a TMDL) to Category 4A, which are impaired waters where all listed constituents have been addressed by an EPA approved TMDL (State Water Board 2017a).

Table 2-2. Numeric Compliance Targets for 2004 TMDLs (Table 5-9n in Santa Ana Water Board 2004a)

Indicator	Lake Elsinore	Canyon Lake
Total Phosphorus Concentration (Final)	Annual average no greater than 0.1 mg/L to be attained no later than 2020	Annual average no greater than 0.1 mg/L to be attained no later than 2020
Total Nitrogen Concentration (Final)	Annual average no greater than 0.75 mg/L to be attained no later than 2020	Annual average no greater than 0.75 mg/L to be attained no later than 2020
Ammonia Nitrogen Concentration (Final)	Calculated concentrations to be attained no later than 2020 *Acute*: 1-hour average concentration of total ammonia nitrogen (mg/L) not to exceed, more than once every three years on the average, the Criterion Maximum Concentration (CMC) (acute criteria), where $CMC = 0.411/(1+10^{7.204-pH}) + 58.4/(1+10^{pH-7.204})$ *Chronic*: 30-day average concentration of total ammonia nitrogen (mg/L) not to exceed, more than once every three years on the average, the Criterion Continuous Concentration (CCC) (chronic criteria), where $CCC = (0.0577/(1+10^{7.688-pH}) + 2.487/(1+10^{pH-7.688})) * \min(2.85, 1.45*10^{0.028(25-T)})$	Calculated concentrations to be attained no later than 2020 *Acute*: 1-hour average concentration of total ammonia nitrogen (mg/L) not to exceed, more than once every three years on the average, the CMC (acute criteria), where $CMC = 0.411/(1+10^{7.204-pH}) + 58.4/(1+10^{pH-7.204})$ *Chronic*: 30-day average concentration of total ammonia nitrogen (mg/L) not to exceed, more than once every three years on the average, the CCC (chronic criteria), where $CCC = (0.0577/(1+10^{7.688-pH}) + 2.487/(1+10^{pH-7.688})) * \min(2.85, 1.45*10^{0.028(25-T)})$
Chlorophyll-*a* concentration (Interim)	Summer average no greater than 40 micrograms/liter (µg/L); to be attained no later than 2015	Annual average no greater than 40 µg/L; to be attained no later than 2015
Chlorophyll-*a* Concentration (Final)	Summer average no greater than 25 µg/L; to be attained no later than 2020	Annual average no greater than 25 µg/L; to be attained no later than 2020
Dissolved Oxygen Concentration (Interim)	Depth average no less than 5 mg/L; to be attained no later than 2015	Minimum of 5 mg/L above thermocline; to be attained no later than 2015
Dissolved Oxygen Concentration (Final)	No less than 5 mg/L 1 meter (m) above lake bottom to be attained no later than 2015	Daily average in hypolimnion no less than 5 mg/L; to be attained no later than 2015

Table 2-3. 2004 TMDL Wasteload and Load Allocations for Lake Elsinore (adapted from Table 5-9r in Santa Ana Water Board 2004a)

TMDL	Specific Allocations	Final Total Phosphorus Allocations (kg/yr)[1,2]	Final Total Nitrogen Allocations (kg/yr)[2]
Wasteload Allocations	Supplemental Water[3]	3,721	7,442
	Urban[4]	124	349
	Concentrated Animal Feeding Operation (CAFO)[4]	0	0
	Total WLA	**3,845**	**7,791**
Load Allocation	Internal Sediment	21,554	197,370
	Atmospheric Deposition	108	11,702
	Agriculture[4]	60	213
	Open/Forest[4]	178	567
	Septic Systems[4]	69	608
	Total LA	**21,969**	**210,461**
Allocation to Canyon Lake Watershed - Applicable to Canyon Lake Overflows		2,770	20,774
	Total TMDL	**28,584**	**239,025**

[1] Compliance with final allocation to be achieved as soon as possible, but no later than December 31, 2020.
[2] TMDL and allocations specified as 10-year running average
[3] WLA for supplemental water should be met as soon as possible as a 5-year running average
[4] Allocation only applies to where this land use occurs downstream of Canyon Lake

Table 2-4. 2004 TMDL Wasteload and Load Allocations for Canyon Lake (adapted from Table 5-9q in Santa Ana Water Board 2004a)

TMDL	Specific Allocations	Final Total Phosphorus Allocations (kg/yr)[1,2]	Final Total Nitrogen Allocations (kg/yr)[2]
Wasteload Allocations	Supplemental Water	48	366
	Urban[3]	306	3,974
	Concentrated Animal Feeding Operation (CAFO)[3]	132	1,908
	Total WLA	**487**	**6,248**
Load Allocation	Internal Sediment	4,625	13,549
	Atmospheric Deposition	221	1,918
	Agriculture[3]	1,183	7,583
	Open/Forest[3]	2,037	3,587
	Septic Systems[3]	139	4,850
	Total LA	**8,204**	**31,487**
	Total TMDL	**8,691**	**37,735**

[1] Compliance with final allocation to be achieved as soon as possible, but no later than December 31, 2020.
[2] TMDL and allocations specified as 10-year running average
[3] Allocation applies to where this land use occurs upstream of Canyon Lake

2.1.3 Basis for TMDL Revision

The post-TMDL implementation period from 2004 to 2018 has been a period of planning, monitoring, and scientific research. Findings from these efforts have been used to support the implementation of watershed-wide and in-lake projects (see summary in Section 1), evaluate the effectiveness of the projects and, where appropriate, refine or reassess implementation activities. Using this adaptive management approach, substantive new information regarding typical hydrologic and water quality conditions and cycles that exist in each lake has been developed. In total, the body of work completed to date provides a firm foundation regarding what is potentially attainable with regards to water quality given the highly managed conditions that exist. Accordingly, these prior work products will serve as the primary resources for updating and revising the current TMDLs.

In June 2015, the LECL Task Force petitioned the Santa Ana Water Board to reopen and revise the TMDLs based on new information developed since TMDL adoption (LESJWA 2015). The Santa Ana Water Board agreed to make this effort a high priority for staff (Santa Ana Water Board 2015a, b). As part of this agreement, the LECL Task Force accepted responsibility to develop the documentation needed to update and amend the nutrient TMDLs for Lake Elsinore and Canyon Lake.

This Problem Statement updates the previously developed 2000, 2001 and 2004 Problem Statements. The sections below provide relevant information regarding our current understanding of water quality conditions, lake biology and unique characteristics of the lakes and surrounding watershed after many years of study. This new information will be critical in updating all elements of the TMDLs, including, but not limited to, numeric targets, source assessment, linkage analysis, and allocations.

2.2 Waterbody Characteristics

2.2.1 San Jacinto River Watershed

Lake Elsinore and Canyon Lake lie within the San Jacinto River watershed (see Figure 2-1), an area encompassing approximately 780 square miles (mi^2) in the San Jacinto River Basin. Located approximately 60 miles southeast of Los Angeles and 22 miles south of the City of Riverside, the San Jacinto River watershed lies primarily in Riverside County with a small portion located within Orange County. Area climate is characterized as semi-arid with dry warm to hot summers and mild winters. Average annual precipitation in the entire watershed area is approximately 11 inches, occurring primarily as rain during winter and spring seasons. Within just the upper portion of the watershed that drains to these lakes, the precipitation averages 18.7 inches annually. Historically, land use development in the San Jacinto River watershed has been associated with agricultural activities. However, a continual shift from agricultural to urban land use has been occurring for many years (e.g., see WRCAC 2011 versus WRCAC 2018a).

There are several impoundments upstream in the San Jacinto River watershed that are upstream of Canyon Lake and Lake Elsinore that retain most runoff from their respective drainage areas; including (see Figure 2-1):

- *Lake Perris* – Lake Perris is a drinking water reservoir for the State Water Project which is used to meet demands in the region. An undeveloped drainage area of approximately 10 mi^2

surrounds Lake Perris and contributes runoff to the lake. Lake Perris does not overflow to the San Jacinto River and therefore this drainage area is excluded from the watershed source assessment.

- *Lake Hemet* – Lake Hemet is a reservoir within the San Jacinto National Forest that is used by the Lake Hemet Municipal Water District to provide water to a service area in and around Garner Valley. Lake Hemet was formed by construction of Hemet Dam in 1887. Runoff from an approximately 65 mi^2 watershed, comprising the headwaters of the South Fork of the San Jacinto River, is captured in Lake Hemet for recreational and municipal uses.

- *Mystic Lake* – Mystic Lake is a large depression area in the San Jacinto River watershed that captures all runoff from the upper watershed. Mystic Lake has a storage capacity of approximately 17,000 acre-feet (AF), which is sufficient to retain all runoff from the upper watershed in most years. However, in those years when Mystic Lake's storage volume is filled, the lake may overflow, sending large volumes of water to downstream Canyon Lake. Mystic Lake overflows are known to have occurred in the 1993-1994, 1995-1996, and 1998-1999 water years (Hamilton and Boldt 2015a, b), but not in subsequent wet years when flow gauge data showed no overflows occurred (notable being the 2004-2005 season). The storage capacity of Mystic Lake is changing. U.S. Geological Survey (USGS) topographic surveys by Dr. D. M. Morton in 2004 and 2014 have shown that the depression that forms Mystic Lake is subsiding at an average rate of ~1 inch/year (in/yr) (RCFC&WCD 2015). Interpretation of these topographic surveys suggests a storage capacity increased by approximately 200 acre-feet per year (AFY) from 2004 to 2014 (RCFC&WCD 2015). In setting WLAs, the 2004 TMDLs assumed overflows of Mystic Lake would occur in 16 percent of hydrologic years. The TMDL revision includes a revised estimate of overflow frequency and volume for use in developing allocations for external loads that considers the rate of subsidence and relevant hydrological conditions (see Section 4.1.3.4).

- *Concentrated Animal Feeding Operations* – CAFOs must retain runoff from up to a 25-year return period storm event on-site. Retention ponds within CAFO properties are used to comply with this permit requirement, which also serves to limit any discharge to the San Jacinto River or Salt Creek during most hydrologic years. In addition to compliance with these runoff retention requirements, most manure generated today by local dairies is hauled out of the San Jacinto River watershed. Detailed data is currently being developed to demonstrate this condition (personal communication, Pat Boldt, November 30, 2018). The TMDL revision proposes to account for successful compliance with CAFO Permits.

2.2.2 Lake Elsinore

Lake Elsinore is the largest natural lake in Southern California. Originally, at a lake elevation of 1,260 feet (ft) the surface area of the lake was approximately 5,950 acres with an average depth of 21.5 ft) (Engineering-Science 1984). This section provides a detailed history of the lake, which demonstrates that (a) under historical natural conditions, Lake Elsinore periodically became a dry lakebed, eliminating aquatic life as well as opportunities for recreation; and (b) even under current conditions, the lake continues to experience significant fluctuations in lake levels that have a significant impact on the attainability of beneficial uses in the lake.

2.2.2.1 Historical Background of the Lake Elsinore Area

The history of anthropogenic activity in Lake Elsinore area has been well-documented by a number of sources for various reasons. Following is a summary of this activity from the pre-historical period to today generally compiled by Engineering-Science (1984) or City of Lake Elsinore (2011a), which relied primarily on James (1964), County of Riverside Historical Committee (1968), Beck and Haase (1974), Hudson (1978), O'Neill and Evans (1980) and Hoover (1966):

About 2,000 years ago the inhabitants in the Lake Elsinore area were the ancestors of other known inhabitants of southern California, in particular the Luiseño and a related group, the Juaneño. It is unknown which people the Lake Elsinore area belonged to but there is evidence that the Juaneño had ties to the area based on a known trail that linked the Elsinore area with San Juan Capistrano on the coast of California. Per Engineering-Science (1984), there is a "reference to a Juaneño creation myth, in which 'man was created out of the mud of the lake (Elsinore)' (Harrington, cited in O'Neil and Evans 1980)." In addition, the Elsinore Hot Springs in the local area had religious significance to the Juaneños and Luiseños.

The Spanish missions began to be established in southern California in 1769. The San Luis Rey Mission, which had an influence in the Lake Elsinore area, was established in 1798 near what is now Oceanside California. In 1810, the water level of the *Laguna Grande* was first described by a traveler as being little more than a swamp about a mile long (USGS 1917).

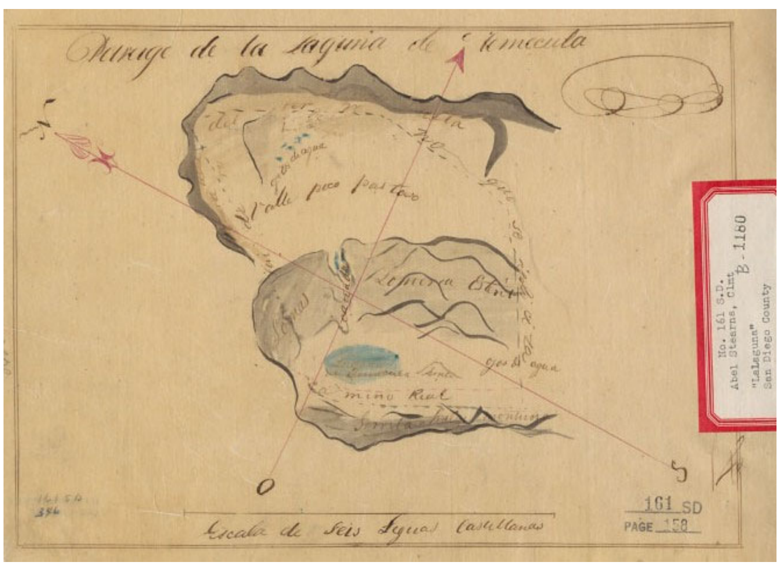


Figure 2-4. Historic Drawing of Laguna Grande (Source: Online Archive of California, https://oac.cdlib.org/ark:/13030/hb4k4005ht/?brand=oac4)

Leandro Serrano settled in the Lake Elsinore area that the Spanish referred to as Laguna Grande in 1818. He is the first known non-Indian to have settled in the area. The settlement he established, Glen Ivy Hot Springs, is today located in the Temescal Valley approximately nine miles northwest of Lake Elsinore. Laguna Grande is the name that the Spanish gave to Lake Elsinore (**Figure 2-4**) and La Laguna is the historic name for what is today the City of Lake Elsinore.

In 1844 Julian Manriquez, after receiving a 13,339-acre land grant from the Governor of Mexico, established La Laguna Rancho. This adobe was described by Benjamin Hayes, who stayed there overnight on January 27, 1850 (Wolcott 1929):

> *"In about 15 miles reach some timber where the hills approach near, apparently the termination of the valley of Temecula, a sort of low divide over which we enter into another*

valley. In both these is much good soil, although in the latter more of the wiry grass and more marshy, some little evergreen oak among the hills.

"Come to the Laguna, two miles from the divide. Some good young grass, great deal of elder on its banks; as we rode along frequent flocks of geese rose from the shore; many shots at them; none brought down. The water of the Laguna is saltish, the animals cannot drink it; if they could, such a sheet of fresh water here would be invaluable to the owner of this land….

"At sunset the moon rises behind the snowy peaks to the eastward and is reflected on the lake. Wild sage; the lake has evidently once, near the house, been with a much broader basin. How is it supplied with water? Clover around it. The house is a substantial adobe. A small stream seems to enter it on the east. A low range of hills nearly surrounds the lake, higher where we are encamped on the southern side. The lake valley seems to be higher than that of Temecula."

Figure 2-5. Streets of Elsinore in the 1880s (Source: City of Lake Elsinore, http://www.lake-elsinore.org/visitors/history/city-timeline)

Abel Stearns took possession of this land in 1851 as a result of foreclosure proceedings and then sold the land to Augustin Machado in 1858. Augustin Machado further developed La Laguna Rancho and between 1858 and 1861 the Butterfield Overland Mail Route (between Temecula to the south and Temescal Station to the north, a distance of about 30 miles) regularly stopped at Machado's ranch house.

Charles Sumner acquired most of Augustin Machado's Laguna Rancho in 1873. Sumner is credited with being the first person to note the potential benefits of hot springs in the area. When lake levels were low, Sumner noted the presence of more than 300 hot springs in the area. Three investors, including Franklin Heald, who is the founder of the City of Lake Elsinore (**Figure 2-5**), purchased Laguna Rancho in 1883 and developed a health resort called "Elsinore Colony." The Crescent Bath House, which is today a registered national historic site in the City Lake Elsinore, was established in 1887. During the latter part of the 19th century a yacht, the Marguerita, ferried passengers across the lake. A steamship, the Lady Elsinore provided lake cruises.

The California Southern Railroad began building a rail line from San Diego to Barstow in 1881 and completed it in 1885. In the Lake Elsinore area, the railroad was built through what was then the San Jacinto River Canyon, but later renamed Railroad Canyon. The La Laguna rail station was established just east of Lake Elsinore near what is now the intersection of Mission Trail Road and Diamond Drive.

Figure 2-6. Boating on Lake Elsinore, ca. 1940 (Source: Lake Elsinore Naval School)

Elsinore became known as a small town in 1883, incorporated in 1888, and was designated as a city in 1893 (see Figure 2-5). The establishment of the railroad and later a highway connection increased the number of residents and visitors. The completion of the lakefront resort, Laguna Vista Club House, and the Mount Elsinore County Club in the 1920s made Lake Elsinore a destination for visitors. Around the same time efforts continued to support a tourist industry centered on the lake (**Figure 2-6**). In 1926 a double-decked pier was built on the lake; in 1927 the National Speed Boat Race was held on the lake. In the 1930s a “ship pier” was constructed on the south side of the lake. During World War II, the lake was used to test seaplanes. The City of Lake Elsinore has grown significantly in the last few decades. **Table 2-5** summarizes population growth in the area since 1900 (City of Lake Elsinore [2011a] for 1900-2011; State of California for 2017 [2017]).

Table 2-5. Population Changes in the City of Lake Elsinore, 1900 – 2017

Census Date	Population
1900	279
1910	488
1920	633
1930	1,350
1950	2,068
1960	2,432
1970	3,530
1980	5,982
1990	18,285
2000	28,928
2011	52,503
2017	62,092

2.2.2.2 Lake Level Dynamics

The USGS published a summary of anecdotal records that illustrate the variation in wet and dry periods that have occurred in southern California from 1770 to 1913 (USGS 1918). Wet and dry records were compiled from a San Diego County resident who had lived in the county since 1869 and the records of Mission Fathers. **Table 2-6** summarizes the published findings. In addition, the USGS published a summary of anecdotal descriptions of Lake Elsinore lake levels for generally the same time period (USGS 1917):

Table 2-6. Recorded Wet and Dry Year Conditions in Southern California (adapted from USGS 1918)

Year(s)	Conditions	Year(s)	Conditions
1770	Drought	1853	Big floods and snow
1786	Copious rainfall	1850-1856	Flood and good years
1787	Rainfall insufficient; crops short	1856-1857	Driest in 20 years
1791	Extremely dry; no rain for whole year	1857-1862	Medium rainfalls
1794	Rainfall insufficient; crops short	1862-1863	Dry years
1795	Very dry	1863-1869	All good wet years
1811	Flood year	1869	Very exceptional year; rainfall in December estimated at 12 inches in 24 hours
1815	Flood year	1869-1870	Dry season
1819	Short in rain and crops	1870-1871	Dry season
1825	Great flood changed course of Santa Ana River	1872-1874	Fairly wet seasons
1826-1828	Dry years	1875-1876	Good rainfall
1832	Short in rain and crops	1876-1877	Dry season
1840-1841	Driest years every known	1877-1882	Good seasons
1841-1842	Wettest year ever known	1882-1883	Dry years
1842-1843	Very dry	1883-1884	Wettest winter known
1843-1844	Very dry; no grain grown in Sacramento Valley	1885-1893	Series of good years
1845	Drought	1893-1894	Short rainfall
1845-1846	Wet in north; dry in southern California; cattle starved	1895-1897	Three good wet years
1846-1847	Considerable rain; crops good	1897-1900	Three dry years
1848-1849	Most snowy winter known; rainfall moderate	1901-1910	Fairly good wet years
1849-1850	One of the wettest and most "floody" winters	1910-1913	Dry years at end of season
1850-1851	Rainfall moderate	1912-1913	Dry year

"Apparently the earliest specific reference to the amount of water in Elsinore Lake is contained in the notes of a traveler through southern California about 1810, who mentions 'Laguna Grande,' the original Mexican name for the lake, as being little more than a swamp about a mile long. For the period between that time and 1862 data as to its rise and fall are not available, but in 1862 it was very high and probably overflowed. During the succeeding dry period, especially during the years 1866 and 1867, when practically no rain fell on the drainage area tributary to the lake, it receded very rapidly but was full again in 1872 and overflowed down its outlet through Temescal Canyon. After this it again evaporated to a level probably as low as it has ever been since, but the great rains of the winter of 1883-84 filled it to overflowing in three weeks.

"Americans had settled around it [The Lake] by this time and their descriptions of conditions say that large willow trees surrounding the low-water shoreline were of such size that they must have been thirty or more years old. The rainfall in the next ten years was excessive, and the lake stayed high and overflowed naturally during three or four years of the decade. It [The Lake] was purchased by the Temescal Water Co. for the irrigation of lands at Corona, California, and its outlet channel was deepened, permitting gravity flow to Corona for a year or more after the lake level had sunk below the elevation of its outlet. As the surface still receded a pumping plant was installed and the water was raised a maximum of about 10 feet and then flowed down the natural channel of Temescal Canyon. Pumping was continued a couple of seasons, but the concentration of salts in the lake, due to the evaporation and low rainfall, soon made the water unfit for irrigation.

"After 1893 the water level sank almost continuously for nearly ten years, with, of course, a slight rise every winter. The heavier precipitation, beginning in 1903, gradually filled the lake to about half the depth between its minimum level since 1883 and its high level or overflow point. The flood of January 1916, rapidly raised the level, to overflowing, although the run-off from its drainage area into the lake appears to have been considerably less than that of the wet years of 1883-84 and 1888-89. The fact that large trees were growing 20 feet or more below the high-water level when the lake filled in 1883-84 indicates that the high water of the sixties and seventies must have been of very short duration. The stumps of the trees were still visible in 1888 and 1889 many hundred feet from shore, but by the time the lake receded in the middle nineties these had disappeared."

Figure 2-7. Period of Drying in Lake Elsinore in the Early 1900s (Source: Lake Elsinore Historical Society 2008, page 51)

A comparison between the noted high lake levels in the above USGS descriptions and Table 2-4 shows some correspondence between anecdotal wet/dry condition records and known Lake Elsinore water levels. For example, the reference to rapid filling of the lake in 1883-1884 is consistent with the notation that the 1883-1884 winter was the "wettest winter known" and a drying period is shown to have begun around 1910 (**Figure 2-7**). Differentiations are no doubt caused by the fact that the wet/dry condition records are not specifically from the San Jacinto River watershed. Regardless, there is a wide range of wet and dry conditions and varying lake levels documented in early written reports for the region.

Hudson (1978) provides a 200-year historical perspective of the Lake Elsinore area from 1776 to 1977. This compilation of historical records provides a number of anecdotal descriptions of Lake Elsinore, especially during the 19th century. **Table 2-7** summarizes this information.

Table 2-7. Anecdotal Descriptions of Lake Elsinore from 1797-1932 (adapted from Hudson [1978])

Date	Anecdotal Description
1797	Francisco Padre Juan Santiago described Lake Elsinore as a full lake, with trees around the edges and lots of animals
1858-1872	"In those days, as now, the lake had its full years and its low years. While the wet seasons were blessed with more grass for livestock, perhaps a high level of the lake itself was not so much desired by the Machado's, for a very good reason: when the lake was low there was a great meadow at the east end where cattle and sheep would graze. And, high or low lake, there was always water for thirsty animals."
1875	"The lake did not go completely dry, but before the rains came it was only a pool of stagnant water in a vast sea of mud. It was this period that Sumner later wrote that there were more than three hundred springs in and around the lake. These springs, he said, where of many varieties, including black Sulphur, soda and salt, hot sulphur [sic] water and clear cold water. "
~1883	"with scant rainfall the San Jacinto River became only a dry streambed. Willows along the shore of the lake died. Fish in the lake died and their stench fouled the clean air. Immense swarms of lake-bred gnats, with no fish to eat their larvae, took flight to pester man and livestock. As if in protest against the drought there was an upheaval in the lake that caused water to sprout up, geyser like, and to turn blood red. The Mexicans and Indians thought it was the blood of an evil spirit. Perhaps it was."
1884	"The rains which Ida spoke started in January 1884 and continued as late as June. Rainfall records vary, but some say that sixty-two inches of rain fell during that time. The railroad through Railroad Canyon was washed out and months passed before it was again ready for use. The lake rose so high that it overflowed into Water Springs Creek." (same as Temescal Creek).
1926	"By the end of February 1926 the San Jacinto River was flowing and the level of Lake Elsinore was rising. The rains that caused the river to flow were timely, for four years had passed since the lake had been replenished." Winter of 1926-27, the tracks are washed out again (also washed out in 1891).
1931-1932	"19 inches of rain had fallen in the valley in 1931. Lake Elsinore rose ten inches during the winter and on March 3, 1932 flood gates at Railroad Canyon Dam were opened, pouring almost ten thousand acre feet of water into the Lake and bringing the lake level to 1244.32."

In 1931, the Metropolitan Water District of Southern California commissioned the preparation of a report that compiled and studied available information "for the purpose of determining and reconstructing the record of rainfall and run-off fluctuations in Southern California since the arrival of the Spanish Mission Fathers in 1769" (Lynch 1931). Based on this research, Lynch (1931) reconstructed lake elevations for Lake Elsinore from the 1770s through 1930 using reported elevations, reported wet/dry conditions and interpolation (**Figure 2-8**). Lynch (1931) stated the following as the basis for his reconstruction:

> *"Lake Elsinore forms by far the best link which we have in Southern California for directly comparing present and past run-off conditions. Its level has fluctuated widely from overflow to practical dryness. Since 1859 these fluctuations have been recorded in testimony in lawsuits, in maps made at the time, and since 1915 in measurements by the United States Geological Survey. In addition are memories as to previous water levels and conditions by men still living. Prior to 1859 are a few references to its level. As in all of this work, periods of rainfall shortage show more clearly than periods of excess."*

Based on this reconstruction, the periods of time with the lowest lake elevations was 1810 and 1860. Times of lowest rainfall and lake elevation occurred prior to 1810, around 1830, prior to 1860, the early 1880's and around 1905. Per Hudson (1978), the lake was completely dry in 1810, 1859 and 1882, consistent with several of the records documented by Lynch (1931).

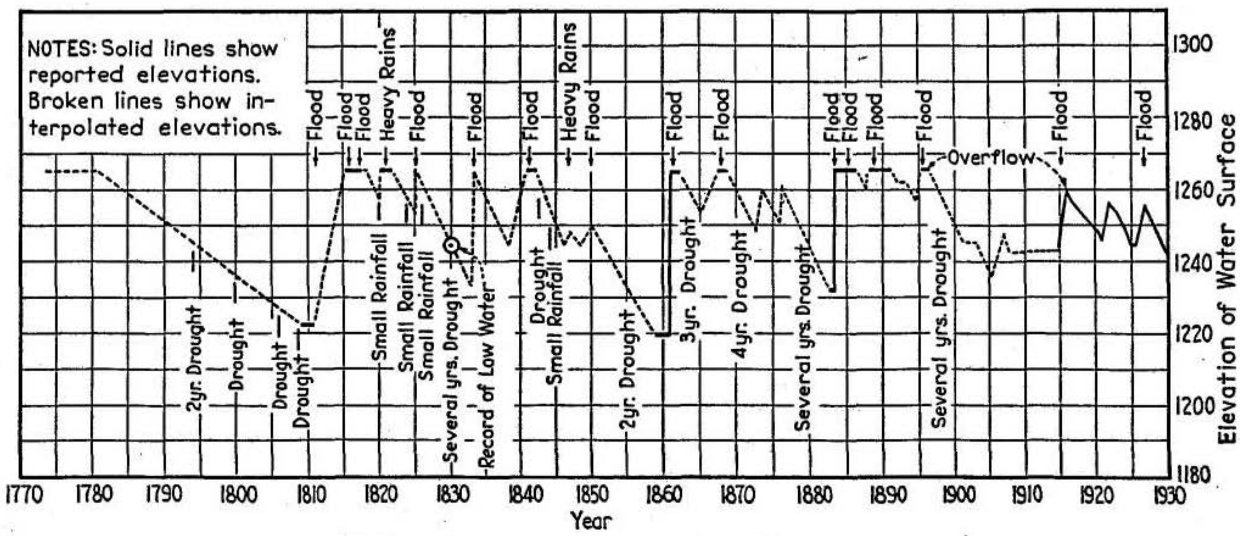


Figure 2-8. Estimated Lake Elsinore Lake Levels Based on Historical Records (from Figure 8, Lynch 1931)

Figure 2-8 also shows periods when Lake Elsinore was likely full (surface water elevation of approximately 1,265 ft), especially in 1815 and following, early 1840s, several years in the 1860s, and in the mid to late 1880s. Lynch (1931) illustrates the extreme variability in lake level through the following findings:

- If no water flowed into the lake, a full lake would evaporate and become completely dry in about 11 years.
- When the lake overflows, it may be an indicator of what the previous year's inflow was like, but it is not an indicator of conditions over any period of years. Lynch (1931) notes as an example that the single wet season of 1861-1862 filled the lake from it being almost completely dry to where there was a significant overflow.
- The lowest elevation was estimated at 1,220 ft above mean sea level (msl). The shallow nature of the lake as a whole is demonstrated by the fact that at elevation 1,224 ft the water surface would covers more than two square miles and at elevation 1,234 ft the lake covers more than four square miles.
- The evaporation rate of the lake is not only significant but as the lake fills and its water surface expands laterally, the rate of evaporation increases rapidly. This characteristic prevents the lake from overflowing, except as a result of an extended period of heavy rainfall.
- Based on reports, Lake Elsinore overflowed in 1841, 1862, 1868, several years between 1884 and 1895 and in 1916. The 1916 overflow was significant as reports indicate the flow was as much as 10 ft above the outlet elevation.
- The latter part of the 1800s illustrates the dynamic nature of the wetting and drying cycles in Lake Elsinore. The lake overflowed in 1841, but during the generally long dry period from 1841 to 1883 the lake's level dropped 40 ft; it refilled and overflowed 1862 and 1868. After 1868, the lake again lowered over thirty feet.

The work of Lynch (1931) was updated and extended in ACOE (1987) through the addition of information provided by the RCFC&WCD based on information found in 1842, 1859, 1875, and 1884 diaries (no specific references provided) and State Park Ranger data (no specific reference provided). **Figure 2-9** illustrates the updated Lynch (1931) figure (i.e., Figure 2-2). The figure again shows the dry lakebed that occurred in 1810, 1859 and 1882, but expands the record to show the dry lake bed that occurred off and on in the 1950s and 1960s. The figure also illustrates the dramatic change that occurred as a result of a very wet period that began in 1978 (ACOE 1987):

> *"...1978 marked the beginning of consecutive wet years when heavy rains raised the lake elevation approximately 15 ft. to about 1,245 ft. Although there is no available flood damage data from the 1800s, the recent floods of 1980 and 1983 are well documented. Of these two years, 1980 was the most significant. The rainfall of 1980 had, by February, equaled the total annual average for the Elsinore area. Beginning on February 13, and continuing for the next six days, the area again received an amount of precipitation in excess of the total annual average. The lake level reached 1265.72 ft. and over 250 homes were flooded leaving one-third of the Lake Elsinore residents temporarily homeless...the 1980 flood is estimated to closely represent the conditions of a 100-year lake level."*

When Lake Elsinore goes through periods of drying the descriptions of the lake illustrate how poor conditions can become. For example, in an April 1936 letter from the Chief State Bureau of Sanitary Engineering to the Mayor of Elsinore, the following description was provided (EDAW 1974):

> *"…(the Lake) depth is now about 10 feet…concentration of the Lake water is at a dizzy speed…rapid change of chemical characteristics of the water is almost certain to affect the variations of life that will be encountered from now on…we calculated 135,000 tons of algae crop….comparison with the algae figure for April, 3 years ago, when the fish died, indicates there are now over 200 times the quantity of algae…there are probably 20 to 30 acres of mud flats covered with a pastey, black sludge – it is intensely foul smelling…we sincerely hope that a proper balance of nature will prevail through the summer…"*

The longest dry period that has occurred in Lake Elsinore was in the mid-1950s and again in the early 1960s. The complete dry up of the lake in 1954 was the subject of an extensive article on the lake (Fortnight: The Magazine of California 1954) (**Figure 2-10**):

> *"Lake Elsinore's reputation stems from its annoying habit of drying up at inconvenient intervals, and also from an irrational tendency to spew forth dead fish along its lovely shoreline. One year it may be the garden spot of Southern California…the next year its resorts may be deserted…its once invigorating atmosphere palsied o'er with the unmistakable order of dead fish, and maverick hordes of gnats singing their siren song over all…Why? Because Lake Elsinore has done one of its periodic disappearing acts, its cool blue waters transformed into a barren sea of pitted, pock-marked earth.*
>
> *This year the Lake is choosing to be particularly perverse. It is dry enough to make the Oklahoma Dust Bowl seem like a summer sunning of the French Riviera. There is not even a mud puddle to remind observers of the glories that used to be. Its surface is lined with cracks, its center a dangerous quicksand area. Boiling pots bubble continuously."*

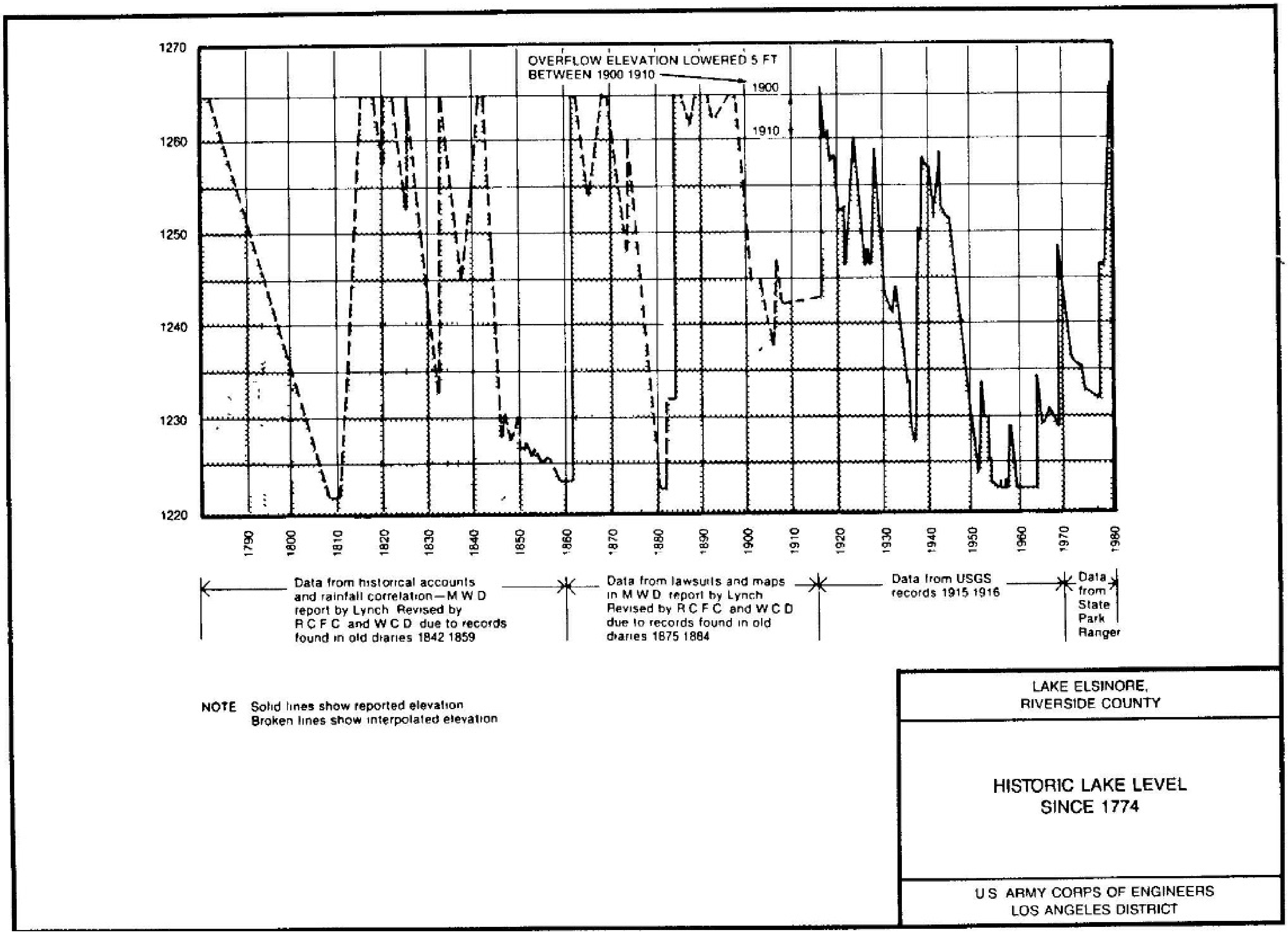


Figure 2-9. Historic Lake Levels in Lake Elsinore Based on Revision of Lynch (1931) and Additional Information (Figure 6 in ACOE 1987)

LAKE ELSINORE NOW: "Cool blue waters transformed into a barren sea of pitted, pock-marked earth..."

LAKE ELSINORE THEN: "It is to Elsinore Valley what the Alps are to Switzerland, or the desert to Arabia..."

Figure 2-10. Comparison of Lake Level Extremes in Lake Elsinore (Source: Fortnight: The Magazine of California 1954)

2.2.2.3 Modifications to the Watershed and Lake Elsinore

Since the 1920s, changes have occurred in the San Jacinto River watershed and the natural characteristics of Lake Elsinore. These changes are described in the subsections below.

Construction of Canyon Lake

The establishment of Railroad Canyon Reservoir in 1928, had the potential to significantly impact the downstream Lake Elsinore, especially given that the reservoir is only about five river miles upstream of Lake Elsinore (**Figure 2-11**). Because of a lawsuit filed by George Tilley, the Tilley Agreement was established to ensure that a minimum amount of water reached Lake Elsinore. The terms of the October 29, 1927 settlement stipulated that Canyon Lake was entitled to a maximum of 2,000 AF of watershed runoff. Lake Elsinore would receive any water over that amount (California Public Utilities Commission 2009). Within the Agreement, which was between Temescal Water, owners of Railroad Canyon Reservoir and the people below the reservoir, the following justification for ensuring sufficient water reaches Lake Elsinore was included (EDAW 1974):

> *"...unless the water level of Lake Elsinore be maintained at a level of 1245 feet above sea level or higher, that the water line recedes so far into the bed of the Lake as to make the shores unsightly; algae form in abundance in the Lake, and die and rot and cause a green slime to accumulate upon the surface of the Lake along the shore and over a large area of the Lake, which at such times, gives off noxious odors..."*

Overflows from Canyon Lake to Lake Elsinore occur only periodically (**Figure 2-12**), and, as noted above, even with the Agreement, Lake Elsinore continued to experience significant fluctuations in water levels, with the lake completely drying out periodically in the 1950s and 1960s (see discussion above).

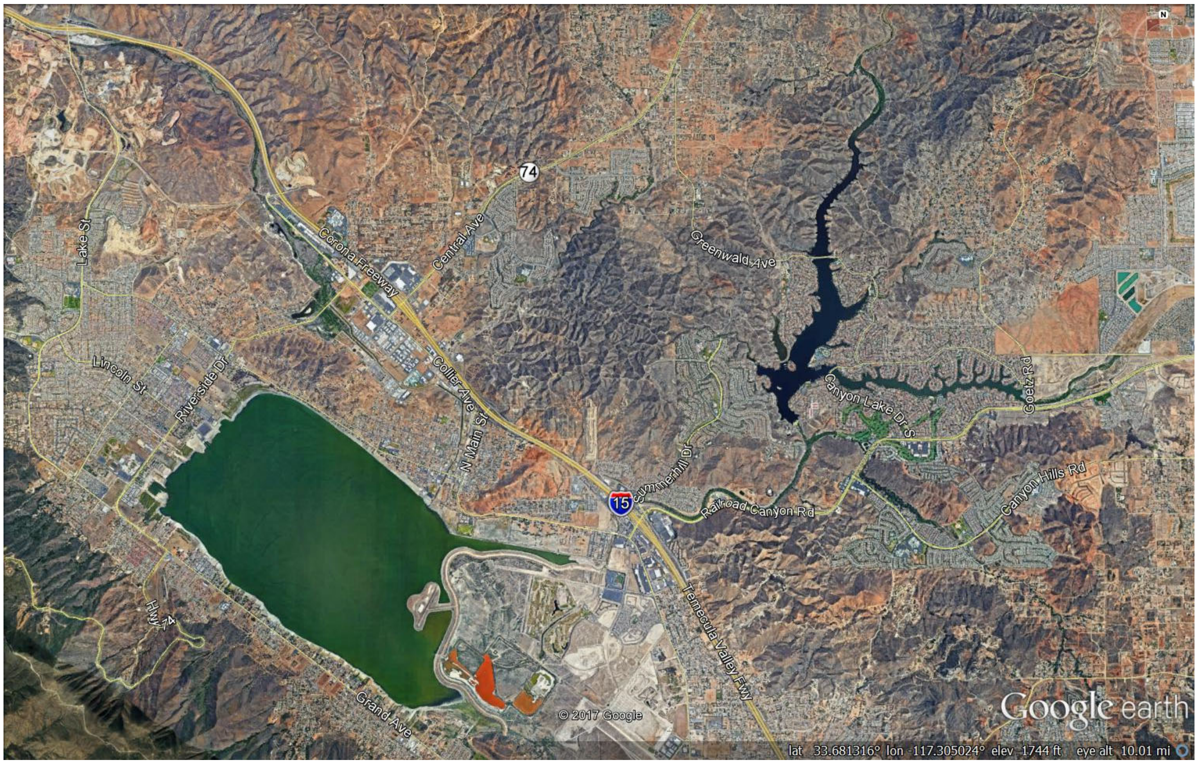


Figure 2-11. Proximity of Canyon Lake Reservoir to Lake Elsinore

Modification of Lake Elsinore

In the early 1980s new efforts were initiated to resolve concerns with the lakes dynamic behavior which resulted in significant fluctuations in lake elevation and associated shoreline variability, flooding and water quality problems (Engineering-Science 1984). While this was the latest effort to address these lake concerns, Engineering-Science (1984) notes that the search for solutions had been the subject of evaluation for some time:

Figure 2-12. Overflow of Canyon Lake Dam, approximately 1936-1937 (Source: Lake Elsinore Naval School)

"The development and evaluation of options for the long-term solution to the problems associated with Lake Elsinore has been nearly a constant activity during the past two decades. In the 1960s, deep wells were installed to provided replenishment water to Lake Elsinore during periods of drought. In the early 1970s, plans for establishing a permanent lake were formulated. In the early 1980s, programs for minimizing flood damage were investigated following the disastrous floods in 1979 and 1980. "

The outcome of the latest effort was the proposed Lake Elsinore Management Project (LEMP). Per the Environmental Assessment (EA), the key purposes of the proposed project included (Engineering-Science 1984):

- Provide a reliable source of agricultural water;
- Prevent localized flooding;
- Provide recreation opportunities;
- Improve water quality;
- Reduce fluctuation in lake water levels;
- Maintain a minimum pool in the lake basin, and
- Manage the lake to meet the above objectives.

With regards to water quality concerns, the Need and Purpose of the EA included the following description (Engineering-Science 1984):

> *"The character of Lake Elsinore has varied from a 'dust bowl' to a 6,000 acre flooded lake covering most of the floor of the Elsinore Valley. The dynamic behavior of this water resource has caused several major problems.*
>
> *Shoreline Fluctuation Problems. Changes in the water levels of Lake Elsinore can be dramatic, ranging from several feet to nearly 20 feet in a single year…Within a period of one to two years, shoreline facilities can be faced with flood water conditions or 'high and dry' as the water's edge recedes several hundred to several thousand feet. The wide migration of the shoreline precludes the full recreational use and long-term development of recreational facilities…*
>
> *Water Quality Problem. Traditionally, Lake Elsinore receives the outflow of the San Jacinto River Watershed and functions as a large evaporation lake, because the natural lake outlet is about 30 to 40 feet higher than the floor of the lake basin. As the lake level drops due to evaporative water losses, the dissolved materials content of the residual lake pool increases and eventually severe water quality problems result. In the past, several fish kills have occurred, and odor problems have preceded the 'drying up' of the lake."*

Table 2-8 provides a comparison of the expected outcomes from construction of the proposed alternative (construction of a levee) and the no project alternative. The proposed alternative or LEMP included three major projects. These projects and their construction dates include:

- Construction of a levee to separate the main lake from the back basin to reduce the lake surface area from about 6,000 to 3,000 acres, and thereby prevent significant evaporative losses (June 1989 – March 1990);

Table 2-8. Comparison of the Expected Outcomes of Implementation of the Proposed LEMP Project or No Project Alternatives (adapted in part from Table 2.5 in Engineering-Science 1984)

Proposed Alternative – Construct Levee	No Project Alternative
• Lake Characteristics – Lake Status – Permanent Lake; levee to separate Lake Elsinore from its southeasterly floodplain – Outlet Elevation – 1,252 ft. – Water Level – 1,235 to 1,252 ft. – Surface Area – 2,700 to 3,060 acres – Average Depth – 9 to 27 ft. • Water Resources – Groundwater – Pump for agricultural use and to replenish lake to 1,235 ft. – Surface Water – Improved water quality (TDS) due to lower evaporation loses and increased flow-through and replenishment sources – Imported water and local groundwater used to supplement natural flows to maintain a minimum pool (elevation 1,235 ft) • Recreation - Establishment of recreational beaches, boat launches and other features to support public fishing • Lake inlet relocated and improved to provide flood protection	• Lake Characteristics – Lake Status – Intermittent Lake; periods of low water will probably predominate; occasional periods of very high water will occur – Outlet Elevation – 1,260 ft. – Water Level – 1,223 (dry) to 1,260 ft. – Surface Area – 0 to 5,950 acres – Average Depth – 0 to 21 ft. • Water Resources – Groundwater – pump during drought periods to replenish water; inconsistent quality of the water in the lake; precludes use of lake as a non-potable water source – Surface Water – ▪ Continued wide fluctuation in water quality; ▪ Gradual deterioration of water quality as lake level drops below 1,260 ft. and especially in the range of 1,226 and 1,230 ft); creates unsuitable habitat for fishes continues to function as a large evaporation lake • Recreation – Shoreline fluctuation will continue preventing establishment of permanent recreational areas – Additional acreage for park but no new boat launching or beach areas; no new fishing access • During times of extreme floods when water levels approach 1,270 ft (1,265 ft = 100-yr floodplain), extensive flood damage will occur

- Realignment of the lake inlet channel to bring natural runoff from the San Jacinto River when Canyon Lake overflows (February 1990 – March 1991); and,
- Lowering of the lake outlet channel to increase outflow to downstream Temescal Creek when the lake level exceeds an elevation of 1,255 ft (October 1993 – April 1995).

With a reduction of lake level fluctuations and improved water quality, it was expected that there would be significant improvement in the biotic resources in the lake (Engineering-Science 1984) (**Figure 2-13**):

> *"The establishment of a permanent lake…is a significant long-term benefit to the biotic resources that are associated with this lake. The development of a stable fishery resource in Lake Elsinore will be realized for two key reasons. Adverse natural factors, such as poor water quality and drying up of the lake, will not continue to depress or to interrupt fish growth rates. Second the establishment of a permanent lake with good water quality will provide a sufficient resource basis for additional game fish stocking…the stabilization of the shoreline within elevations of 1235 and 1252 feet will encourage fuller development of a perennial plant community and associated bird populations.*

Figure 2-13. Illustration of Algal Bloom Along Shoreline of Lake Elsinore in 2016 During Period of Low Water Levels (Source: LESJWA)

As a result of LEMP, Lake Elsinore now has current approximate surface area of 3,000 acres (approximately 50% of the original surface area), average depth of approximately 13 ft, and a maximum depth of approximately 27 ft. Monitoring data indicate that with the exception of brief periods of stratification Lake Elsinore is typically well-mixed with a limited thermocline.

Addition of Reclaimed Water

While one of the key outcomes of LEMP was to stabilize lake water levels, variations in the lake level and water quality can still be substantial in Lake Elsinore due to seasonal fluctuations and alternating periods of drought and heavy rains during El Niño conditions. To mitigate this concern, Elsinore Valley Municipal Water District (EVMWD) has provided an average of 4,700-AFY of reclaimed water since 2007 to maintain lake levels at an adopted operation range of 1,240 to 1,249 ft. Sources of supplemental water since 2007 include EVMWD reclaimed water (~ 95 percent of total input) and production from non-potable wells on islands in the lake (~ 5 percent of total input).

During the most recent dry period prior to the winter of 2016-2017, modeling analyses indicate that Lake Elsinore would have been completely dry without the input of reclaimed water. LEMP coupled with inputs of supplemental water have been successful in avoiding lakebed desiccation or extremely low lake levels, despite the recent period of severe drought.

2.2.2.4 Historical Water Quality and Biological Community Characteristics

As noted above, water quality in Lake Elsinore varies with variation lake elevation. This section provides first an overview of water quality data used to support development of the original TMDLs and the LEMP project. Following this overview, additional water quality information is provided that focuses on (a) salinity characteristics of the lake; (b) fish kills as they may relate to water quality changes; and (c) the most recent water quality observed in the lake collected by the monitoring program to support TMDL implementation.

Water Quality to Support LEMP and the TMDL

Preparation of the LEMP EA included a compilation of relatively recent water quality data available at the time (**Table 2-9**). Data were summarized from two time periods, one with a relatively low lake elevation (1975); the other period was a time of relatively high lake elevation (1981). The differences in water quality between the two reporting periods are notably different, especially for salinity.

When the 2004 TMDL was developed, the following sources provided key water quality data for the TMDL development effort:

- In 1975, EPA conducted a eutrophic survey among 24 lakes and reservoirs in the western United States, including Lake Elsinore (EPA 1978). The study categorized Lake Elsinore as hypereutrophic due to high levels of chlorophyll-*a*, TP, TN, and low Secchi depth readings. As part of the EPA study, an effort was made to determine whether the limiting nutrient was nitrogen or phosphorus. The study consisted of an algal growth test (assay) using the algae *Selenastrum capricomutum*. Results indicated that at that time, nitrogen was the limiting nutrient (EPA 1978). A survey of phytoplankton indicated a dominance of flagellate-green, blue-green algae and diatoms. The abundance of the algal cells increased the turbidity of the water column. The presence of the blue-green algae suggested that nitrogen fixation was a process for the blue-green algae to utilize nitrogen directly from the atmosphere.

- The Santa Ana Watershed Project Authority (SAWPA) was awarded a Clean Water Act §314 grant (Clean Lakes Study) in 1993 to conduct a water quality study of Lake Elsinore. Black & Veatch was retained by SAWPA to conduct a water quality monitoring program under the contract with the then Lake Elsinore Management Authority (LEMA) from 1994 through 1997. The results and findings of the studies were reported in two technical documents prepared in the 1990s and are summarized in the original TMDL Problem Statement for Lake Elsinore (SAWPA 1994; LEMA 1996; Santa Ana Water Board 2000).

Table 2-9. Water Quality Data for Lake Elsinore Under Low Water Level (1975) and High Water Level (1981) Conditions (adapted from Engineering-Science 1984)

Measurement		High Water Level (1,255 ft) – 1981[1]		Low Water Level (1,233 ft) – 1975[2]	
		Range	Average	Range	Average
Conductivity (µS/cm)		1,070 – 1,210	1,118	1,026 - 6,407[3]	5,572
pH (Standard Units)		8.0 – 8.5	8.2	8.5 – 9.4	9.1
Alkalinity ($CaCO_3$) mg/L		178 – 180	179	122 – 1,780	956
Sulfate (SO_4) mg/L		110 – 120	111	Not determined	
Nitrogen (mg/L)	Ammonia	0.2 – 0.4	0.23	0.04 – 0.09	0.058
	Nitrate and Nitrite	< 0.101 – 0.521	0.233	0.03 – 0.31	0.089
	Organic	1.1 – 2.8	1.62	0.5 – 4.9	3.2
	Total Nitrogen	1.513 – 2.521	2.06	0.58 – 5.00	3.25
Phosphorus (mg/L)	Orthophosphate	0.033 – 0.065	0.045	0.03 – 0.27	0.128
	Total Phosphate	0.065 – 0.196	0.087	0.05 – 0.65	0.450

[1] Data collected from 14 lake locations in January 1981 (Engineering-Science 1981)

[2] Data collected from 6 lake locations in March, June and November 1975 (EPA 1976)

[3] Conductivity results from extremely low water levels were in the range of 28,000 to 30,000 µS/cm (see Figure 2-14 below)

Salinity

Water quality varies in Lake Elsinore in large part due to the changing lake elevation. Of particular significance is the variability in salt content that increases with decreasing lake level. This periodic change in salinity has significance to the biology of the lake (see discussion below). Variability in salinity has been well documented through a number of sources dating back to at least 1850 when Benjamin Hayes noted the following description of Lake Elsinore in his diary (Wolcott 1929): "*The* *water of the Laguna is saltish, the animals cannot drink it; if they could, such a sheet of fresh water here would be invaluable to the owner of this land…."*

The USGS provides an indication of salinity concerns in the lake from information developed from the latter part of the 19th century (USGS 1917):

> *"[The Lake water] was purchased by the Temescal Water Co. for the irrigation of lands at Corona, California, and its outlet channel was deepened, permitting gravity flow to Corona for a year or more after the lake level had sunk below the elevation of its outlet. As the surface still receded a pumping plant was installed and the water was raised a maximum of about 10 feet and then flowed down the natural channel of Temescal Canyon. Pumping was continued a couple of seasons,* ***but the concentration of salts in the lake, due to the evaporation and low rainfall, soon made the water unfit for irrigation****."* (emphasis added)

Harbeck and others (1951) reported on the results of a water quality sample collected in 1949 as part of a general survey of western lakes and reservoirs. The elevation of the lake surface was 1,232.7 ft on the sample collection date of June 7, 1949; maximum depth of the lake was approximately 9 ft and the majority of the lake was less than 5 ft deep. A water sample was collected in the afternoon from near the pier at the Aloha Beach Club at Elsinore. The TDS concentration was 8,890 parts per million (ppm); the water temperature was 90 degrees Fahrenheit (°F). Sample results also indicated the presence of hydrogen sulfide.

The State Water Resources Board (1953) conducted an investigation to identify solutions to water quality concerns in the lake and develop a cost estimate for importing Colorado River water from the aqueduct to supplement local supplies for domestic and agricultural use in the basin. The investigation also evaluated the possibility and cost of stabilizing lake levels for recreational purposes. Report findings include:

> *"Since there is ordinarily no outlet from Lake Elsinore, the mineral quality of water in the lake varies inversely with the amount of water it contains. This results from processes of concentration of solubles by evaporation and dilution by inflow.* ***With the lake full in 1916, the water contained about 1,300 ppm of dissolved solids, while with the lake nearly dry, in 1951, it contained about 214,000 ppm of dissolved solids.****" (emphasis added)*

Increased salinity can have a significant impact on the biological community of Lake Elsinore. This relationship is described in the following summary of water quality issues associated with increased salinity (Engineering-Science 1984):

> *"Lake Elsinore basically functions as a large evaporation lake. The lake has no outlet until the water level reaches 1,260 feet, then water flows into Temescal Wash…As a result of the evaporation process, the dissolved materials content of the remaining lake water increases. Inflows from the watershed and other sources can slow down this concentration process; however, the net effect is dependent upon the volume and quality of inflow. Using conductivity as a general index of overall water quality, it is clear that as the lake elevation drops below 1,235 feet the quality of water begins to rapidly deteriorate…As the lake level continues to drop, the dissolved salts increase, plankton begin to die and their decomposition*

consumes the available dissolved oxygen, and fish begin to die. Fish-kills (i.e., 150 tons) have occurred in the past as Lake Elsinore approached the final stages of drying up. These die-offs resulted in serious health hazards and odor problems."

Figure 2-14 from Engineering-Science (1984) illustrates the relationship between lake levels and salinity as known at the time when the LEMP project was under development. This information was further developed in LESJWA (2005a) from water quality work completed by LEMA (1996) (**Figure 2-15**). LESJWA (2005a) notes that at lake elevations of about 1,253 ft or less, the typical state of Lake Elsinore is brackish with TDS concentrations above 1,000 mg/L (typical of freshwaters that are potable) but less than seawater where TDS is > 35,000 mg/L. TDS levels fluctuate in the lake due to varying processes and conditions (LESJWA 2005a):

"As a general observation, it has been historically true that when the lake water surface elevations are low (i.e., lake volumes are low) due to a prolonged periods of inadequate inflows from the San Jacinto River, TDS steadily increases due primarily to evapoconcentration of dissolved constituents. Conversely, when the lake receives substantial inflows during wet water-years, the inflows serve to bring low salinity water to the lake, thereby reducing TDS concentrations…In reality, historical TDS concentrations in Lake Elsinore are a function of: 1) the influent salinity levels; 2) the frequency, duration and magnitude of inflows to the lake; 3) the evaporation rates; 4) the frequency of lake flushing; and 5) the aqueous geochemistry of the system."

More recent monitoring data show how much TDS can fluctuate from year to year (see discussion of current water quality below in Section 2.2.2.5).

Fish Community

Engineering-Science (1984) documented what was known of the fish community at that time, including reference to a California Department of Fish and Game (CDFG) survey (California Department of Fish and Game 1973) that identified seven fish species: largemouth bass, bluegill, channel catfish, white catfish, carp, mosquito-fish and threadfin shad as well as other species reported from U.S Fish and Wildlife survey (U.S. Fish and Wildlife Service 1982): tilapia, crappie, redear sunfish, green sunfish and golden shiner. Engineering-Science (1984) describes the fishery resource within the context of known water quality as follows (see **Figure 2-16**):

"*Although not documented, the fisheries resources in LE [Lake Elsinore] have probably exhibited wide variability due to fluctuating water levels and attendant changes in habitat features, esp. water quality. At higher waters levels (1,240 to 1,265 ft), the resident fish population probably thrived due to the presence of good quality water, inundation of floodplain to the south creating shallow water habitat, and increased growth of plankton populations. As the water level drops to 1240 feet and below, the fisheries resources of the lake begin to experience decline. Loss of habitat occurs and the concentrations of dissolved salts increases. The latter creates conditions for algal blooms. The metabolic breakdown of the biomass generated by the algal blooms soon lowers the dissolved oxygen content of the water, and in some instances, to a concentration that results in fish suffocation. Following the die-off of resident stock in the lake, a new fisheries resource would have to be reestablished beginning with fish planting."*

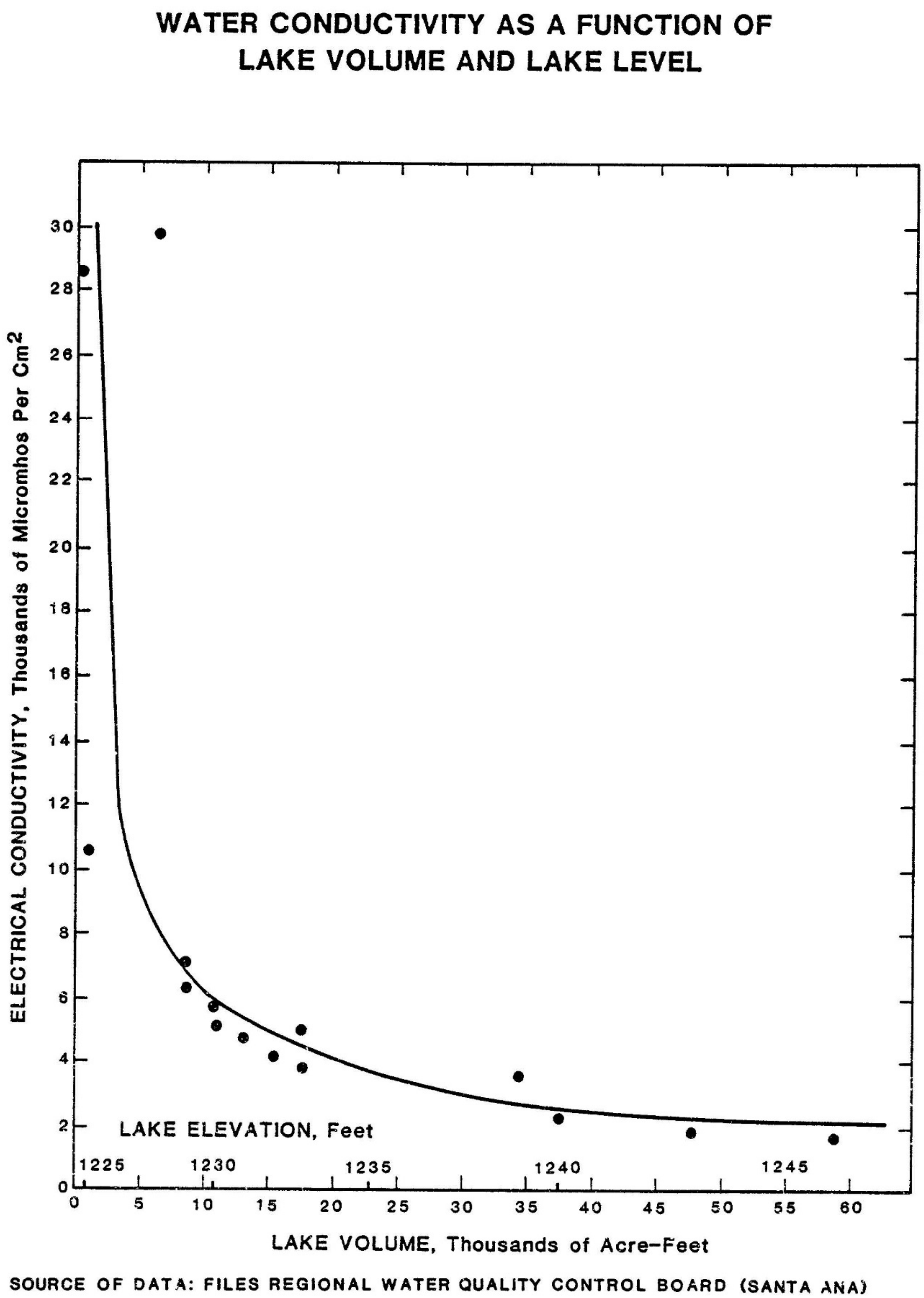


Figure 2-14. Relationship Between Electrical Conductivity (EC) and Lake Elevation in Lake Elsinore (from Figure 2-4 in Engineering-Science [1984]) (Note: TDS equals approximately 0.64 * EC)

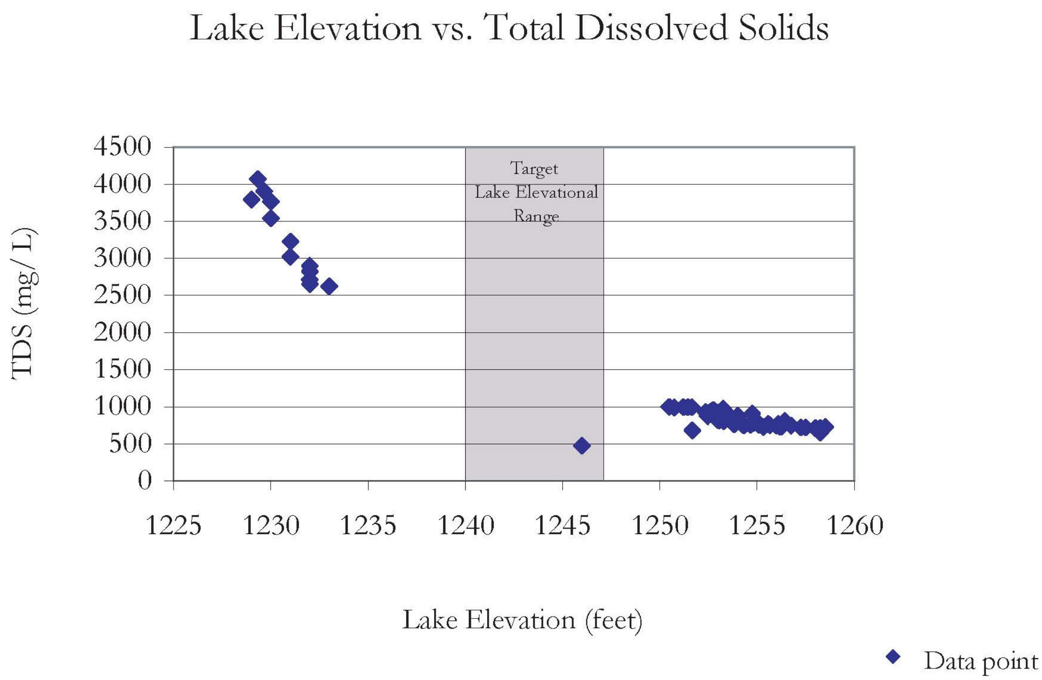


Figure 2-15. Relationship Between TDS (mg/L) and Lake Elevation (ft) in Lake Elsinore (Adapted from LESJWA [2005a] based on data from Lake Elsinore Management Authority [1996]) (Note: "Target Lake Elevational Range" based on analysis in LESJWA [2005a] for implementation of a fish recovery program)

The "die-off" of resident stock in the lake is a well-known phenomenon with the history of such fish kills well-documented as they have been occurring for a long time even prior to development (LESJWA 2005a):

> *"Fish kills have occurred periodically in Lake Elsinore for millennia due to adverse environmental conditions. Even under pristine conditions the lake would shrink and occasionally dry up completely. During these periods the fish fauna would be lost, only to recolonize the lake during more favorable hydrological conditions. Historically, fish kills have been reported at the lake even prior to any significant upstream diversions of water (principally the completion of Railroad Canyon Dam in 1928)."*

Figure 2-16. Algal Bloom in Lake Elsinore, 2016 (Source: Wood Environment and Infrastructure Solutions, Inc.)

Table 2-10 summarizes the documented history of fish kills in Lake Elsinore. This information was largely developed by LESJWA (2005a) and supplemented from other sources where information was available. LESJWA (2005a) has noted that fish kills may occur under a variety of conditions, including when the lake elevation is high. For example, in those instances where lake elevation was known, of 21 fish kills eight or 38% of them occurred when the lake was equal to or greater than 1,240 ft. The remainder occurred when the lake level was low or nearly dry. Anecdotal information from the time of a fish kill illustrates how significant the event can be. For example, in an October 1948 letter from the State Department of Fish and Game to U.S. Department of Interior (as documented in EDAW (1974) (**Figure 2-17**):

> *"…fish losses in Lake Elsinore have occurred to a varying degree almost annually for the past ten to fifteen years…once a good fishing lake containing bass, bluegill and catfish, the Lake now only contains a large population of carp…in 1933, 1940, 1941 and again this year, heavy fish losses occurred…the recent kill August 31-September 2 consisted of the loss of approximately 300-500 tons of carp…losses nothing unusual…causes might be summarized as follows: 1) increased alkalinity and mineral concentration…2) over abundance of plankton algae coupled with high water temperature results in oxygen deficiency…"*

Finally, when the lake dried up in 1951, Fortnight: The Magazine of California (1954) provided additional biological descriptions of lake conditions in association with the lake drying up in 1951:

> *"In 1951, there was another mass death of fish, followed by another horrible stench and another back-breaking hauling away. Then the Lake performed what was in some ways its most diabolical act of all. With the fish dead, clouds of gnats began to descend upon the town…A light trap set up by one of the researches (sic) caught an announced 56,000 gnats in an hour and tests of the lake bottom showed scads of larvae, representing still more generations of the winged pests. (In normal years the larvae would have been eaten by the fish)."*

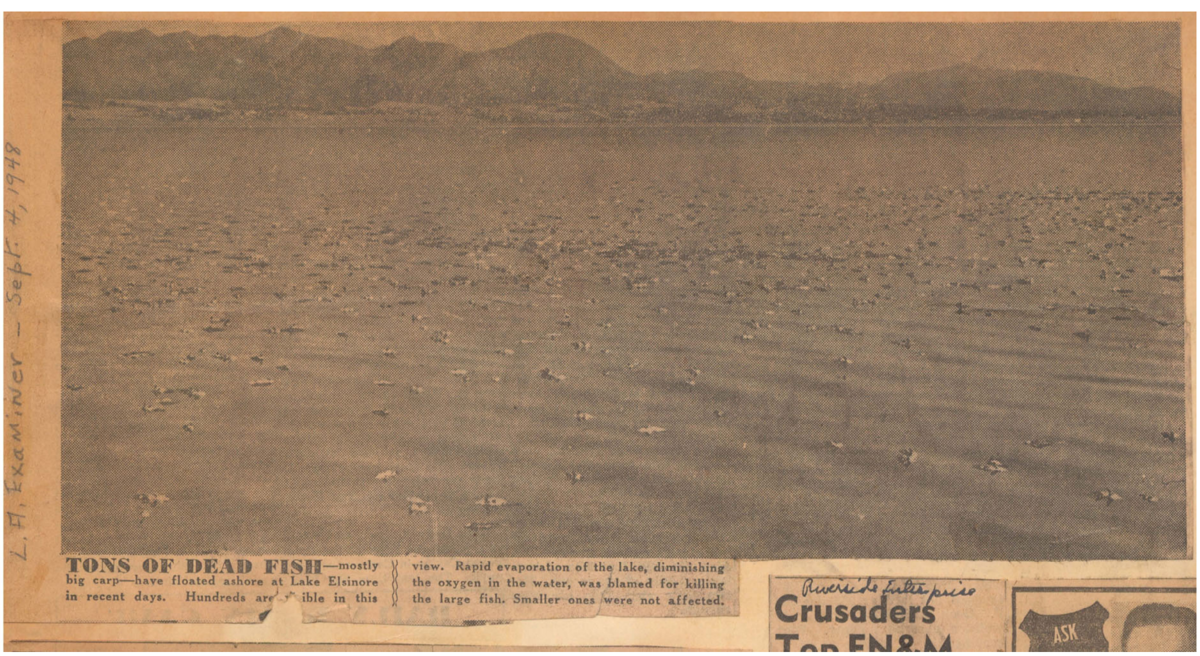


Figure 2-17. Illustration of 1948 Fish Kill in Lake Elsinore (Source: Lake Elsinore Naval School).

Table 2-10. Summary of Known Fish Kills in Lake Elsinore, 1883-2018

Date	Dissolved Oxygen (mg/L)		Duration of Fish Kill (days)	Lake Water Surface Elevation (ft)	Lake Volume (AF)	Fish Species	Estimated Weight of Fish (tons)	Comments	Reference
	Initial	Final							
1883**								"fish died in the lake and their stench filled the air"	Hudson (1978)
Circa 1886[1]						Arroyo chub			Couch (1952)
Circa 1898								Attributed to a sulfurous gas released from the lake bottom	Couch (1952)
January 1906									Couch (1952)
1915				~1,243	48,200	Black Bass		Low lake level and "salty" water	Couch (1952)
1917[2]				~1,258	116,000			High water temperature	Couch (1952)
September 13, 1927			10	~1,253	90,000				Elsinore Valley News (September 22, 1927)
April 7, 1933*			6	~1,242	45,000	Mostly carp and a few "minnows," i.e., arroyo chub		Lake turnover[3]: chlorides = 1,540 mg/L, TDS = 4,386 mg/L, dissolved oxygen at the surface at the shoreline at 25% saturation on April 13. High algal density. *Oscillatoria* about 30% of phytoplankton sample.	Elsinore Leader Press (May 4, 1933)
1936				1,227	5,400			Tons of algae reported	Bovee (1989)
August 15, 1940*				1,252	85,500	Arroyo chub; Small/young fish	Heavy Kill[3]	Sudden change in the mineral content of the lake	Bovee (1989); Couch (1952)
1941							Heavy Kill		See table note 4
August 27, 1948*[5]			6	1,232	16,200	Carp	300-500[6]	(1) Increased alkalinity and mineral concentrations; (2) Over-abundance of algae coupled with high water	Couch (1952); Hudson (1978); Bovee (1989)

Table 2-10. Summary of Known Fish Kills in Lake Elsinore, 1883-2018

Date	Dissolved Oxygen (mg/L)		Duration of Fish Kill (days)	Lake Water Surface Elevation (ft)	Lake Volume (AF)	Fish Species	Estimated Weight of Fish (tons)	Comments	Reference
	Initial	Final							
								temperature resulting in oxygen reduction[7]	
1950*				1,230	12,000			No fish in the lake[8]	Bovee (1989)
1954				1,223	0			Lake dried up[9]	Bovee (1989)
1966*				1,229	9,600		Heavy kill[3]	Dissolved oxygen reduction	Bovee (1989)
August 31, 1972*			8	1,235	24,000	Primarily threadfin shad	800	Water temperatures ranged from 27.2 to 29.5 Celsius (°C)	Bovee (1989)
August 6, 1975			~2	1,230	12,000		Dump Truck Loads		Bovee (1989)
Fall 1976				1,229	9,600		41		Bovee (1989)
August 1987				1,240	39,000	Threadfin shad	Minor kill[3]		Bovee (1989)
October 1988				1,233	18,700		Minor; 300 lbs		Bovee (1989)
July/August 1990	6	0	60[10]	1,237	28,400		1500		MWH (2002)
1991								"120 thousand tons of fish killed by algae"	Press Enterprise
July/August 1992	6.5	2	60[11]	1,231	14,000				MWH (2002)
June/July 1995	9	3	60[12]	1,254	95,000	Various species	200	Low dissolved oxygen	North County Times (August 22, 2002); MWH (2002)
1996								"in August, smaller fish die off"	Press Enterprise

Table 2-10. Summary of Known Fish Kills in Lake Elsinore, 1883-2018

Date	Dissolved Oxygen (mg/L)		Duration of Fish Kill (days)	Lake Water Surface Elevation (ft)	Lake Volume (AF)	Fish Species	Estimated Weight of Fish (tons)	Comments	Reference
	Initial	Final							
1997								On April, 7 tons of shad died of oxygen depletion	Press Enterprise
November 11, 1998*				~1,250	76,000	Threadfin Shad	240	Migratory birds stressing high density shad population during period of low dissolved oxygen	Kilroy (1998)
August 2001				1,239	35,000	Carp			LESWA (2005a)
August 22, 2002			2	1,236		Primarily Carp	50	Low dissolved oxygen	North County Times (August 24, 2002)
November 28, 2006				1,236		Threadfin Shad, small minnows		"significant die-off (~200,000) of quite small Threadfin Shad minnows."	Kilroy (2010)
July 26, 2009				1.241		Threadfin Shad and other unidentified larger fish	116.33	"Staff estimates a loss of approximately two large fish per surface acre and 2-3% of the threadfin shad (baitfish) population;" equates to ~1,000,000 shad and 6,000 larger fish	Kilroy (2010) & City of Lake Elsinore (2018)
August 14-16, 2009				1,240		Threadfin Shad		"Staff estimates a loss of more than 10 million minnows (baitfish) died to due to low oxygen levels in the Lake. Threadfin shad are the most oxygen sensitive fish in the Lake and have grossly overpopulated the Lake."	Kilroy (2010) & City of Lake Elsinore (2018)
2010						Threadfin Shad	22.86		City of Lake Elsinore (2018)
2012						Threadfin Shad	5.22		City of Lake Elsinore (2018)
August 4-10, 2015				1,236			17.44		City of Lake Elsinore (2018)

Table 2-10. Summary of Known Fish Kills in Lake Elsinore, 1883-2018

Date	Dissolved Oxygen (mg/L)		Duration of Fish Kill (days)	Lake Water Surface Elevation (ft)	Lake Volume (AF)	Fish Species	Estimated Weight of Fish (tons)	Comments	Reference
	Initial	Final							
August 17-19, 2015						Threadfin Shad mostly; some Carp and other sport fish	5.87		City of Lake Elsinore (2018)
August 3-5, 2017						Carp and Threadfin Shad			City of Lake Elsinore (2018)
May 28-30, 2018						Mostly Threadfin Shad and some Carp			City of Lake Elsinore (2018)

[1] Based on the memory of Jessie Stephens. Unreliable record.

[2] Letter from James Gyger, Fish and Game warden, written in 1919 and published in the Lake Elsinore Valley Press on June 13, 1919. States: "About every 15 or 20 years it [Lake Elsinore] gets so low that everything in it dies."

[3] Definition or description of what constitutes a minor or heavy kill is not provided in LESJWA (2005a)

[4] Fish kill observed to have begun over the deep part of the lake.

[5] Letter from the CDFG to the U.S. Department of the Interior states "… fish losses in Lake Elsinore have occurred to a varying degree almost annually for the past 10-15 years." Quoted by Bovee (1989).

[6] Estimated at 1,000 tons in Hudson (1978).

[7] Letter from the CDFG to the U.S. Department of the Interior quoted by Bovee (1989).

[8] The lake dried up in 1951. Probably few to no fish in the lake since the fish kill in August/September 1948.

[9] Lake partially refilled in 1952 to about 11 feet deep.

[10] Fish mortality occurred over this period of time.

[11] Fish mortality occurred over this period of time.

[12] Fish mortality occurred over this period of time.

* In both LESJWA (2005a) and Santa Ana Water Board Staff Report (Santa Ana Water Board 2004).

** In Hudson (1978)

2.2.2.5 Recent Water Quality Findings

A significant body of monitoring data has been collected for Lake Elsinore since the start of the development of the original TMDL in May 2000. These data are reviewed here with the goal of developing statistical relationships to understand the dominant drivers of water quality (especially chlorophyll-*a* concentrations). Importantly, this time period includes periods of pronounced drought, resulting in increased salinities and lower lake levels, as well as El Nino events with large freshwater inputs that are generally elevated in dissolved nutrients. Water samples were routinely collected for nutrient analysis, chlorophyll-*a*, and a number of other associated measures including biological and chemical oxygen demand (BOD and COD), total and dissolved organic carbon (TOC and DOC), and TDS at one to three sampling stations, LEE1, LEE2, and LEE3 located along a central axis in the center of the lake (**Figure 2-18**). The highest frequency of monitoring occurred at the most central location, LEE2.

Between 2001 and 2012 monitoring was typically performed at a weekly or bi-weekly frequency during the summer months (June, July, August, and September), and bi-weekly or monthly from October through May. Water samples for nutrients and other associated measures generally were collected as an integrated composite of the water column. Chlorophyll-*a* has frequently been measured as an integrated surface sample representative of the top 2-m of the water column. Physical parameters such as temperature, DO, pH, conductivity, and water clarity were also measured at three-ft intervals at the time of sample collection.

Between 2000 and 2012 a number of other special studies were performed to gather nutrient-related water quality data at a number of other locations to enhance understanding of spatial variability throughout the lake, assess any changes in water quality related to amending the lake with reclaimed water and groundwater, and to assess the effectiveness of the aeration/ mixing system (Anderson and Lawson 2005; Veiga Nascimento and Anderson 2004; Anderson 2006; Anderson 2008a; Anderson 2010; Santa Ana Water Board 2007b; and Horne 2009). A break in monitoring occurred between 2012 and 2015 to reallocate resources for the implementation of water quality BMPs in both Lake Elsinore and Canyon Lake, but monitoring was reinitiated in 2015 (**Figure 2-19**).

Currently, monitoring and analysis of nutrients and chlorophyll-*a* occurs monthly during the summer months of July, August, and September, and bi-monthly between September and July. Beginning in July 2016, the monitoring frequency of Lake Elsinore was increased to bi-weekly during the summer months of July, August, and September. The increased monitoring in Lake Elsinore during the summer months was performed to provide more data points during this time-frame due to the current TMDL compliance target for chlorophyll-*a*, which is based on a summer average for this lake, as opposed to an annual average in Canyon Lake. Nutrients and TDS are analyzed in a single surface to bottom integrated sample as described in the Work Plan for the current TMDL monitoring program (Haley and Aldrich 2016). Chlorophyll-*a* is measured in both an integrated sample of the entire water column, as well as a surface sample representative of the top 2-m of the water column. Depth profiles of temperature, DO, pH, conductivity, and water clarity are also measured at 1-m intervals on the day of sampling for nutrients. For the first time, these measures are now being performed twice during the day (am and pm) to assess diel variability associated with photosynthesis and respiration cycles of algae which can substantially alter DO concentrations over short periods of time.

Figure 2-18. Location of Lake Elsinore Sample Locations (LE01 [LEE1]; LE02 [LEE2]; and LE03 [LEE3]).

Figure 2-19. Lake Elsinore, September 2016 (Source: Wood Environment and Infrastructure Solutions, Inc.)

In the following subsections data are presented for Site LEE2 given its central location and the greatest history of data at this site. In addition, spatial differences on any given day for nutrients are generally limited based on a review of past monitoring data. Note that supporting water quality analyses presented in tables and graphs within this section for Lake Elsinore focus on the most recent available data collected in a consistent manner over the past 14-16 years. These data are now available in a single California Environmental Data Exchange Network (CEDEN)-compatible database and has been collated and validated through a third party prior to analysis. Older data are referenced where applicable, but are not presented graphically. All values presented in the associated figures represent water column averages derived from depth-integrated water column samples, with the exception of DO which is plotted as both a depth-integrated value and discreet values measured at 1-m from the bottom. Data are also presented in relation to the current 2004 TMDL compliance metrics for comparison purposes.

Nutrients (Phosphorus and Nitrogen)

The current TMDL includes a numeric target for TP in Lake Elsinore of 0.1 mg/L to be achieved by 2020 as an annual average concentration (see Table 2-2). The TMDL numeric target for TN in Lake Elsinore is 0.75 mg/L, also to be achieved by 2020 as an annual average concentration (see Table 2-2).

Phosphorus exists in the water in either a dissolved phase or a particulate phase. Dissolved inorganic phosphate (orthophosphate or Ortho-P) is the soluble reactive form of phosphorous that is readily available to algae (bioavailable) and under certain conditions it can stimulate excess algae growth. Both TP and Ortho-P are routinely analyzed in water quality data collected from Lake Elsinore.

TP and Ortho-P concentration data from 1992 through 1997 are shown graphically in the 2000 Nutrient TMDL Problem Statement for Lake Elsinore (Santa Ana Water Board 2000). Prior to January 1993, orthophosphate concentrations in Lake Elsinore were below the detection limit (0.05 mg/L). In January 1993, Canyon Lake overflowed, which altered the phosphorus concentrations in Lake Elsinore. After the Canyon Lake overflow, both Ortho-P and TP increased dramatically: Ortho-P increased from non-detect to 0.5 mg/L, and TP increased from 0.5 mg/L to 1.2 mg/L. The increase in phosphorus more than likely came from the Canyon Lake overflows to Lake Elsinore, which comprised a higher Ortho-P fraction than in Lake Elsinore prior to the overflow.

Phosphorus concentrations from 2002 to present have also exhibited strong seasonal and inter-annual variations as well. **Figure 2-20** shows a graphical summary of available TP data from 2002 to 2016, representing depth-integrated water column average concentrations. **Table 2-11** provides the associated range, average, and median values of TP from 2002 to present. For the summaries that follow, only TP is presented for direct comparability to Basin Plan objectives and the existing TMDL targets. In general, a majority of the TP is in the organic form and trends between the two are tightly coupled. Note that available water quality data between 1997 and 2002 is limited and inconsistent, and thus not included as a part of the evaluations in this document.

Overall, TP has averaged between 0.1 and 0.4 mg/L in Lake Elsinore between 2002 and 2016 with the majority of observations below 0.6 mg/L and no visually discernable long-term trend. Low values of < 0.1 mg/L have been reported on a few dates (October 2002, April 2008, and May 2012). Values increased to > 0.5 mg/L in 2003-2004. Concentrations decreased beginning in 2005 and have more recently ranged from about 0.2 to 0.3 mg/L with the exception of one large spike to 0.9 mg/L in April 2011 and a spike to 0.5 mg/L in June of the same year. Current values over monitoring periods in July 2015 to August 2016 have ranged from 0.3 to 0.6 mg/L (Figure 2-20).

All forms of nitrogen were analyzed in the Clean Lakes Study and the subsequent TMDL compliance monitoring efforts: nitrate, nitrite, ammonium, and total kjeldahl nitrogen (TKN). TN is calculated as the sum of TKN, nitrate, and nitrite. Like phosphorus, nitrogen concentrations also exhibit strong seasonal and inter-annual variations as well.

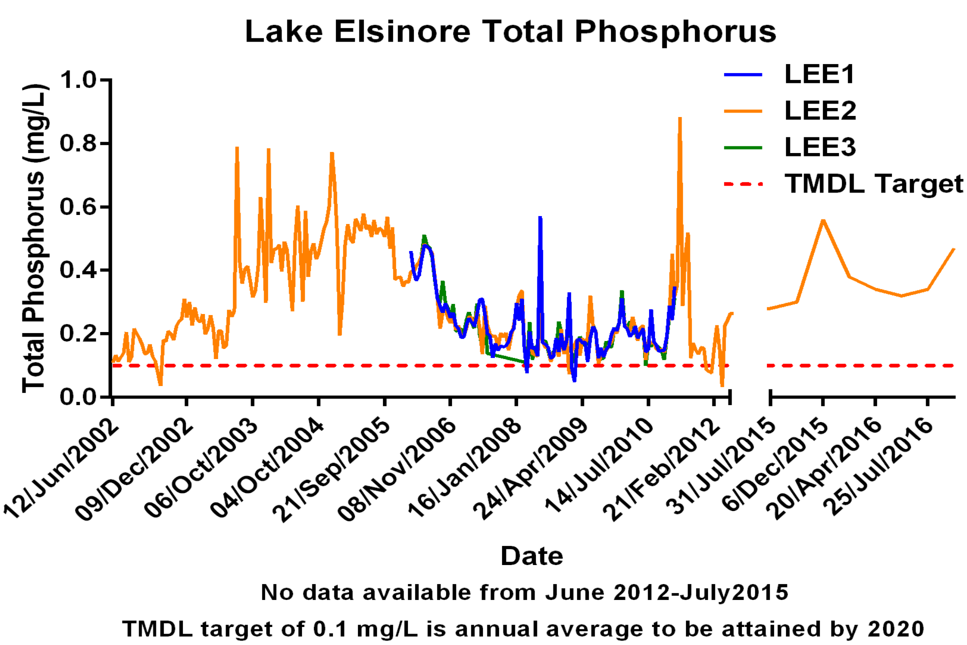
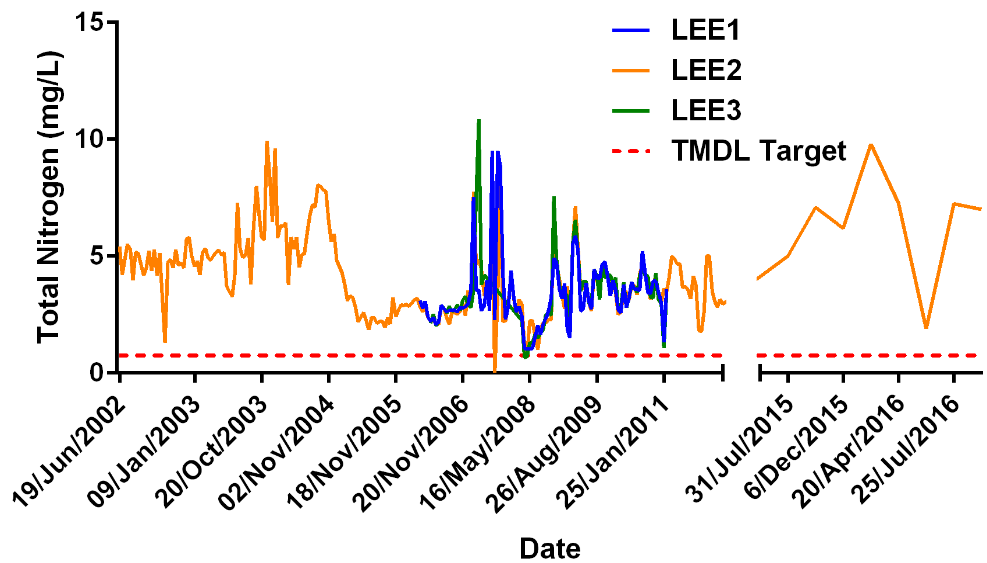


Figure 2-20. Depth-Integrated Average Total Phosphorus Concentrations in Lake Elsinore: 2002-2016 (Note discontinuous data record on x-axis)

Table 2-11. Historical Dissolved Oxygen, Nutrient, Chlorophyll-*a*, and TDS Summary for Lake Elsinore TMDL Compliance Monitoring between 2002 and 2016 (N = Number of Samples)

Parameter	Date Type	2002-2012					2015-2016				
		N	Min	Max	Mean	Median	N	Min	Max	Mean	Median
Dissolved Oxygen (mg/L)	Depth-Integrated	113	2.0	11.7	6.3	6.1	7 to 8	3.0	11.1	5.0	4.1
	Bottom 1-m	113	0.02	10.5	4.2	4.2		0.65	11.0	3.3	2.4
Chlorophyll-*a* (µg/L)	Depth-Integrated	178	6.2	440	137	116		172	326	236	250
Total Nitrogen (mg/L)	Depth-Integrated	226	0	9.9	4.1	3.8		5.0	9.8	6.4	7.1
Total Phosphorus (mg/L)	Depth-Integrated	235	0.03	0.89	0.29	0.23		0.28	0.56	0.37	0.34
Total Ammonia (mg/L)	Depth-Integrated	187	< 0.05	1.52	0.18	0.11		0.05	0.71	0.21	0.05
Un-ionized Ammonia (mg/L)	Depth-Integrated	187	0	0.28	0.04	0.02		0.01	0.26	0.05	0.02
TDS (mg/L)	Depth-Integrated	188	427	2,240	1,376	1,433		2,600	3,500	3,000	3,000

In Lake Elsinore, the major form of nitrogen exists as organic nitrogen. During the Clean Lakes Study, nitrogen forms were reported separately, but a majority of the TN was captured by TKN with generally very low concentrations of nitrate and nitrite in Lake Elsinore. The concentration of TKN was as high as 13 mg/L prior to the Canyon Lake overflow in January 1993. After the overflow, nitrogen concentrations dropped dramatically to 2 mg/L. There was an increase in TKN concentration (mostly the organic nitrogen) in October 1993, up to 6 mg/L, possibly due to an algal bloom. There are no data for TKN concentrations in 1994; analyses resumed in 1995 and the TKN concentrations remained stable from 1995 through 1997 at approximately 3 mg/L. **Figure 2-21** shows a graphical summary of available TN data from 2002 to 2016. Table 2-11 provides the associated range, average, and median values of TN from 2002 to present. Between 2002 and 2012, TN concentrations were generally between 2 and 6 mg/L with an average of approximately 4.0 mg/L. As with phosphorus, there appears to be no visually discernable long-term trend in nitrogen concentrations. There have been several spikes of TN greater than 8.0 mg/L in November 2003, January 2004, and August and October of 2004, and most recently in February 2016. The near record runoff in the winter of 2005 dramatically reduced TN concentrations in the lake. Within a period of a couple months TN concentrations declined from 8 mg/L to almost 2 mg/L. The lowest concentration of TN recorded in Lake Elsinore since 2002 was 0.8 mg/L in May 2008.



No data available from June 2012-July2015

TMDL target of 0.75 mg/L is annual average to be attained by 2020

Figure 2-21. Depth Integrated Average Total Nitrogen Concentrations in Lake Elsinore: 2002-2016 (Note discontinuous data record on x-axis)

An evaluation of the ratio of TN to TP (TN:TP, i.e., Redfield Ratio) can be used to determine whether the limiting nutrient is nitrogen or phosphorus with regard to algal productivity. In general, a TN:TP ratio of < 10 indicates a lake with productivity limited by nitrogen, while a TN:TP ratio > 20 indicates a lake with productivity limited due to phosphorus (EPA 1999a). Once the limiting nutrient is identified, specific control measures targeted at that nutrient can be identified and implemented. A plot of the ratio of TN to TP from 1992 to 1997 in Lake Elsinore is provided in Santa Ana Water Board (2000). Phosphorus was the limiting nutrient from 1992 to the 1993 before the overflow of Canyon Lake. After Canyon Lake overflowed, nitrogen became the limiting nutrient in Lake Elsinore. From 1995 to 1997, phosphorus became the limiting nutrient once again. The TN:TP ratio has varied strongly over the past decade (**Figure 2-22**). Ratios suggesting phosphorus-limitation are typical, as well as intervals in 2005-2006 and short periods in 2008 and 2011 where nitrogen-limitations might be inferred based on a TN:TP ratio of < 10. The shift to nitrogen limitation following wetter hydrologic years is not surprising given that TN:TP ratios in watershed runoff are typically less than 10.

Despite varying TN:TP ratios, the overall availability of nutrients, based on concentration, has generally been sufficiently high that light or other limitations are thought to be more important in regulating algal productivity in the lake. For example, periods of low dissolved silicon are traditionally seen during the spring, likely serving as a limitation to diatom production.

It is apparent from evaluation of the data during both wet and dry conditions, that both nitrogen and phosphorus can be critical nutrients with regards to algal growth in Lake Elsinore. Because the limiting nutrient can vary depending on the hydrologic conditions, the current TMDL address both nutrients.

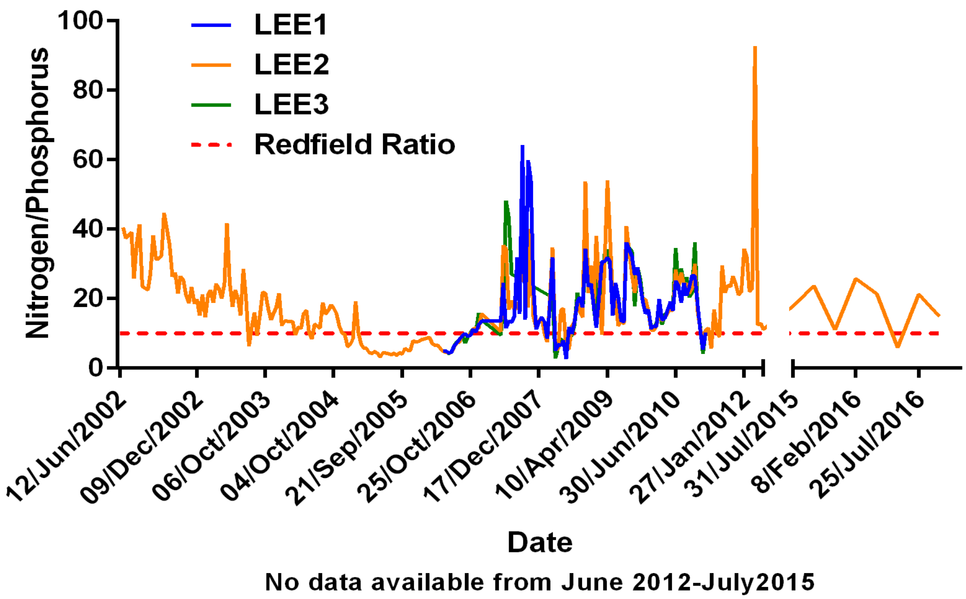


Figure 2-22. Nitrogen to Phosphorus Ratios in Lake Elsinore: 2002-2016 (Note discontinuous data record on x-axis)

Ammonia

Ammonia is a toxic component of the nitrogen cycle, formed and released from the breakdown of organic material under anoxic conditions. Acute and chronic objectives for total ammonia are derived based on the pH and temperature of the lake at the time of sampling (see Table 2-1). These parameters, particularly pH, drive the fraction of un-ionized ammonia, which is the most toxic form of this compound. As pH increases, the fraction of un-ionized ammonia increases.

Concentrations of ammonia were not reported in the studies summarized in the 2000 TMDL Problem Statement that included results from the 1975 EPA study and monitoring by Black and Veatch between 1992 and 1997 (Santa Ana Water Board 2000). However, results are available and have been summarized for studies from 2002 to 2016 (**Figures 2-23** and **2-24**) representing depth-integrated water column average concentrations. Table 2-11 provides the associated range, average, and median values of total and un-ionized ammonia from 2002 to 2016.

Levels of total ammonia are generally very low in Lake Elsinore with a range from less than 0.05 mg/L to 1.5 mg/L and a mean value of 0.18 mg/L between 2002 and 2012. The mean value for total ammonia in 2015 was 0.08 mg/L, ranging from 0.05 to 0.13 mg/L. Associated measures of un-ionized ammonia throughout the 2002 to 2016 period are also generally very low despite the elevated pH observed in Lake Elsinore. Values range from less than detection to 0.28 mg/L, with an average of 0.02 to 0.04 mg/L which is well below that expected to cause toxic effects to species found in Lake Elsinore as described further in Section 2.3.3 below. These results indicate consistent compliance with the current TMDL target for ammonia based on the EPA 1999 criterion (EPA 1999b), as well as updated more stringent values developed by EPA in 2013 (EPA 2013). Due to its acute toxicity when present, and the potential for rapid spikes in ammonia following plankton blooms under certain conditions, continued monitoring of ammonia is still recommended in Lake Elsinore.

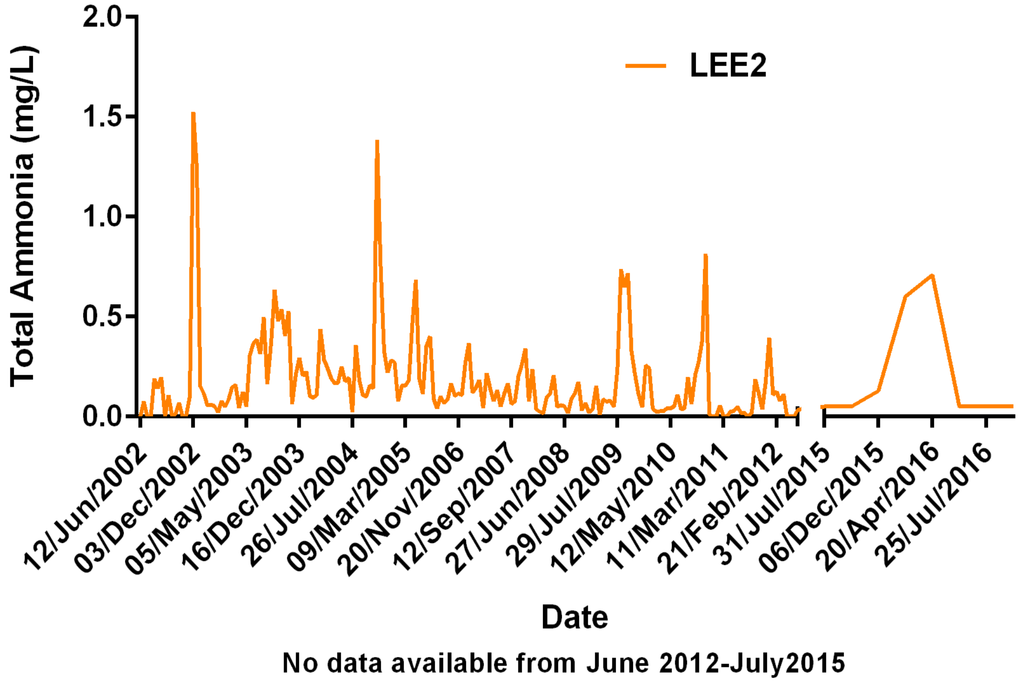


Figure 2-23. Depth-Integrated Average Total Ammonia Concentrations in Lake Elsinore: 2002-2016 (Note discontinuous data record on x-axis)

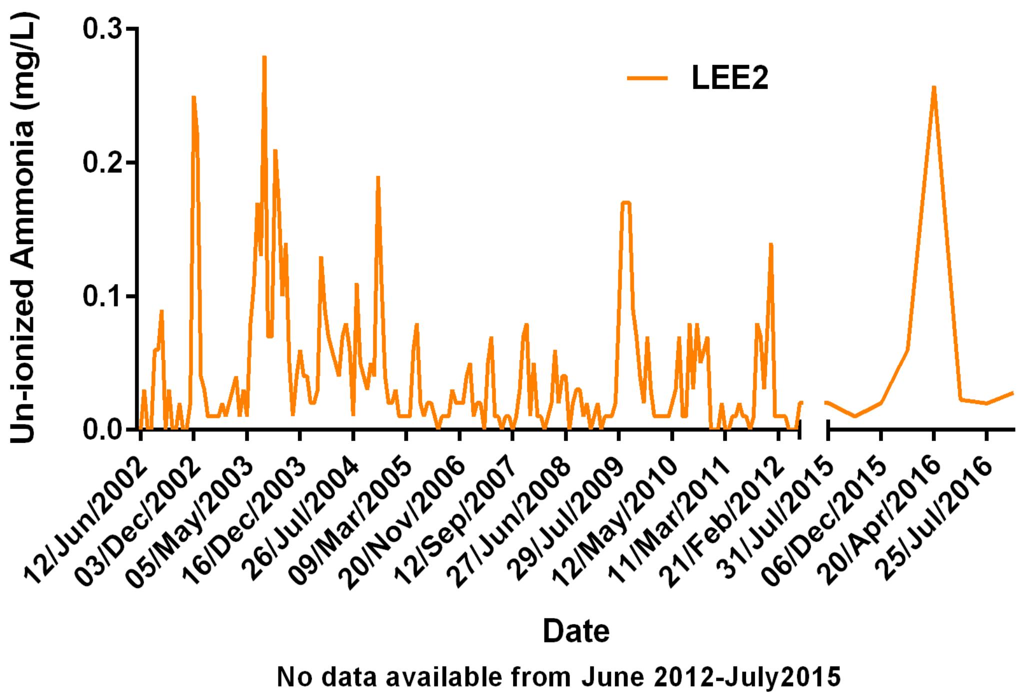


Figure 2-24. Depth-Integrated Average Un-ionized Ammonia Concentrations in Lake Elsinore: 2002-2016 (Note discontinuous data record on x-axis)

Chlorophyll-a

Chlorophyll-*a* is an indicator for algal biomass and eutrophication status. In general, a lake with an average chlorophyll-*a* concentration of over 10 µg/L is considered eutrophic (EPA 1974). The current TMDL compliance threshold target for chlorophyll-*a* in Lake Elsinore is a summer average value of < 40 µg/L in 2015 and ≤ 25 µg/L in 2020 (see Table 2-2).

In the EPA study performed in 1975 (EPA 1976), chlorophyll-*a* in Lake Elsinore ranged from 42 to 118 µg/L (**Table 2-12**). During the Clean Lakes Study and Lake Elsinore Water Quality Monitoring Program chlorophyll-*a* reached a maximum concentration of 950 µg/L in October 1993. A seasonal pattern was observed between 1995 and 1997, with values ranging from 100 to 624 µg/L between July and November, and concentrations ranging from < 10 to 65 µg/L during December to May.

Table 2-12. EPA 1975 Eutrophic Survey Results of Lake Elsinore*

Sampling Date	Chlorophyll-*a* (µg/L)	Total-P (mg/L)	Ortho-P (mg/L)	Inorganic-N (mg/L)	Secchi Depth (m)
3/10/75	52.1	0.52	0.25	0.08	0.3
6/23/75	41.9	0.47	0.09	0.12	0.2
11/13/75	118	0.37	0.05	0.24	0.3
Mean	**70.6**	**0.45**	**0.13**	**0.15**	**0.3**

* As reported in the Santa Ana Water Board 2000 TMDL Problem Statement for Lake Elsinore (Santa Ana Water Board 2000).

Figure 2-25 shows available chlorophyll-*a* data for TMDL compliance monitoring studies performed from 2002 to 2016. Table 2-11 provides the associated range, average, and median values of chlorophyll-*a* during this same period of time. Values presented in Figure 2-25 and Table 2-11 represent average depth-integrated concentrations. Between 2002 and 2012 chlorophyll-*a* concentrations have ranged from < 10 µg/L in a few samples (June 2006 and January 2007), to values in excess of 300 µg/L in late summer-fall of 2002-2004. Concentrations on average were less than 100 µg/L between 2004 and 2008, with a few spikes greater than 200 µg/L. Concentrations of chlorophyll-*a* have generally been increasing since 2008, corresponding with drier conditions overall. During the three most recent monitoring dates between July and August 2016, chlorophyll-*a* concentrations have ranged from 91 to 326 µg/L, with the greatest concentration measured in July 2015. On average, concentrations of chlorophyll-*a* between 2002 and 2012 were greatest in the fall and winter (172 and 150 µg/L, respectively), compared to 100 µg/L in spring and 117 µg/L in summer. These concentrations are frequently well above the current 2004 TMDL summer average target of 40 mg/L by 2015 and 25 mg/L by 2020.

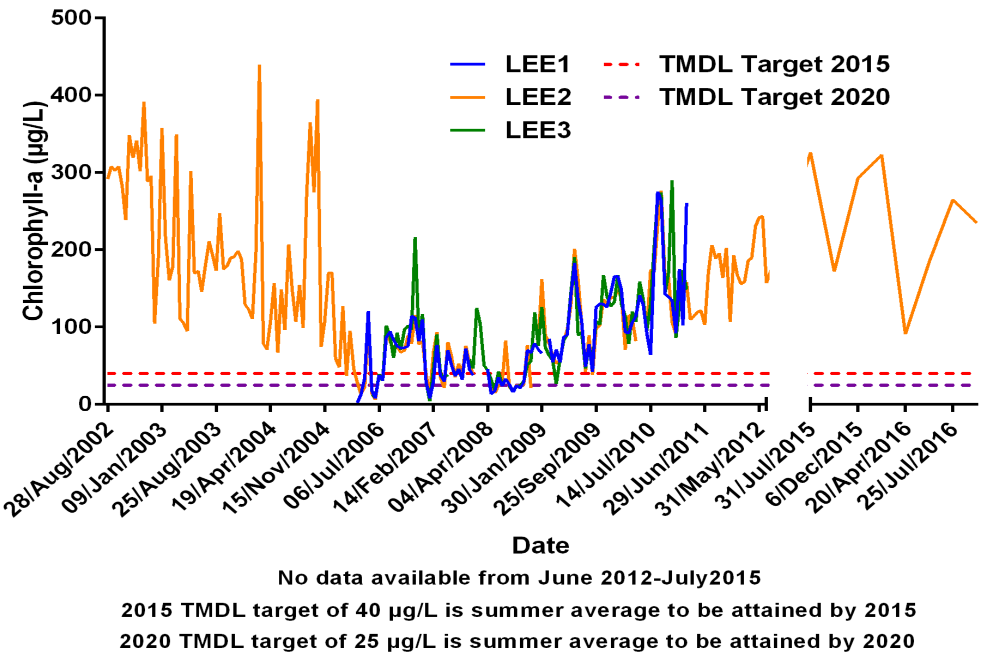


Figure 2-25. Depth-Integrated Average Chlorophyll-*a* Concentrations in Lake Elsinore: 2002-2016 (Note discontinuous data record on x-axis)

Dr. Michael Anderson (UCR) conducted a simple correlation analysis in 2010 to explore statistical relationships between summer-average chlorophyll-*a* concentrations and TP, TN, TN:TP ratio, and TDS (Anderson 2010). A summer average was evaluated to reduce the "noise" associated with seasonal variability in water quality. This simple statistical analysis indicates that TP alone is a poor predictor of summer average chlorophyll-*a* concentrations in the lake, while lake level, salinity and TN each individually account for 49-62% of the variance in observed chlorophyll-*a* levels. Adding a second variable, predictably improved regressions with TDS in combination with TP or TN accounting for 69-72% of the variance in chlorophyll-*a* concentrations. This analysis showed the importance of both phosphorus and nitrogen, as well as other environmental variables, to algae blooms in Lake Elsinore.

Dissolved Oxygen

Santa Ana Water Board (2000) shows the average DO concentrations for the Lake Elsinore stations (measured at the top, middle and bottom of the water column) from March 1994 to June 1996. DO concentrations between 2002 and present are shown graphically in **Figure 2-26** as a top to bottom depth-integrated measure, and in **Figure 2-27** for the portion of the water column approximately 1-m from the bottom of the lake. Table 2-11 provides the associated range, average, and median values from 2002 to present.

Depth-integrated (average) concentrations of DO in Lake Elsinore range from approximately 6.0 to 7.0 mg/L. As with nutrients there is substantial seasonal and inter-annual variability with no discernable visual long-term trend over time for this parameter. Unlike temperature, there often is vertical stratification for this parameter, with typically much lower concentrations near the sediment surface, averaging approximately 4.0 mg/L. This stratification of DO is a natural condition for most lakes. The low DO near the bottom, particularly during the summer months (occasionally at or near zero mg/L), indicates that there is a high oxygen demand from the sediment. Many of the documented historic fish kills have been associated with periods of high temperature and low DO. The elevated DO often recorded at the surface indicates that algae photosynthesis is frequently supersaturating the water with DO.

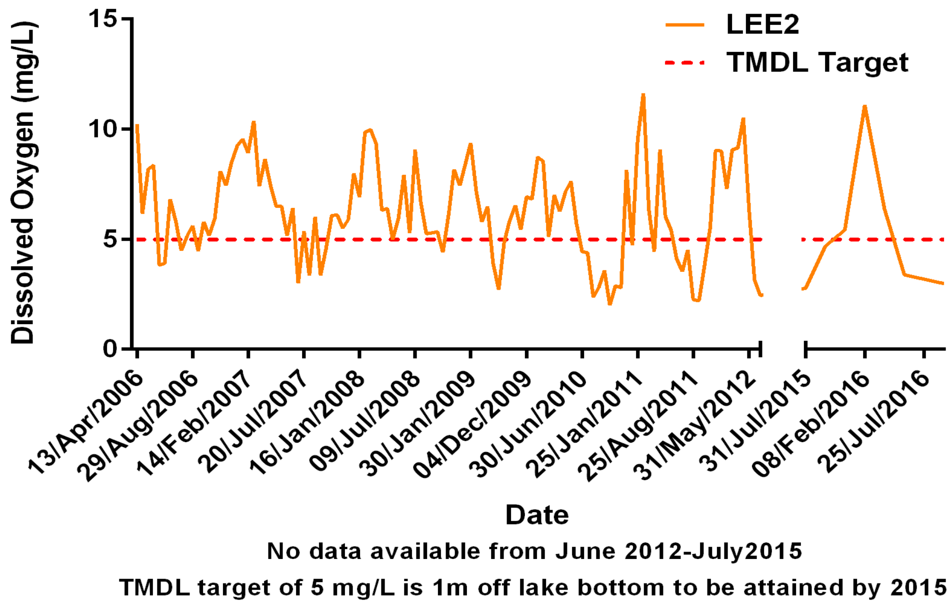


Figure 2-26. Depth-Integrated Average Dissolved Oxygen Concentrations in Lake Elsinore: 2006-2016 (Note discontinuous data record on x-axis)

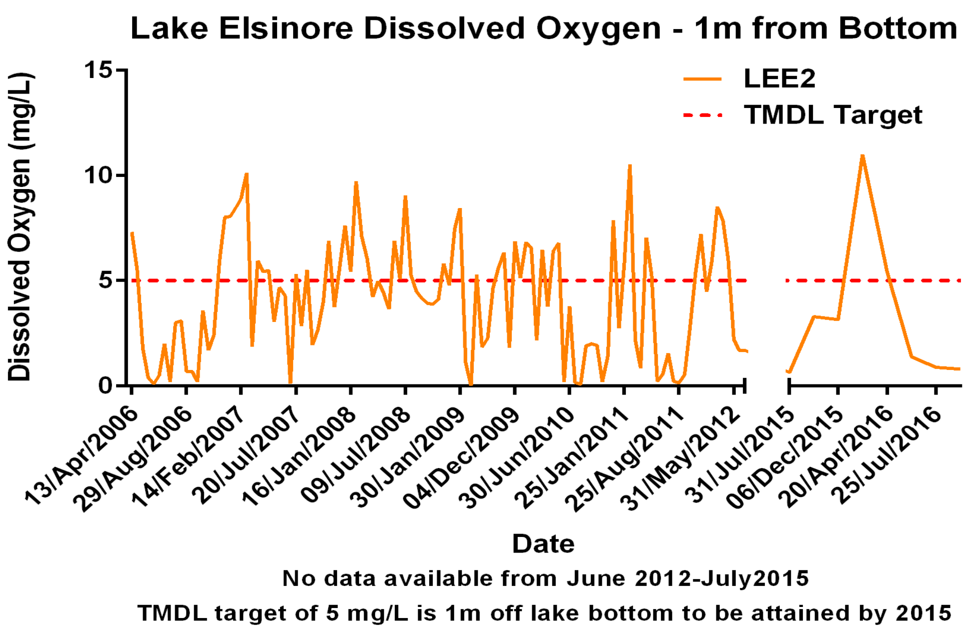


Figure 2-27. Dissolved Oxygen Concentrations (1-m from Bottom) in Lake Elsinore: 2006-2016 (Note discontinuous data record on x-axis)

Total Dissolved Solids

With large evaporative losses from the lake each summer, combined with winters of limited rainfall and periodic El Niño events, TDS concentrations have varied substantially in Lake Elsinore. TDS values were not reported in the studies summarized in the 2000 TMDL Problem Statement that included results from the EPA 1975 study and monitoring by Black and Veatch between 1992 and 1997. However, results are available and have been summarized for studies from 2003 to 2016 (**Figure 2-28**). Table 2-11 provides the associated range, average, and median values of TDS from 2003 to present.

TDS concentrations increased at a nearly exponential rate during the drought of 2000-2002 to values greater than 2,200 mg/L, before decreasing following rainfall and runoff in 2003 to about 1,400 mg/L, and declining further in 2005 to about 800 mg/L as reported by Anderson (2010). TDS concentrations increased from 2006-2007 and remained around 1,600 mg/L into the summer of 2009 (Figure 2-28). In the midst of a severe drought, the most recent concentrations of TDS in the lake have ranged from 2,600 to 3,500 mg/L between July 2015 and August 2016.

Thresholds for TDS and conductivity related to aquatic life are discussed further in Section 2.3.1. Concentrations are below that expected to be problematic for fish species that use the lake, but exceed concentrations at times that will affect invertebrate species, particularly large cladocerans that are more effective at grazing and reducing algae concentrations.

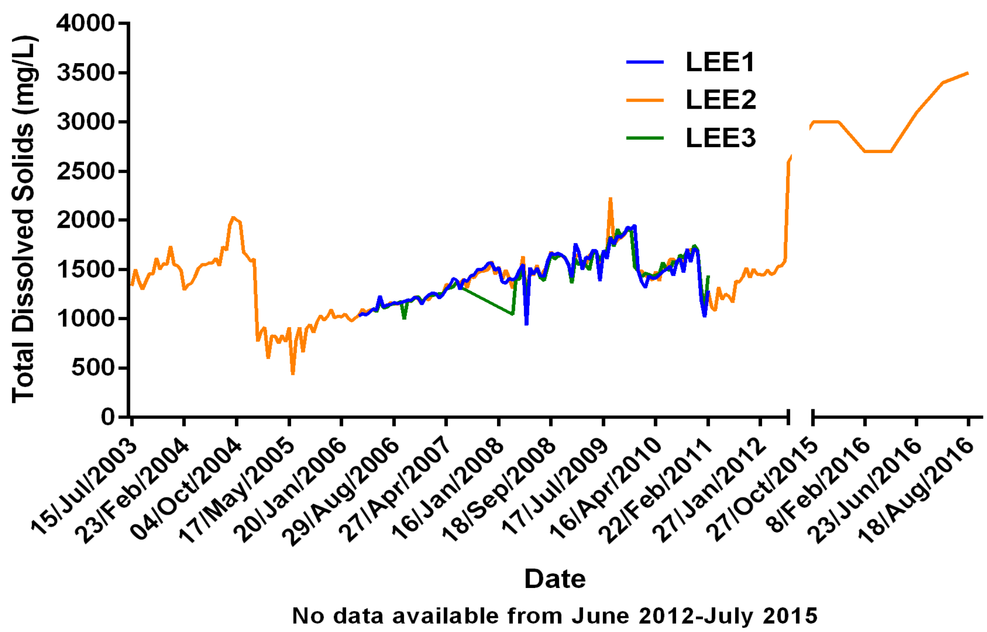


Figure 2-28. Depth-Integrated Average TDS Concentrations in Lake Elsinore: 2003-2016 (Note discontinuous data record on x-axis)

2.2.2.6 Existing Biological Characteristics

The beneficial uses of Lake Elsinore and Canyon Lake include the protection of warmwater biological communities in addition to human use activities. The following subsections summarize our current knowledge of existing fish, invertebrate, and plankton communities with regards to their tolerance to chemical and physical factors of primary concern in the lakes as identified in the TMDL. Identifying biological thresholds of potential concern for desired species found in and relevant to these two lakes can help guide the development of revised numeric targets, validate the appropriateness of current objectives, and where determined appropriate new WQOs. A better understanding of these biological relationships under varying environmental conditions (e.g., elevated TDS) is also important to understand the close connection between these communities and water quality. Furthermore, enhancement of water quality through biological control is possible and has already been applied in Lake Elsinore: removal of carp to reduce nutrient release from their sediment disturbance, and stocking of bass to prey on shiner perch which feeds heavily on large zooplankton, an important grazer of algae. Understanding the preferred and tolerable water quality conditions for species of interest for biological control is important for future success using such approaches. The subsections below provide a summary of the biological characteristics known in Lake Elsinore; supporting figures and tables are provided in Appendix A.

Fish community

Lake Elsinore has a highly variable fishery, with periodic fish kills and intervals of low diversity. The lake has experienced periods of high densities of Common Carp (*Cyprinus carpio*) and a low abundance of sport fish (LESJWA 2005a) as well as periods of increased fish diversity associated with higher densities of sport fish (Anderson 2008b). Historically, the native Arroyo Chub (*Gila orcuttii*) existed in the lake (Couch 1952); however, Lake Elsinore is now a managed fishery with regular stockings of a variety of fish primarily for the purpose of recreational fishing. Stock fish species have included, but are not limited to, Largemouth Bass (*Micropterus salmoides*), Channel Catfish (*Ictalurus punctatus*), Black Crappie (*Pomoxis nigromaculatus*), Bluegill (*Lepomis macrochirus*), and Hybrid Striped Bass (*Morone saxatilis* x *chrysops*).

Other fish known to reside in the lake and considered nuisance species are the Common Carp and Threadfin Shad (*Dorosoma petenense*). The presence of these two nuisance species aggravates the nutrient problem in Lake Elsinore. Carp are benthic feeders that forage for food in the sediment; the foraging activity stirs up the sediment. This action, called "bioturbation," resuspends organic silt and thereby increases the amount of nutrients released to the water column. Shad are zooplanktivores, consuming planktonic cladoceran and copepod species that in turn feed on planktonic algae. This predation by shad reduces the zooplankton population, particularly the large-bodied taxa which are the most efficient feeders, thus reducing the ability of the zooplankton to keep algal blooms in check. Efforts have been made to reduce the populations of these two nuisance species through netting (carp) beginning in 2002 and the stocking of hybrid striped bass which feed on both carp juveniles and shad. The carp removal program in Lake Elsinore has been successful in that it has reduced the percentage of large fish composed of carp from 88.5 percent in 2003 to 15-43 percent in 2008, and reduced the pounds of carp per acre from 533 in 2003 to 62 in 2008. At the same time, large gamefish density increased from 9.5 percent of fish captured in 2003 to 57-85 percent in 2008 (City of Lake Elsinore 2008).

Due to the natural cycle of periodic lake drying events (see Section 2.2.2.2), mass extinction events of the fish populations have occurred. The in-lake fishery has recovered from these drying events primarily as a result of stocking and secondarily by repopulation from upstream sources (i.e., Canyon Lake) during high flow events.

The most recent hydroacoustic survey of the fish population was performed by Dr. Michael Anderson in April 2015 (Anderson 2016b). This survey found the density of fish within the lake to be approximately 56,600 fish per acre (fish/acre), more than double the highest density observed among previous surveys of 27,720 fish/acre in December 2010. The vast majority of the fish observed in April 2015 (95.6%) were < 3.5 centimeters (cm) in length, consistent with threadfin shad, known to be a dominant fish in the lake. Previous surveys of the fish population in Lake Elsinore by Dr. Anderson in April 2008 and March/December 2010 have yielded fairly consistent mean fish length ranging from 4.0 – 4.7 cm (Anderson 2008b). However, the April 2015 survey indicated a dramatic decrease in mean size to 1.8 cm. The number of large fish per acre (> 20 cm) has fluctuated somewhat decreasing from a high of 1,050 in April 2008, to a low of 6 in March 2010, rebounding in December of 2010 to 273, and the most recent survey exhibiting a density of 12 large fish/acre. However, the large fish population have never comprised more than 5.8 percent of the fish community in Lake Elsinore.

There is a long history of fish kills in Lake Elsinore documented back to 1883 (see Table 2-10). The severity of these fish kills has been minor, consisting of 300 pounds (0.15 tons) of fish, to major, consisting of 100,000 tons of fish. Potential historical causes of the kills have been linked to "sulfurous gases", lake level, "salty water", temperature, DO, over-abundance of algae, "sudden change in mineral content", and the lake drying up (also see LESJWA 2005a).

Invertebrate Communities

There are two distinct types of invertebrate populations in Lake Elsinore: a benthic community which resides in or on the lake-bottom sediment, and a pelagic zooplankton community residing in the water column. The primary source of planktonic community studies in Lake Elsinore is research conducted by Dr. Michael Anderson's laboratory at UCR (Veiga Nascimento 2004 and Tobin 2011). These two zooplankton studies demonstrate that while there were some similarities, some large differences were exhibited between both seasons and years. An additional extensive benthic invertebrate study of multiple sites was performed by the Santa Ana Water Board in 2003 (Santa Ana Water Board 2007b).

- *Benthic Invertebrates* - The 2003 Santa Ana Water Board study sampled both the wet (April) and dry (June & October) seasons. Low overall taxa richness was observed across all sample locations and during both sample seasons. None of the stations contained sensitive, pollutant-intolerant taxa. The taxa present were those typically found at disturbed or stressed sites and included: snail (*Physa* sp.), benthic daphnids (water fleas), amphipod (*Hyalella* sp.), chironomid spp. (midges), tubificid spp. (worms), corixid species (water boatmen), and ostracod spp. (seed shrimp).

- *Zooplankton* - The zooplankton community in Lake Elsinore is composed of three primary types of invertebrates: cladocerans (water fleas), copepods, and rotifers. Of these three groups, the algal grazing rates of large bodied cladocerans such as *Daphnia* spp. are considered to be quite high compared to the other zooplankton (Moss 1998).

The zooplankton populations in Lake Elsinore exhibit large seasonal variations in composition and density (Appendix A, Figures A-1 to A-3). Veiga Nascimento (2004) found that with the exception of two rotifer species, the winter of 2003 appeared to be a period of overall reduction in the Lake Elsinore zooplankton community, as all three of the major zooplankton groups were noticeably reduced at this time. During the period of this study (February 2002 to May 2005) the zooplankton populations generally exhibited their peak populations during the late spring and summer. Copepod and rotifer communities were typically on the order of hundreds to thousands of organisms per liter (organisms/L, org/L) at their peaks, while the cladocerans reached approximately 60 org/L during this same time period. Overall, the cladoceran density was substantially lower in comparison to the copepod and rotifer densities. Additionally, those cladocerans that were observed in the lake were small-bodied and did not have efficient filtering capacities. In particular, the important filter feeder *Daphnia exilis* was rarely present.

Tobin (2011) observed a slightly different pattern in 2009 and 2010. The zooplankton community was composed primarily of smaller zooplankters, dominated by rotifers during summer through fall and cyclopoid copepods, which were more prominent during cooler seasons (Appendix A, Figure A-4). Again, the cladoceran community in the lake was very small to nonexistent (Appendix A, Figure A-5) and only found early in 2010 after heavy rainfall caused Canyon Lake to spill over into Lake Elsinore. Estimated zooplankton species richness was greatest in February 2010 with a second, slightly lower peak in October 2010 and the lowest values in June 2010.

Anderson (2016b) sampled Lake Elsinore zooplankton at two locations (San Jacinto River inlet and Site LEE2) in March 2015. Adult copepods dominated the zooplankton community, comprising 83.8 percent of the total individuals counted. Juvenile copepods (nauplii) were the second most abundant group of zooplankton at 14.7 percent of the community. Few rotifers were observed and only comprised 0.8 percent of the entire sample. A single *Daphnia* individual was present in the samples, corresponding to a relative abundance of 0.2 percent within the zooplankton community.

These zooplankton studies demonstrate that while there were some similarities between seasons and years, some large differences were exhibited as well. Anderson (2016b) and Tobin (2011) observed copepod dominance during early spring, while Veiga Nascimento (2004) observed a noticeable reduction in all three groups at this time. The low proportion of *Daphnia* within the zooplankton community in 2015 was consistent with findings from 2003-2004 and 2009-2010 when cladocerans comprised approximately < 0.6% of the community.

Phytoplankton community

As with zooplankton, the primary sources of phytoplankton community data have been studies conducted by Dr. Michael Anderson's UCR laboratory (Veiga Nascimento 2004 and Tobin 2011). Tobin (2011) described the phytoplankton community of Lake Elsinore as a complex assemblage of genera and species that followed a seasonal succession dominated by diatoms in the winter and cyanobacteria during summer months (Appendix A, Figure A-6) – a finding that may be expected for a shallow eutrophic lake.

Veiga Nascimento (2004) noted a similar pattern in 2002 through 2004, the cyanobacteria *Pseudanabaena limnetica* (formerly *Oscillatoria*) was the dominant phytoplankton. Evidence suggests that *Daphnia* growth and reproduction is reduced as concentrations of *P. limnetica* approach 400 cells/mL, even in the presence of adequate food supplies (Infante and Abella 1985).

Similarly, Anderson (2016b) found the cyanobacteria *P. limnetica* to dominate (> 95 percent) the algal community during the spring and summer of 2015. This same species dominated the community during the very poor transparencies and very high chlorophyll-*a* concentrations observed in 2002-2004 (Veiga Nascimento 2004), and was also the dominant phytoplankton during the summer of 2010 (75-90 percent of the biomass in June-August 2010) (Tobin 2011). While the cyanobacteria *P. limnetica* is not known to form cyanotoxins (Dr. Michael Anderson, pers. comm.), three potentially toxic cyanobacteria were present during the 2010 sampling season: *Planktothrix agardhii, Pseudanabaena catenata, Cylindrospermopsis raciborskii* (Tobin 2011).

This seasonal successional pattern of shifting to a population to high levels of cyanobacteria over the summer likely reflect the high nutrient levels and conditions that are characteristic of a terminal basin with long residence times and increasing eutrophication. Similar phytoplankton assemblages (*P. agardhii*, *P. limnetica*, *C. raciborskii*, and *Aphanizomenon* species) and successions (cyanobacteria dominant in summer through fall) to those observed in Lake Elsinore have been observed in three eutrophic lakes (shallow and deep) in Eastern Germany (Nixdorf et al. 2003). A shallow, hypereutrophic lake, Albufera in Spain, also showed a similar composition of genera to Lake Elsinore and some similar seasonal trends (Romo and Miracle 1994). Cyanobacteria tend to develop more in summer when water residence times are longer, while diatoms and green algae are often dominant in winter during periods when water residence times are short (Wetzel 2001).

The State of California has established trigger levels for cyanobacteria to provide guidance for the posting of advisory signs (CCHAB 2016; State Water Board 2016). These trigger levels were developed to protect human and animal (dogs, livestock) health from cyanobacteria harmful algal blooms (see discussion regarding protection of recreation beneficial uses in Section 3.1.2). The Southern California Coastal Water Research Project (SCCWRP) observed elevated concentrations of cyanobacteria and associated toxins in southern California lakes, including Lake Elsinore (Howard et al. 2017; State Water Board and SCCWRP 2016). Based on these findings, monitoring of harmful algal bloom (HAB) toxins was initiated in Lake Elsinore in June 2017 in coordination with the routine LECL TMDL monitoring program (see Section 8).

Concentrations of common HAB toxins were measured in both depth-integrated and surface-grab samples on a monthly basis from June through October 2017. Additional bimonthly samples were collected from December 2017 through April 2018. Findings from this data collection effort showed the following:

- Microcystin was the dominant cyanobacteria found, as it was detected in all months except February 2018 (**Figure 2-29).** Concentrations of microcystins were similar between surface and depth-integrated samples for all sample events except July and October 2017. Surface samples for these two months had levels of microcystins that spiked above the "Danger Tier II" threshold (defined as 20 µg/L in CCHAB 2016). Depth-integrated cyanotoxin levels exceeded the "Caution Trigger Level" in July 2017 and the "Warning Tier I" threshold in October (defined as 0.8 µg/L and 6 µg/L, respectively, in CCHAB 2016). Cyanobacteria have the ability to migrate within the water column, rising to the surface during the day to take advantage of increased sunlight, likely causing the higher concentrations found in surface grabs.

- Anatoxin exceeded the "Caution Action Trigger" (defined as any level of detection per CCHAB 2016) and was periodically present at low levels (< 0.3 µg/L) during summer and fall months in Lake Elsinore.
- Cylindrospermopsin was only detected below trigger levels (defined as < 1 µg/L in CCHAB 2016) in April 2018.
- Nodularin was not detected in any of the samples.

Overall, cyanobacteria monitoring in Lake Elsinore has demonstrated increased toxin concentrations in summer and fall months, with decreased concentrations occurring in winter and early spring. These findings are consistent with previous lake eutrophication studies (Wetzel 2001; Nixdorf et al. 2003) that experience similar seasonal patterns. While this trend is evident, it is not known precisely which factors, or combination of factors, trigger the production of cyanotoxins in algal cells. High nutrient loading, warm temperatures, and low turbulence have historically been associated with increased cyanobacterial blooms, however cyanobacteria do not always produce toxins for reasons that are currently not well understood (de Figueiredo et al. 2004). Shallow water depths, warm temperatures, elevated salinity, and limited flushing associated with a terminal basin like Lake Elsinore are additional characteristics that may favor cyanobacterial blooms (Kosten et al. 2012, Berg and Sutula 2015).

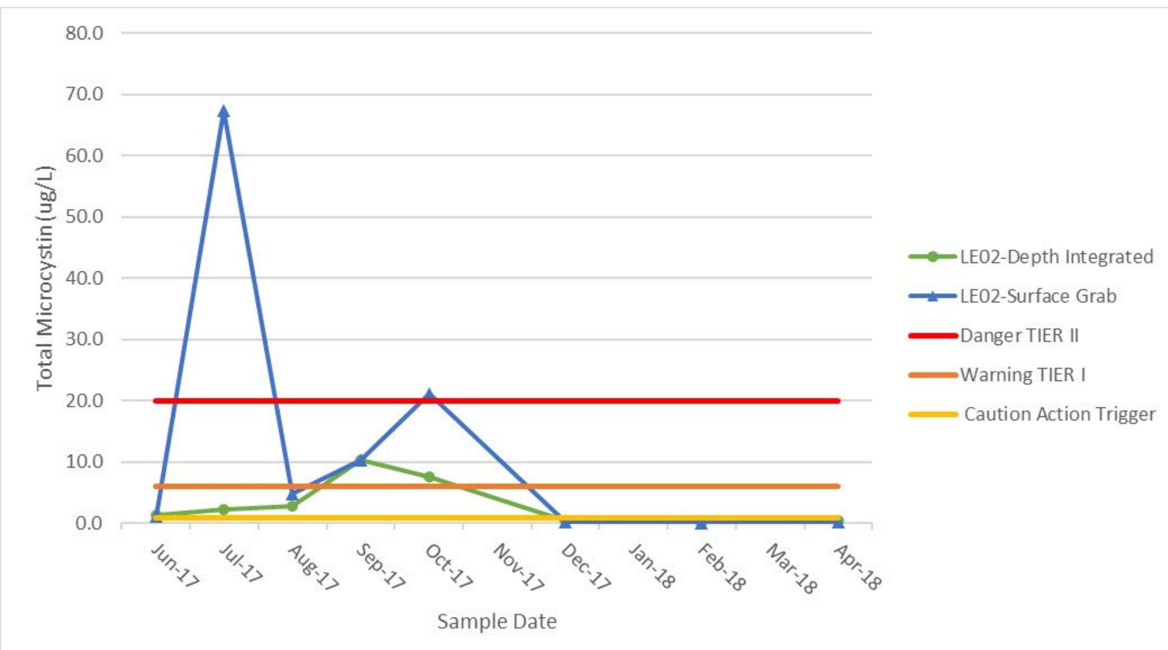


Figure 2-29. Microcystin Concentrations in Lake Elsinore from June 2017 to April 2018 (The trigger levels or thresholds to protect recreation shown with the yellow, orange and red horizontal lines, are those currently recommended by CCHAB (2016))

2.2.3 Canyon Lake

2.2.3.1 Establishment of Canyon Lake

Canyon Lake, also known as Railroad Canyon Reservoir was constructed to store water from the San Jacinto River for agricultural irrigation in the area (**Figure 2-30**). The Railroad Canyon Reservoir Dam is located approximately five river miles upstream from Lake Elsinore. Approximately 735 mi^2 of the San Jacinto River watershed drains into Canyon Lake before potentially reaching Lake Elsinore. In many dry years under dry weather conditions, there is no flow or only limited flow from the San Jacinto River to Canyon Lake. Moreover, when this flow from the San Jacinto River does reach Canyon Lake, this flow terminates at Canyon Lake without ever reaching Lake Elsinore.

Figure 2-30. Canyon Lake Reservoir (Source: Wood Environment and Infrastructure Solutions, Inc.)

The City of Canyon Lake has documented the establishment of the Railroad Canyon Reservoir, which is now known as Canyon Lake. Following are excerpts of this early history (**Figure 2-31**):[2]

Figure 2-31. Undated Photograph of the Evans Camp that Supported Fisherman at Railroad Canyon Reservoir (Source: USGenweb Archives, http://www.usgwarchives.net/ca/riverside/postcards/evcamp.jpg**)**

> *"The California Southern Railroad built a line in 1882 from Perris to Elsinore along the east side of the [San Jacinto] river. Later the Santa Fe Railroad bought the line and joined it with their line from San Bernardino. However, the floods of 1884, 1916, and 1927 washed out the tracks, and Santa Fe decided to abandon the line…"*

> *"The Temescal Water Company of Corona spent $500,000 for the development of a water supply in Ethanac (now called Romoland) and its transportation through Railroad Canyon to Corona…Around 1920, the water levels dropped in the Ethanac wells, and the water became saline and unusable. Plans*

[2] http://www.cityofcanyonlake.org/history

were made to build a dam across the San Jacinto River for water storage. There were already open ditches and pipelines to continue the water flow to Corona, and Temescal Water [Company] obtained the land for the future reservoir by purchase or condemnation. Henry Evans, the largest landowner at that time, sold 1,150 acres to the company. Construction of the dam started in 1927 and was completed in 1929. "Joy Jamison, then president of the Temescal Water

Company, became the brunt of "Jamison's folly" jokes made by board members in Corona when, after the completion of the dam, sparse rains prevented the river from bringing water. Eventually winter rains returned, and the lake slowly began to fill with water."

The area around Canyon Lake was sparsely populated during this time period but it was a popular destination for fishermen. A temporary disruption occurred beginning in 1949 when the lake was drained to repair the dam's floodgates. The area began to change in 1968 when the Corona Land Company began the development of 5,000 lots around the reservoir (**Figure 2-32**). The lake and the fringe of land around it were owned by the Temescal Water Company and leased to the Canyon Lake Property Owners Association (POA) for recreational purposes. Subsequently, the EVMWD bought the Temescal Water Company, and in 1989, EVMWD entered into a contract to acquire the lake and these leases. The agreement between EVMWD and the Canyon Lake POA requires that the minimum lake elevation be kept at 1,372 ft above sea level. The City of Canyon Lake was incorporated on December 1, 1990 and population records show that the local population has remained relatively stable since then (State of California 2017) (**Table 2-13**).

Table 2-13. City of Canyon Lake Population Since Incorporation in 1990

Census Date	Population
1991	10,292
2000	9,978
2010	10,561
2017	10,891

The surface area of Canyon Lake is approximately 500 acres, with an estimated current storage capacity of 8,760 acre-feet. The lake has three key areas: (1) Main Lake, which is the deepest part of the lake upstream of the dam; (2) East Bay, the relatively shallow east arm of the lake upstream of the causeway crossing the lake; and (3) North Ski Area, north portion of the lake above the causeway crossing upstream of the Main Lake. Canyon Lake receives inflows from two sources: (1) San Jacinto River drains to the North Ski Area above the Main Lake; and (2) Salt Creek drains to the East Bay. Canyon Lake has a small surface area (500 acres) and steep topography. Water depth varies greatly depending on the location in the Lake. The Main Lake is deepest (over 50 ft near the Dam); the East Bay is shallow (approximately 8 ft near the Salt Creek inflow). A detailed bathymetric survey was conducted by UCR in the summer of 2015 to map the lake bottom elevation and to study the nutrient cycles in Canyon Lake (**Figure 2-33**) (Anderson 2016c).

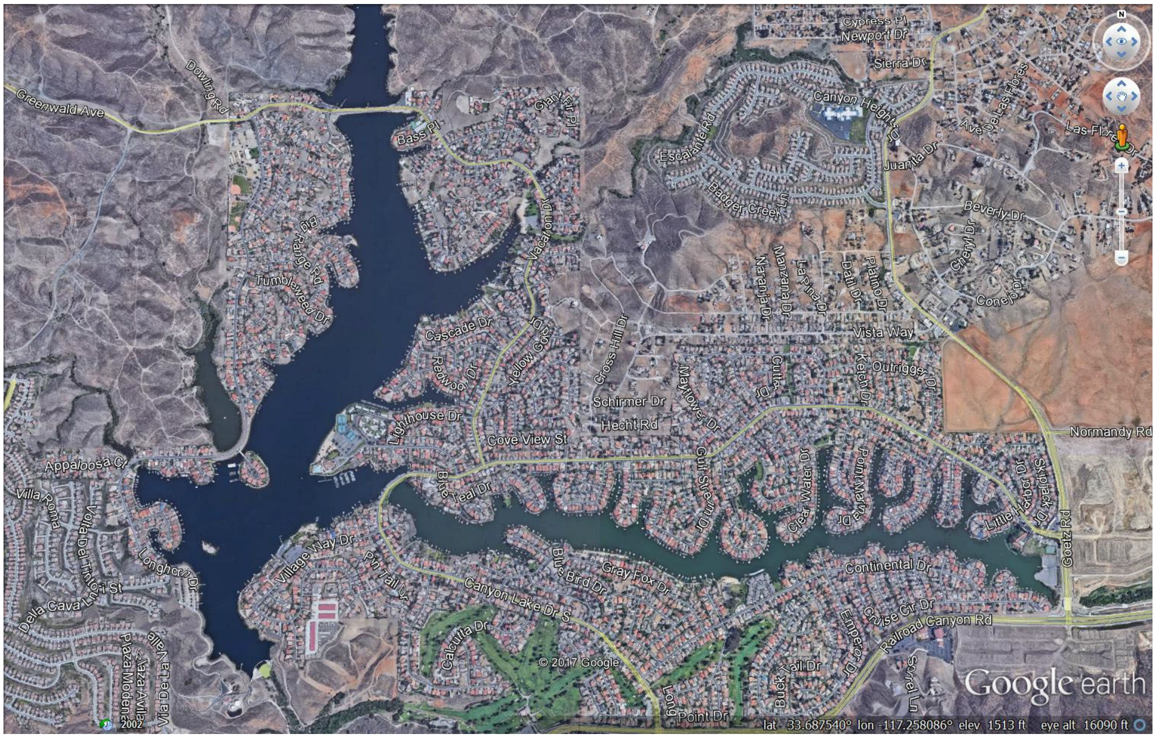


Figure 2-32. Development of Property around Canyon Lake Today (Source: Google Earth, July 26, 2017)

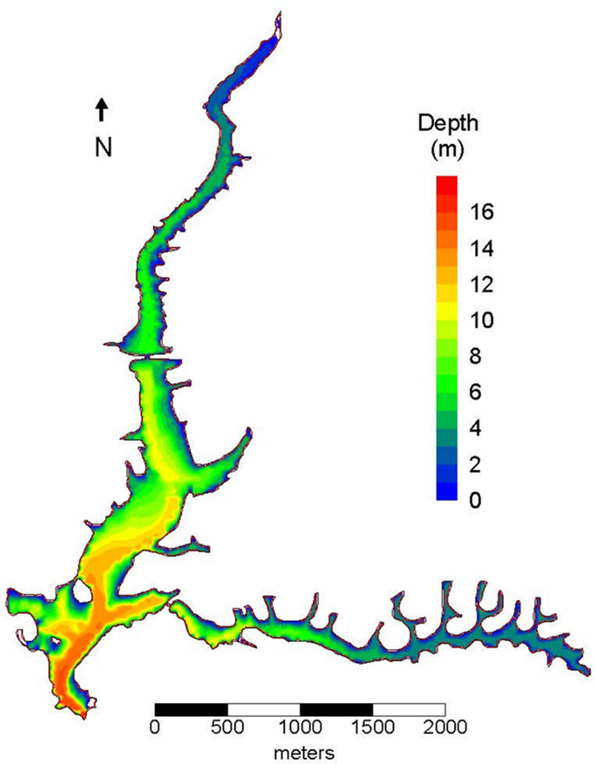


Figure 2-33. Bathymetric map of Canyon Lake (Anderson 2016c).

The temperature profile of the Canyon Lake water column routinely demonstrates that the Lake is thermally stratified in the summer. The most pronounced stratification occurs at the Dam where the water is deepest. Thermal stratification within Canyon Lake disappears in the fall and winter when the lake turns over resulting in more uniform water temperatures and DO profiles throughout the water column. The water column at the East Bay sampling locations is generally well-mixed year-round in areas less than 3-m deep. **Table 2-14** summarizes the total depth and mean Secchi depths observed at four sampling locations within Canyon Lake.

Table 2-14. Canyon Lake Water Depth and Secchi Depth from July 15 – August 2015 (see Figure 2-35 for sample site locations)

Sample Site	Location Description	Total Depth (ft)	Secchi Depth (in)
CL07	At Dam	48	74
CL08	North Channel	28	73
CL09	Canyon Bay	23	54
CL10	East Bay	11	44

Canyon Lake is a local source of drinking water. EVMWD draws water from Canyon Lake (near the Dam) and treats it at the Canyon Lake Water Treatment Plant, before delivery to the District's customers. The eutrophic conditions in Canyon Lake may impact the MUN beneficial use. Low oxygen levels result in high concentrations of manganese and iron in the hypolimnion. When manganese levels in the water column exceed 0.45 mg/L, EVMWD shuts down the water treatment plant. The high algal productivity also necessitates periodic shutdown of the Canyon Lake Water Treatment Plant because algal cells can clog the water treatment filters.

2.2.3.2 Historical Water Quality

Prior to the 1980s, few water quality data, in particular nutrient data, are available from Canyon Lake. Since then water quality data became available from various sources (Santa Ana Water Board 2001):

- Regional Board staff collected water samples from Canyon Lake from 1983-1986 for various constituents as part of the Region's monitoring and assessment program.
- Earth Sciences Consultants measured temperature, DO and electrical conductivity at three stations in Canyon Lake and five stations in Lake Elsinore on August 19, 1994. The three stations in Canyon Lake, "Boom", Buoy", and "Intake", were all in close proximity to the dam.
- SAWPA measured DO, water temperature, specific conductance, and pH near the Canyon Lake dam on July 10, 1996 in order to compare Canyon Lake water quality with Lake Elsinore. The results were similar to those obtained by the Earth Sciences Consultants in 1994.
- Black & Veatch collected water samples (one composite from the upper level and one composite sample from the lower level) from one station in Canyon Lake for conventional chemical constituent analysis in July and October 1995 and January, April and July 1996.

- EVMWD began monitoring the water quality of Canyon Lake in March 1996. A Hydrolab multi-probe has been used to measure the water temperature, DO and other parameters. These data are used by EVMWD to develop the water column depth profile to determine the appropriate depth for water withdrawal and also to determine when lake "turn-over" occurs. EVMWD also collected surface water samples from near shore locations for analysis of various constituents. EVMWD continues to monitor the physical and chemical characteristics of Canyon Lake at their treatment plant uptake points; however, EVMWD discontinued the surface water quality monitoring program since the Santa Ana Water Board and stakeholders initiated the TMDL monitoring program in the summer of 2000 (see below).
- The USGS began the National Water Quality Assessment (NAWQA) Study in the Santa Ana River watershed in 1998. One sediment core was taken in Canyon Lake to determine the sedimentation rate and to analyze for metals, organochlorine pesticides, and polyaromatic hydrocarbons.
- RCFC&WCD collected water quality data in the San Jacinto River watershed (1992-1999) as required by their MS4 stormwater permit. The data provided some understanding of the dynamics of Canyon Lake in relation to its watershed.

2.2.3.3 Recent Water Quality Findings

The Santa Ana Water Board and stakeholders began monitoring the water quality of Lake Elsinore and Canyon Lake in May 2000, specifically for nutrients and chlorophyll-*a*, as part of TMDL development (**Figure 2-34**). Water samples were collected for nutrient analysis at four sampling stations, CL07, CL08, CL09 and CL10 (**Figure 2-35**). From 2001 to 2012, monitoring was typically performed at a weekly or bi-weekly frequency during the summer months (June, July, August, and September), and bi-weekly or monthly from October through May. Water samples generally have been collected at two to three depths to characterize the vertical variation. Physical parameters such as temperature, DO, pH, conductivity, and turbidity are also measured at three-foot intervals at the time of sample collection. This nutrient TMDL monitoring program continued through 2012.

Figure 2-34. Water Quality Monitoring on Canyon Lake (Source: Wood Environment and Infrastructure Solutions, Inc.)

A break in monitoring occurred between 2012 and 2015 to reallocate resources for the implementation of water quality BMPs in both lakes, but was reinitiated in 2015. Currently field monitoring and analysis of nutrients and chlorophyll-*a* occurs monthly during the summer months of July, August, and September, and bi-monthly between September and July. Vertical depth profiles of pH, temperature, DO, and conductivity are performed twice during each monitoring event (am and pm), with these values averaged at each depth for a given day.

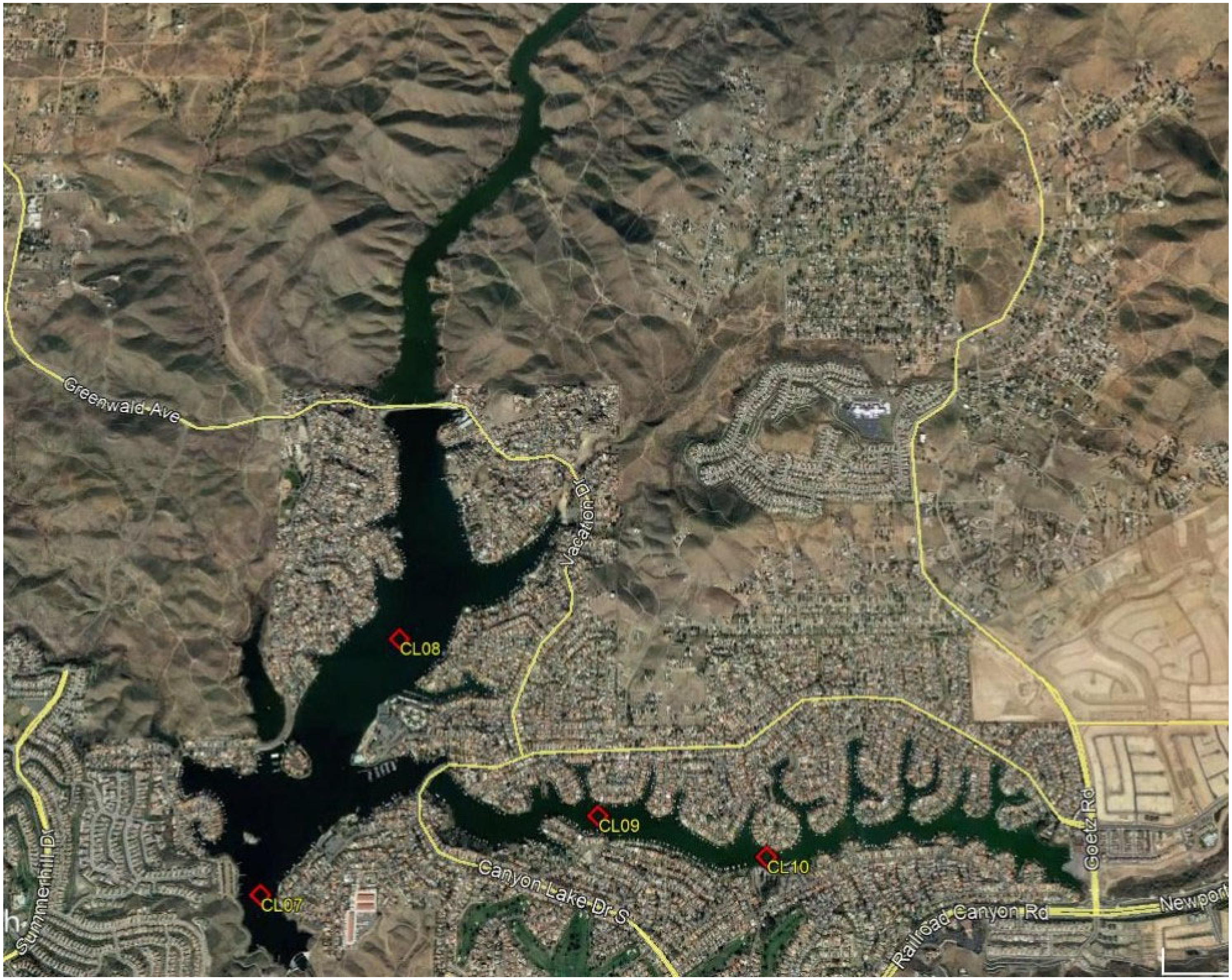


Figure 2-35. Location of Canyon Lake Sample Locations (CL07, CL08, CL09, and CL10).

The subsections below discuss water quality conditions in Canyon Lake based on the monitoring studies completed to date. As with data presented for Lake Elsinore, supporting water quality analyses graphically presented in tables and graphs within this section for Canyon Lake focus on the most recent available data collected in a consistent manner over the past 14-16 years. These data are now available in a single CEDEN-compatible database and has been collated and validated through a third party prior to analyses. Older data are referenced where applicable, but are not presented graphically. All values presented in the associated figures represent water column averages derived from depth-integrated water column samples, with the exception of DO which is plotted as depth-integrated (average) values both above and below the thermocline defined as the epilimnion (above the thermocline) and hypolimnion (below the thermocline), respectively.

Nutrients (Phosphorus and Nitrogen)

There are several forms of phosphorus and nitrogen in the water column; both phosphorus and nitrogen are essential nutrients for algal growth. As in Lake Elsinore, phosphorus concentrations in Canyon Lake exhibited strong seasonal and inter-annual variations. **Table 2-15** provides a tabular summary of nutrient measurements conducted by the Santa Ana Water Board in 2000-2001. **Figure 2-36** shows a graphical summary of available depth-integrated TP data collected during TMDL compliance monitoring efforts from 2001 to 2016. **Tables 2-16 and 2-17** provide the associated range, average, and median values of TP from 2001 to 2016 for the Main Basin (Sites CL07 and CL08), and East Basin (Sites CL09 and CL10) sites, respectively.

During TMDL compliance monitoring efforts in Canyon Lake between 2001 and 2016, the concentrations of TP have ranged from 0.09 to 2.3 mg/L, with a mean of 0.47 mg/L in the Main Basin and 0.45 in the East Basin (Tables 2-16 and 2-17). These values encompass the range observed by the Santa Ana Water Board in 2000-2001. As in Lake Elsinore, a majority of the phosphorus in the water column in Canyon Lake exists in soluble reactive form (Ortho-P). Spikes in TP of greater than 1.0 mg/L were recorded in August 2007, and several dates between October 2010 and June 2011. The elevated concentrations in the spring and early summer of 2011 appear to follow a few large storm events and some flooding that was documented in December 2010 - January 2011. Notably, the mean concentrations of TP during the four monitoring events from July 2015 through August 2016 are substantially lower than that historically observed, with an average concentration of 0.05 and 0.13 mg/L in the Main and East Basins of the lake, respectively. The reduced concentrations of phosphorus during this time frame correspond with the application of alum treatments designed to reduce mobility of phosphorus from the sediments in the lake, indicating that these efforts appear to be successful. A discussion of the ongoing alum treatment program and its relevance to implementation of existing TMDL requirements and its potential role as an implementation element in revised TMDLs may be found in Section 7.

Like phosphorus, nitrogen concentrations also exhibit strong seasonal and inter-annual variations as well. **Figure 2-37** shows a graphical summary of depth-integrated TN data collected during TMDL compliance monitoring efforts from 2001 to 2016. Tables 2-16 and 2-17 provide the associated range, average, and median values of TN from 2001 to 2016 for the Main Basin (Sites CL07 and CL08) and the East Basin (Sites CL09 and CL10), respectively.

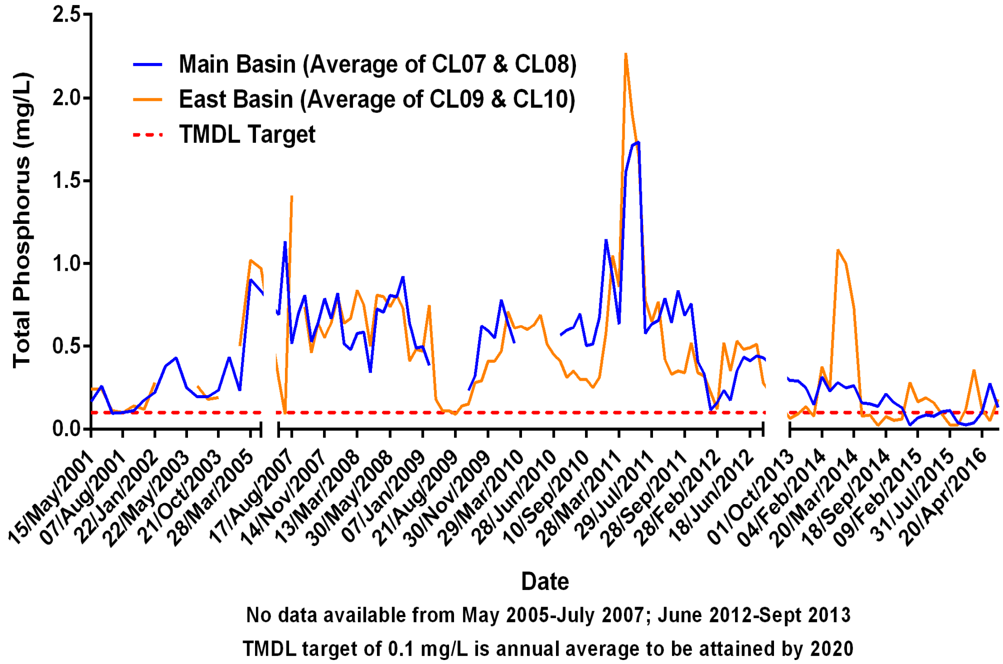


Figure 2-36. Depth-Integrated Average Total Phosphorus Concentrations in Canyon Lake: 2001-2016 (Note discontinuous data record on x-axis)

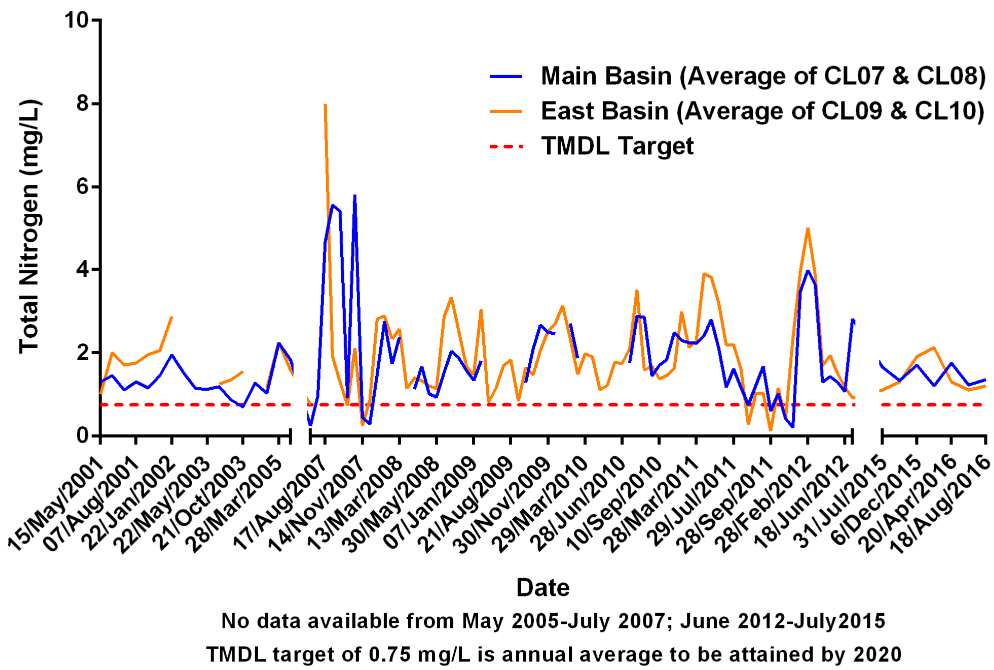


Figure 2-37. Depth-Integrated Average Total Nitrogen Concentrations in Canyon Lake: 2001-2016 (Note discontinuous data record on x-axis)

Table 2-15. Nutrient and Chlorophyll-a Concentrations in Canyon Lake between 2000 and 2001* (ND = Non-Detect; NA = Not Available)

Parameter	Detection Limit	N	Min	Max	Mean	Median
Chlorophyll-*a* (µg/L)	1	64	ND	180	NA	17.6
Ortho-P (mg/L)	0.02	116	ND	1.61	0.46	0.18
Total Phosphorus (mg/L)	0.02	129	0.06	1.9	NA	0.25
TKN (mg/L)	0.5	139	ND	7	NA	1.1
Nitrate as N (mg/L)	0.1	139	ND	0.38	NA	ND
Nitrite as N (mg/L)	0.1	130	ND	ND	NA	ND
Ammonium-N (mg/L)	0.1	143	ND	5.4	NA	0.14
TKN/P Ratio	NA	46	2	15.7	7.97	7.8

* As reported in the Santa Ana Water Board, Canyon Lake Problem Statement (Santa Ana Water Board 2001)

Table 2-16. Historical Dissolved Oxygen, Nutrient, Chlorophyll-*a*, and TDS Summary for Canyon Lake between 2002 and 2016 - Sites CL07 and CL08 (Main Basin or Lake) (TMDL Compliance Monitoring)

Parameter	Date Type	2002-2012					2015-2016				
		N	Min	Max	Mean	Median	N	Min	Max	Mean	Median
Dissolved Oxygen (mg/L)	Above the Thermocline	74	1.2	19	8.7	8.4		4.6	12	8.8	9.1
	Hypolimnion	74	0.0	6.3	0.59	0.21		0.10	5.3	1.3	0.3
Chlorophyll-*a* (µg/L)	Depth-Integrated	53	5.2	459	45	40		24	79	50	43
Total Nitrogen (mg/L)	Depth-Integrated	61	0.20	5.81	2.0	1.7		1.2	1.8	1.5	1.4
Total Phosphorus (mg/L)	Depth-Integrated	77	0.10	1.74	0.57	0.57	7 to 8	0.03	0.28	0.10	0.10
Total Ammonia (mg/L)	Depth-Integrated	75	0.03	2.88	0.84	0.83		0.05	1.5	0.57	0.35
Un-ionized Ammonia (mg/L)	Depth-Integrated	75	0.0	0.18	0.03	0.02		< 0.01	0.03	< 0.01	< 0.01
TDS (mg/L)	Depth-Integrated	101	152	985	593	593		665	825	746	735

CDM Smith

Table 2-17. Historical Dissolved Oxygen, Nutrient, Chlorophyll-*a*, and TDS Summary for Canyon Lake between 2002 and 2016 - Sites CL09 and CL10 (East Basin or Bay) (TMDL Compliance Monitoring)

Parameter	Date Type	2002-2012					2015-2016				
		N	Min	Max	Mean	Median	N	Min	Max	Mean	Median
Dissolved Oxygen (mg/L)	Above the Thermocline	44	5.6	16	10	10	4	7.1	14	10.5	10.3
	Hypolimnion	44	0.0	4.0	0.59	0.24		0.25	10.3	3.1	1.8
Chlorophyll -*a* (µg/L)	Depth-Integrated	61	1.0	220	60	53		14	102	42	25
Total N (mg/L)	Depth-Integrated	73	0.11	8.0	2.0	1.7		1.1	2.1	1.4	1.3
Total P (mg/L)	Depth-Integrated	83	0.09	2.3	0.52	0.47		0.03	0.36	0.13	0.12
Total Ammonia (mg/L)	Depth-Integrated	67	0.03	1.54	0.51	0.35		0.05	0.14	0.07	0.05
Un-ionized Ammonia (mg/L)	Depth-Integrated	67	0	0.5	0.04	0.02		< 0.01	< 0.01	< 0.01	< 0.01
TDS (mg/L)	Depth-Integrated	97	336	1206	701	671		640	930	820	870

As in Lake Elsinore, nitrate and nitrite are typically below analytical detection limits (0.1 mg/L) in Canyon Lake. Since nitrate and nitrite are mostly below detection limits, TKN represents TN. Ammonium is the main form of inorganic nitrogen in Canyon Lake; often 100 percent based on the few detections of nitrate and nitrite.

During TMDL compliance monitoring efforts in Canyon Lake between 2001 and 2016, the concentrations of TN have ranged from 0.01 to 8.0 mg/L, with a mean of 1.8 mg/L and 1.9 mg/L in the Main Basin and East Basin, respectively (Tables 2-16 and 2-17). These values encompass the range observed by the Santa Ana Water Board in 2000-2001. A few spikes in TN above 4.0 mg/L were recorded from August to November 2007 and again in February 2012. Mean concentrations of TN during the seven monitoring events from July 2015 through August 2016 are similar to that historically observed, with an average concentration of 1.4 and 1.3 mg/L in the Main and East Basins of the lake, respectively.

The TN:TP ratio for Canyon Lake is variable, ranging from 0.3 to 96, with an average of 6.5 in the Main Basin and 7.7 in the East Basin (**Figure 2-38**). The ratio varies spatially and temporally in Canyon Lake. On average, conditions throughout Canyon Lake are nitrogen-limited, which is the opposite of that for Lake Elsinore. However, since 2015 and application of the alum treatments, Canyon Lake appears to have shifted to a more phosphorus-limited condition which was a goal for this water quality management approach (see Section 7). Shifting the lake to a more phosphorus-limited state is considered desirable due to the proven effectiveness of alum in its ability to reduce phosphorus in other lake systems, and literature that suggests limitation of phosphorus is more important than limiting nitrogen with regard to resulting algal blooms (Wang and Wang 2009). In addition, actively limiting nitrogen availability *in situ* is a more difficult task in comparison to limiting phosphorus availability, based on existing available technologies.

A review of seasonal trends indicates that phosphorus is occasionally the limiting nutrient for brief periods in the summer; in the fall and winter, nitrogen becomes the limiting nutrient. At various times and locations, both phosphorus and nitrogen can be the limiting nutrient in Canyon Lake; therefore, both nutrients could be controlled to manage excessive algal growth.

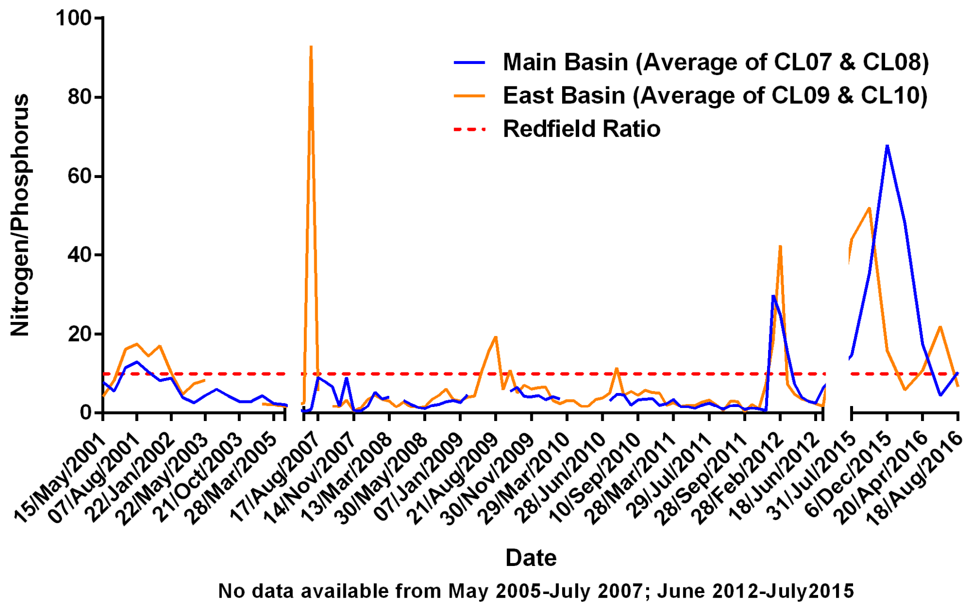


Figure 2-38. Nitrogen to Phosphorus Ratios in Canyon Lake: 2001-2016 (Note discontinuous data record on x-axis)

Ammonia

Consistent with Lake Elsinore, levels of total ammonia are generally low in Canyon Lake, though slightly greater overall in this waterbody. Total ammonia in Canyon Lake during TMDL compliance monitoring efforts between 2007 and 2012 ranged from less than 0.05 mg/L to 2.9 mg/L, with corresponding mean values of 0.82 mg/L in the Main Basin and 0.47 mg/L in the East Basin (**Figure 2-39** and Tables 2-16 and 2-17). These values encompass the range observed by the Santa Ana Water Board in 2000-2001 with the exception of a greater maximum value of 5.4 mg/L reported during that timeframe.

Associated measures of un-ionized ammonia throughout the 2001 to 2016 period are also generally low, but can vary substantially with depth on any given day given a gradient of pH that is often lower near the bottom and greater near the surface in Canyon Lake. Integrated depth-averaged total ammonia and pH values were used to derive the un-ionized values presented herein. Concentrations of un-ionized ammonia ranged from less than detection to 0.5 mg/L, with an average of 0.03 in the Main Basin and 0.04 in the East Basin (**Figure 2-40**; Tables 2-16 and 2-17). These average values are well below that expected to cause toxic effects to species found in Canyon Lake as described further in Section 2.3.3 below. A single transient spike of greater than 0.5 mg/L was recorded in 2008 which might approach a chronic toxicological threshold of potential concern for fish species in the lake.

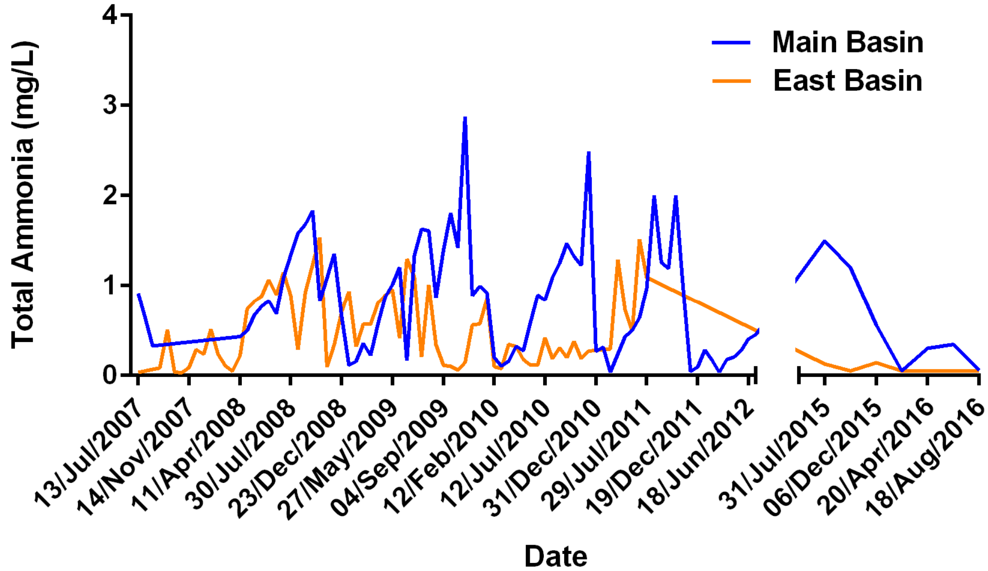


Figure 2-39. Depth-Integrated Average Total Ammonia Concentrations in Canyon Lake: 2007-2016 (Note discontinuous data record on x-axis)

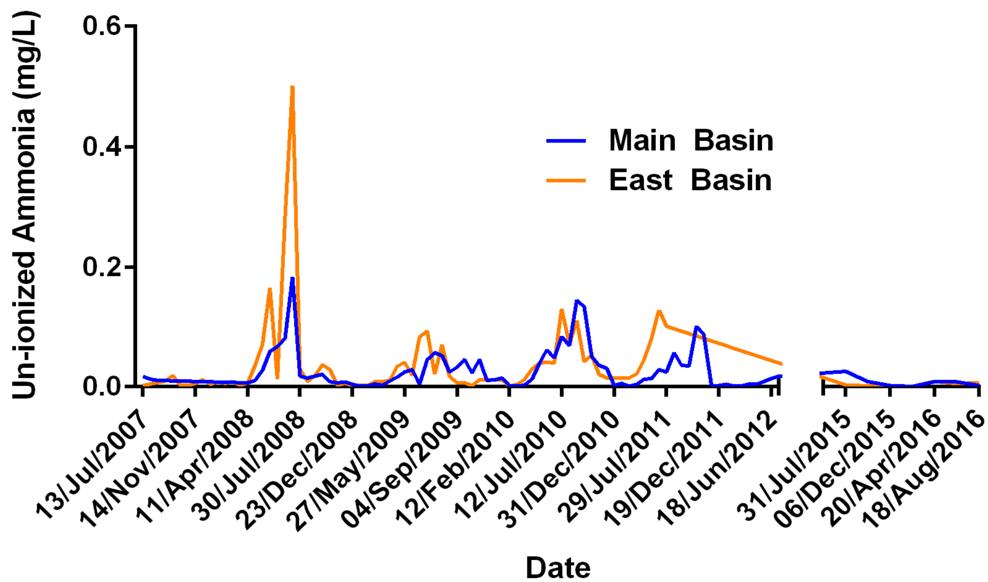
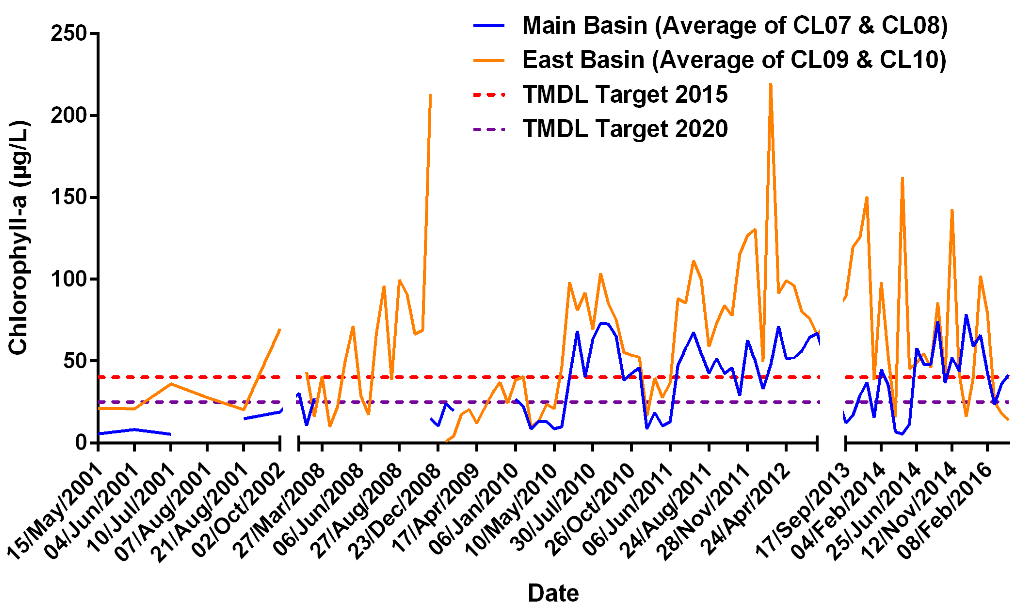


Figure 2-40. Depth-Integrated Average Un-ionized Ammonia Concentrations in Canyon Lake: 2007-2016 (Note discontinuous data record on x-axis)

Chlorophyll-a

The current TMDL compliance threshold target for chlorophyll-*a* in Canyon Lake is a summer average value of ≤ 40 µg/L in 2015 and ≤ 25 µg/L in 2020. During TMDL compliance monitoring efforts in Canyon Lake between 2001 and 2016, the concentrations of chlorophyll-*a* have varied widely from 1 µg/L to a maximum of 220 µg/L in the East Basin. Unlike nutrient concentrations which are relatively similar in all portions of the lake on a given day, average concentrations of chlorophyll-*a* can vary across the lake (**Figure 2-41**; Tables 2-16 and 2-17). These values encompass the range observed by the Santa Ana Water Board in 2000-2001. Chlorophyll-*a* concentrations are routinely less in Canyon Lake relative to that in Lake Elsinore.

A few spikes in chlorophyll-*a* above 100 µg/L were recorded in Canyon Lake in November 2008, August 2010, July through February 2011, and most recently in December 2015. All of these values were reported within the East Basin with the exception of the December 2015 result which was reported in the Main Basin.



No data available from October 2002-August 2007; June 2012-Sept 2013
2015 TMDL target of 40 µg/L is annual average to be attained by 2015
2020 TMDL target of 25 µg/L is annual average to be attained by 2020

Figure 2-41. Depth-Integrated Average Chlorophyll-*a* Concentrations in Canyon Lake: 2001-2016 (Note discontinuous data record on x-axis)

Chlorophyll-*a* concentrations at all sites in Canyon Lake generally remain low in the summertime and then increase in the fall/winter season when the lake turns over, though this trend is not consistent all the time (see Figure 2-41). During summertime, the lake is stratified so that the nutrients in the hypolimnion are not available for algae uptake; meanwhile the nutrients in the epilimnion can be used for algal productivity, but are in limited supply. When the lake turns over, the hypolimnion provides a new source of nutrients that can cause an increase in algal productivity. Since turnover usually occurs in the fall/winter period when temperatures are lower and days are shorter, algal responses and growth are not as likely to result in severe algal blooms. Such a phenomenon is quite different from Lake Elsinore, which usually has algal blooms in the summertime when the lake bottom water becomes more anoxic. Because Lake Elsinore is much shallower and does not stratify during the summer, nutrients released from the sediments are readily available for algal growth at all times. Although Canyon Lake receives more nutrients from the San Jacinto River and Salt Creek watersheds than Lake Elsinore, algal blooms and fish kills are not as severe as those that occur in Lake Elsinore. The greater water depth and strong thermal stratification in Canyon Lake prevents the nutrients from the sediment from becoming available for algal growth in the photic zone above the thermocline.

Because of the algal biomass increase during the Canyon Lake turnover period, EVMWD typically stops operation of the Canyon Lake Water Treatment Plant for about two weeks because algal cells can clog the filters in the treatment plant. Occasionally, copper sulfate is applied by the Canyon Lake POA and EVMWD staff as an algaecide during algal blooms to improve water clarity.

Dissolved Oxygen

Figures 2-42 and **2-43** show DO concentrations between 2002 and 2016 for the Main Basin (average for Sites CL07 and CL08), and East Basin (average for Sites CL07 and CL08) areas, respectively. Depth-integrated average values are shown for the epilimnion and the hypolimnion. When a thermocline was not present depth-integrated average values are presented for measures taken throughout the entire water column. Tables 2-16 and 2-17 provide the associated range, average, and median values from 2002 to 2016 in the epilimnion and hypolimnion, respectively.

DO levels in Canyon Lake range from over-saturation at the surface to near zero below at the thermocline. During the TMDL compliance monitoring efforts from 2007 through 2016 average concentrations of DO in Canyon Lake in the epilimnion when the lake is stratified ranged from approximately 1.2 to 19 mg/L with average values of 8.7 mg/L in the Main Basin and 10 mg/L in the East Basin. Average concentrations of DO in the hypolimnion ranged from approximately 0.0 to 10 mg/L with average values of 0.67 mg/L in the Main Basin and 1.01 mg/L in the East Basin. The low DO below the hypolimnion, particularly during the summer months (occasionally at or near zero mg/L), is likely attributable to the decomposition of algae, high oxygen demand from the sediment surface, and the lack of mixing. This stratification of DO is a natural condition for most lakes. Low DO levels below approximately 5.0 mg/L for extended periods of time may cause effects to aquatic life including occasional fish kills. When the lake is not stratified depth-integrated DO concentrations ranged from 2.2 to 8.7 mg/L with an average value of 5.4 mg/L in the Main Basin while concentrations in the East Basin ranged from 2.9 to 11.6 mg/L, with an average of 7.3 mg/L over the same time period.

The low DO levels have also resulted in the release of high levels of soluble manganese and iron from the sediment. EVMWD shuts down the Canyon Lake Water Treatment Plant when the manganese concentration is above 0.45 mg/L. The anoxic condition in the hypolimnion may also facilitate the release of phosphorus and ammonia from the sediment, both of which then become available for algal growth when the lake turns over.

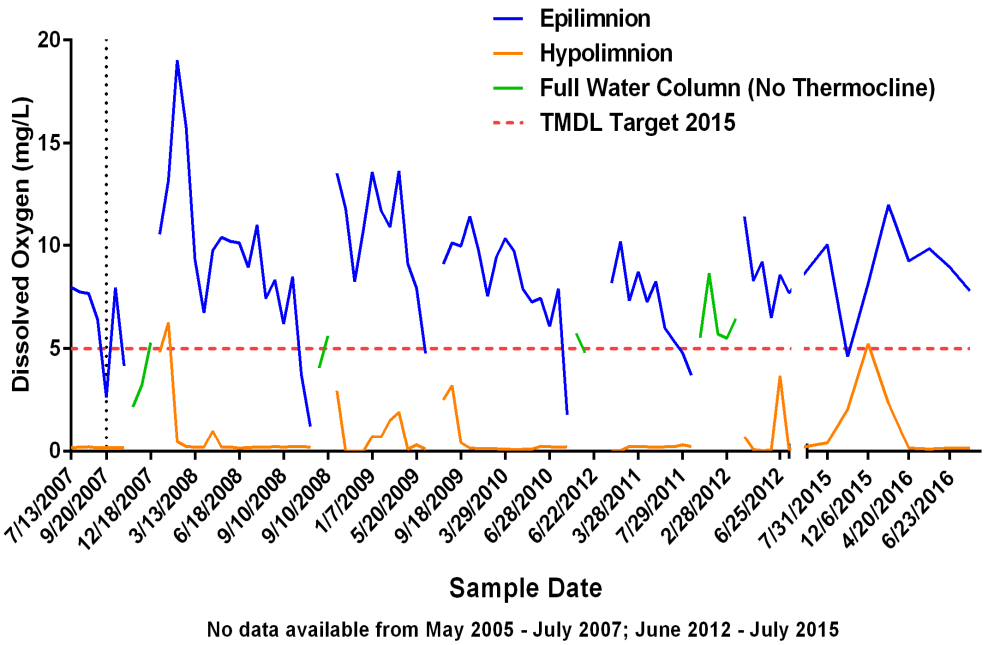


Figure 2-42. Depth-Integrated Average Dissolved Oxygen Concentrations in Canyon Lake (Main Basin): 2007-2016 (Note discontinuous data record on x-axis)

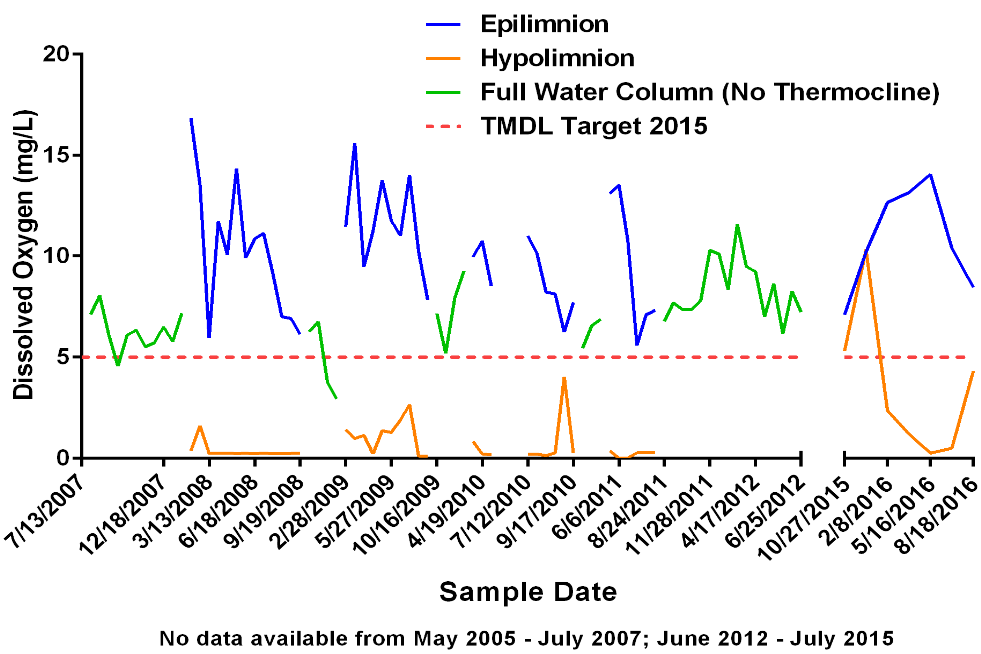


Figure 2-43. Depth-Integrated Average Dissolved Oxygen Concentrations in Canyon Lake (East Basin): 2007-2016 (Note discontinuous data record on x-axis)

Total Dissolved Solids

During TMDL compliance monitoring efforts in Canyon Lake between 2001 and 2016, the concentrations of TDS have varied from 152 to 1,206 mg/L with average concentrations of 602 in the deeper Main Basin, and 709 mg/L in the shallower East Basin (**Figure 2-44**; Tables 2-16 and 2-17). These concentrations are comparable with the range of TDS observed in watershed runoff to Canyon Lake from Salt Creek. Concentrations of TDS from the San Jacinto River entering the north arm and Main Basin of the lake are generally less than 200 mg/L. TDS concentrations are consistently much lower in Canyon Lake relative to that in Lake Elsinore. Thresholds for TDS and conductivity related to aquatic life are discussed further in Section 2.3.1. Concentrations are below that expected to be problematic for fish species that reside in the lake, but do at times approach concentrations which could affect survival and reproduction of sensitive invertebrate species.

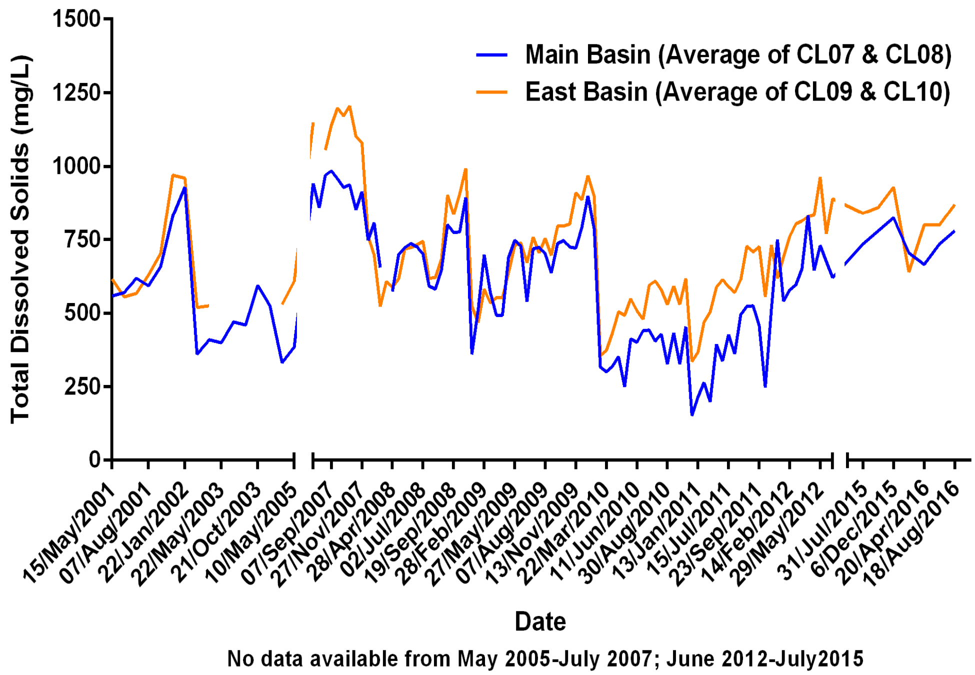


Figure 2-44. Depth-Integrated Average TDS Concentrations in Canyon Lake: 2001-2016 (Note discontinuous data record on x-axis)

Chemical Stratification

As discussed above, Canyon Lake is thermally stratified in the summer, mixes in the fall and stays mixed through the winter (**Figure 2-45**). During late spring, the lake stratifies again. This thermal stratification can also result in the chemical stratification of constituents such as Ortho-P, total phosphate-P and TKN during the summertime. When the lake turns over, the chemical concentrations throughout the water column become uniform until stratification occurs again in the spring or summer. A review of historic data indicates that stratification of nutrients is generally limited overall in Canyon Lake, though trends are apparent occasionally. Due to limited differentiation between the top and bottom of the water column, current TMDL compliance monitoring methods include the collection of a single depth-integrated sample for analysis of nutrients and TDS. Stratification of chlorophyll-*a*, however has been more prominent, with values typically greater near the surface where sunlight penetrates and algae accumulates. Given this trend, chlorophyll-*a* is currently measured in both a top to bottom depth-integrated sample, as well as a 0-2 m depth integrated sample representing just the surface.

2.2.3.4 Existing Biological Characteristics

This section provides a summary of the biological characteristics as known in Canyon Lake. Supporting figures and tables are provided in Appendix A.

Fish Community

Figure 2-45 Canyon Lake Reservoir (Source: Wood Environment and Infrastructure Solutions, Inc.)

The fish community characteristics of Canyon Lake are less known than the fish community in Lake Elsinore. The lake was originally populated with fish that had migrated (or been washed down) from the San Jacinto River watershed as the lake filled after completion of the dam. The lake was owned by the Evans family who started a fishing business on the lake in 1937. During this time Canyon Lake was marketed as a fishing "hot spot". The lake was drained in 1949 to perform repairs to the floodgates, and the lake slowly refilled over the next two years. In 1951, the CDFG restocked the lake with largemouth bass, crappie, and bluegill. Heavy rains in 1952 brought the water level high enough that the resort could reopen in 1953. The fishing camp was in operation until 1968.

It is likely that the lake contains catfish and other sunfish (*Lepomis* spp.), as well as small baitfish such a threadfin shad given its prevalence in Lake Elsinore. The draft Lake Management Plan for Canyon Lake notes that the lake, which has crappie and bluegill, is stocked with catfish and bass by the Canyon Lake POA (Canyon Lake POA 2016).

Unlike Lake Elsinore, very little information is available on fish kills in Canyon Lake. In the original TMDL staff report (Santa Ana Water Board 2004b), the Regional Board staff stated it could find no written record of fish kills for Canyon Lake, but anecdotal information indicated that there have been fish kills. However, the document also states that Canyon Lake experiences periods of oxygen depletion due to algae respiration and decomposition that can result in fish kills, adversely affecting the warmwater aquatic habitat beneficial use. More recently, a fish kill was documented on October 29, 2010 when about 50 to 100 shad were observed on Sunset Beach (Canyon Lake POA 2016).

Invertebrate community

Very little is known of the aquatic invertebrate populations in Canyon Lake. At this time, the only known effort to evaluate the invertebrate community in Canyon Lake was a July 2004 benthic invertebrate study (Weston Solutions 2004). This study sampled eight East Basin open water locations as well as four East Basin shoreline locations. Depth at the eight open water locations ranged from 7.6 to 20 ft, with DO concentrations ranging from 6.0 to 8.4 mg/L. The study observed a total of 24 taxa and found a significant difference between the offshore benthic community and those along the shoreline. The open water sites exhibited very low taxa diversity and were composed almost exclusively of one dipteran taxa, the phantom midge *Chaoborus* spp., and a relatively small number of annelid oligochaetes (aquatic worms). The shoreline sites contained from 8 to 18 taxa. The midge, *Chironomus* spp. and the amphipod, *Hyalella* spp. were the most abundant taxa in shoreline samples, comprising 28 and 36 percent of the entire community, respectively. Other shoreline taxa included the damselfly, *Enallagma* sp., the aquatic beetle, *Tropisternus* sp., the mayfly, *Caenis* sp., the caddisfly, *Oxyethira* sp. and the water mite, *Koenikea* sp. Three snail genera were also collected. The study did not observe the presence of any sensitive taxa. Of the entire benthic invertebrate community, 79 percent was considered tolerant of generalized pollutants with a Hilsenhoff Biotic Index (HBI) value of ≥ 7 (Hilsenhoff 1987, 1998) (on a scale of 1 to 10 with higher values indicating a more pollutant-tolerant community.

The findings for Canyon Lake are not atypical for similar moderately deep lakes in other urbanized settings. A benthic community study performed by Amec Foster Wheeler (now Wood Environment and Infrastructure Solutions, Inc.) in Lake Merced, near downtown San Francisco, CA (Amec Foster Wheeler [Wood] 2014) found that in sediments ranging in depth from 11.6 to 20.3 ft, and DO concentrations ranging from 4.1 to 6.7 mg/L, the benthic community primarily consisted of dipterans and oligochaetes (combined, they represented 80 to 100% of the benthic community). The benthic community at these sites was considered highly tolerant with all HBI values > 8.9. Another recent study looking at the functional composition of lake benthic invertebrate communities in urbanized settings (Twardochleb and Olden 2016) also found results very similar to those observed in Canyon Lake. This study found that lakes with high levels of watershed and shoreline development were characterized by relatively dense macrophyte cover in eulittoral zones - a pattern that was associated with lower functional diversity of benthic invertebrate communities. Additionally, among regional characteristics, watershed development was an important predictor that interacted with TP and woody debris habitat, resulting in lower functional diversity in developed lakes.

Phytoplankton community

Information on the phytoplankton community is also limited. The Canyon Lake Nutrient TMDL Problem Statement indicated that the dominant types of algal species in Canyon Lake are flagellate-green and green algae (Santa Ana Water Board 2001). It is likely that diatoms also comprise some proportion of the community during times of the year, given the brownish-green tint of the water during recent 2015-2016 monitoring events.

2.3 Sensitivity of Biological Communities to Proximate Stressors

Proximate stressors are those that are in contact with the organism(s) in question, e.g., chemical constituents that can cause a direct effect on the organisms, such as low DO, elevated ammonia, or conductivity. This is opposed to indirect stressors such as nutrients or chlorophyll-*a*, which are related, but are not the causative agent of deleterious effects. The following sections describe the sensitivity of the organisms found in Lake Elsinore and Canyon Lake (or closely related organisms) to four probable proximate stressors within these lakes.

2.3.1 Conductivity

Conductivity in Lake Elsinore is elevated and has been measured as high as 8,650 µS/cm (4.8 parts per thousand [ppt] salinity) during routine water quality monitoring events dating back to 2002. It has been identified as a likely stressor particularly to the zooplankton populations in the lake. The conductivity in Canyon Lake is considerably lower, measured as high as 1,719 µS/cm in the East Basin in October 2007. While this conductivity level approaches the threshold effect level (1,820 µS/cm 10-day LC_{50} [the concentration at which one would expect 50 percent mortality] (Veiga-Nascimento and Anderson 2004), for the most sensitive daphnid zooplankter observed in either lake, the long term 15-year mean (May 2001 – February 2016) for Canyon Lake is 900 µS/cm in the Main Basin and 1,060 µS/cm in the East Basin, well below the LC_{50} threshold effect level. Therefore, conductivity is not likely a significant stressor to the biological community in Canyon Lake.

Elevated conductivity acts as an osmotic stressor by interfering with the proper balance of salts and water within the body of an organism, which is necessary to maintain various physiological and biochemical processes. The fish and zooplankton that reside in Lake Elsinore are exposed to rising levels of conductivity during summers and particularly during extended drought periods when rainfall totals do not keep up with evaporation rates. The addition of recycled supplemental water to Lake Elsinore has helped to decrease spikes in conductivity during drought periods, but also elevates the long term mean conductivity.

Conductivity levels currently observed in Lake Elsinore do not appear to be high enough to cause significant acute stress to the fish found there, as these taxa exhibit a relatively high tolerance to elevated conductivity (Appendix A, Table A-2). However, the conductivity threshold of cladocerans (water fleas) is within the range in which a toxicological effect would be expected at typical conductivities observed in Lake Elsinore (Appendix A, Table A-3). Rotifers and copepods exhibit a higher tolerance to conductivity than cladocerans, with LC_{50} values above the highest conductivity measured during routine water quality monitoring events dating back to 2001.

2.3.2 Dissolved Oxygen

Both Lake Elsinore and Canyon Lake experience low DO concentrations for at least some portion of the lake and for some portion of the year. During summer months Canyon Lake stratifies with rapidly decreasing DO concentrations below the thermocline, and often times super-saturated waters near the surface. During summer months DO concentrations are near zero at the bottom. As the lakes turnover in late fall and winter, in addition to the increased winds causing mixing of the water column in late fall and early winter (e.g., Santa Ana winds), and low DO water near the bottom mixes with surface water potentially causing impacts to fish and other organisms which can no longer escape to higher oxygenated surface areas of the lake. Lake Elsinore does not stratify or turnover in the classic sense. Some limited temperature and DO stratification may occur when winds are calm for some period, but when winds occur, the lake generally mixes.

Fish are more sensitive to low DO levels in general (relative to some invertebrates), and particularly sensitive to DO levels that drop sharply. Fish are able to adapt to short term exposures to low DO (assuming the concentration is not zero) and are more likely to adapt if the DO concentration exhibits a gradual decline. Additionally, fish have the ability to move to areas of higher DO when localized depressed concentrations are experienced. Sharp drops in DO, such as during lake turnover or caused by algal respiration at night during algal blooms, can cause acute mortality in short periods of time.

Given that fish kills were cited as a major factor in the original 303(d) impairment listing, data are provided here for both acute and chronic DO sensitivity thresholds of the various fish species found in both lakes (Appendix A, Table A-4). Of the fish observed in Lake Elsinore and Canyon Lake, largemouth bass appears to be the most sensitive to decreased DO levels. Petit (1973) reported that largemouth bass begin to experience distress (e.g., increased respiration and reduced metabolic rate) when DO concentrations fall below 5.0 mg/L. Moore (1942) reported that black crappie begin to experience decreased survival rates when held at a DO concentration of 4.3 mg/L for more than 24 hours at 26 °C. Carp begin to experience stress related to low DO concentrations at 4.2 mg/L (Beamish 1964) and increased mortality at concentrations < 1.0 mg/L (Opuszyfiski 1967). Krouse (1968) reported that striped bass (*Morone saxatilis*) begin to experience reduction in survival at 3.0 mg/L DO and Bailey et al. (2014) reported an LC_{50} of 1.6 mg/L DO. Gizzard shad (*Dorosoma cepedianum*), a close relative of the threadfin shad, begins to experience increased mortality at 2.0 mg/L (Gephart and Summerfelt 1978).

DO availability to fish is also influenced by temperature, with increases in temperature causing a reduction in the ability of water to hold oxygen (i.e., lower saturation). Studies have shown that as the DO saturation level declines to less than 50 percent saturation, significant reductions in the survival times of some fish species occur when exposed to lethal solutions of un-ionized ammonia concentrations. Therefore, there are interactions between chemical constituents that may cause accelerated responses or synergistic effects at concentrations that would normally be benign for either constituent.

2.3.3 Ammonia

Ammonia, in particular the un-ionized fraction, is acutely toxic to aquatic life. While the ratio of total ammonia to un-ionized ammonia is driven by pH, salinity, and temperature, it is primarily driven by pH, with a sharp increase in un-ionized ammonia as pH rises above 8.3.

Fish are much more sensitive to elevated levels of un-ionized ammonia than are invertebrates, as can be seen in the two species sensitivity distributions (SSD) presented in (Appendix A, Figures A-7 and A-8). According to these SSDs, at 1.0 mg/L un-ionized ammonia, approximately 44 percent of the invertebrate species surveyed would exhibit a lethal response. At the same concentration of un-ionized ammonia, this lethal response increases to 70 percent of fish species surveyed.

Of the fish species found in the lakes, the hybrid striped bass with a species mean acute value (SMAV) of 0.43 mg/L un-ionized ammonia appears to be the most sensitive, followed by bluegill (0.99 mg/L), largemouth bass (1.09 mg/L), channel catfish (1.43 mg/L), and carp (1.44 mg/L) (Appendix A, Table A-5). The invertebrate population in the lakes consisting primarily of planktonic rotifers, copepods, cladocerans, and benthic midges is less sensitive to un-ionized ammonia. The water flea, *Ceriodaphnia acanthine* (a close relative of *Ceriodaphnia quadrangula* found in Lake Elsinore) was the most sensitive of the invertebrates surveyed, with an SMAV of 0.62 mg/L un-ionized ammonia (Appendix A, Table A-6).

Historical concentrations of un-ionized ammonia in Lake Elsinore calculated using historical depth integrated total ammonia values, along with depth integrated mean pH, temperature, and salinity show that these concentrations are generally below the levels expected to cause acute toxicity to fish and invertebrates in Lake Elsinore (Appendix A, Figure A-9). However, the sensitivity of one fish species, the white perch, *Morone americana*, not found in the lake, but within the same genus as the hybrid striped bass, does have an estimated SMAV of 0.27 mg/L un-ionized ammonia, which is within the upper range of historical un-ionized ammonia concentrations observed in Lake Elsinore (maximum un-ionized ammonia concentration observed March 2002 to June 2012 is 0.28 mg/L). As such, there is the potential for un-ionized ammonia to be at concentrations that are potentially toxic to fish in Lake Elsinore, but to date it has not been related to any fish kills. Lake Elsinore is dynamic and toxic conditions can be fleeting as it relates to the presence of un-ionized ammonia. Under the right conditions (high pH and high temperature) acutely toxic concentrations of un-ionized ammonia can have a quick effect on fish populations, which may not be detected during routine monitoring activities which are “point-in-time” measures. The effects of elevated un-ionized ammonia concentrations can be exacerbated by low DO and elevated temperature, which add additional stresses to the fish.

2.3.4 Zooplankton Food Sources

Zooplankton, particularly the types found in Lake Elsinore, feed largely on phytoplankton, with a relatively minor portion of their diet consisting of protozoans, bacteria, and detritus. The zooplankton community at Lake Elsinore is heavily dominated by copepods and rotifers, which are not as efficient at grazing dense phytoplankton populations as cladocerans. The small population of cladocerans observed in the lake were small-bodied and did not have efficient filtering capacities. However, even a robust *Daphnia* population may not be able to adequately graze the majority phytoplankton in the lake due to the strong dominance of *Pseudanabaena limnetica* (formerly *Oscillatoria*). This species of blue-green algae is a poor food resource for filter-feeding *Daphnia* and other large-bodied cladocerans, since the algal filaments are too large to enter the mouth and further interfere with filtration of smaller phytoplankton. This species is also thought to potentially produce neurotoxins (Jakubowska et al. 2013) which could induce acute or chronic effects in both fish and invertebrates. Therefore, while phytoplankton (a major proportion of diet of zooplankton) densities are high, the carrying capacity of the lakes for populations of large bodied cladocerans may be suppressed by the type of algae that typically dominates the phytoplankton community.

2.4 Unique Characteristics of Lake Elsinore and Canyon Lake

More than ten years of studies completed on Lake Elsinore and Canyon Lake have provided new insight regarding water quality characteristics of each lake. These studies have identified a number of unique factors that must be considered in developing revised TMDLs for the lakes. These factors include:

- Under natural conditions in Lake Elsinore, extended droughts may cause severe evapoconcentration of salts and nutrients to levels that cannot support expected biological communities as well as periodic lakebed desiccation that completely eliminates the aquatic ecosystem (also see Section 2.2.2.2 and 2.2.2.4)
- Highly efficient retention of runoff and associated sediment in both Canyon Lake and Lake Elsinore, which severely limits or reduces losses of nutrient loads by flushing, i.e., overflow to downstream waters.
- Natural land cover in the San Jacinto River watershed is characterized by highly erodible soils that are rich in nutrients that generate significant sediment and associated nutrient loads to the lakes during extreme wet weather events.

These factors lead to evapoconcentration of salts in Lake Elsinore during periods of extended drought and, if reclaimed water were not discharged to the lake, eventual lakebed desiccation. In Canyon Lake, sedimentation rates far in excess of typical ranges for reservoirs facilitate the buildup of nutrient rich lake bottom sediments that continually depletes DO and sustains hypereutrophic conditions through repeated internal cycling.

In addition to these unique factors, which are discussed in more detail below, the LECL Task Force has been conducting studies that have provided better understanding of lake dynamics. These findings will also need to be considered when revising the TMDLs, as discussed below.

2.4.1 Extended Drought

Section 2.2.2.2 provides a summary of the historical nature of lake elevations in Lake Elsinore. This section builds on that information particularly as it relates to revision of the TMDLs. Measured inflows to Canyon Lake and outflows from Canyon Lake to Lake Elsinore show that extended drought, upstream runoff retention, and the very large drainage area exasperate long-term fluctuations in water delivered to the lakes. While the watershed to Canyon Lake is large relative to the lake surface area, it is also very efficient at retaining runoff in upstream impoundments such as Lake Hemet and Mystic Lake and through natural channel bottom recharge. In addition, Canyon Lake is used as a water supply source for EVMWD. Complete retention of runoff inflows to Canyon Lake has occurred in approximately half of hydrologic years since 1916. Conversely, in very wet years, runoff volumes commonly greater than the total Canyon Lake storage capacity are flushed through to Lake Elsinore.

USGS gauge data for inflows to Lake Elsinore show significant variability exists even when considering decadal averages (**Figure 2-46**). Review of cumulative runoff volume delivered to Lake Elsinore from the San Jacinto River shows that as much as two thirds of total inflow volume since the lake was dry in 1964 has been delivered during just five of 52 years. (**Figure 2-47**).

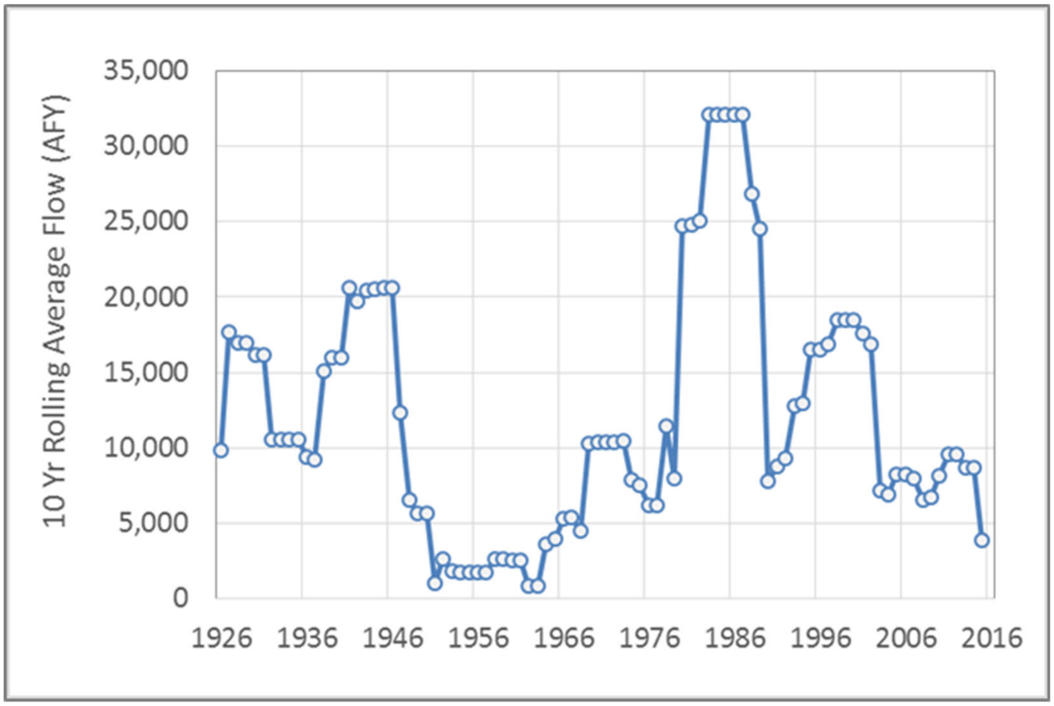


Figure 2-46. 10-Year Rolling Average Annual Runoff Inflow to Lake Elsinore from San Jacinto River Watershed

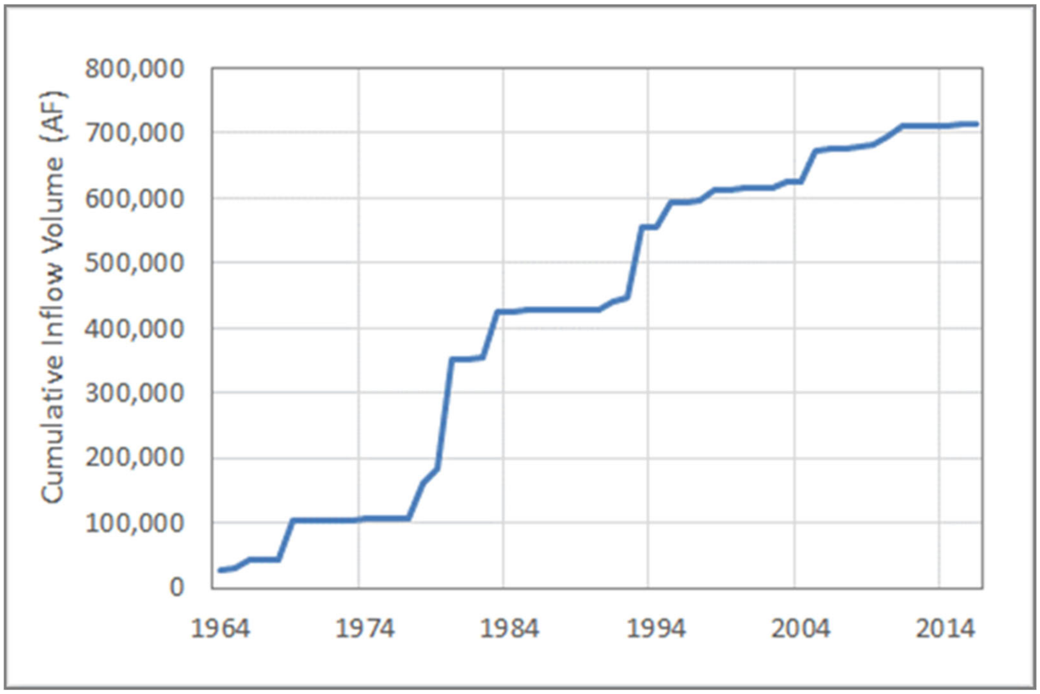


Figure 2-47. Cumulative Delivery of Runoff Volume to Lake Elsinore from the San Jacinto River (1964-2016)

Long-term periods of low (1950-1966) and high (1980-1990) inflow volumes can alter the hydrology of Lake Elsinore. This hydrology varies from complete lakebed desiccation at a water elevation of approximately 1,225 ft to wet weather overflow to Temescal Creek at water elevation 1255 ft, as shown in historical water level records (**Figure 2-48**). Management of Lake Elsinore's water level by addition of supplemental water began after 1964 and has successfully avoided extremely low water levels from occurring in Lake Elsinore. The Dynamic Reservoir Simulation Model (DRYESM) – Computational Aquatic Ecosystem Dynamics Model (CAEDYM)[3] for Lake Elsinore includes a water budget, which suggests that without any supplemental water additions, the current extended drought would have yielded a lake level of 1225 ft. (Anderson 2016d). This level would be comparable to the modeled level around 1960, when multiple references document the presence of a completely dry lakebed (see Figure 2-9). Further, without the implementation of the LEMP project to reduce the surface area of Lake Elsinore, it is plausible that even sharper water level declines would have occurred in response to the current drought.

The impact of extended droughts that historically lead to lakebed desiccation is a complete reset of the aquatic ecosystem. Prior to desiccation, water quality is degraded by evapoconcentration of nutrients and other salts in the water column. As the lake volume slowly declines to zero, the concentrations of ammonia and TDS reach extremely high values that far exceed acute toxicity thresholds for aquatic organisms (see Section 2.3). In addition, nutrient concentrations reach levels that may sustain blooms of algae in the remaining volume to harmful levels. Thus, not only does the drying out of the lake pose a significant threat to the aquatic ecosystem, but also the evapoconcentration during extended droughts prior to complete desiccation causes water quality conditions that may substantially impact most organisms.

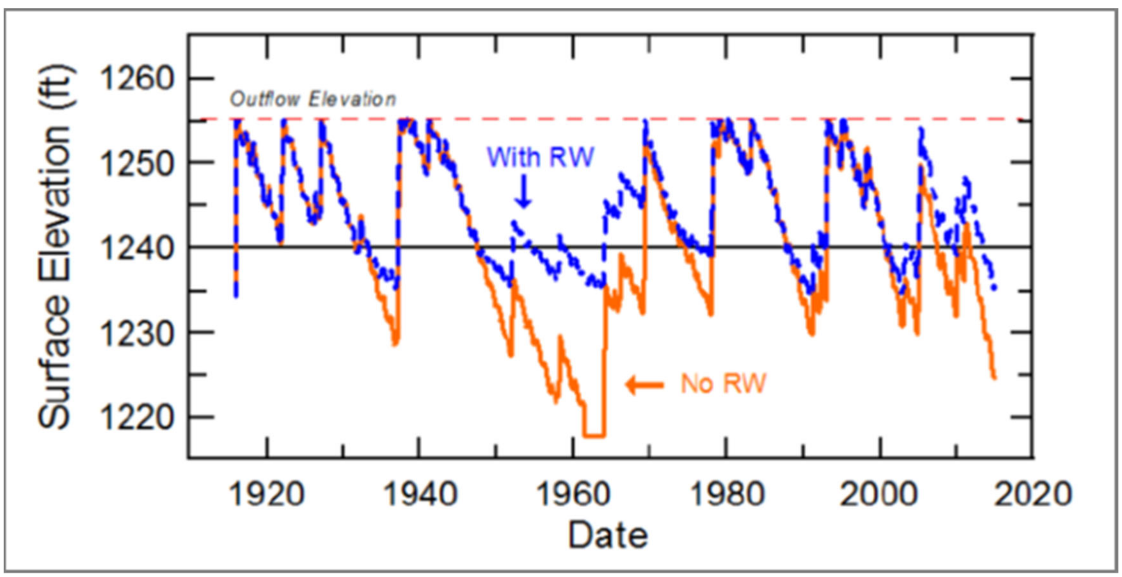


Figure 2-48. Modeled Water Level in Lake Elsinore for Scenarios with and without Supplemental Water Additions (from Anderson 2016d)

[3] See Section 3.2.2.4 and Section 5 for discussion regarding the use of these models for the revised TMDLs.

Prevention of such use impairment requires interventions involving supplemental water additions. Supplemental water available to stabilize the water level in Lake Elsinore has a typically higher concentration of TDS than runoff in overflows from Canyon Lake or stormwater from the City of Lake Elsinore. DYRESM-CAEDYM model results estimated a higher long-term average TDS concentration in the lake with supplemental water addition, but successful avoidance of lakebed desiccation or evapoconcentration to levels that exceed toxicity thresholds in most years (Anderson 2016e).

2.4.2 Sediment and Nutrient Retention

Flushing is a hydrologic process involving the conveyance of detained water through a waterbody to downstream waters. The water quality benefits of hydrologic flushing are to remove nutrients and algae contained in stored water and reduce the residence time of bioavailable nutrients to support new algal growth. Generally, lakes with low storage capacity relative to their drainage area size, like Lake Elsinore and Canyon Lake, overflow during moderately sized storms. However, highly variable hydrology and upstream retention limit the amount of flushing that these lakes experience. The opposite of flushing is retention. Runoff retention equates to complete retention of external loads of sediment and nutrients, which enhances eutrophic conditions of increased productivity and cycling of nutrients within the waterbody. Even without retaining all runoff, sediment and nutrients may still be retained by settling to the lake bottom before overflowing to the downstream waterbody.

Both Lake Elsinore and Canyon Lake have a low rate of hydrologic flushing; moreover, these waterbodies are configured in a way that facilitates retention of most external loads of sediment and nutrients. These characteristics can impact lake water quality and biological conditions. Sediment and nutrient retention characteristics of each lake are discussed below.

2.4.2.1 Lake Elsinore

In the period with concurrent gauge data (2001-2015), almost 90 percent of overflow volume from Canyon Lake to Lake Elsinore occurred during two wet seasons: 2004-2005 and 2010-2011. The volumes delivered in these wet seasons amounted to 4-5 times the total storage capacity of Canyon Lake. No overflows from Lake Elsinore to Temescal Creek have occurred since 1995, and therefore all runoff and associated sediment and nutrients that have passed through Canyon Lake have been retained in Lake Elsinore.

When overflows to Temescal Creek do occur, significant water quality benefits are expected, in particular salt, nutrient, and algae export via flushing. Historically, overflows to Temescal Creek occurred in roughly 10 percent of hydrologic years, but more efficient upstream retention appears to be reducing the frequency of overflows with the last event occurring in 1995 (Anderson 2016d).

2.4.2.2 Canyon Lake

Canyon Lake retains a significant portion of sediment and nutrients. Horne (2002) compared bathymetry mapping for East Bay conducted in 1986 and 1997 to estimate the accumulation of sediment over the 11-year period between surveys and found unusually high sedimentation rates of 2-3 in/yr, which are roughly 60 times greater than a typical lake (**Table 2-18**).

CDM Smith

Table 2-18. Sediment Accumulation in Canyon Lake East Bay from 1986 to 1997

Site	Approximate Sediment Depth (ft)		Average Annual Sediment Deposition (in/yr)
	1986	1997	
Site 1	6.5	9.1	2.8
Site 2	2.2	4.3	2.3
Site 3	2.7	4.5	2.0
Site 4	1.4	3.2	2.0
Site 5	1.2	3.5	2.5

An earlier USGS survey of 56 U.S. lakes, including Canyon Lake, involved different age-dating techniques to estimate sediment accumulation rates (Van Metre et al. 2004). The radionuclide ^{137}Cesium (Cs) was used as the primary age-dating technique for 42 of 56 lakes and is based on the apparent peak in ^{137}Cs that occurred after fallout from a short period of extensive testing of nuclear weapons in 1964. For Canyon Lake, the peak ^{137}Cs activity was identified at 118 cm depth from a single core collected from the downstream end of the Main Lake in November 1998, equating to an average annual sediment accumulation of 3.5 cm/yr (1.4 in/yr). This rate is based on a Main Lake sediment core and is lower than estimates for East Bay (see Table 2-18).

In the most recent bathymetric survey, Anderson (2016c) collected hydroacoustic echograms at three frequencies which allowed for mapping of the lake bottom, as well as an estimate of the thickness of sediment. Sediment samples collected from five sites across the lake at the same time as the hydroacoustic surveys showed that mobile-P was correlated to the low frequency echograms, which facilitated mapping of areas with greater organic content and mobile-P across the lake bottom (**Figure 2-49**). These areas, generally in the more downstream region of each lake segment pose the greatest potential for oxygen depletion and for releasing bioavailable nutrients to the water column.

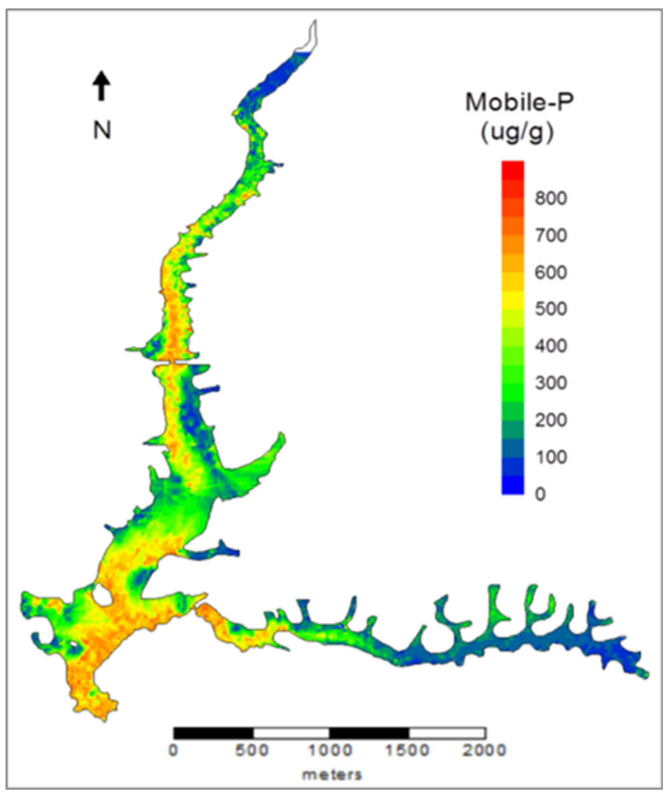


Figure 2-49. Estimated Concentration of Mobile-P in Canyon Lake Bottom Sediments Based on 2014 Hydroacoustic Survey (from Anderson 2016c)

Historically, the sediment and nutrients retained in Canyon Lake would naturally (without Railroad Can yon Dam) have been delivered to Lake Elsinore, since 94 percent of the Lake Elsinore watershed area is upstream of Canyon Lake. Of the sediment and nutrient loads that are not retained in Canyon Lake, referred to as pass-through, most are ultimately retained within Lake Elsinore.

The nutrient load to Canyon Lake and from Canyon Lake to Lake Elsinore can be determined from historical flow and water quality data from the two inputs to Canyon Lake (Salt Creek and San Jacinto River[4]) and overflow to Lake Elsinore. Continuous flow data was obtained from USGS gauges at these sites for the period of 2001 through 2014. **Figure 2-50** compares the total inflow runoff volume to Canyon Lake from Salt Creek and the San Jacinto River with overflow volume to Lake Elsinore. The estimate of Canyon Lake overflow is from USGS Gauge 11070500 (San Jacinto River near Lake Elsinore), which is approximately 2 miles downstream of the Canyon Lake spillway and therefore includes some runoff from a small subarea (~7,000 acres) between the two lakes in addition to Canyon Lake overflows. Annual runoff volumes from this gauge were summed for years when Canyon Lake exceeded its spill water elevation of 1,381.76 ft (2003-2005, 2008, and 2010-2011). In dry years when the lake did not reach its spill elevation, outflow was assumed to be zero (2002, 2006, 2007, and 2009). Results from wet weather monitoring during 25 storm events since 2007 for inflows to and outflow from Canyon Lake show that nutrient concentrations are reduced by approximately 50 percent when overflows are occurring (see Section 4). Combining nutrient and sediment loads that are retained when volume is retained and the estimated settling prior to overflows in wet years, an estimated 62 and 41 percent of long-term average external loads of TP and TN, respectively, is retained in Canyon Lake.

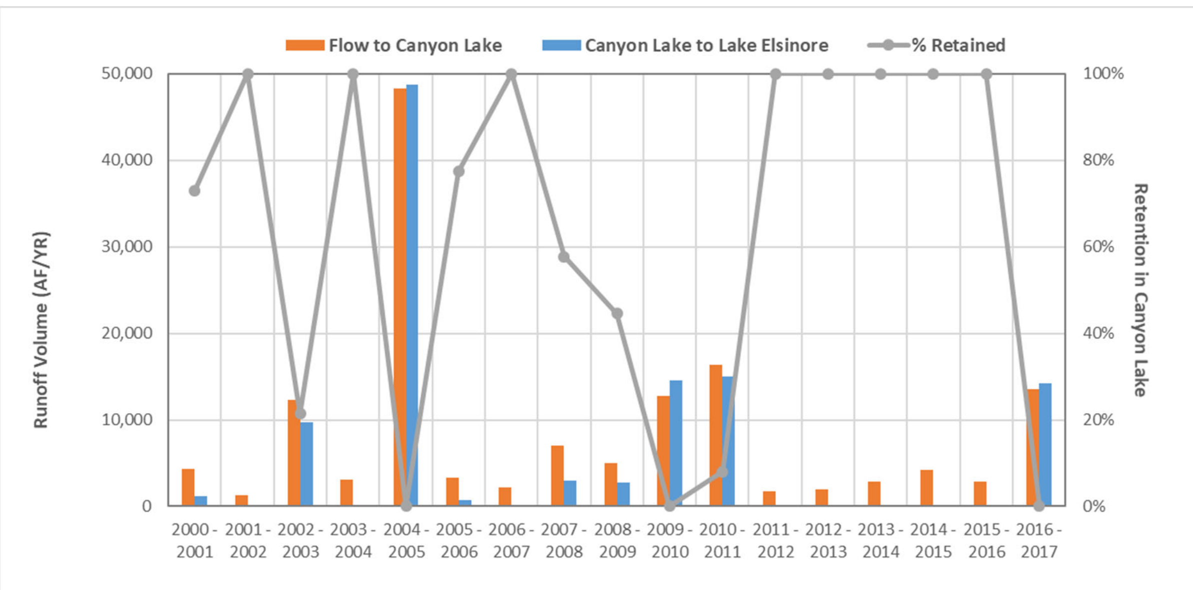


Figure 2-50. Annual Runoff Volume into Canyon Lake and Overflow to Lake Elsinore

[4] However, as noted in Section 2.2.1, flows from the San Jacinto River watershed need to be revised per new understanding regarding upstream retention, e.g., in the Mystic Lake subwatershed.

2.4.3 Watershed Soil Erosion

Monitoring data show very high concentrations of suspended solids and nutrients during high intensity storm events (most recently in January 2011) that generate significant soil erosion, even from undeveloped hillsides. Sediment loads from these types of events may exceed typical winter storms by 100 times (Horne 2002). While these events may be infrequent and episodic, the impact to water quality in the downstream lakes persists for multiple years in the form of enrichment of bottom sediments and subsequent nutrient flux rates to the water column (see Section 4). Anderson (2012d) estimated the half-life ($t_{1/2}$) of nutrients delivered to the lake bottoms of Canyon Lake ($t_{1/2}$ of 6.7 years for organic-P and 16.7 years for TN) and Lake Elsinore ($t_{1/2}$ of 60.4 years for organic-P and 30.1 years for TN). The TMDL revision must consider that these episodic nutrient loads are partially attributable to natural background land areas and would be likely to occur in a pre-developed or "reference" watershed. Moreover, returning loads to a reference level will not provide immediate water quality improvements.

2.4.4 Canyon Lake Dynamics

The existing nutrient TMDL for Canyon Lake employed a linkage analysis that assumed a single fully mixed lake basin and thereby developed a single set of allocations for external loading. However, as described above and as demonstrated by studies, Canyon Lake has three distinct segments, namely the Main Lake, North Ski Area, and East Bay. The North Ski Area and Main Lake receive runoff from the San Jacinto River. Runoff from the San Jacinto River flows into the North Ski Area and then through culverts under Greenwald Avenue to the Main Lake. Hydraulically, these two lake segments are completely connected, and the North Ski Area is an extension of the Main Lake to its transition to the San Jacinto River inflow. For this reason, these two lake segments are not treated as separate receiving waters in the TMDL revision.

Conversely, the East Bay of Canyon Lake is very different in many ways from the Main Lake (**Table 2-19**). The East Bay has an entirely different drainage area than the Main Lake, with most runoff coming from Salt Creek. During wet weather events, water from East Bay outflows to the lower part of the Main Lake via a single 12-foot culvert under Canyon Lake Drive. Exchanges between the Main Lake and East Bay are minor during dry weather conditions. Thus, it is important for East Bay, and its Salt Creek source area, to be treated separately in the revised TMDL.

Table 2-19. Key Differences between Canyon Lake Main Lake and East Bay

Characteristic	Main Lake	East Bay
Watershed	San Jacinto River	Salt Creek
Lake Depth	30-60 feet	5-15 feet
Thermal Stratification	Hypolimnion ~1,500 AF (30% of full pool) April – November	Hypolimnion ~200 AF (5% of full pool) April – September
Water Quality Drivers	Low DO, high NH3, Soluble Reactive Phosphorus (SRP) in hypolimnion mixes over water column at turnover, which may cause fish kills, algal blooms	Nutrient rich sediments from large watershed loadings, flux to water column sustains algal blooms throughout the year
Primary Conveyance	Overflow to Lake Elsinore	To Main Lake through culvert

2.5 Summary

This Problem Statement summarized existing water quality regulations and the basis for the adoption of the 2004 TMDLs for each lake. In addition, this section provided a review of the current understanding of the characteristics and dynamics of Lake Elsinore and Canyon Lake and the San Jacinto River watershed, including key findings from almost 15 years of research completed since adoption of the 2004 TMDLs. These findings, which provide the basis for development of subsequent sections of this technical report and revisions to the TMDLs, include:

- Better understanding of the San Jacinto River watershed and retention of flows in the upper watershed, e.g., as retained by Mystic Lake.
- The highly managed nature of Lake Elsinore and Canyon Lake and the influence of these management actions on expected water quality and biological conditions.
- Water quality conditions related to naturally occurring hydrologic cycles that influence water quality and aquatic biological expectations, especially for Lake Elsinore.
- Dynamics of sediment and nutrient retention and their influence on conditions in each lake.
- Role that natural background levels of nutrients in the watershed have on downstream water quality.
- Better understanding of the differences in the dynamics in the East Bay and North Ski Area versus the Main Lake in Canyon Lake and how this may influence water quality expectations.

Section 3
Numeric Targets

Lake Elsinore and Canyon Lake are impaired for the WARM, REC1 and REC2 beneficial uses. Canyon Lake is also listed as impaired for the MUN use. A TMDL establishes numeric targets to provide a basis for demonstrating attainment of WQOs and protection of impaired beneficial uses. That is, achievement of the numeric target(s) is expected to result in the waterbody of concern no longer being impaired. Where the WQOs are narrative, the TMDL translates the narrative WQO into appropriate response targets to assure attainment of the objective. This section establishes the numeric targets for the revised TMDLs and provides the technical basis for the selection of these targets.

Table 2-3 in the 2004 TMDLs presents the numeric targets for Lake Elsinore and Canyon Lake for interim (2015) and final (2020) compliance timelines (see Table 2.2 in this document). The Staff Report for the TMDL describes the scientific basis used to determine these targets (Santa Ana Water Board 2004b). This TMDL revision uses additional scientific understanding from research performed after the existing TMDL was adopted to revise these numeric targets for Lake Elsinore and Canyon Lake (Main Lake and East Bay). The primary objective in the development of revised numeric targets is to establish water quality conditions that are equal to or better than what would occur in the lakes if the watershed was returned to a reference condition (i.e., pre-development). This section is organized into the following sections to describe how this objective has been achieved with the revised TMDL numeric targets described below:

- *Section 3.1 - Water Quality Standards Interpretation*: Water quality standards include beneficial use classifications, WQOs, and antidegradation criteria for named waters in the Basin Plan. For Lake Elsinore and Canyon Lake, nutrient TMDLs were developed to address impairment of water quality standards in these lakes. The WQOs applicable to the beneficial uses of these lakes serve as the building blocks for developing the TMDL numeric targets described in this section.

- *Section 3.2 – Establishment of a Reference Watershed*: No watersheds comparable to Canyon Lake or Lake Elsinore exist in southern California or other areas with similar climatic regimes. As such it is not possible to establish allowable pollutant loads using another watershed/downstream waterbody combination as a means to describe an expected reference condition. Instead, using data from reference subwatersheds within the San Jacinto River watershed upstream of Lake Elsinore and Canyon Lake, a lake water quality modeling scenario representative of a hypothetical reference watershed condition for drainage areas to Lake Elsinore and Canyon Lake was developed to provide the basis for establishing numeric targets. This approach will be described in this section. In addition, this section will briefly describe the characteristics of the reference watershed condition for Lake Elsinore and Canyon Lake.

- *Section 3.3 - Numeric Targets*: – Numeric targets are presented as cumulative distribution functions (CDFs) to characterize spatial and temporal variability in water quality that may be expected in Lake Elsinore and Canyon Lake (Main Lake and East Bay) under a reference watershed condition. This section contains CDFs of model results for a reference watershed scenario for indicators of beneficial use impairments, including nitrogen, phosphorus, chlorophyll-*a*, DO, and ammonia. The CDFs results are provided along with corresponding time series, histogram and box and whisker data presentations.

3.1 Water Quality Standards Interpretation

Water quality standards set forth in the Basin Plan include beneficial use designations, WQOs required to protect those uses, and an antidegradation policy. Where water quality standards are not being attained and a finding has been made that one or more beneficial uses is not protected, the waterbody is considered impaired and placed on the state 303(d) List. Subsequently, a TMDL is developed to establish the maximum allowable pollutant loads that the waterbody may receive from all sources and meet water quality standards. The Lake Elsinore and Canyon Lake Nutrient TMDLs were developed as a result of impairment of the WARM, REC1, and REC2 uses. The TMDL for Canyon Lake also considered impairment of the MUN beneficial use.

3.1.1 Warm Freshwater Habitat (WARM) Beneficial Use

The Basin Plan defines the WARM beneficial use as follows (Santa Ana Water Board 2016, as amended):

> *"WARM waters support ecosystems that may include, but are not limited to, preservation and enhancement of aquatic habitats, vegetation, fish and wildlife, including invertebrates."*

Protection of this beneficial use requires consideration of a number of water quality characteristics. These characteristics as well as the Basin Plan WQOs established to protect this use are discussed in the following sections.

3.1.1.1 WARM Use Protection

Table 3-1 identifies specific metrics that may support an impairment finding for the WARM use. These metrics are listed in a hierarchy of causality ranging from direct measures of impairment of the WARM use (Levels 1 and 2) to indirect measures.[1] Use of indirect measures often require an understanding of complex inter-relationships among several factors prior to determining that the WARM use is impaired (Levels 3, 4, 5). Level 5 nutrients are causal variables because all other use impairment indicators at higher levels in the hierarchy are ultimately caused by excess nutrients. Accordingly, factors such as algae concentrations (Level 4) and water quality stressors (Level 3) may be referred to as response variables. However, in the impairment hierarchy, Level 3 and 4 indicators may also cause direct use impairments themselves. For example, low levels of DO can directly impair the WARM use.

Direct impairment of the WARM use can be assessed with indices of biological integrity and frequency of fish kills. Since fish kills do not routinely occur and biological integrity indices

[1] Levels 1 and 2 are direct indicators of use impairment or 'measures of effect'; Levels 3, 4 and 5 are indirect indicators of use impairments, with levels 3 and 4 comparable to 'intermediate measures' and level 5 comparable to 'measures of exposure' as defined in the California's numeric nutrient endpoint (NNE) framework for freshwater (Tetra Tech, Inc. 2006).

require focused snapshot surveys, using these indicators to measure progress towards attainment is challenging. The State Water Board is in the process of developing a Biological Integrity Assessment Implementation Plan (for Perennial Streams and Rivers),[2] which may evolve to include lakes and incorporate a new methodology for the evaluation of biological data to evaluate use impairments in future assessments. Currently, other indicators can be measured directly using field and laboratory techniques including Level 3 water quality stressors.

Table 3-1. Hierarchal Assessment of WARM Use Attainment in Lake Elsinore and Canyon Lake

Priority	Beneficial Use Integrity Indicator	Direct or Indirect Measure[1]
Level 1	Fish kills	Direct
Level 2	Biological health indices: Species richness & abundance	Direct
Level 3	Water quality stressors: DO, un-ionized ammonia, hydrogen sulfide (H_2S), cyanotoxins	Indirect
Level 4	Algae bloom concentration and persistence	Indirect
Level 5	Nutrients: Nitrogen and phosphorus	Indirect

[1] See discussion of direct and indirect measures in Section 3.1.1.1.

Level 3 water quality stressors include a series of indicators that may contribute, in varying degrees, to impacts on biological community health and occurrence of fish kills. The degree to which each contributes individually is unknown, i.e., to date, little to no data exist to discern which of these stressors are the primary cause of impairment of the WARM use in Lake Elsinore or Canyon Lake. Each Level 3 stressor is described below:

- *Dissolved Oxygen*: When algae decay and settle, the lake bottom sediments become enriched with nutrients and oxygen demanding organic matter. Sediment oxygen demand creates anoxic conditions in lake bottom waters. For stratified lake segments, there is not enough reaeration from the lake surface to offset sediment oxygen demand and oxygen can be depleted throughout most of the hypolimnion. Turnover is the mixing of bottom waters with top waters after the lake mixes (de-stratifies) around October-November when the top waters cool. Immediately following turnover, low DO conditions throughout the water column may occur and cause stress for fish.

- *Un-ionized Ammonia*: Anoxic conditions in the lake bottom, an indirect result of algae decay and enrichment of bottom sediments as described above, facilitates the process of ammonification. Ammonification is the conversion of organic nitrogen to ammonia by anaerobic decomposition. In its un-ionized form (NH_3), ammonia is toxic to aquatic species. The un-ionized fraction of ammonia increases exponentially with changes in temperature and pH (EPA 2013). Photosynthesis by algae in lakes increases pH, which in turn increases the NH_3 fraction of total ammonia nitrogen.

[2] http://www.swrcb.ca.gov/plans_policies/biological_objective.shtml

- *Total Dissolved Solids*: Lakes with limited flushing and significant evaporative losses relative to average runoff inflows experience increased TDS by evapo-concentration, most severely in periods of extended drought. TDS is a stressor for freshwater aquatic life, including many fish species. Zooplankton communities that graze upon algae, which can mitigate the duration and magnitude of algal blooms, are often highly vulnerable to rises in TDS.

- *Hydrogen Sulfide (H_2S)*: Anoxic conditions in the lake bottom, an indirect result of algae decay and enrichment of bottom sediments as described above, also facilitate sulfate reduction to H_2S by anaerobic bacteria respiration. H_2S is toxic to aquatic species.

The revised TMDL includes a numeric target for chlorophyll-*a*, which is a measure of a pigment found within algae, and a commonly used measure of algae concentration in surface waters. Algae require sunlight for photosynthesis and therefore are generally found within the photic zone of a surface water. The TMDL numeric target for algae is for the average chlorophyll-a concentration within the top 1-m of the water column. Below 1-m, light penetration is often inhibited by algal and inorganic turbidity.

At the bottom of the hierarchy as shown in Table 3-1 are the nutrients nitrogen and phosphorus, which influence algae growth and persistence of algal blooms. Nutrients are the only indicator that can be accounted for in external inputs to the lakes, and therefore provide the basis for the existing TMDL, expressed as the total allowable load of nutrients to each lake segment. The relationship between Level 5 indicator nutrients and Level 1 and 2 direct measures of WARM use attainment involves many complex physical, chemical, and biological processes, as illustrated in **Figure 3-1**. The TMDL linkage analysis will identify the relationships between nutrients and higher-level use attainment indicators, such as algae (as measured as chlorophyll-*a*), DO, and ammonia toxicity. These are better measures of impairment and will be used as the basis for establishing revised numeric targets in the TMDLs.

Not included in the WARM use attainment hierarchy (Table 3-1) is the potential effects of extended drought. For example, extended drought can impact algae as depicted in Figure 3-1, and the influence of extended droughts in the watersheds that drain to Canyon Lake and Lake Elsinore can contribute to the severity of WARM use impairments. For example, Figure 3-1 shows how increased salinity by evapo-concentration constrains zooplankton communities, which in turn limits the effectiveness of this aquatic community to graze and mitigate algal levels. Also, as salinity rises, the types of algae (e.g., cyanobacteria that may contain toxins) that thrive in higher TDS conditions are more prevalent and tend to be less edible for zooplankton. This process of increasing salinity is most applicable to Lake Elsinore because of its greater susceptibility to extended droughts because of its almost complete lack of flushing, significant evaporative loss from its large surface area, and reduced inflow of freshwater from retention of runoff upstream in Hemet Lake, Mystic Lake and other recharge basins, as well as within Canyon Lake.

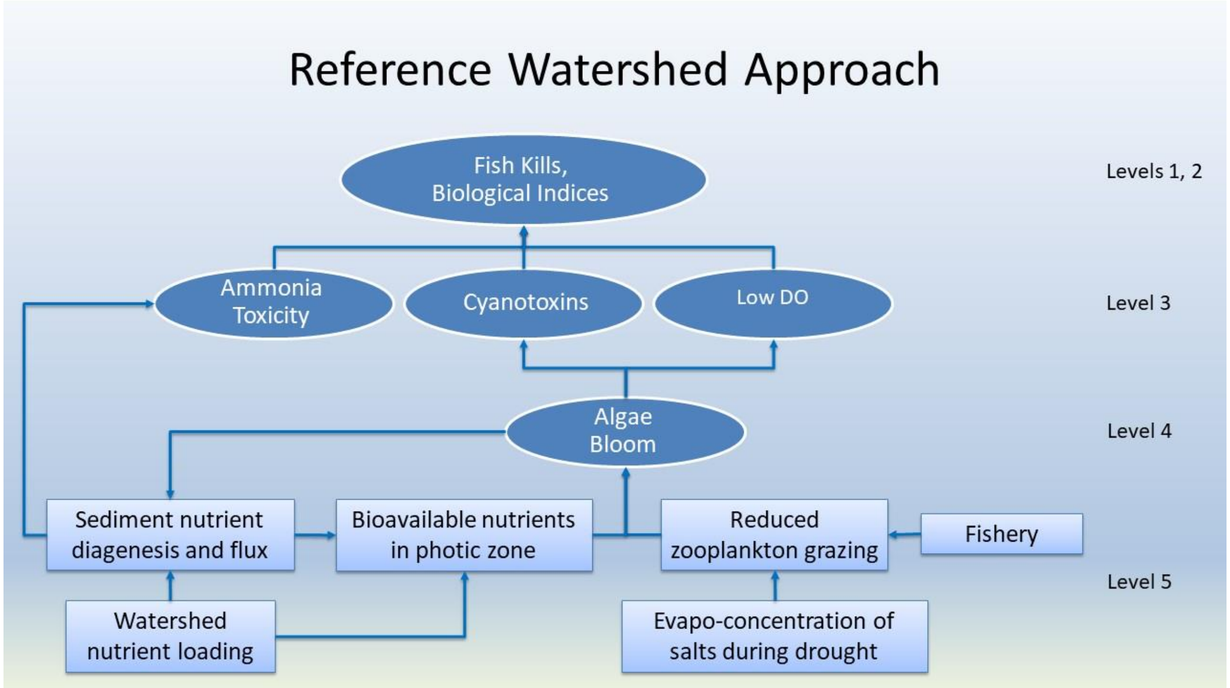


Figure 3-1. Processes that Cause Impairment of the WARM Beneficial Use Organized According to the WARM Use Hierarchy (see Table 3-1)

3.1.1.2 Water Quality Objectives

The Basin Plan includes WQOs for several of the water quality indicators presented above. Table 2-1 in Section 2 (Problem Statement) summarizes these objectives. The following sections summarize how these objectives have been considered in the development of numeric targets for the revised TMDLs:

Algae

The WQO for algae is narrative and therefore does not include a numeric threshold value for use in developing TMDL numeric targets (Santa Ana Water Board 2016, as amended). Specifically:

> *"Waste discharges shall not contribute to excessive algal growth in inland surface receiving waters"*

Development of a TMDL numeric target requires interpretation of the above narrative language, most notable being the need to interpret the term "excessive" used to describe the level of algae growth that is to be controlled. The approach used to set TMDL numeric targets for Canyon Lake (Main Lake and East Bay) and Lake Elsinore is based on the premise that "excessive" is equivalent to any amount of algae above that would occur if the upstream watershed were to be returned to a reference condition (see Section 3.2 below). Chlorophyll-*a*, a pigment found within algae, is a commonly used measure of algae concentration in surface waters and therefore numeric targets in nutrient TMDLs are based on concentrations of chlorophyll-*a*.

Dissolved Oxygen

The Basin Plan WQO for DO is as follows (Santa Ana Water Board 2016, as amended):

> *"The dissolved oxygen content of surface waters shall not be depressed below 5 mg/L for waters designated WARM, or 6 mg/L for waters designated COLD, as a result of controllable water quality factors"*

The WQO is used to develop TMDL numeric targets based on the threshold concentration of 5 mg/L for the WARM use. The Basin Plan DO WQO specifically limits the responsibility to dischargers to "controllable water quality factors." This qualifier supports the use of a reference watershed approach, where impacts to DO in the downstream waterbodies can be related to controllable factors in a developed watershed. The corollary case is that DO impairments that occur naturally, as a result of reference watershed loads, i.e., under pre-development conditions, could be reasonably categorized as resulting from uncontrollable water quality factors.

The DO WQO does not include any guidance on how compliance should be evaluated, particularly with regards to spatial or temporal averaging. With regards to the former, DO concentrations may vary significantly from the surface to the bottom of a lake simply because of natural processes associated with stratification. The applicability of DO objectives to the entire water column for Lake Elsinore and Canyon Lake was uncertain per the 2004 TMDL Staff Report, which stated (Santa Ana Water Board 2004b):

> "*The Basin Plan does not identify the depth over which compliance with this objective is to be achieved, nor does it reflect seasonal differences that may result in DO variations associated with stratification in the lakes… As the relationship between nutrient input and dissolved oxygen levels in the lakes is better understood, the TMDL targets for dissolved oxygen can be revised appropriately to ensure protection of aquatic life beneficial uses."*

From a biological standpoint, it is important that fish and aquatic life have sufficient access to waters with greater than 5 mg/L in enough portions of key habitat areas of the lake volume to find refuge during periods of depressed oxygen levels. This is especially important given that fish kills resulting from low DO conditions generally occur over small windows of time. The development of numeric targets for the revised Lake Elsinore and Canyon Lake TMDLs will define the spatial and temporal extent of water with greater than 5 mg/L DO based on conditions that would be expected for a reference watershed (see Section 3.2 below).

Ammonia Toxicity

In 2013, EPA published final ammonia criteria (EPA 2013) based on new scientific studies. These criteria updated the previously published 1999 criteria (EPA 1999b). The 2013 EPA ammonia criteria involves a calculated acute and chronic concentration for total ammonia-N that is dependent upon temperature and pH, which impact the portion of total ammonia that is in the toxic un-ionized form. The 2013 criteria address the frequency for which acute and chronic concentrations must be protected, as follows:

- Acute - One-hour average concentration does not exceed, more than once every three years on the average.

- Chronic - Thirty-day average concentration does not exceed, more than once every three years on the average.
- Highest four-day average within the 30-day period should not exceed 2.5 times the chronic criteria, more than once every three years on the average.

Two sets of criteria have been published depending upon whether the waterbody contains highly sensitive freshwater mussels in the unionid family. This family of mussels was not present in any surveyed southern California lakes in recent surveys (Howard et. al. 2015 and Howard 2010), nor from historical surveys by Coney (1993). The 2013 EPA criteria have not been adopted as WQOs in the Basin Plan. Accordingly, these criteria were not considered as part of the development of revisions to the TMDLs.

The Basin Plan includes a narrative objective for general toxic substances (Santa Ana Water Board 2016, as amended):

> *"The concentrations of toxic pollutants in the water column, sediments or biota shall not adversely affect beneficial uses."*

Lake Elsinore continues to be listed as impaired for toxicity (State Water Board 2017a). Given this listing and because Lake Elsinore and Canyon Lake remain listed as impaired for nutrients, the revised TMDL will continue to have a numeric target for ammonia. However, because the Santa Ana Water Board has not yet updated its ammonia WQOs consistent with EPA (2013), the revised TMDL numeric targets for ammonia will be for total ammonia-N, based on conditions that would be expected for a reference watershed (see Section 3.2 below).

3.1.2 Recreational Beneficial Uses

The Basin Plan defines the REC1 and REC2 beneficial uses as follows (Santa Ana Water Board 2016, as amended):

- *REC1* - Waters used for recreational activities involving body contact with water where ingestion of water is reasonably possible. These uses may include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, whitewater activities, fishing and use of natural hot springs.
- *REC2* - Waters used for recreational activities involving proximity to water, but not normally involving body contact with water where ingestion of water would be reasonably possible. These uses may include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing and aesthetic enjoyment in conjunction with the above activities.

The REC uses were determined to be impaired based on nutrient levels and presence of excessive algae, which "produces offensive odors and an unsightly lakeshore, adversely affecting use of the lake for water-contact and non-contact recreational purposes" (Santa Ana Water Board 2004 a, b). Cyanobacteria, also known as blue-green algae, naturally occur in the environment but certain species, when lysed, release cyanotoxins such as microcystins that can be stressors to other aquatic species and be toxic to humans and pets. Reducing the occurrence of these types of bacteria is an important consideration when ensuring protection of recreation beneficial uses.

The CCHAB Network is developing toxin thresholds to be used as guidance for posting advisory signs on waterbodies where cyanobacteria may be a concern (CCHAB 2016; State Water Board 2016; also see discussion regarding cyanotoxin observations in Lake Elsinore in Section 2.2.2.6). Considering a recent national study that related TN and chlorophyll-*a* levels to the probability of the presence of microcystins (Yuan et al. 2014) and expected concentrations of TN and chlorophyll-*a* under reference conditions (see Section 3.3 below), it is likely that microcystins will be present at levels above recommended thresholds even under reference conditions. However, Yuan et al. (2014) notes that their findings were derived from a national-scale dataset and lake-specific analyses would more accurately predict expected responses in a specific lake.

3.1.3 Municipal and Domestic Water Supply

The Basin Plan defines the MUN beneficial use as follows (Santa Ana Water Board 2016, as amended):

> *"Waters are used for community, military, municipal or individual water supply systems. These uses may include, but are not limited to, drinking water supply."*

EVMWD uses Canyon Lake as a domestic water supply for its customers. The MUN use was listed as impaired because of high algal productivity which periodically caused EVMWD to shut down the Canyon Lake Water Treatment Plant because high levels of algae may cause clogging in water treatment filters (Santa Ana Water Board 2004b).

3.2 Establishment of a Reference Watershed

Development of numeric targets for this TMDL revision relies on the use of a lake water quality modeling scenario that is representative of a hypothetical reference watershed condition for the areas that drain to Lake Elsinore and Canyon Lake. Characteristics of a reference condition for the SJR watershed and the modeling approach employed to develop TMDL numeric targets are described below.

3.2.1 Overall Approach

The revision of the Lake Elsinore and Canyon Lake TMDLs relies on the use of a reference watershed approach for setting numeric targets and determining allowable loading capacity for developing allocations (**Figure 3-2**). The process shown in Figure 3-2 characterizes the reference watershed approach involving first an estimate of nutrient loads for a reference watershed, which is then followed by a linkage analysis and numeric target determination. The primary objective of developing a TMDL using a reference watershed approach is to establish targets that when met result in water quality conditions in each lake segment that are equal to or better than would be expected for a natural, or reference, waterbody.

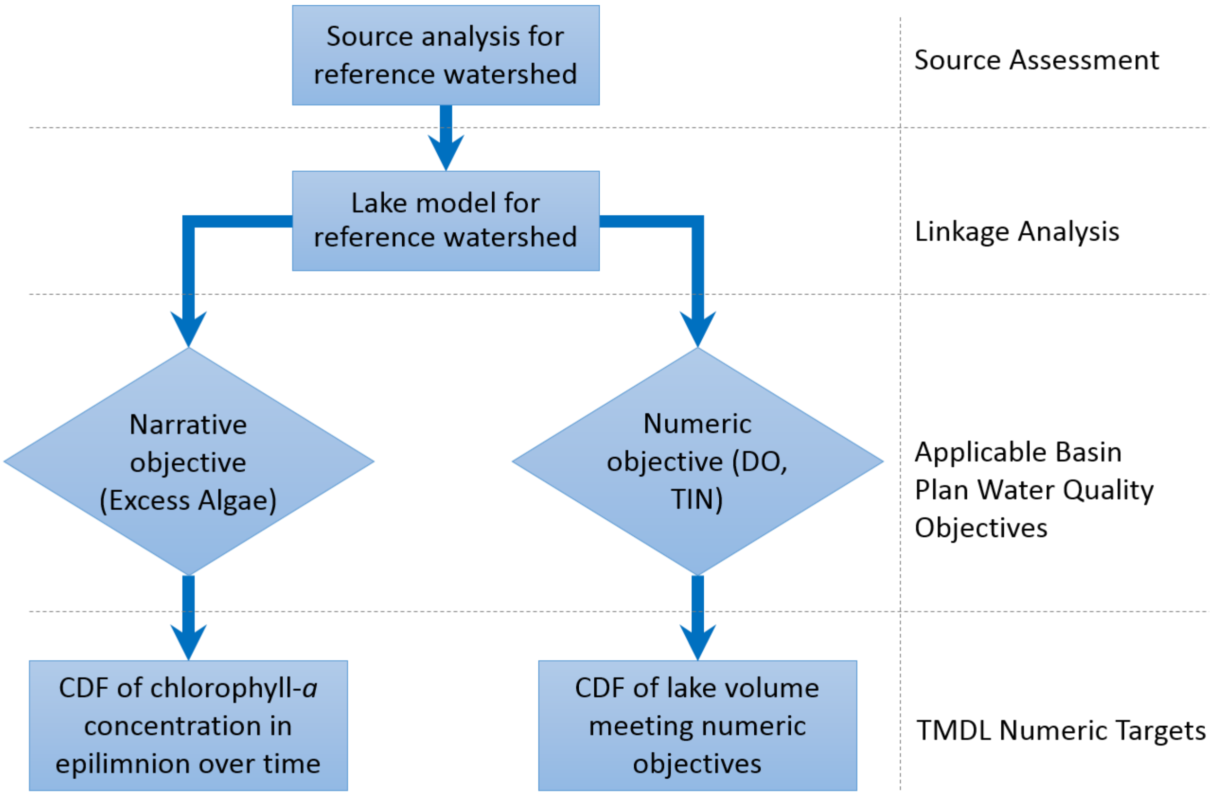


Figure 3-2. Process for Developing TMDL Numeric Targets Using a Reference Watershed Approach (Note: For a narrative objective, it may be necessary to define what is an exceedance of the objective)

The reference watershed approach embodies the State Water Board's basis for making an impairment finding (State Water Board 2015a):

> *"A water segment shall be placed on the section 303(d) list if the water segment exhibits significant degradation in biological populations and/or communities as compared to reference site(s) and is associated with water or sediment concentrations of pollutants including but not limited to chemical concentrations, temperature, dissolved oxygen, and trash."*

3.2.1.1 Use of the Watershed to Define the Reference Condition

There are no comparable inland lakes to Lake Elsinore or Canyon Lake that could be considered reference sites. These lakes have unique conditions that are very unlikely to be replicated downstream of a natural watershed in the same geographic region where urban development is widespread. These unique conditions were described in the Problem Statement (see Section 2.4). Therefore, for the revised TMDLs a hypothetical scenario was employed to define the reference site, whereby runoff nutrient concentrations representative of a completely natural, or reference, watershed were assumed to comprise the entire drainage area to the existing lake basins. This approach is consistent with EPA Region 9 in Guidance for Developing TMDLs in California (EPA 2000). This guidance recognizes the utility of hillslope targets, such as a reference watershed nutrient concentration, for setting numeric targets in a TMDL for impaired receiving waters:

> *"…It is sometimes possible to supplement instream indicators and targets with hillslope targets - measures of conditions within the watershed which are directly associated with waterbodies meeting their water quality standards for the pollutant(s) of concern."*

Within the context of this TMDL revision, this guidance is interpreted to mean that measures of hillslope, or watershed, conditions are directly associated with attainment of water quality standards in their downstream waterbodies. Hence, since Lake Elsinore and Canyon Lake are downstream waterbodies within the San Jacinto River watershed, upstream reference watershed conditions may be used to establish appropriate TMDL targets for these waterbodies.

3.2.1.2 Spatio-temporal Variability

In a reference watershed condition, external nutrient loads are delivered with extreme temporal variation within a single wet season and with year to year variability extending over decadal timescales. The dynamic water quality response within the downstream lakes is even more variable because of other factors that control nutrient cycling, productivity, and sediment diagenesis. Also, Lake Elsinore and Canyon Lake are not completely mixed and exhibit naturally occurring spatial variability in nutrients and aquatic ecosystems. For these reasons, it is inappropriate to set lake-wide average numeric targets based on a static condition. The California approach considered for setting NNEs came to this same conclusion for freshwaters, stating (Tetra Tech, Inc. 2006):

> *"Evaluation of a target also needs to consider questions of temporal and spatial applicability consistent with the desired use protection. Temporally, a chlorophyll a target can be defined as a point-in-time measurement (or frequency of such measurements) … Spatially, the target could be applied….in relation to specific sub-habitat areas."*

The TMDL requires reduction of nutrient sources to mitigate beneficial use impairments in excess of a frequency and magnitude (spatial extent) that would be expected for a reference watershed condition. A critical question for setting numeric targets is, how does one decide what is an excess level of a water quality constituent such that the beneficial use is impaired relative to a reference condition accounting for naturally occurring spatio-temporal variability? In short, this question is best addressed by expressing the Lake Elsinore and Canyon Lake TMDL numeric targets as CDFs.

A CDF is a plot of a statistical distribution for a set of data. **Figure 3-3** shows a series of historical depth-integrated chlorophyll-*a* concentrations converted to a CDF. Review of the time series history plot gives a sense for the long-term temporal variations in water quality. Translation to a CDF removes the consecutive order in a time series plot and instead expresses the long-term frequency of occurrence for different levels of water quality. It would be nearly impossible for future water quality to follow the same temporal pattern shown in the historical time series plot on the left in Figure 3-3. Fluctuations caused by short-term weather phenomena and longer-term climate patterns are expected to be similar, but will occur in a unique order. However, over time, future water quality data converted to a CDF should align with the CDF of historical water quality, if no significant changes are made in the watershed or to the lakes that impact water quality in the lakes.

The CDF graphs should be interpreted as follows: As shown in Figure 3-3 chlorophyll-*a* exceeded 100 µg/L about 50 percent of the time based on historical monitoring over a 14-year monitoring period. Without any significant change in management practices, future water quality monitoring results over any other 14-year period would also be expected to have about 50 percent of samples exceeding 100 µg/L chlorophyll-*a*.

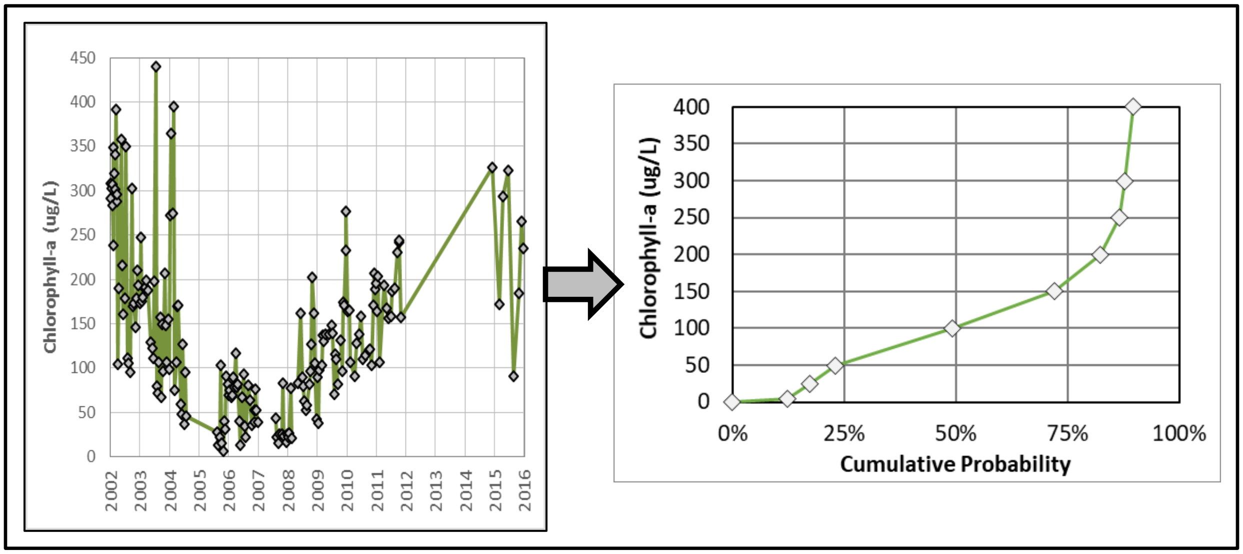


Figure 3-3. Conversion of a Long-term Routine Monitoring Data Set to a CDF Curve

In the case of CDF-based TMDL numeric targets, the data are daily average model results for a reference watershed scenario for beneficial use impairment indicators. This expression of the targets is based on the logical premise that returning loads from the watershed to reference levels would cause in-lake use impairment indicators to exhibit the same spatial and temporal variability expected for a reference watershed condition.[3] In other words, TMDL compliance will be achieved when CDFs developed from future long-term post-implementation monitoring are similar to the reference watershed model-based numeric target CDFs.

The concept for using CDF curves as a basis for defining expected water quality has been used elsewhere. For example, the State of Virginia adopted water quality standards for Chesapeake Bay segments that included a similar approach involving the use of a criteria reference curve for assessing water quality standards attainment. The reference curve was developed to account for naturally occurring conditions of hypoxia in Chesapeake Bay suggested from multiple lines of evidence (EPA 2003). The guidance states:

> *"Attainment of these criteria shall be assessed through comparison of the generated cumulative frequency distribution of the monitoring data to the applicable criteria reference curve for each designated use. If the monitoring data cumulative*

[3] However, note that the true natural reference condition for Lake Elsinore is a terminal lake that dried up periodically (See Section 2.2.2). Modifications to the watershed (construction of Canyon Lake Reservoir) and changes to the physical structure of Lake Elsinore (implementation of LEMP) have created a modified reference condition that is irreversible.

> *frequency curve is completely contained inside the reference curve, then the segment is in attainment of the designated use."*

This EPA criteria guidance, which supported the use of a reference criteria curve approach for making an attainment assessment, was adopted into the water quality standards for the States of Virginia (Virginia Administrative Code 2017) and Maryland (Code of Maryland Regulations 2017) for Chesapeake Bay segments. The approach described above and illustrated in Figure 3-3 is appropriate for situations where the WQO is narrative. **Figure 3-4** portrays an alternative approach for using a CDF to establish a TMDL numeric target where the Basin Plan establishes a numeric WQO for a constituent, such as the WQO for DO not to be depressed to below 5 mg/L to support the WARM use. In this case, the CDF approach is modified to account for both the frequency and spatial extent of impairments. This is accomplished by changing the value expression for the y-axis of the CDF from the spatially averaged concentration to the fraction of the total lake volume that is within the numeric WQO threshold (Figure 3-4).

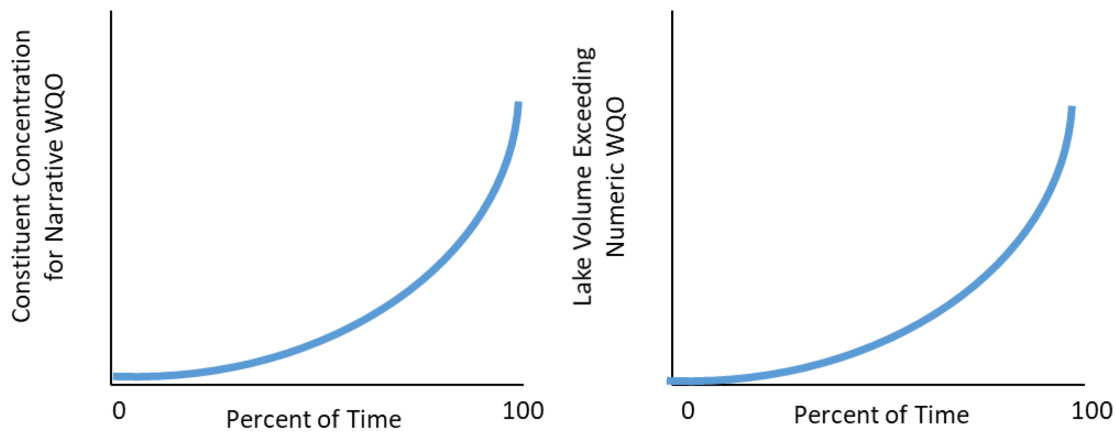


Figure 3-4. CDF Plots to Evaluate Attainment with Selected Constituents. Left - Narrative WQOs, e.g., Algae; Right - CDFs of Lake Volume Meeting Numeric WQOs for DO and TDS

This alternative method of expressing the CDF is apparent in the methods description for the development of reference criteria curves in the Chesapeake Bay (EPA 2003), as follows:

> *"The cumulative frequency distribution methodology for defining criteria attainment addresses the circumstances under which the criteria may be exceeded in a small percentage of instances…the frequency of instances in which the water quality threshold (e.g., dissolved oxygen concentration) is exceeded, as a function of the area or volume affected at a given place and over a defined period of time."*

3.2.1.3 Estimation Methods

Source Assessment

The reference watershed approach shown in Figure 3-2 above begins with a source assessment for nutrients in runoff from a reference watershed. Section 4 below presents the source assessment for the revised TMDL, including data analysis and modeling of nutrients in watershed

CDM Smith

runoff for current land use conditions. The same database and watershed model was used to estimate nutrients in runoff reaching the lake segments for a reference watershed.

Linkage Analysis

The impact of nutrient loads within each lake segment is assessed using a dynamic lake water quality model (see Figure 3-2 above). This step serves as the linkage analysis when developing a TMDL using a reference watershed approach. In other words, the linkage analysis estimates the water quality response of the lake segments to predetermined allowable external nutrient concentrations estimated for a reference watershed. Conversely, TMDLs that use a stressor-response approach use the linkage analysis to determine the allowable external nutrient load that can be delivered to the receiving waterbody to yield stressor concentrations that would not impair water quality standards. Section 5 below provides the linkage analysis for the revised TMDLs.

Numeric Target Setting

The results of the linkage analysis are interpreted to develop TMDL numeric targets that account appropriately for spatial and temporal variability in water quality under a reference watershed condition. Different expressions of TMDL numeric targets are used depending upon whether the Basin Plan includes a narrative or numeric WQO. Lake Elsinore and Canyon Lake numeric targets associated with narrative Basin Plan objectives include the following:

- *Algae* - The linkage analysis employs a dynamic lake water quality model that assesses temporal variability of algae (measured as chlorophyll-*a* concentration) that may result from reference watershed nutrient load inputs. Laterally averaged chlorophyll-*a* concentrations for each lake segment from the top 1-m of the water column are used to characterize a reference watershed condition. Dynamic simulation results of chlorophyll-*a* data are plotted as CDFs to represent the TMDL numeric targets to prevent excessive algae. Under this reference condition, algae such as cyanobacteria would also be expected to be present in concentrations indicative of a reference condition. Thus, the management of nutrient loads to meet the expected reference condition for chlorophyll-a is also expected to result in cyanobacteria concentrations representative of a reference condition.

Lake Elsinore and Canyon Lake numeric targets associated with numeric Basin Plan objectives include the following:

- *Dissolved Oxygen* - For the TMDL revision, the TMDL numeric target will be expressed as a volume of lake expected to have DO concentrations within the thresholds required to support the WARM use under a reference watershed condition. Lake water quality, including DO concentrations in a reference condition, is dynamic, and the volume of the lake that would support WARM use varies temporally. This variability is accounted for by employing a dynamic lake water quality model to generate continuous simulation results reported as total lake volume with DO greater than 5 mg/L. These model results are converted to a CDF to serve as the numeric target. The resulting targets would represent conditions that may have occurred naturally, even if those conditions potentially result in periodic stress to fish populations from low DO.

- *Ammonia* - As described above, the fraction of total ammonia-N that is toxic is dependent upon pH and water temperature. It is not possible to calculate the toxicity of ammonia for all volume elements at a daily time-step, using the lake water quality models developed in the linkage analysis. Moreover, it would be infeasible for future monitoring to assess whether ammonia toxicity is at levels that would naturally occur at a comparable spatial scale. Instead, development of TMDL numeric targets was simplified to depth average concentrations of total ammonia-N, to be evaluated at compliance monitoring sites (see Section 8 on Monitoring Requirements). The technical basis for this approach is as follows:

  - Total ammonia-N is controlled by the same nutrient cycling mechanisms that must be addressed to return total in-lake nutrient mass, algae, and DO to reference levels;

  - pH is expected to be returned to reference levels with control of algal productivity; and

  - Water temperature is not impacted by development in the watershed and current levels are assumed to remain unchanged as a result of San Jacinto River watershed development in the future.

These assumptions will be evaluated in the future through implementation of a monitoring program.

In-lake nutrient concentrations for TN or total TP were not included as causal numeric targets in the revised TMDLs. There are multiple combinations of these two nutrients that would effectively limit algal productivity to cause a return to reference levels for beneficial use impairment indicators (algae, DO, ammonia) higher in the hierarchy. Thus, in-lake nutrients will be evaluated in the implementation section. For example, one implementation alternative could involve reduction of TP below reference levels to ensure it is the growth limiting nutrient and to achieve reference conditions for chlorophyll-*a* with or without returning TN to reference levels.

3.2.2 Characterization of Reference Conditions

Characteristics that define the reference watershed condition and serve as model inputs and assumptions include hydrology, water quality, and the physical structure of each lake segment. The following sections describe data and assumptions that represent a hypothetical reference watershed state for the drainage areas to Canyon Lake and Lake Elsinore (see additional information in Section 4). This condition provides inputs and boundary conditions for the linkage analysis to develop a continuous simulation of lake water quality that serves as the basis for determining TMDL numeric targets.

3.2.2.1 Lake Condition

Both Lake Elsinore and Canyon Lake look different than they would have under natural pre-development conditions. The existing physical condition of Canyon Lake and Lake Elsinore is an element of the reference watershed approach. Relevant assumptions for each lake include:

- *Lake Elsinore* - Projects to change the physical condition of the lake were implemented by LEMP in the early 1990s (see additional details in Section 2.2.2.3). These changes included: (a) Construction of a levee (1989-1990) to separate the main lake from the back basin, reducing the lake surface area from about 6,000 to 3,000 acres to prevent significant evaporative losses and improve water quality (**Figure 3-5**); and (b) Lowering the lake outlet channel (1993-1995) to increase outflow to downstream Temescal Creek to provide flood protection when the lake level exceeds an elevation of 1,255 ft. Since the levee was constructed for the purpose of improving water quality, the modeled reference condition is based on the pre-LEMP bathymetry. Conversely, the outlet was lowered for purposes of flood protection, and, therefore, the modeled reference condition assumes the lowered outlet elevation of 1,255 ft.

- *Canyon Lake* – This reservoir did not exist prior to the construction of Railroad Canyon Dam, which was completed in 1928. This modification to the watershed is irreversible; accordingly, the reference condition assumes the existence of Railroad Canyon Dam.

Figure 3-5. Comparison of Current Lake Elsinore Hydrography with Approximate Pre-LEMP Hydrography (shapefile from NHD)

3.2.2.2 Watershed Hydrology

The runoff response from rainfall over a reference watershed is different than a developed watershed. Development increases impervious or compacted surfaces, which reduces attenuation by infiltration over undisturbed pervious areas. Surface conveyance features such as ditches and gutters serve to concentrate runoff for more efficient delivery to larger downstream flood control facilities. This also reduces infiltration of rainfall into watershed soils and increases the peak runoff from storm events. Conversely, runoff downstream of a reference watershed is characterized by less flashy hydrographs and lower total volume. In the case of Lake Elsinore and Canyon Lake, extended drought has a drastic and long-lasting negative impact to lake water quality. Increase in the total volume of freshwater delivered from the watershed as a result of urban development to the lakes provides a greater net benefit to protection of MUN and WARM uses than would be afforded by meeting a reference hydrologic condition. For this reason, the LECL Task Force and Santa Ana Water Board agreed to develop the TMDL based on current inflows as measured by USGS gauges and focus on nutrient concentrations in developing numeric targets representative of a reference watershed condition.

Lake Elsinore

A 100-yr hydrologic record of runoff volumes that reach Lake Elsinore from Canyon Lake overflows is provided from a USGS gauge on the San Jacinto River near Elsinore (Station 11070500) (**Figure 3-6**). Daily flows from this gauge were used as hydrologic inputs to the lake water quality model for setting numeric target CDFs in Lake Elsinore.

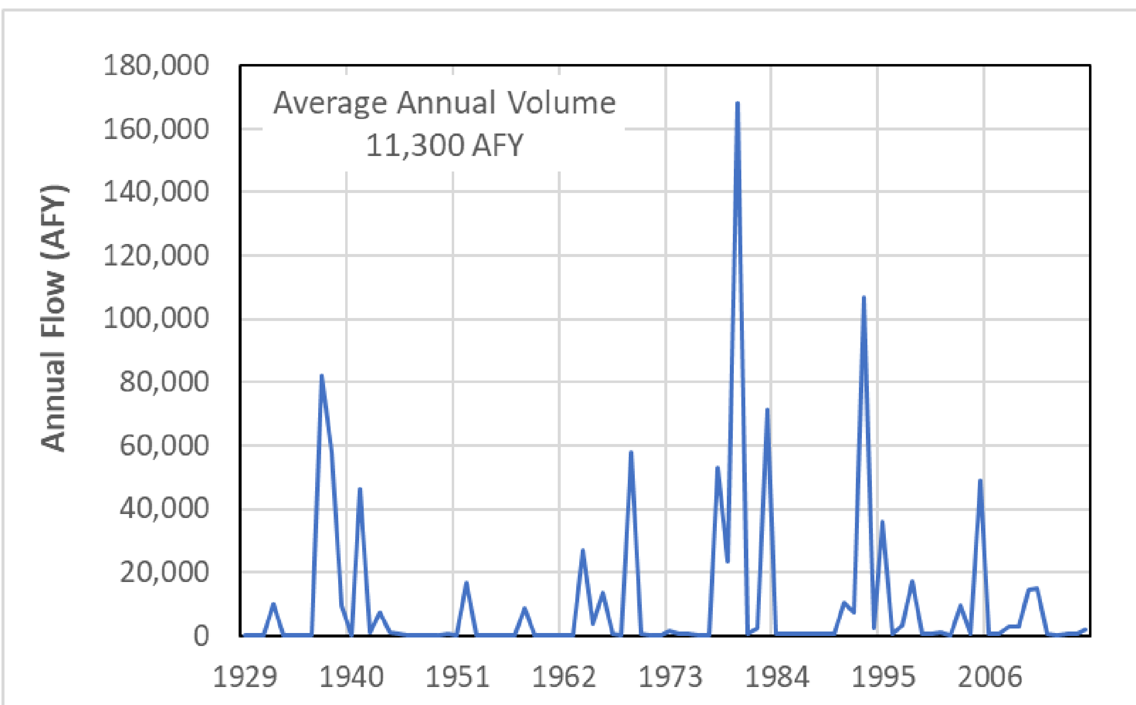


Figure 3-6. Annual Runoff from USGS Gauge Station San Jacinto River near Elsinore (USGS 11070500)

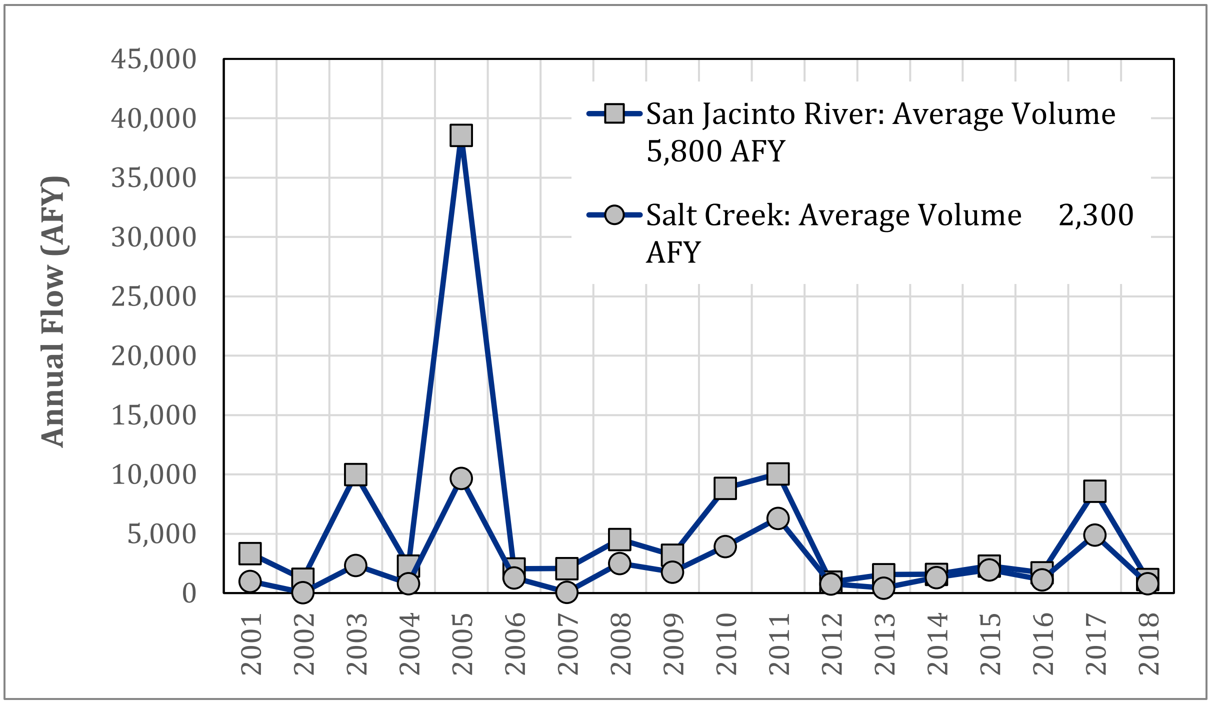


Figure 3-7. Hydrologic Record of Runoff Volumes that Reach the Main Lake of Canyon Lake from the San Jacinto River and the East Bay of Canyon Lake from Salt Creek

A portion of the drainage area to Lake Elsinore is downstream of Canyon Lake (~10 percent of the total watershed area) and is referred to as the 'local Lake Elsinore' watershed. An estimate of daily runoff from this subwatershed to Lake Elsinore based on method used in Anderson (2016e) was added to gauged Canyon Lake overflows for total inflow volume to Lake Elsinore.

Canyon Lake

A 17-yr hydrologic record of runoff volumes that reach Canyon Lake Main Lake from the San Jacinto River and Canyon Lake East Bay from Salt Creek are provided from USGS gauges 11070365 and 11070465 (**Figure 3-7**). Daily flows from these gauges were used as hydrologic inputs to the lake water quality model for setting numeric target CDFs in Canyon Lake.

3.2.2.3 Nutrient Washoff

Nutrient concentrations representative of a reference watershed were estimated from water quality monitoring data collected from a site on the San Jacinto River at Cranston Guard Station. This site was added to the 2004 TMDL monitoring plan as a reference station. The 142 mi^2 watershed to this site is comprised of predominantly undeveloped forest or scrublands in the San Jacinto National Forest. The US Forest Service (USFS) collected 54 samples from this reference site over the course of 11 wet weather events in 2003-2005, 2008, and 2010. The median concentrations of these samples were 0.32 mg/L TP and 0.92 mg/L TN. These median nutrient concentrations were applied to all runoff volume inflow to the lakes to estimate loads for a hypothetical reference watershed condition. The basis for the revised TMDL is conservative in selecting to use a median value from the reference station data as opposed to a geometric mean (TP: 0.4 mg/L, TN: 1.24 mg/L) or arithmetic mean (TP: 2.43 mg/L, TN 2.60 mg/L) or median of event averages (TP: 0.39 mg/L, TN: 1.35 mg/L). Thus, a margin of safety (MOS) much greater than 10 percent can be assumed to be accounted for in the TMDL revision by the selection of a median value from the reference site.

Other monitoring programs in the San Jacinto River watershed have collected samples from sites downstream of mostly undeveloped lands: (a) LECL Task Force on the San Jacinto River at Ramona Expressway on January 21, 2010; (b) Post-fire sample collection by RCFC&WCD on Ortega Channel on February 28, 2014; and (c) WRCAC on Salt Creek on December 12, 2014. The range of nutrient concentrations from these sampling events was (a) TP: 1.0 – 13.0 mg/L; and (b) TN: 3.5 – 16.9 mg/L TN. These ranges exceed the median concentrations measured at Cranston Guard Station, which also supports the conclusion that the estimated value for a reference condition is conservative for the San Jacinto River watershed.

It is important to note that this sampling represents expected water quality from an undeveloped watershed in the modern era and not a predevelopment condition. Other sources of nutrients may exist outside of the jurisdictional control of the TMDL, such as atmospheric deposition of nutrients that may be dominated by sources originating from outside of the watershed boundary.

3.2.2.4 Lake Water Quality Models

Water quality models provide an alternative means to estimate the response within the lakes for a hypothetical reference watershed condition. CAEDYM is a lake water quality model (Hipsey et al. 2006) developed to test management alternatives for Lake Elsinore and Canyon Lake (Anderson 2016a). This model is also used to develop the linkage analysis for this TMDL revision (see Section 5). With a reference watershed approach, the linkage analysis is used to estimate the long-term lake water quality that would be expected to have occurred in Lake Elsinore and Canyon Lake for a hypothetical scenario involving a reference upstream watershed, and without any of the existing in-lake nutrient management strategies.

For Lake Elsinore, water quality modeling to support the development of TMDL numeric targets involved a very long simulation period from 1916-2016. This was imperative to capture the full range of dynamic water quality conditions that naturally occur in Lake Elsinore (see Section 2). CAEDYM is an aquatic ecosystem model and is coupled with a hydrodynamic model to facilitate boundary conditions and simulation of spatially varying mechanisms. For Lake Elsinore, a simple 1-D hydrodynamic model, DYRESM, was used for development of laterally averaged vertical profiles. This is appropriate for Lake Elsinore because it has a fairly uniform morphology. For Canyon Lake, there is substantial variability in the lake basin morphology and water quality processes, which required the development of a 3-D hydrodynamic model, the Estuary and Lake Computer Model (ELCOM). These tools are described in Section 5 on Linkage Analysis.

3.3 TMDL Numeric Targets

The data used to establish the numeric targets for each constituent is illustrated in four ways: (a) time history or series of the data which illustrates how the concentration changes over time; (b) histogram that provides the frequency of occurrence of concentrations as binned; (c) box and whiskers, which illustrates the median value and range of observations; and (d) the CDF which shows the probability of a particular concentration being exceeded over time. The CDF is the numeric water quality target. Several methods are provided for demonstrating compliance with the numeric target CDF in Section 9.

3.3.1 Lake Elsinore

DYRESM-CAEDYM model results of water quality for the reference watershed scenario for the period from 1916-2016 serve as the basis for setting numeric targets for chlorophyll-*a*, DO, and ammonia-N in Lake Elsinore. The CDF numeric targets and associated time history, histogram, and box and whiskers for chlorophyll-*a*, DO, and total ammonia-N in Lake Elsinore are as follows:

- *Chlorophyll-a*: Surface (top 1 meter) average of daily model results plotted for the reference condition (**Figure 3-8**).
- *Dissolved Oxygen*: The fraction of the total volume of Lake Elsinore with daily average DO greater than 5 mg/L plotted for the reference condition (**Figure 3-9**).
- *Total Ammonia-N*: Water column depth average of daily model results plotted for the reference watershed condition (**Figure 3-10**).

3.3.2 Canyon Lake

ELCOM-CAEDYM model results of water quality for the reference watershed scenario for the period from 2000-2016 serve as the basis for setting numeric targets for chlorophyll-*a*, DO, and ammonia-N in Canyon Lake Main Lake and East Bay. The CDF numeric targets and associated time history, histogram, and box and whiskers for chlorophyll-*a*, DO, and ammonia-N in Canyon Lake (Main Lake and East Bay) are as follows:

3.3.2.1 Canyon Lake Main Lake

- *Chlorophyll-a*: Surface (top 1 meter) average of daily model results for Canyon Lake Main Lake for the reference condition (**Figure 3-11**).
- *Dissolved Oxygen*: The fraction of the total volume of Canyon Lake Main Lake with daily average DO greater than 5 mg/L plotted for the reference condition (**Figure 3-12**).
- *Total Ammonia-N*: Water column depth average of daily model results for Canyon Lake – Main Lake plotted for the reference watershed condition (**Figure 3-13)**.

3.3.2.2 Canyon Lake East Bay

- *Chlorophyll-a*: Surface (top 1 meter) average of daily model results for Canyon Lake East Bay for the reference condition (**Figure 3-14**).
- *Dissolved Oxygen*: The fraction of the total volume of Canyon Lake East Bay with daily average DO greater than 5 mg/L plotted for the reference condition (**Figure 3-15**).
- *Total Ammonia-N:* Water column depth average of daily model results for Canyon Lake East Bay plotted for the reference watershed condition (**Figure 3-16**).

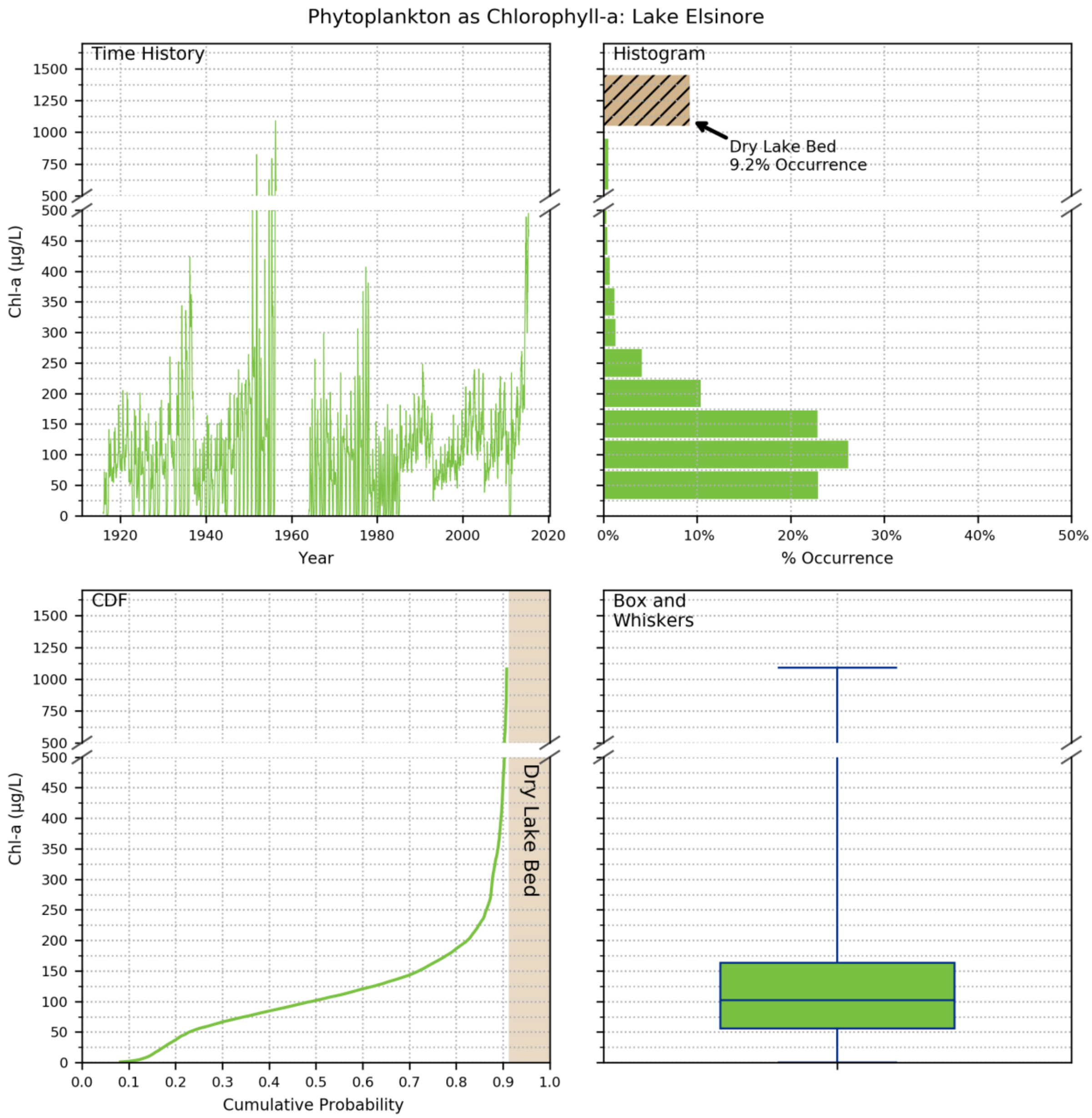


Figure 3-8. Chlorophyll-a Results for Lake Elsinore: Time History (upper left); Histogram (upper right); Box and Whiskers (lower right); and Numeric Target CDF (lower left)

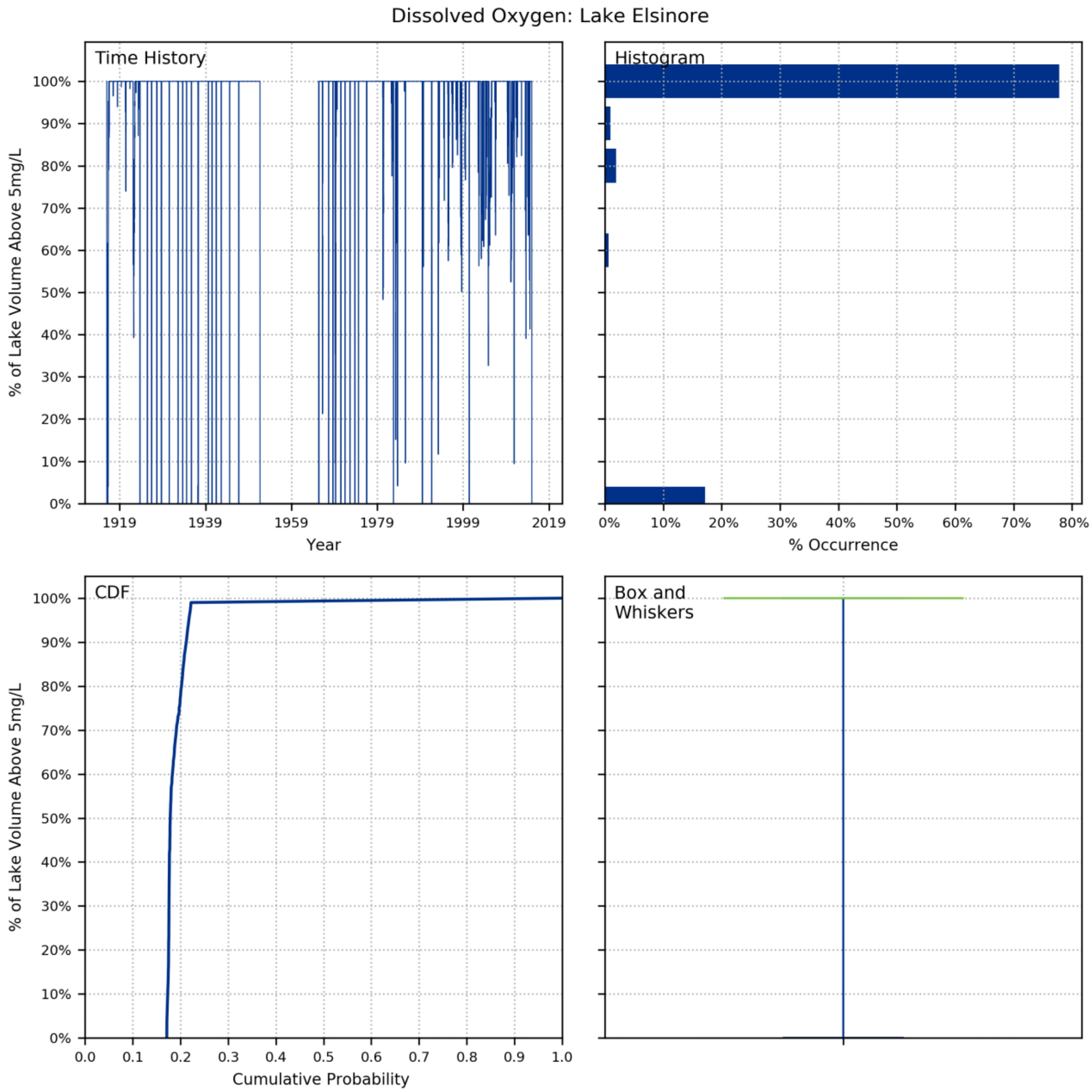


Figure 3-9. Dissolved Oxygen Results for Lake Elsinore: Time History (upper left); Histogram (upper right); Box and Whiskers (lower right); and Numeric Target CDF (lower left)

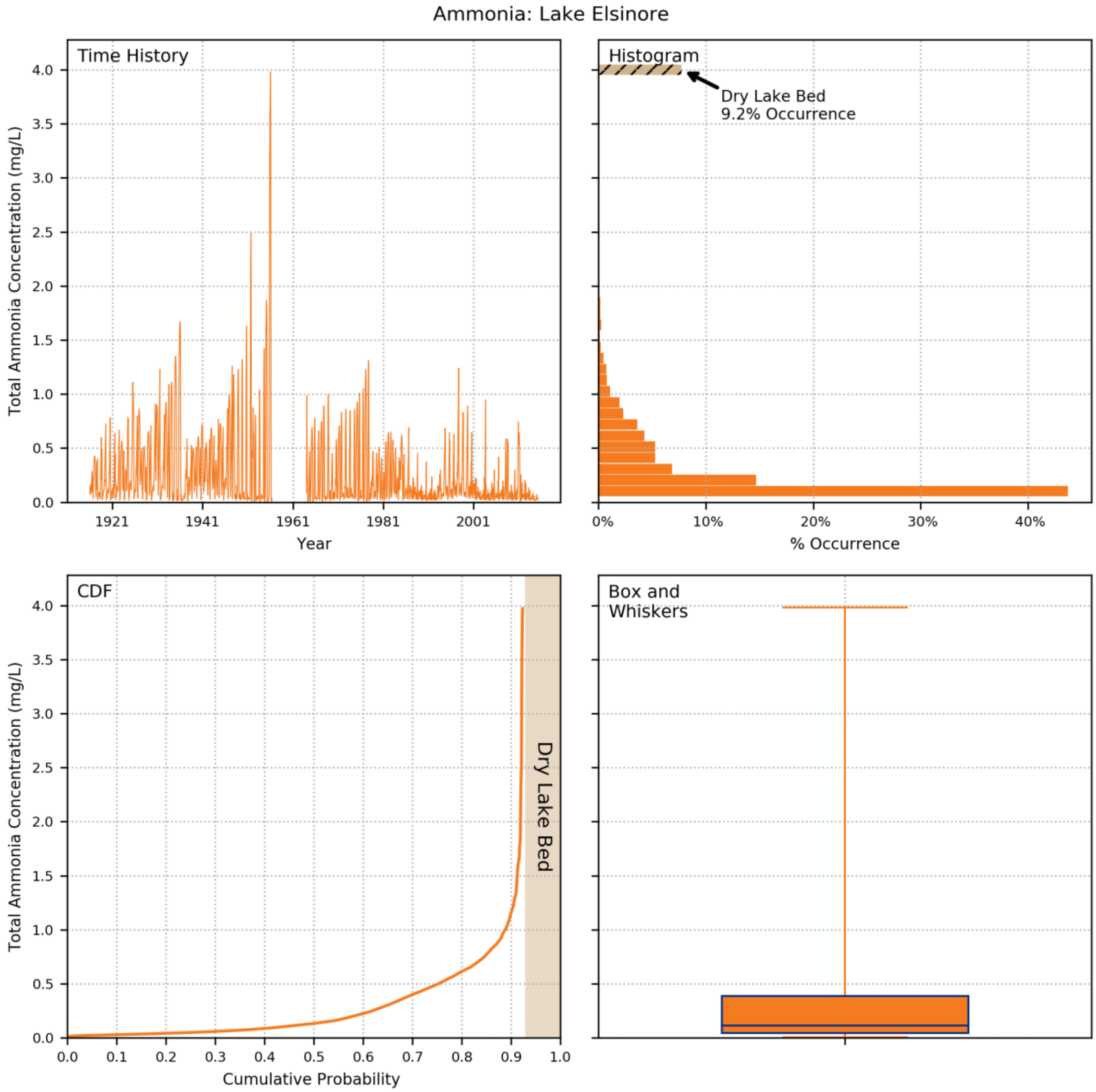


Figure 3-10. Total Ammonia-N Results for Lake Elsinore: Time History (upper left); Histogram (upper right); Box and Whiskers (lower right); and Numeric Target CDF (lower left)

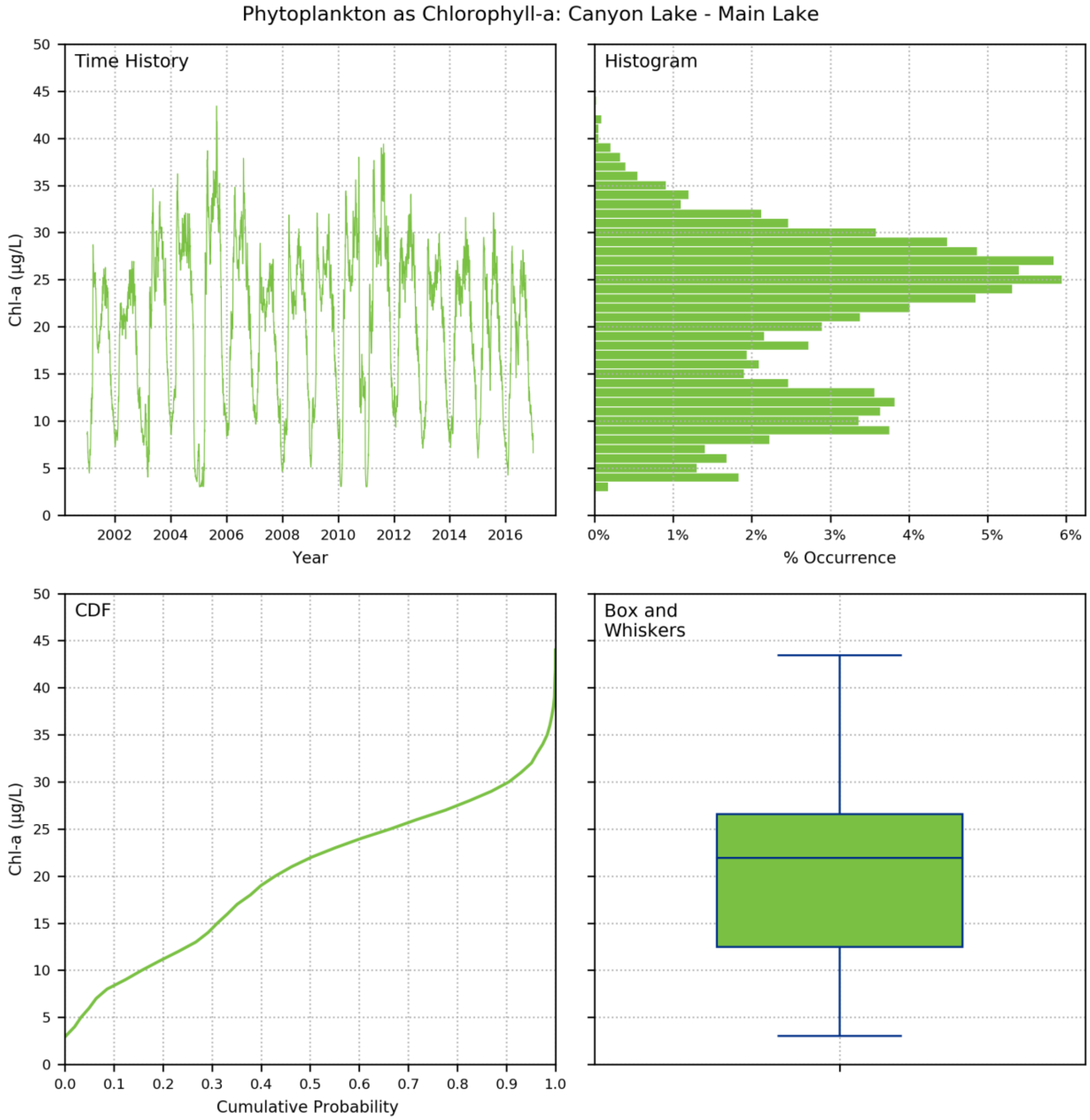


Figure 3-11. Chlorophyll-*a* Results for Canyon Lake – Main Lake: Time History (upper left); Histogram (upper right); Box and Whiskers (lower right); and Numeric Target CDF (lower left)

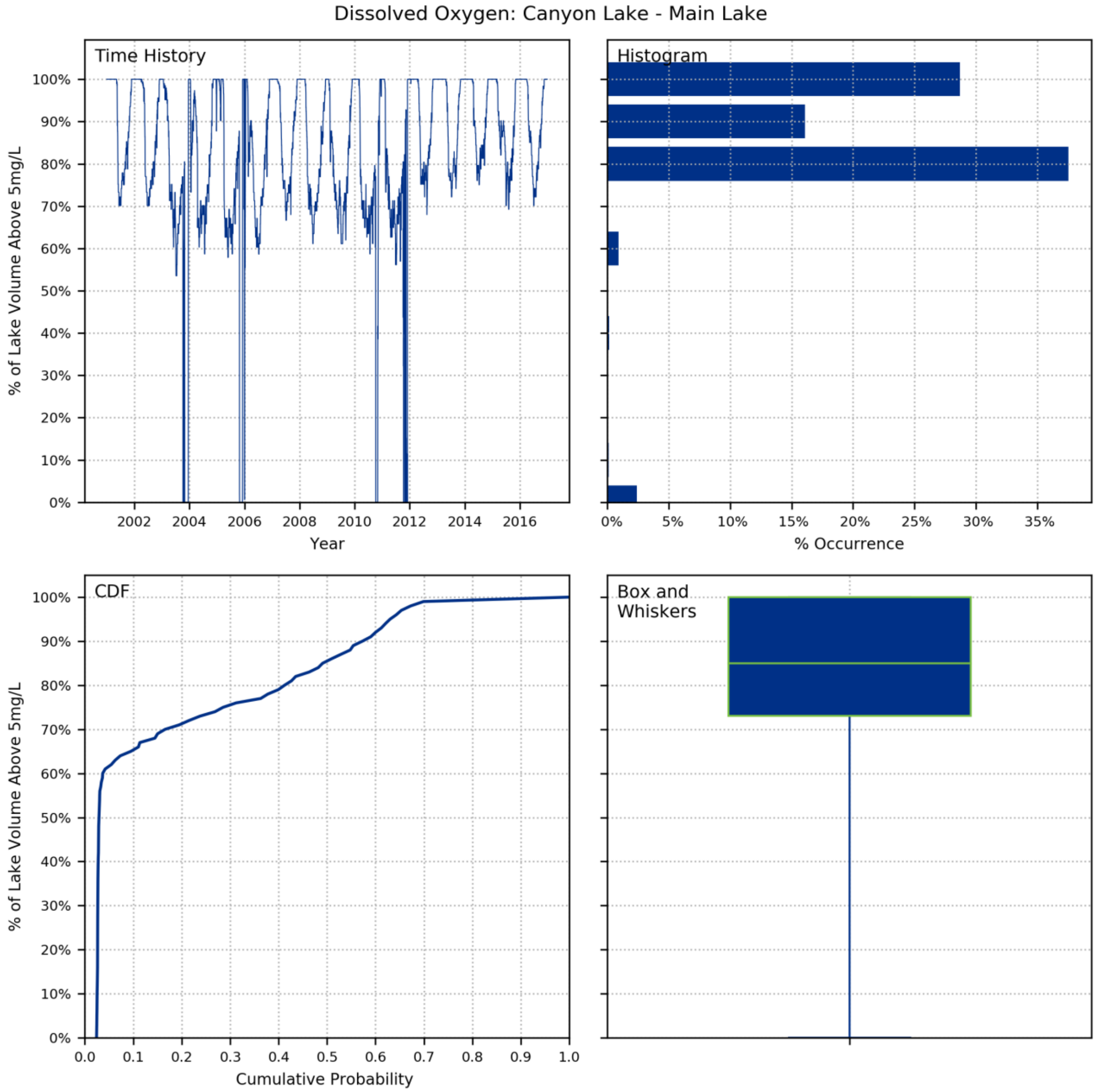


Figure 3-12. Dissolved Oxygen Results for Canyon Lake – Main Lake: Time History (upper left); Histogram (upper right); Box and Whiskers (lower right); and Numeric Target CDF (lower left)

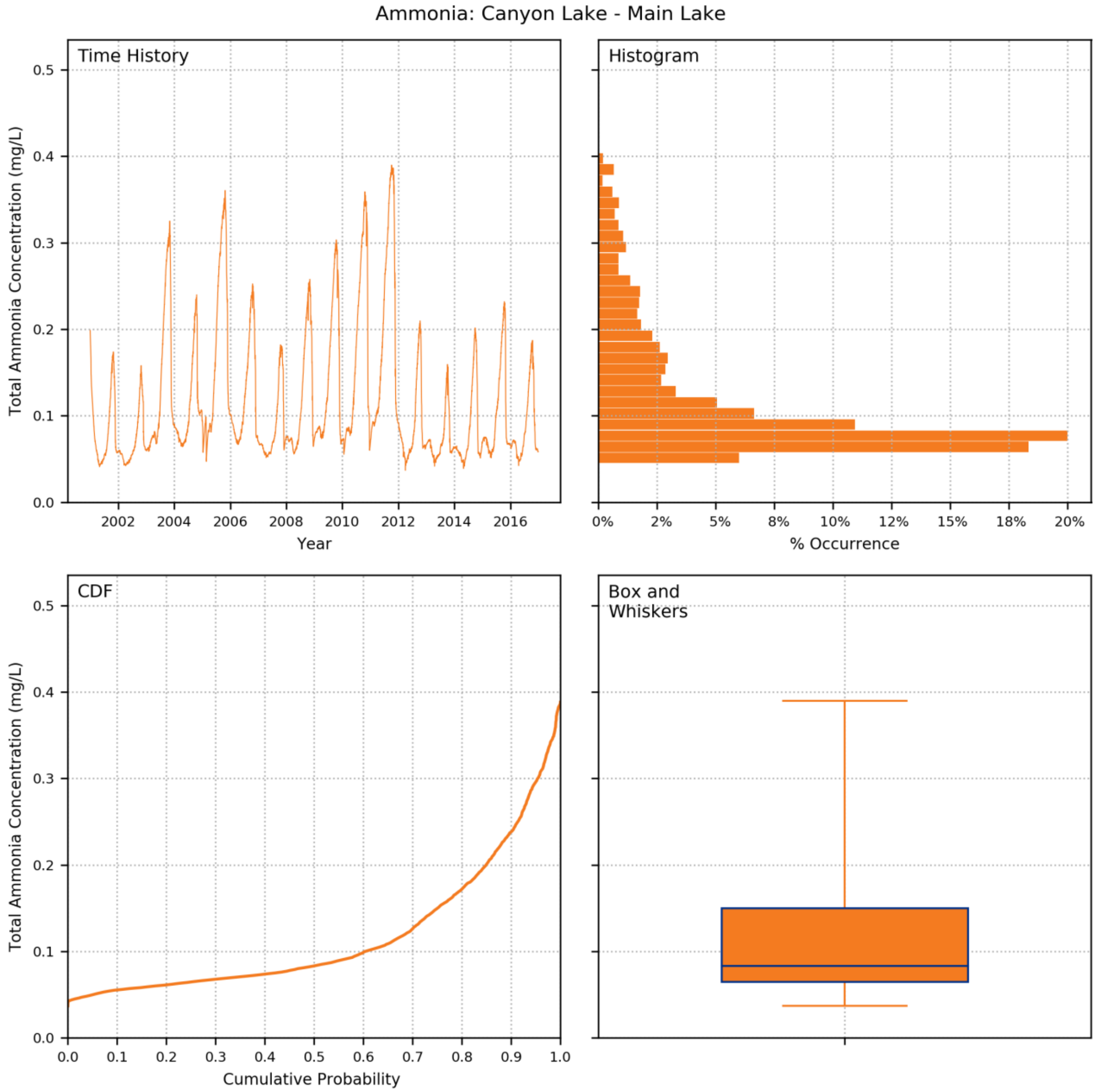


Figure 3-13. Total Ammonia-N Results for Canyon Lake – Main Lake: Time History (upper left); Histogram (upper right); Box and Whiskers (lower right); and Numeric Target CDF (lower left)

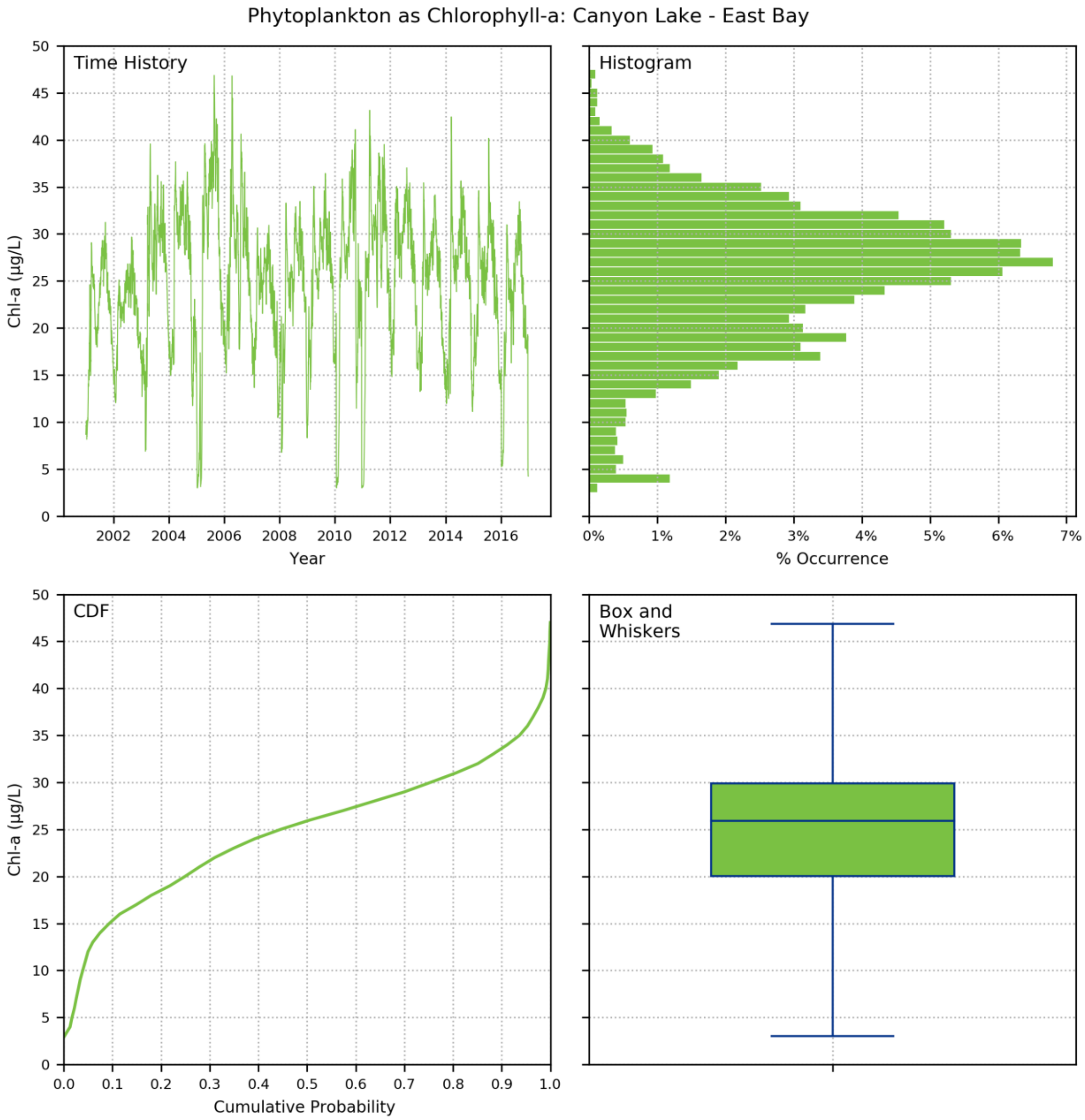


Figure 3-14. Chlorophyll-*a* Results for Canyon Lake – East Bay: Time History (upper left); Histogram (upper right); Box and Whiskers (lower right); and Numeric Target CDF (lower left)

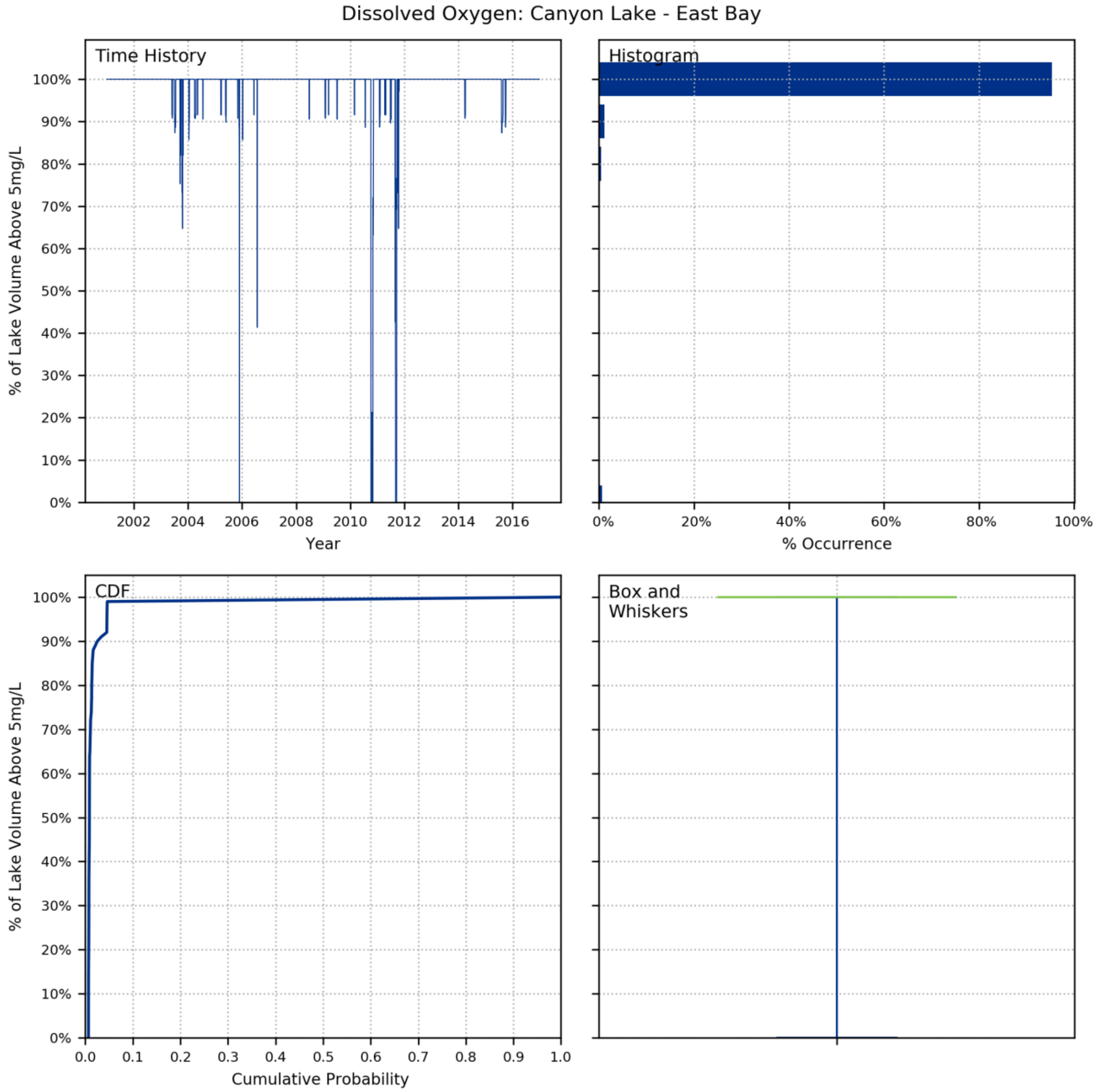


Figure 3-15. Dissolved Oxygen Results for Canyon Lake – East Bay: Time History (upper left); Histogram (upper right); Box and Whiskers (lower right); and Numeric Target CDF (lower left)

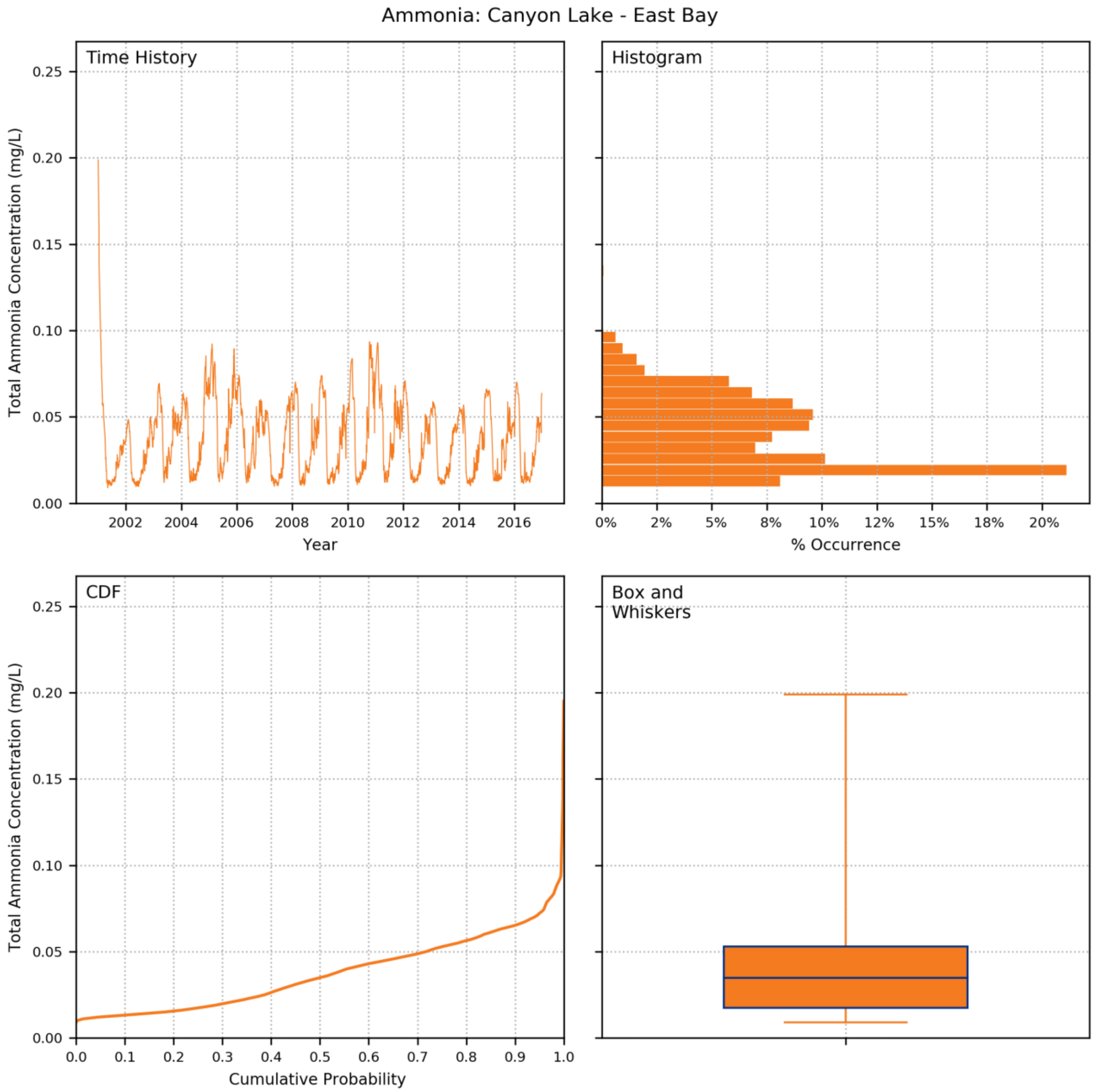


Figure 3-16. Total Ammonia-N Results for Canyon Lake – East Bay: Time History (upper left); Histogram (upper right); Box and Whiskers (lower right); and Numeric Target CDF (lower left)

Section 4

Source Assessment

Sources of nutrients to Lake Elsinore and Canyon Lake are characterized in this section. These lakes receive nutrients via two key external delivery mechanisms (watershed runoff and supplemental water deliveries), and internal sediment sources within the lakes. This section describes each of these key sources of nutrients:

- *Watershed Runoff (Section 4.1)* – Nutrients washed off from land areas in the watersheds to each lake segment; these land areas represent unique combinations of land use, jurisdiction, and subwatershed characteristics.
- *Supplemental Water (Section 4.2)* – Nutrients contained within supplemental water inputs to each lake; most notable being the addition of reclaimed water to Lake Elsinore by EVMWD.
- *Internal Sources (Section 4.3)* – Internal sources of nutrients within each lake. Mechanisms that influence the significance of these sources include physical (resuspension by wind, propeller driven turbulence or bioturbation), biological (diagenesis of externally loaded organic matter or decaying phytoplankton within the lake bottom), and chemical (diffusive flux from bottom sediments to water column). Deposition of nutrients from the atmosphere directly on the surfaces of Lake Elsinore and Canyon Lake is also described in this section.

4.1 Watershed Runoff

Flow gauges are operated by the USGS that continuously record discharge rates at the two inputs to Canyon Lake (Salt Creek and San Jacinto River) and from San Jacinto River inflows (mostly from Canyon Lake overflow)[1] to Lake Elsinore. These data characterize the annual volumes of runoff that reached each lake segment over the period of record. Summary statistics for each of these gauges is presented in **Table 4-1**.

Table 4-1. Summary Data for USGS Flow Gauges at Inflows to Lake Elsinore and Canyon Lake (cfs = cubic feet/second)

Station	Upstream Drainage Area (acres)	Period of Record	Average Annual Runoff (AFY)	Historical Peak Discharge (cfs)
San Jacinto River at Goetz Road (11070365)	358,400	2000 - 2018	5,777	3,470
Salt Creek at Murrieta Road (11070465)	74,200	1983 – 1984; 2000 - 2018	2,287	2,550
San Jacinto River near Elsinore (11070500)	462,700	1916 - 2018	11,315	16,000

[1]USGS Gauge 11070500, San Jacinto River near Elsinore, is approximately 2 miles downstream of the Canyon Lake spillway and therefore includes runoff from a small subarea (~7,000 acres) between the two lakes in addition to Canyon Lake overflows. Thus, in years when no Canyon Lake overflows occurred, there is still runoff recorded at this gauge from the San Jacinto River into Lake Elsinore

Continuous flow data from these USGS gauges for the period of 2001 through 2017 was used to calibrate a watershed runoff model for the drainage areas to the lake segments (described in Section 4.1.3 below). **Figure 4-1** shows runoff inflows to Canyon Lake from the San Jacinto River and Salt Creek and to Lake Elsinore from the San Jacinto River. Also shown in Figure 4-1 is an estimate of runoff volume retained within Canyon Lake during each wet season. Volume retention was estimated as the difference between the summed annual volume between USGS gauges upstream and downstream of Canyon Lake for years when Canyon Lake elevation data exceeded its spill water elevation of 1,381.76 ft (2003-2005, 2008, and 2010-2011), indicating that overflows occurred. In dry years when the lake did not reach its spill elevation, outflow was assumed to be zero (2002, 2006, 2007, 2009, and 2012-2014) equating to complete volume retention.

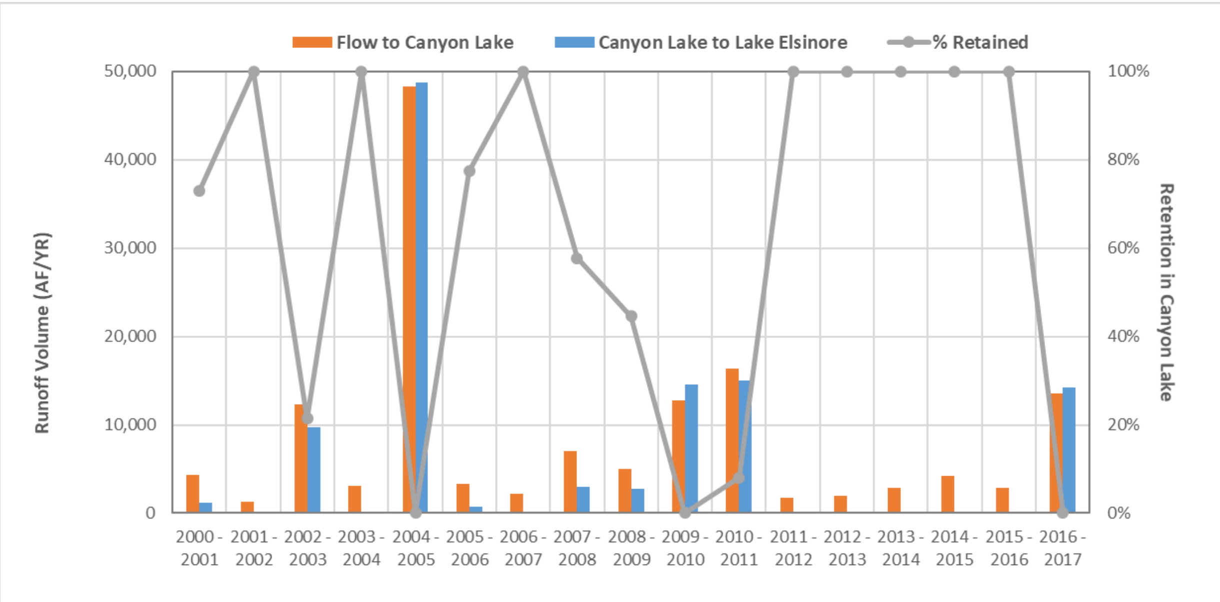


Figure 4-1. Annual Runoff Volume into Canyon Lake and Overflow to Lake Elsinore

4.1.1 Model Selection

The most significant external source of nutrients to the lakes is from rainfall driven runoff over watershed lands. To quantify the existing load of nutrients from watershed areas to the lakes, it is important to estimate the rainfall response for runoff volume (hydrology) and associated nutrient concentration (water quality). USGS gauge stations and LECL Task Force watershed monitoring sites provide sound, representative measurements of nutrient loads, or mass emissions, delivered to Canyon Lake and in overflows to Lake Elsinore. Given a robust set of mass emission data at key inflows to the lake segments, a model is not needed for the purpose of estimation of downstream loads in watershed runoff for current conditions. Instead, downstream mass emission data allow for reasonable parameter adjustments to fit a model of runoff volume and quality to measured data.

This source assessment does require the development of a watershed model for other important functions. The primary objective for the watershed model that was developed to support the

TMDL revision is to evaluate the origin of the nutrient loads across the large upstream drainage areas. The relative contribution to downstream loads from sources is used in setting allocations and determining load reductions needed from individual sources to meet those allocations. Also, the watershed model will be useful in implementation as it allows for detailed accounting of jurisdictional loadings to each lake segment.

There are different options for modeling watershed runoff volume and quality of varying complexity, which commonly determines the required levels of expertise needed for development, calibration, and management scenario evaluation. The Loading Simulation Program in C++ (LSPC) that was used for the 2004 TMDL and again in the 2010 watershed model update (LESJWA 2010) represents a more complex watershed model. This model involves a deterministic simulation of rainfall and runoff including complex soil hydrology processes that govern runoff generated from pervious land areas. For water quality, nutrients are simulated by buildup or accumulation of nutrients during dry periods and washoff during rain events. Continuous simulation at the daily time-step allows for variable buildup periods between events and thus variable accumulation of pollutant available for washoff. Also, the portion of accumulated nutrients that washes off during a rainfall event to downstream waters is a function of runoff depth.

For the source assessment for Lake Elsinore and Canyon Lake watersheds, neither the existing LSPC tool was updated, nor was a potential new complex dynamic rainfall-runoff and buildup / washoff water quality model developed for the following reasons:

- Downstream lake segments are characterized as having limited flushing and significant internal loading of bioavailable nutrients, therefore variability between events does not significantly impact the pool of bioavailable nutrients for algae. Eutrophication occurs at seasonal timescales in Canyon Lake and it is the total wet season retained nutrient load that controls the magnitude and duration of early spring algae blooms. For Lake Elsinore, bioavailable nutrients are predominantly from internal sources (see Section 4.3.1 below) and lake water quality is frequently controlled by food web dynamics with multi-decadal trends, thus variability in nutrient loads between individual storm events exerts negligible differences.

- Review of watershed monitoring data shows nutrient concentrations are not related to inter-event period (number of dry days prior to an event) nor runoff volume. In fact, dynamic calibration plots presented in the TMDL and watershed model update (LESJWA 2010) show simulation results that have comparable central tendencies and ranges to measured data, but significant error when comparing discrete events. Thus, other processes influence watershed nutrient loads that may not be characterized by buildup / washoff dynamics.

A static model of long-term average annual runoff volume and nutrient loads, EPA's Pollutant Loading Estimator tool (PLOAD) (EPA 2001), was selected to support this TMDL revision. PLOAD is a component of EPA's TMDL development framework, Better Assessment Science Integrating Point and Non-Point Sources (BASINS) (EPA 2017). For this TMDL revision, PLOAD was developed outside of the BASINS environment in a Microsoft Excel spreadsheet to allow for greater flexibility and transferability to potential end users.

The use of a static model of long-term averages with empirically defined parameters is scientifically defensible for this watershed because of the limited flushing in the receiving waters, long-term timescales over which eutrophication occurs, apparent complexity of watershed runoff and nutrient loading that may be infeasible to represent in any EPA approved, dynamic, deterministic modeling tools, and robustness of mass emission data available for all major inflows to each lake segment.

4.1.2 Establishment of Model Subareas

The first step in the watershed runoff nutrient source analysis is to define the spatial discretization for simulation of rainfall driven runoff and associated washoff of nutrients. The selected modeling approach, comparable to PLOAD, is a spatially lumped parameter model. This means that commonality of key parameters, not geography, is used to define distinct subareas. Watershed runoff simulations were developed for land areas with common land use, jurisdiction, and subwatershed zone, referred to as model subareas. **Figure 4-2** shows the geographic distribution of these three defining attributes for the entire watershed to Lake Elsinore and Canyon Lake.

Hydrology and water quality modeling is performed separately for each model subarea. **Figure 4-3** shows the interconnectivity of model subareas and conveyance within receiving waters. Respectively, the green hatching and red outlines represent agricultural and urban jurisdictional groups within each subwatershed zone. Within each of these watershed elements of this schematic, one or more land uses may exist. In total, there are over 500 distinct model subareas developed to support source assessment and development of allocations. These model subareas are not geographically contiguous, but rather they are spatially lumped portions of drainage area with common parameter sets. For example, a single model subarea exists to represent all commercial/industrial land area within the City of Moreno Valley within subwatershed Zone 5. Appendix B provides a tabular summary of each model subarea and reports important characteristics used for parameterizing the watershed runoff model.

The schematic in Figure 4-3 also shows how runoff is routed from model subareas to receiving waters. Subwatershed zone delineations were developed based on this routing, as indicated in each of the blue receiving water elements. Some model subareas drain directly to one of the three TMDL lake segments: Canyon Lake Main Lake, Canyon Lake East Bay, and Lake Elsinore. Other model subareas are routed through the San Jacinto River, Perris Valley Channel, or Salt Creek prior to reaching a TMDL lake segment. The position of Mystic Lake as an important impoundment to be accounted for in the source assessment is also shown in the schematic. Model subareas draining to Mystic Lake are treated differently as discussed in Section 4.1.3.4 below.

For this TMDL revision, several subwatershed boundary revisions were incorporated to update the boundaries used in the 2004 TMDL and TMDL model update in 2010 (**Figure 4-4**). Hatched areas in Figure 4-4 show where boundaries have been revised and labels indicate the change from the 2004 TMDLs to these revised TMDLs. The revisions are summarized as follows:

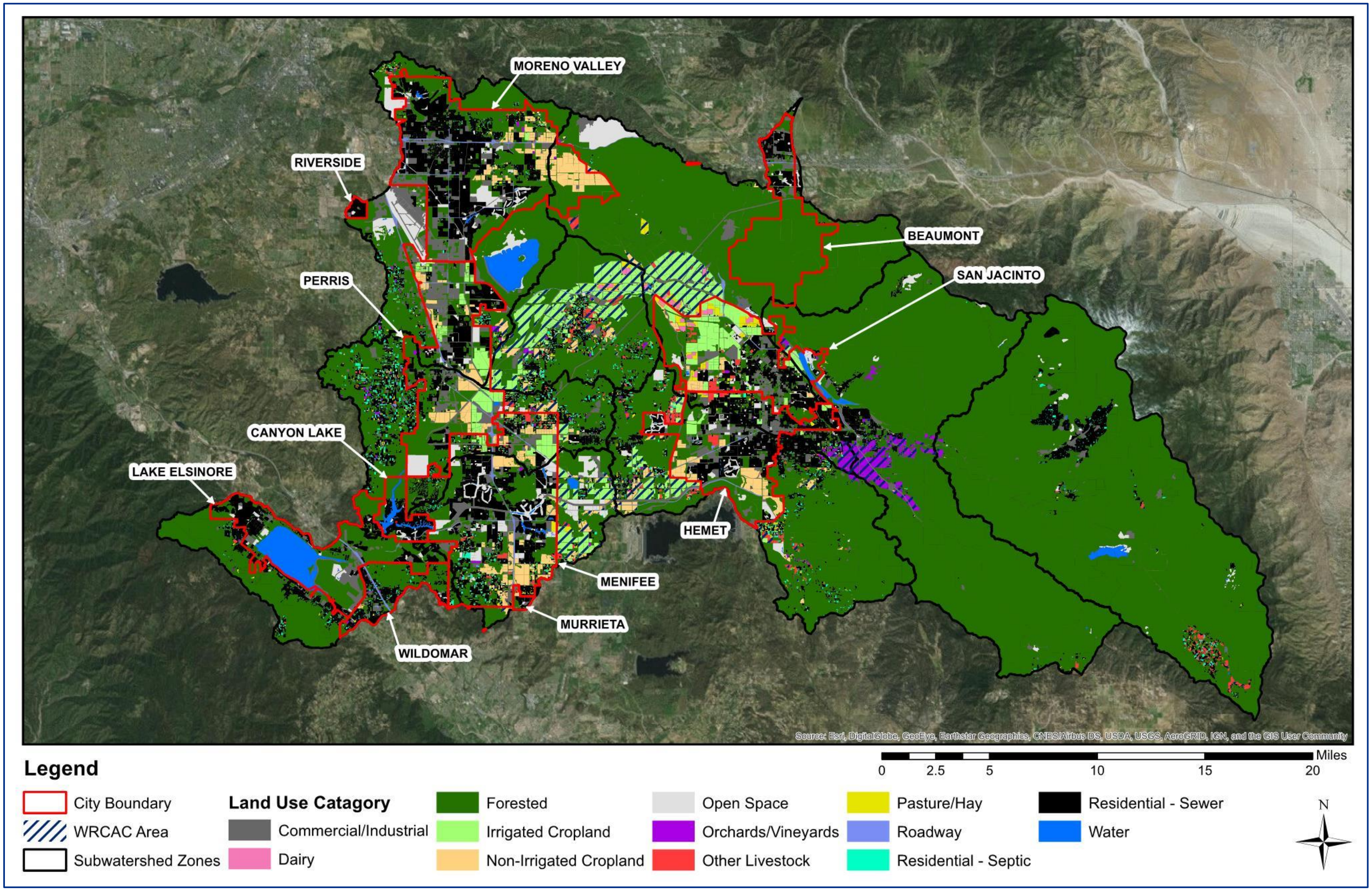


Figure 4-2. Map of Subwatershed Zones, Jurisdictions, and Land Use for Development of Watershed Model Subareas

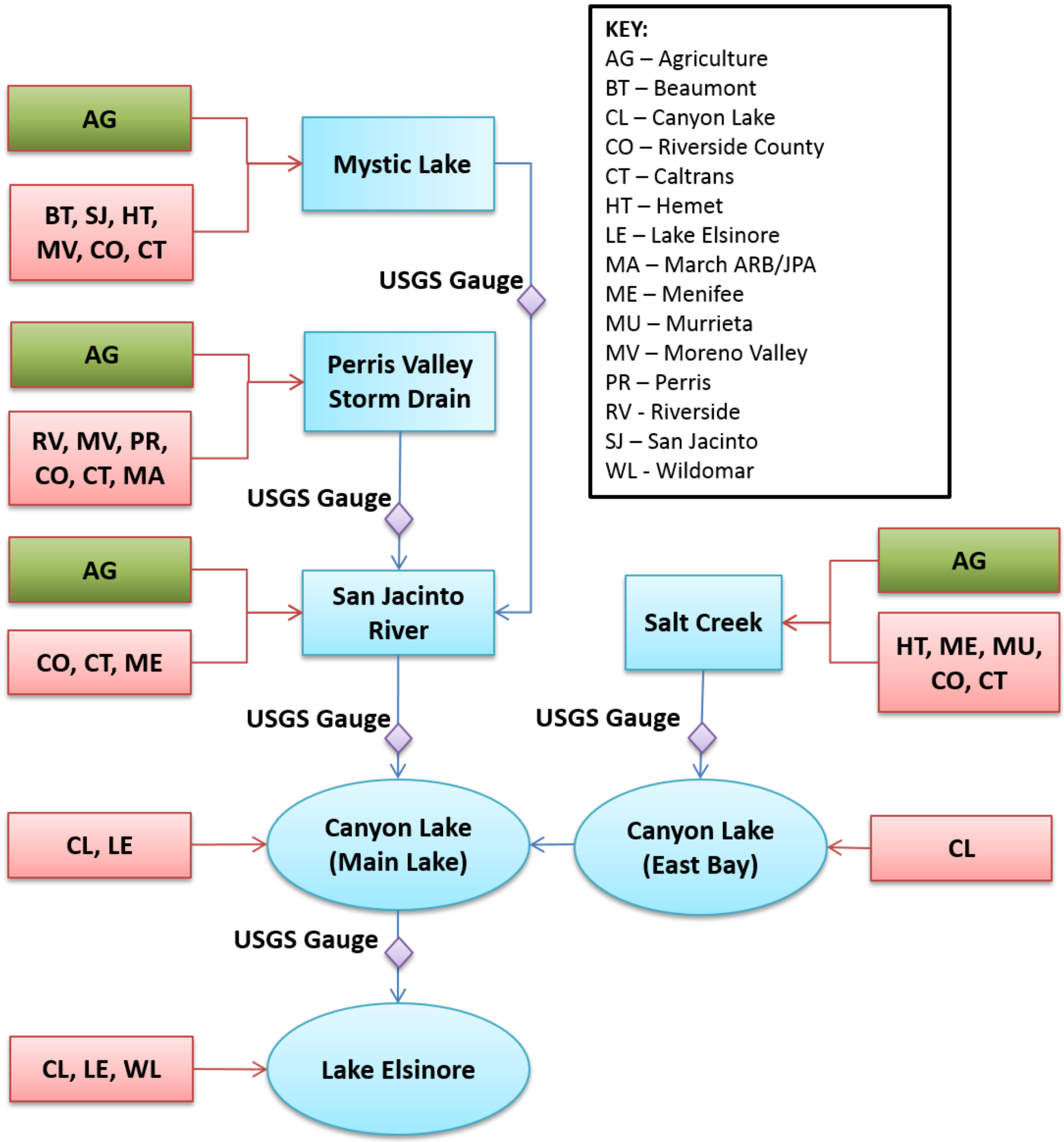


Figure 4-3. Schematic of External Runoff Loading Pathways for Watershed Runoff Sources and Receiving Waters that Retain, Convey, and Cycle Nutrients

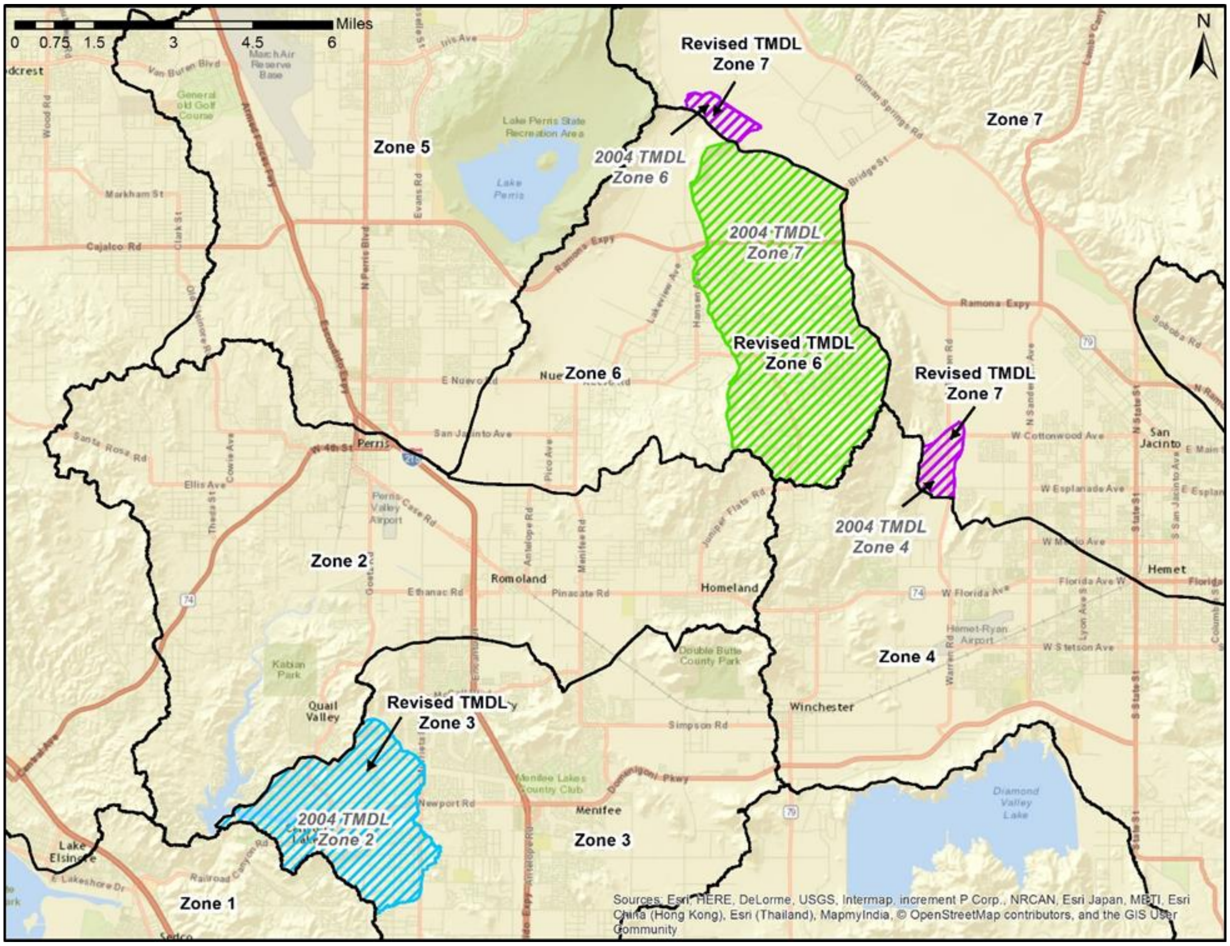


Figure 4-4. Map of Revisions to Subwatershed Zone Boundaries (Blue = area removed from Zone 2 and added to Zone 3; Green = area removed from Zone 7 and added to Zone 6; Purple = area removed from Zones 4 or 6 and added to Zone 7)

- *Mystic Lake tributary area correction* – The drainage area to Mystic Lake, subwatershed Zones 7, 8, and 9 in the 2004 TMDL, was re-evaluated by WRCAC to support the TMDL revision. An elevation map of the region combined with knowledge of surface features was used to develop a new, technically correct delineation of the area tributary to Mystic Lake (WRCAC 2013b). Revisions are shown in green (drainage area taken out of Zone 7) or purple (drainage area put into Zone 7) hatching in Figure 4-4. The revisions included removal of a large drainage area near the bend of the San Jacinto River that is not tributary to Mystic Lake; instead this area contributes runoff to Canyon Lake in most hydrologic years. Also, the boundary near North Warren Rd in the vicinity of the Colorado River aqueduct was modified. In total, the changes amount to a net reduction of ~5,000 drainage acres to Zone 7, and a net increase in the same amount for subwatersheds downstream of Mystic Lake.

- *Local Canyon Lake tributary area to East Bay / Main Lake* – Subwatershed Zones 2 and 3 in the 2004 TMDL and 2010 watershed model update represent the downstream portions of San Jacinto River and Salt Creek, respectively. However, downstream of the USGS gauges /

watershed monitoring stations, the boundary between these subwatershed zones in the 2004 TMDL did not properly delineate areas draining directly to the Main Lake of Canyon Lake (from the San Jacinto River) versus draining directly to the East Bay of Canyon Lake (from Salt Creek). The blue hatched area in Figure 4-4 indicates the areas that were revised to properly reflect drainage to East Bay.

4.1.3 Hydrology

A static model was developed within a Microsoft Excel spreadsheet to simulate the volume of average annual runoff in model subareas as a result of rainfall:

$$Q_{annual} = Precip_{annual} * RC$$

where,
Q_{annual} = annual flow volume
$Precip_{annual}$ = average annual rainfall depth
RC = runoff coefficient

This hydrologic method is used in the EPA approved public domain watershed model PLOAD. The following sections describe the methods used to develop the hydrologic model for the watersheds that drain to Lake Elsinore and Canyon Lake.

4.1.3.1 Precipitation

Precipitation input data for the model was extracted from RCFC&WCD rainfall stations distributed throughout the watershed (**Figure 4-5**). **Table 4-2** presents long-term average annual rainfall from these stations, which are assigned to represent specific subwatershed zones. For subareas above Mystic Lake (i.e., subwatershed Zones 7-9), rainfall from the San Jacinto Station 186 was used to represent drainage areas with elevations below 3,000 ft and rainfall from the Idyllwild Station 90 was used to represent areas with elevation greater than 3,000 ft. Table 4-2 provides average annual rainfall for different periods representing the full period of record at each station for comparison with the selected subsets for model calibration and allocation setting. The period used for model calibration (2000-2017) coincides with the period of record for USGS flow gauges at the two primary inflows to Canyon Lake: San Jacinto River at Goetz Road (USGS Station 11070365) and Salt Creek at Murrieta Road (USGS Station 11070465). The allocation setting period of 1948-2017 was selected as the period with continuous rainfall records with no missing data from all of the stations used in the watershed model. The average annual rainfall from this period is very similar to the average for the full period of record for each station.

4.1.3.2 Runoff Coefficient

The runoff coefficient (RC) is a factor to express the ratio of rainfall to surface runoff. Simple hydrologic modeling methods, such as the Rational Method and derivations thereof, estimate the runoff coefficient as a function of watershed imperviousness. The connectivity of impervious land cover to MS4 inlets is an important consideration, especially in newer developments that employ LID site designs that strive to disconnect impervious areas to prevent runoff reaching surface waters. Similarly, lower density residential land use is characterized by unpaved or partially paved walkways and driveways that have less directly connected impervious area (DCIA).

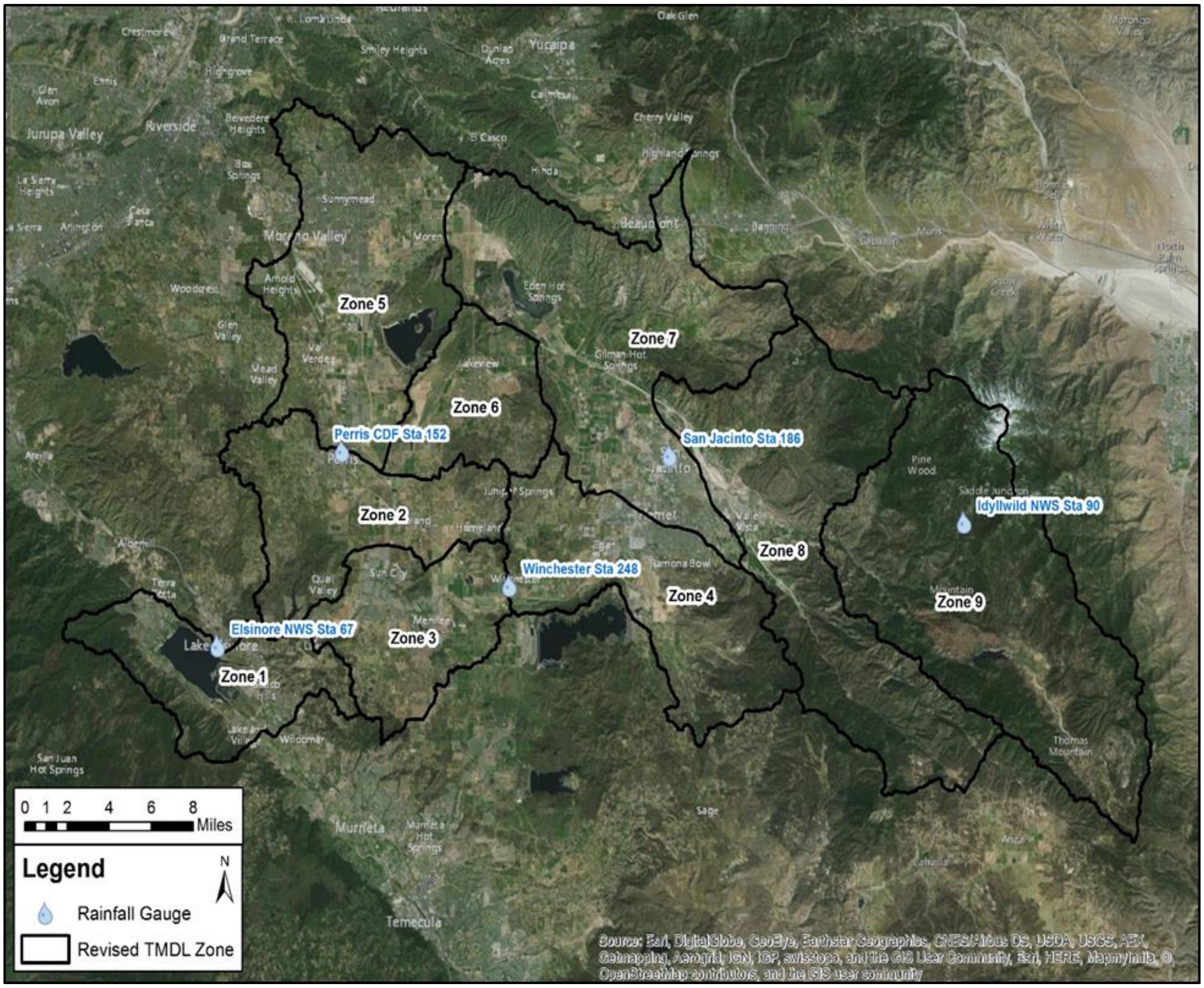


Figure 4-5. Map of Rainfall Stations Used for Long-term Rainfall Depth Inputs to the Watershed Model

Table 4-2. Rainfall Station Summary Statistics and Linkage to Model Subwatersheds

Station	Period of Record	Period of Record Average Rainfall (in/yr)	1948-2017 Average[1] Rainfall (in/yr)	2000-2017 Average[2] Rainfall (in/yr)	Subwatershed Zone
San Jacinto Station 186	1903 – Present	12.7	12.0	10.2	6, 7, 8, 9 (below 3,000 ft)
Elsinore NWS Station 67	1896 - Present	12.1	11.4	9.2	1, 2, 3
Perris CDF Station 152	1910 – Present	10.5	10.3	11.4	5
Winchester Station 248	1940 - Present	10.9	10.8	9.1	4
Idyllwild NWS Station 90	1929 – Present	25.8	25.7	22.1	7, 8, 9 (above 3,000 ft)

[1] Average annual rainfall used to estimate runoff volume for determining existing and allowable loads for TMDL

[2] Average annual rainfall used to fit watershed runoff model to measured data at USGS gauging stations

Given these considerations regarding imperviousness an exponential function was selected to estimate runoff coefficients that best relates increased connectivity with increased imperviousness (Bochis-Micu and Pitt 2005). Two factors are included in the exponential function, including: (1) watershed-wide estimate of runoff / rainfall ratio for pervious lands (a); and (2) exponent factor (b) for imperviousness (IMP).

$$RC = a * e^{(b*IMP)}$$

An initial parameter estimate of *a* = 0.05 was selected for model development based on typically measured runoff ratios for varying levels of imperviousness in 47 hydrology studies from across the nation (Schueler 1987). Pervious area runoff is variable and influenced by factors such as slope, soil health, and vegetative cover fraction, which can vary between watersheds. Thus, this value was allowed to be adjusted within +/- 50 percent (from 0.0 to 0.1) during model calibration. Bochis-Micu and Pitt (2005) suggest that the coefficient in the exponent be set to meet an assumption of a 90 percent runoff ratio for a completely impervious watershed. Thus, for the exponent coefficient *b*, a value of 2.0 was set as default when *a* = 0.055. These two factors provided the best fit between results of the PLOAD model and measured annual average runoff volumes.

The Multi-Resolution Land Characteristics Consortium (MRLC)[2] maintains a national map of impervious surfaces with a spatial resolution of 30-m, most recently updated in 2011 (Homer et al. 2015). Imperviousness within the watersheds to Lake Elsinore and Canyon Lake was extracted from this national map and used for estimating runoff coefficients from model subareas with the above equation (**Figure 4-6**).

4.1.3.3 Downstream Retention in Unlined Channels

Not all rainfall that runs off into a surface water reaches Canyon Lake because of recharge that occurs in bottom sediments of unlined channel bottoms. **Figure 4-7** shows the unlined channel bottom segments throughout the watershed where downstream retention and groundwater recharge of runoff is known to occur. The major unlined channel segments that infiltrate upstream runoff include Salt Creek, San Jacinto River, and Perris Valley Channel. Under dry weather conditions, flows in these waterbodies typically infiltrate into the channel bottom.

To estimate the annual loss of runoff within these channel bottoms, a separate hydrologic data analysis was completed. The potential daily infiltration volume into the channel bottom segments was approximated from typical percolation rates for soils and the extent of the unlined channel bottom (**Table 4-3**). Daily runoff data from the period of record at the inflows to Canyon Lake (2000 – 2016) was evaluated to estimate the number of days when channel bottoms may have actively infiltrated upstream runoff. This was accomplished by assuming infiltration within unlined channel bottoms only occurred on days when the nearest downstream gauged flow exceeded a threshold indicative of wet weather conditions. The final column of Table 4-3 presents the estimated average annual yield of infiltrated runoff in each channel bottom segment.

[2] http://www.mrlc.gov/

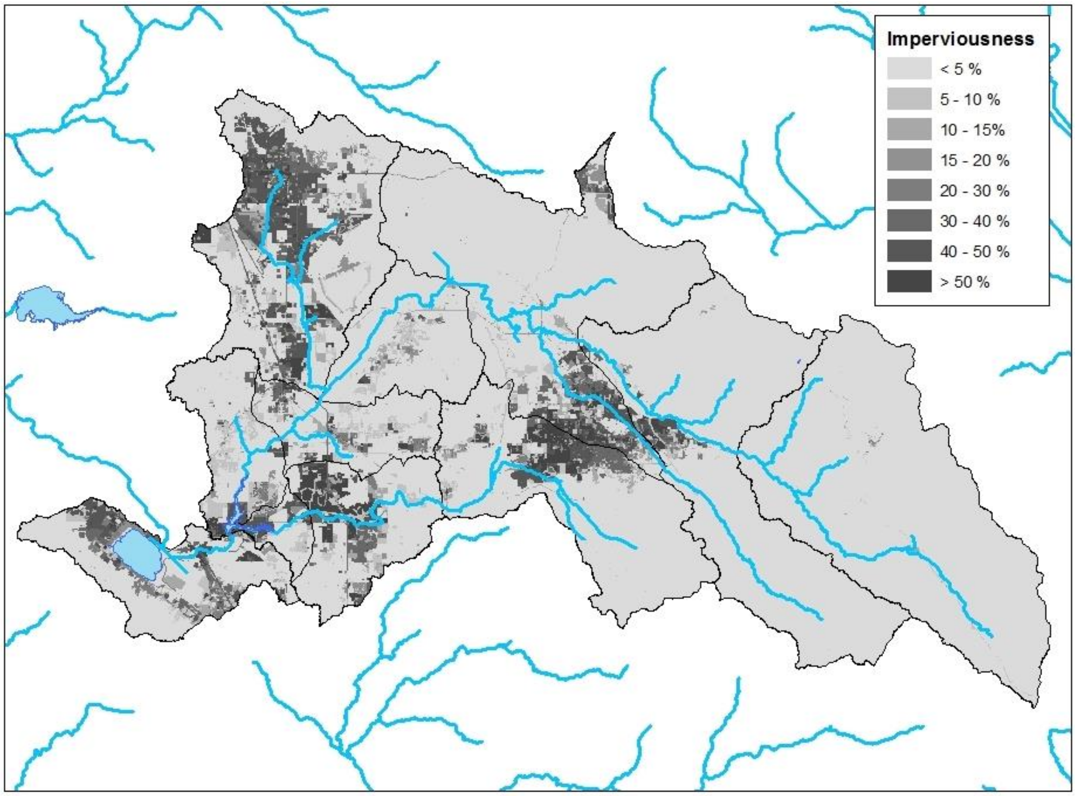


Figure 4-6. Imperviousness in the Lake Elsinore and Canyon Lake Watersheds

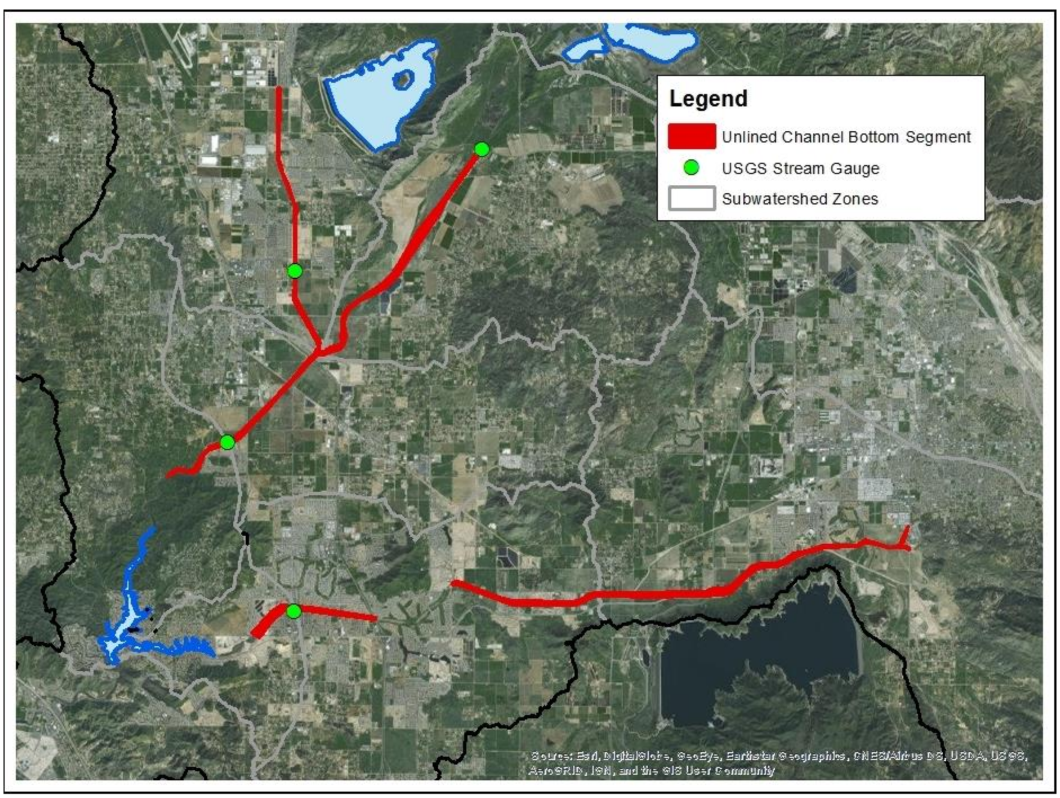


Figure 4-7. Unlined Channel Bottom Segments in the Lake Elsinore and Canyon Lake Watersheds

Table 4-3. Unlined Channel Bottom Segments and Estimated Average Annual Runoff Retained from Upstream Drainage Areas

Channel	Bottom Area (acres)	Recharge Rate (ft/day)	Downstream Flow Threshold (cfs)[1]	Number of Recharge Days (2000-2015)	Estimated Annual Recharge (AFY)[2]
San Jacinto River	111	0.1	20	280	145
Perris Valley Channel	222	0.1	20	280	290
Salt Creek	600	0.2	10	258	1,730

[1] Downstream flow gauges: (a) San Jacinto River and Perris Valley Channel: San Jacinto River at Goetz Rd (Station 11070365); (b) Salt Creek: Salt Creek at Murrieta Rd (Station 11070465). Period of record for these gauges is 2000-2016.
[2] Additional recharge of ~200 AFY from capture within Menifee Lakes Golf Course ponds.

This estimated annual recharge volume (in AFY) for each unlined channel bottom segment is converted into a depth of runoff from the upstream drainage areas within that subwatershed zone: (a) subwatershed Zone 5 to Perris Valley Channel; (b) subwatershed Zone 6 to San Jacinto River; and (c) subwatershed Zone 4 to Salt Creek. The estimated depth of watershed runoff retained in channel bottoms ($D_{retention}$) is added into the hydrologic model for subareas in these zones as follows:

$$Q_{annual} = (Precip_{annual} * RC) - D_{retention}$$

4.1.3.4 Influence of Mystic Lake

Watershed runoff in the upper San Jacinto River is captured in Hemet Lake within the National Forest and ultimately Mystic Lake, a large shallow depression in the San Jacinto valley (**Figure 4-8**). Mystic Lake has a storage capacity of approximately 17,000 AF, which is sufficient to retain all runoff from the upper watershed in most years. In addition, runoff is captured for water supply at Lake Hemet and groundwater recharge by Eastern Municipal Water District (EMWD) in a series of spreading grounds (Figure 4-8).

In years when Mystic Lake's storage volume is filled, large volumes of runoff may be delivered to Canyon Lake from the upper watershed, i.e. subwatershed Zones 7-9. Mystic Lake overflows are known to have occurred in the 1993-1994, 1995-1996, and 1998-1999 water years (Hamilton and Boldt 2015a, b), but not in subsequent wet years when flow gauge data showed no overflows occurred (notable being the 2004-2005 season). There are no downstream flow data for inflows to Canyon Lake during any overflow year (USGS gauge installed in 2000 after most recent known overflow in 1998). Thus, runoff from model subareas in subwatershed Zones 7-9 is assumed to be entirely retained in Mystic Lake for the calibration of runoff for the 2000-2017 period.

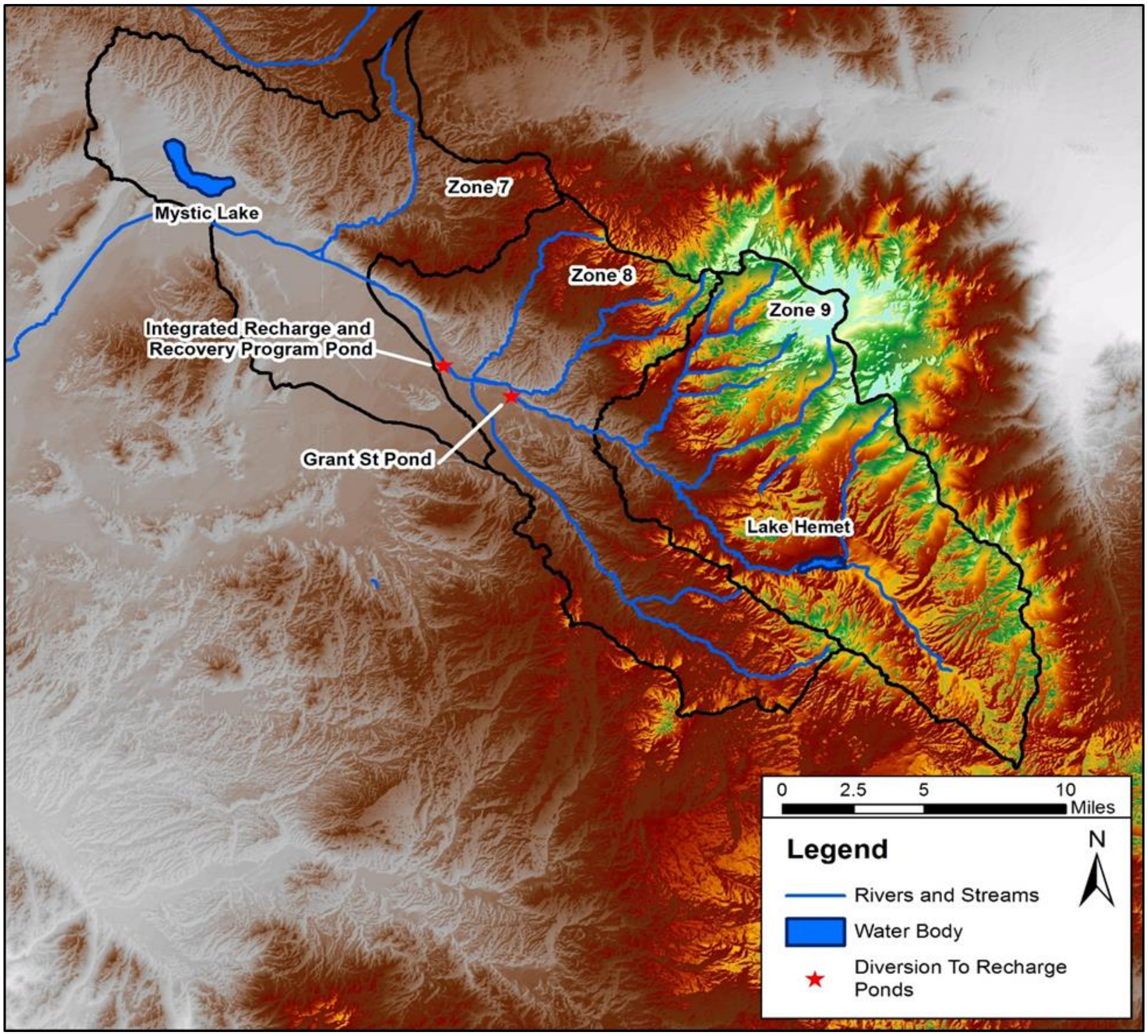


Figure 4-8. Drainage Area Upstream of Mystic Lake.

Rainfall stations in the region have actively collected data for 112 years at RCF&CWCD Station 186 San Jacinto and 86 years at RCFC&WCD Station 90 Idyllwild (see Table 4-2 above). These two rainfall stations are used to estimate runoff in model subareas within subwatershed Zones 7, 8, and 9 with San Jacinto rainfall used for subareas below 3,000 ft elevation and Idyllwild rainfall used for subareas above 3,000 ft elevation. The watershed model was used to conduct a time series analysis for years with concurrent rainfall data at both of these stations (1929 – 2016). Estimated runoff was reduced to account for significant attenuation in these subwatershed zones with retention in Lake Hemet and EMWD groundwater recharge basins (~15,000 AFY) that capture surface runoff from diversions in the upper San Jacinto River. For a 17,000 AF Mystic Lake storage volume, results met the conditions that would generate overflows in water years 1993-94, 1995-96, and 1998-99, but not in water year 2004-05, based on a reservoir water budget analysis described below. **Figure 4-9** illustrates the modeled estimates of annual runoff from the San Jacinto River into Mystic Lake over this period**.**

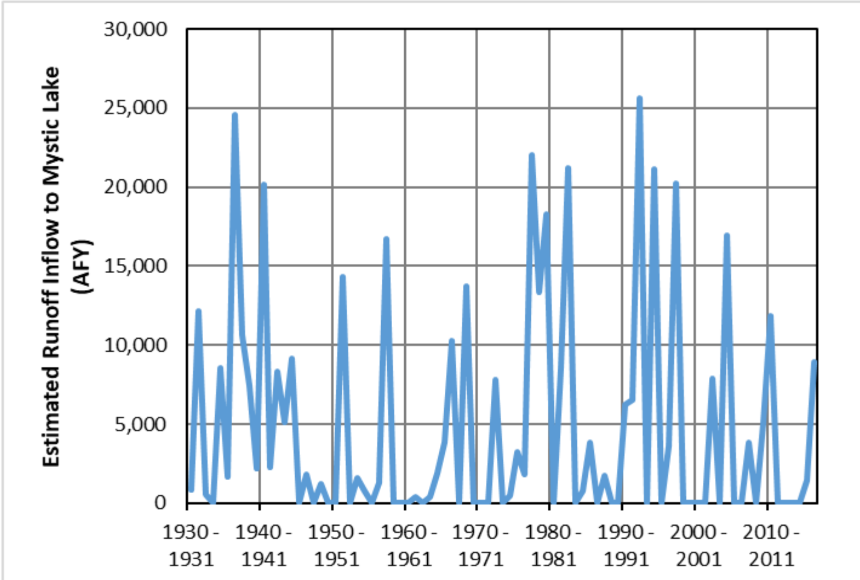


Figure 4-9. Modeled Runoff Inflow to Mystic Lake

A reservoir water budget analysis after Gilbert (1970) was developed to approximate the volume of overflow in a given wet season (O_i) from Mystic Lake to Canyon Lake by estimating key water budget components of runoff inflow (R), available storage capacity (S), and dry season evaporative losses (E), as follows:

$$O_i = R_i - (S_{MAX} - S_i)$$

$$S_i = R_{i-1} + S_{i-1} - E_{i-1} - O_{i-1}$$

Subsidence of land within the Mystic Lake basin bottom is continually adding an estimated 200 AF of storage capacity each year, as documented with review of historical bathymetric maps (Morton and Miller 2006). Looking forward, an estimated 5,000 additional AF of storage capacity may exist in 2040. To account for this future rise in storage capacity, the water budget analysis was developed with an assumed maximum storage capacity (S_{MAX}) of 22,000 AF, greater than the current estimate of 17,000 AF. The results predict that overflows from a future condition (with 22,000 AF of storage capacity) of Mystic Lake to Canyon Lake may have occurred in 10 of 86 years since 1929, with the most recent event occurring during the 1997-1998 wet season. During the 2004-2005 wet season, Mystic Lake was very close to full capacity, but did not overflow based on field observations (Hamilton and Boldt 2015a, b). More important than the frequency of overflows, is the volume of runoff that reaches Canyon Lake from the upper watershed. The reservoir routing analysis predicted that an average of ~4,000 AFY in overflow years with a range of < 500 AFY to > 10,000 AFY (**Figure 4-10**).

This water budget analysis was used to assess the influence of subsidence and associated increase in storage capacity on long-term runoff overflow volume. **Figure 4-11** shows the estimated long-term overflow volume with assumed constant storage capacities ranging from 12,000 – 22,000 AF. Re-visiting the 2004-2005 wet season, a storage capacity of 17,000 AF for Mystic Lake was sufficient to result in a nearly full Mystic Lake with no overflow, which was the condition observed in the field and later reported by Hamilton and Boldt (2015a, b). Thus, without subsidence, there may have been an overflow in the 2004-2005 wet season.

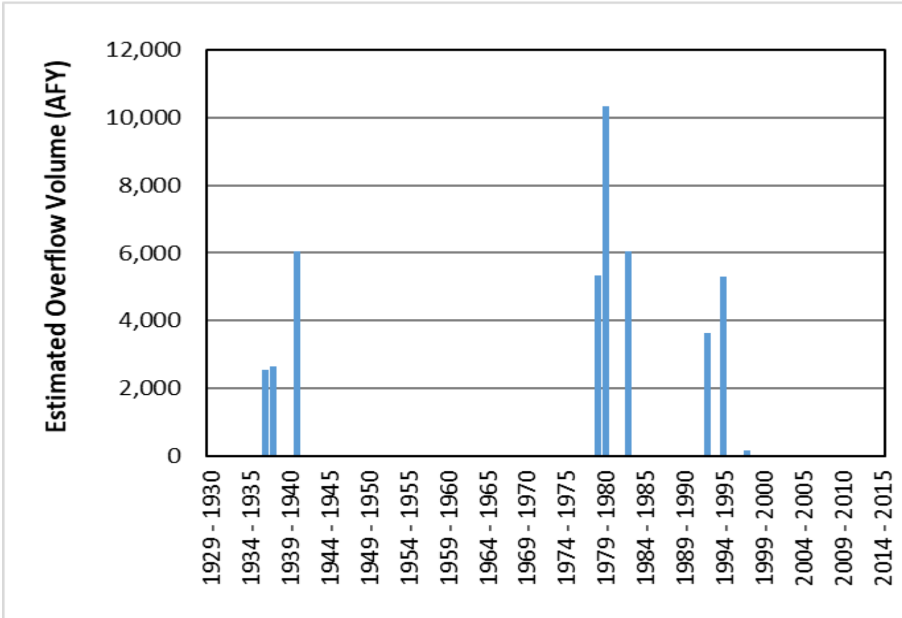


Figure 4-10. Modeled Overflow Volume from Mystic Lake to Canyon Lake (Note: Years not shown did not result in a spill)

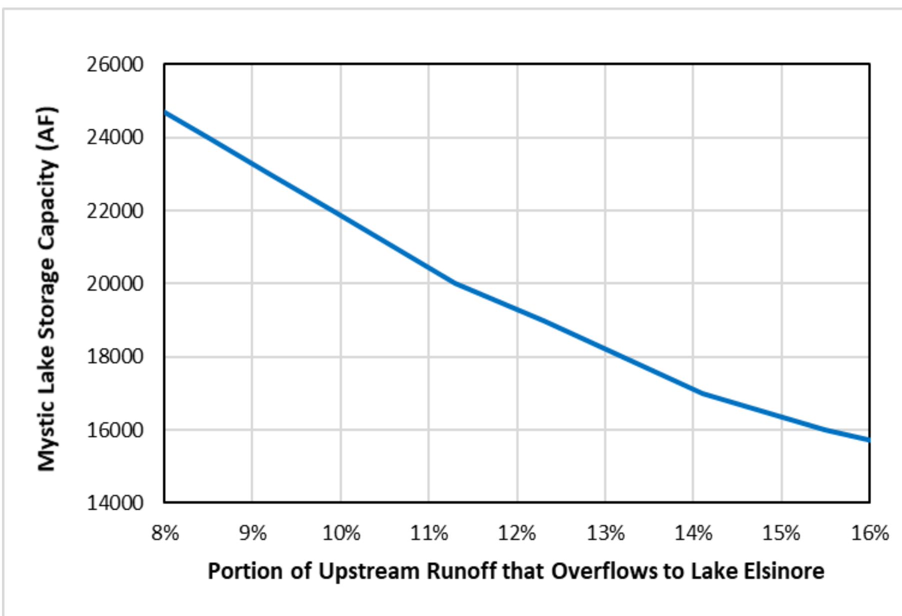


Figure 4-11. Modeled Overflow Ratio from Mystic Lake to Canyon Lake for Varying Levels of Storage Capacity in Mystic Lake

The water budget analysis showed that storage (S_{i-1}) was close to S_{MAX} in wet seasons leading up to each overflow year. Comparing the estimated overflow of ~500 AFY (including years with zero overflow) to the total runoff volume from the upper watershed (into Mystic Lake) for the 86-year simulation period of ~4,200 AFY suggests that ten percent of long-term runoff from subwatershed Zones 7-9 may reach Canyon Lake. Thus, an overflow ratio factor of 0.1 is applied in the model to estimate long-term average runoff and associated pollutant loads from the upper watershed to the Main Lake of Canyon Lake.

4.1.3.5 Hydrologic Model Results

Comparisons were made between measured and modeled average annual runoff delivered to Canyon Lake from model subareas upstream of the USGS gauges on San Jacinto River at Goetz Road and Salt Creek at Murrieta Road. To make this comparison it was necessary to do an additional delineation for subwatershed Zones 2 and 3 downstream of these gauges, in order to discount modeled runoff from portions of these subwatersheds that are downstream of the San Jacinto River at Goetz Road and Salt Creek at Murrieta Road USGS gauge stations. The ungauged portions comprise ~25,000 acres and amount to ~16 percent of the total drainage area to Canyon Lake below Mystic Lake. These ungauged areas include land areas that drain directly to the shoreline of Canyon Lake and a large tributary referred to as Meadow Brook (**Figure 4-12**).

The factors used to estimate runoff coefficients as a function of subarea imperviousness were adjusted (a=0.055, b=2) to fit modeled long-term average annual runoff volume to averages from the USGS gauges (**Figure 4-13**). Fitting a static condition of annual average runoff volume allows for a very close fit of model estimates to measured data by attenuating the natural dynamic variability.

Average annual runoff volume was estimated using long-term average rainfall based on the entire period of concurrent rainfall data at RCFC&WCD stations of 1948-2017 (shown in Table 4-2 above). Results shown in **Table 4-4** represent the estimated average annual volume of runoff delivered to Canyon Lake, Main Lake and East Bay, and Lake Elsinore from all watershed lands. These results account for losses in unlined channel bottom segments and include the long-term average of runoff overflow volume (computed including years with zero values) from drainage areas upstream of Mystic Lake. The runoff inflow volume shown for Lake Elsinore is for the local drainage and does not include overflows from Canyon Lake.

4.1.4 Water Quality

The preceding section describes a static model for estimating volume of watershed runoff generated from different model subareas that is delivered to each lake segment. Watershed runoff contains nutrients, total phosphorus and total nitrogen, that are conveyed through drainage features to the downstream lake segments. In wet years, the greatest source of nutrients to the lakes segments comes from the watershed with runoff. The following sections describe types of nutrient sources in the model subareas, the concentration of nutrients washed off from different land use types, and the total load of nutrients delivered to the lake segments as external loads in watershed runoff.

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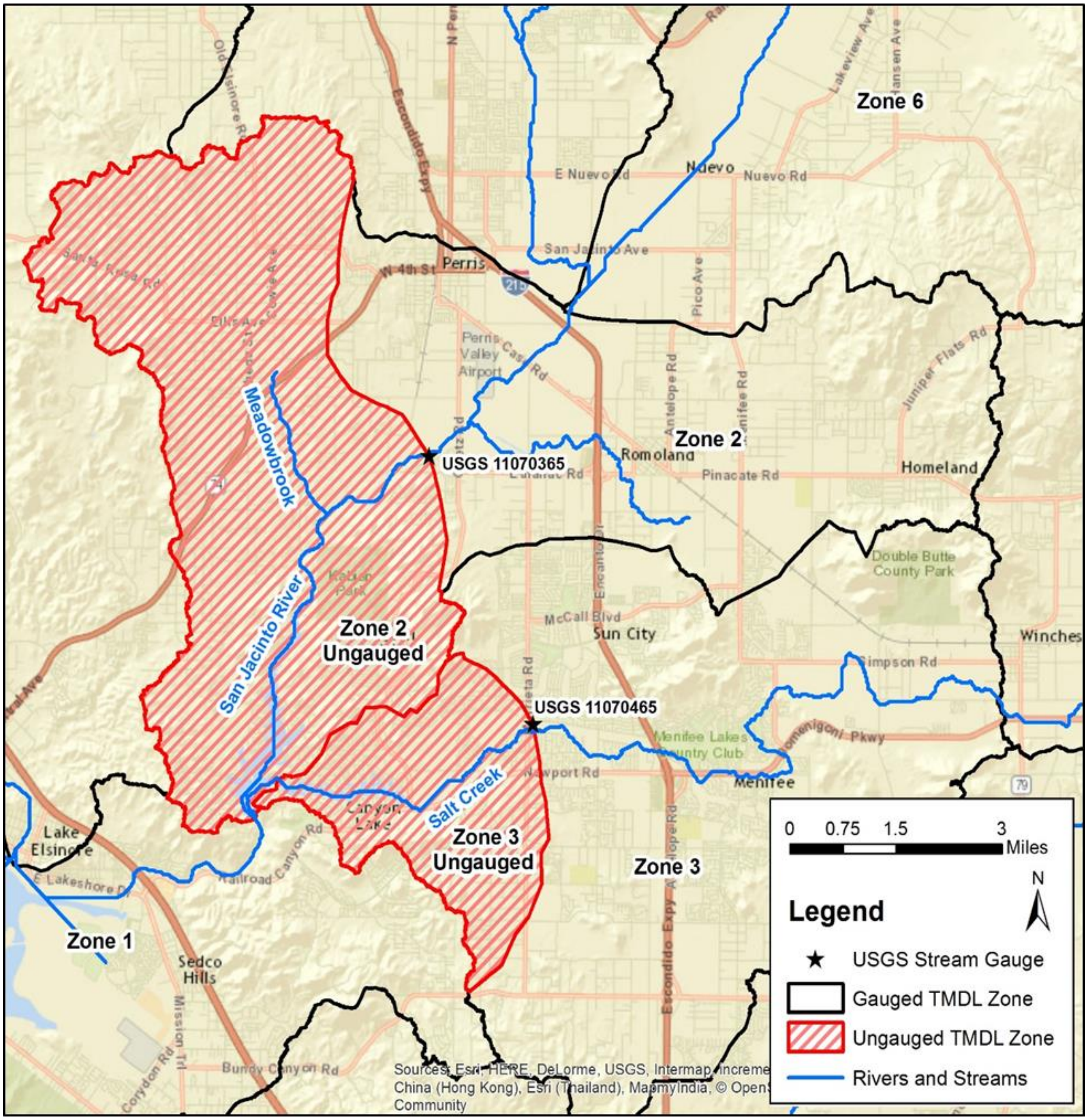

Figure 4-12. Drainage Areas Downstream of USGS Gauge Stations Not Included in Comparison of Modeled to Measured Runoff Volume

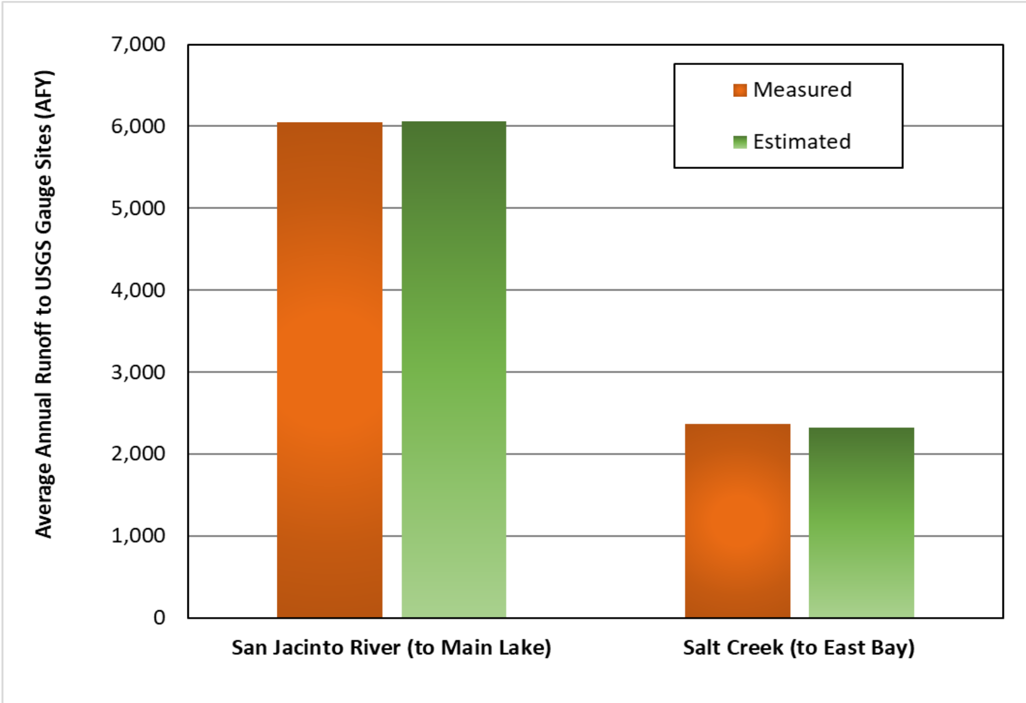

Figure 4-13. Comparison of Modeled and Measured Average Annual Runoff Volume (2000-2017) for Primary Inflows to Canyon Lake

Table 4-4. Estimated Long-Term (1948-2017) Average Runoff Volume Delivered to Lake Segments from All Watershed Lands

Average Annual Runoff Inflows to Lakes (AFY)	San Jacinto River (to Main Lake of Canyon Lake)	Salt Creek (to East Bay of Canyon Lake)	Local Lake Elsinore	Mystic Lake Overflow	Total
Modeled - Current Land use	6,855	3,447	2,011	1,974	14,288

4.1.4.1 Sources of Nutrients in Watershed Runoff

Specific sources of nutrients that may be available for washoff with runoff are listed below:

- Trash
- Fertilizers
- Green waste
- Pet waste
- Septic system failure
- Detergents
- Construction sites
- Erosion of exposed soils

The source assessment estimates TN and TP washoff from model subareas for generalized land use categories in drainage areas upstream of Canyon Lake (Main Lake and East Bay) and Lake Elsinore (local drainage downstream of Canyon Lake) (**Table 4-5**). Detailed land use distributions by subwatershed zone and jurisdiction are provided in Appendix B.

Table 4-5. Distribution of Land Use (Acres) in Areas that Drain to Lake Elsinore and Canyon Lake

Land Use	San Jacinto River (to Main Lake)[1]	Salt Creek (to East Bay)	Local Lake Elsinore	Total
Commercial / Industrial	17,937	5,215	1,854	25,006
Dairy	812	0	4	816
Forested	252,805	34,323	17,465	304,594
Irrigated Cropland	16,446	3,800	0	20,245
Non-Irrigated Cropland	13,394	12,840	29	26,263
Open Space	8,797	4,303	544	13,644
Orchards / Vineyards	3,953	322	56	4,330
Other Livestock	2,150	1,149	30	3,329
Pasture / Hay	2,454	665	53	3,173
Roadway	2,509	786	240	3,534
Water	1,479	442	3,183	5,103
Residential – Septic[2]	2,589	1,020	254	3,863
Residential – Sewer	41,592	17,482	6,652	65,726
Total Acres	**366,916**	**82,347**	**30,365**	**479,627**

[1] Acres shown include drainage areas upstream of Mystic Lake in Subwatershed Zones 7-9
[2] Residential land use on septic systems was approximated by intersecting GIS layers of Riverside County parcels containing a septic tank with 2014 land use areas mapped as low-density residential
[3] Acres shown include agricultural parcels that are < 20 acres in size

4.1.4.2 Nutrient Loading to Lake Segments

The existing loads to Canyon Lake and from Canyon Lake to Lake Elsinore can be approximated from historical flow and water quality data from the two inputs to Canyon Lake (Salt Creek and San Jacinto River) and from San Jacinto River inflows to Lake Elsinore. The gauges are downstream of the majority of drainage area to the lake segments, although adjustments are made in the modeling approach to account for ungauged drainage areas, as described in the following section 4.1.4.3. The concentration of nutrients for inflows to and outflows from Canyon Lake have been monitored during 36 storm events between 2001 and 2016. Data are sufficiently robust from these watershed monitoring activities to be considered representative of long-term averages and to characterize most of the expected variability associated with seasonality and magnitude of storm events. Event based summary data is presented in **Table 4-6**. Medians are presented for the entire set of events for model calibration. For estimating current levels of external loads, accounting for watershed BMP deployments, median concentrations are limited to more recent monitoring events (i.e., from the 2010-2011 wet season to present).

Table 4-6. Nutrient Concentrations (mg/L) from Storm Event Means at Watershed Monitoring Sites

Event	Date	San Jacinto River at Goetz Rd		Salt Creek at Murrieta Rd		Canyon Lake Overflow		Cranston Guard Station	
		TP	TN	TP	TN	TP	TN	TP	TN
1	1/11/2001	0.62	7.03	0.32	4.83			0.29	1.43
2	1/26/2001	0.21	10.60	0.20	5.80				
3	2/13/2001	0.49	5.50	0.28	3.24				
4	2/25/2001	0.41	4.98	0.44	3.40	0.17	2.70		
5	2/12/2003	0.64	2.56	0.61	2.62			0.13	0.60
6	2/25/2003	1.94	2.93	0.82	2.83	1.00	1.69	0.92	1.41
7	10/27/2004	1.50	3.01	0.96	2.07	0.41	2.00	4.13	3.80
8	1/12/2005	1.47	2.95					0.16	0.98
9	3/23/2005	0.78	1.32	1.35	2.05			0.11	0.58
10	2/28/2006	0.69	2.82	0.44	2.68				
11	4/5/2006	0.32	1.80	0.37	2.36				
12	1/5/2008			0.62	2.49			0.39	1.15
13	1/27/2008	0.58	1.90	1.08	2.70	0.46	1.82	1.22	4.00
14	2/3/2008							0.81	1.35
15	11/26/2008	1.51	3.07	0.77	1.57			0.43	1.03
16	2/16/2009	0.68	2.08	1.32	3.65	0.45	1.49		
17	12/12/2009	0.46	1.94	0.61	2.70				
18	1/20/2010	1.12	2.13	0.99	2.33	0.58	1.95		
19	2/5/2010	1.12	3.81	0.77	2.20	0.80	2.43	10.13	7.09
20	12/21/2010	0.72	2.01			0.46	1.56		
21	2/18/2011	1.87	3.60	0.42	2.81	0.56	1.38		
22	2/26/2011	4.19	3.56	0.54	2.11	0.94	2.21		
23	3/17/2012	0.94	2.56	0.33	2.12				
24	3/25/2012	0.26	1.85	0.23	1.73				
25	4/26/2012	0.56	2.58	0.41	2.18				
26	2/20/2013	0.73	2.39	0.30	2.11				
27	3/8/2013	0.56	2.57	0.33	1.70				
28	2/28/2014	0.85	2.16	1.15	3.32				
29	12/2/2014	0.56	2.00	0.79	2.65				
30	3/2/2015	0.33	1.59	0.29	1.91				
31	1/5/2016	1.40	2.42	0.91	3.18				
32	1/31/2016			0.38	2.29				
33	3/7/2016			0.28	2.05				
34	12/16/2016	0.71	2.22	0.32	2.38				
35	1/19/2017					0.38	1.78		
36	2/17/2017	0.78	1.69	1.10	2.03	0.34	1.97		
Median of all Events		**0.71**	**2.56**	**0.44**	**2.37**	**0.46**	**1.89**	**0.39**	**1.35**
Median (2010/11 wet season to present)		**0.73**	**2.30**	**0.38**	**2.12**	**0.46**	**1.78**	**n/a**	**n/a**

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Table 4-6 shows the median event nutrient concentrations (C_{median}) from the two inputs to Canyon Lake (Salt Creek and San Jacinto River) and overflow to Lake Elsinore, when active. Use of a flow-weighted average was considered but not used because no significant relationship was found between flow rate and nutrient concentration when comparing events. The median values were applied to annual volumes measured at the USGS gauges to estimate loading to the lakes from most of the watershed, as follows:

$$L_{annual} = Q_{annual} * C_{median}$$

Figures 4-14 and 4-15 show estimated annual nutrient loads based on measurements of daily flow and average of water quality monitoring data. The estimated retention of nutrient loads within Canyon Lake is computed from measured data in a manner similar to volume retention (see Figure 4-1 above). Retained nutrient loads are estimated as the difference between the summed annual loading for stations upstream and downstream of Canyon Lake for years when Canyon Lake elevation data are greater than the spill water elevation of 1,381.76 ft (2003-2005, 2008, and 2010-2011), indicating that overflows occurred. In dry years when the lake did not overflow, all nutrients loads are assumed to be retained.

4.1.4.3 Nutrient Washoff Model

PLOAD was employed to estimate nutrient washoff to downstream lake segments. This method computes downstream annual nutrient loads (L_{annual}) as a function of average annual runoff (Q_{annual}) and nutrient washoff concentrations for spatially lumped subareas with common land use (C_{LU}), subwatershed zone (Z), and jurisdiction (J), as follows:

$$L_{annual} = \sum_{LU,Z,J} Q_{annual} * C_{LU}$$

Thus, the estimation of nutrient loads delivered to downstream lake segments is based on hydrologic model results and assumed values for TP and TN concentrations in washoff from general land use categories. No accounting for variability in runoff volume or land use nutrient washoff concentration as a result of disproportionate deployment of watershed BMPs by individual jurisdictions was included in this source assessment.

Non-Agricultural and Dairy Land Uses

Table 4-7 presents non-agricultural and dairy land use-based nutrient washoff concentrations used to develop the source assessment. Table 4-7 also documents the basis of estimation for each of these nutrient washoff concentrations using monitoring sites representative of general land use categories (**Figure 4-16**). Commercial/Industrial and Residential - Sewer land uses were characterized from NPDES monitoring conducted by RCFC&WCD at core monitoring sites at Corona Storm Drain and Sunnymead Channel, respectively.[3] The National Stormwater Quality Database (NSQD 2017) contains data from multiple freeway sites in the vicinity of the San Jacinto River watershed. These data were used to characterize transportation land use in the watershed. San Jacinto National Forest data and San Jacinto Basin Resource Conservation District (2009) provided information on open space/forested and dairy land uses, respectively.

[3] Http://rcflood.org/npdes/monitoring.aspx

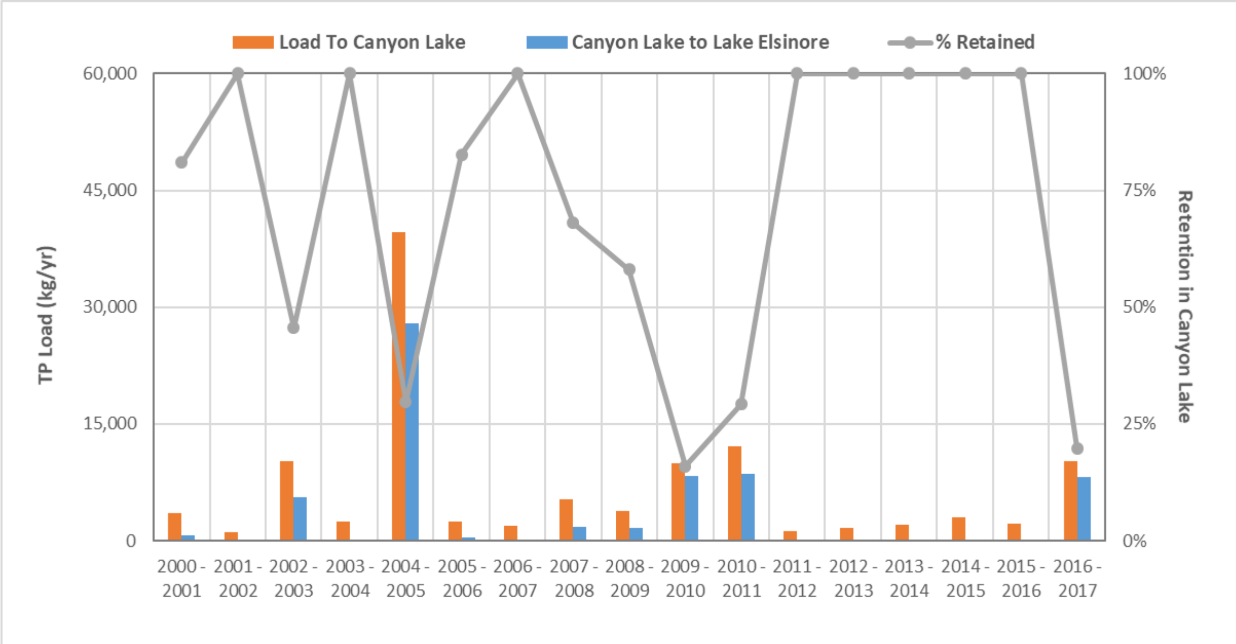


Figure 4-14. Annual Total Phosphorus Load into Canyon Lake and Overflow to Lake Elsinore

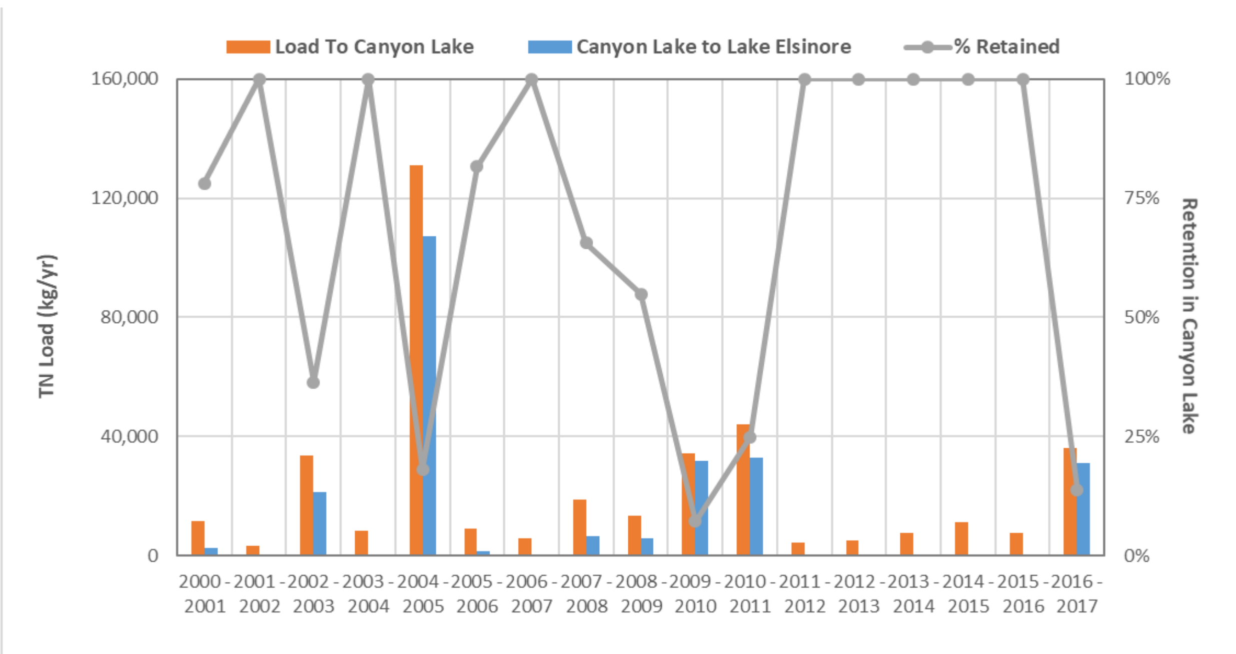


Figure 4-15. Annual Total Nitrogen Load into Canyon Lake and Overflow to Lake Elsinore

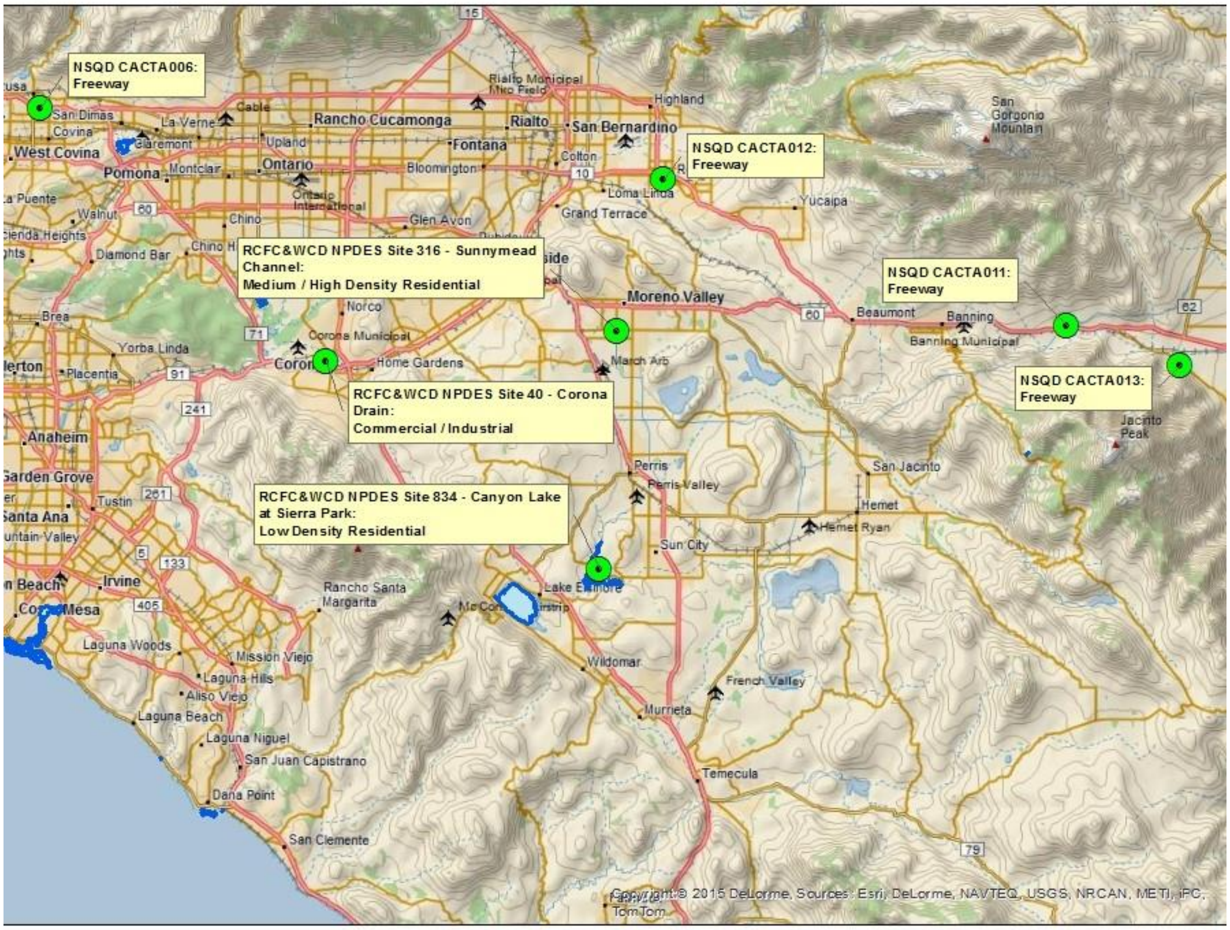


Figure 4-16. Map of Water Quality Monitoring Sites in the San Jacinto River Watershed and Vicinity Used to Estimate Land Use-based Washoff Concentrations for TP and TN

Table 4-7. Non-Agricultural and Dairy Land Use-specific Nutrient Washoff Concentrations Used for Source Assessment

Land Use	TP (mg/L)	TN (mg/L)	Site Name	Source (No. of Samples; Period of Record)
Commercial / Industrial	0.54	3.89	Corona Storm Drain (Station 40)	RCFC&WCD (N=30; 2004–2014)
Residential - Sewer	0.48	2.93	Sunnymead Channel (Station 316)	RCFC&WCD (N=30; 2004–2015)
Residential - Septic	0.59	5.30	Canyon Lake at Sierra Park (Station 834)	RCFC&WCD (n=21; 2000-2004)
Roadway	0.31	4.88	Freeway (FW) CACTA006, 011, 012, 013	NSQD (N=14; 1997-1999)
Open Space / Forested	0.32	0.92	Cranston Guard Station	USFS (N=54; 2001–2010)
Dairy	9.10	14.90	SJBRCD1	San Jacinto Resource Conservation District 2009

For the Residential – Septic land use, land use-based monitoring was conducted from 2001-2004 to support the 2004 TMDL, including a site downstream of Quail Valley, a low density residential area that was not historically serviced by any centralized sewer system (Canyon Lake at Sierra Park Station 834). A large project to bring sewer service to this area is currently underway. Monitoring at the downstream sample site was conducted prior to any sewer construction and therefore may be representative of residential land use with on-site sanitary treatment and disposal systems (OSTDS), referred to as septic systems in this report. The nutrient concentration data from this site show similar TP levels to sewered residential but approximately 80 percent greater TN concentration. This difference makes sense given that adsorption of nitrogen in soils is less efficient than phosphorus. A similar water quality response was observed from a smaller sample set collected from Meadow Brook, a tributary to the San Jacinto River just above the inflow to Canyon Lake Main Lake, with elevated TN concentrations averaging over 10 mg/L (RCFC&WCD 2013, see Attachment B).

Both Quail Valley and Meadow Brook are situated over portions of the watershed with shallow (< 2 m) depths to bedrock, thereby posing a greater risk of short-circuiting septic leachfields during wet weather events. A review of regional Soil Survey Geographic Database (SSURGO) soil survey mapping (NRCS 2017) showed that most other residential – septic model subareas (displayed in Figure 4-2 above) in the watersheds to Lake Elsinore and Canyon Lake also overlay areas with shallow depth to bedrock. Thus, the revised TMDLs applied a nutrient washoff concentration specifically for model subareas identified as residential – septic to account for nutrients from potentially failing septic systems watershed-wide. This approach differs from the method in the 2004 TMDL source assessment, which involved a separate loading analysis to attempt to quantify nutrient loads in potentially failing septic systems. The previously employed approach required rough assumptions about failure rates and how wet weather conditions mobilize incompletely treated sewage.

Agricultural Land Uses

For agricultural land uses, the estimate for nutrient washoff concentration was developed using preliminary results from a baseline soil health study conducted by WRCAC (WRCAC 2011). The study, conducted in March 2018, is a key step in the implementation of an Natural Resources Conservation Service (NRCS) Conservation Innovation Grant for the San Jacinto River watershed (Klang 2018). This study evaluated the concentration of phosphorus and nitrogen within soils from multiple agricultural fields in the San Jacinto River watershed. Averages from preliminary data were used to estimate nutrient concentrations from erosion of soils for agricultural fields in this watershed (**Table 4-8**).

While the study's data provide valuable information for the nutrient content within agricultural field soils, few data are being collected to characterize soil loss to downstream waters. These processes are a function of physical characteristics of individual fields and cannot be generalized from collecting data from a subset of locations. NRCS developed the Modified Universal Soil Loss Equation (USLE-M) to estimate soil loss nationwide from typical 1-acre agricultural lands as a function of soil erosivity, slope length and steepness, runoff ratio, watershed area, and cropping and erosion control practices. Estimates for the winter wheat in the west are used in Table 4-8 to approximate soil erosion from irrigated and non-irrigated one-acre agricultural fields in the San Jacinto River watershed (NRCS 2006).

Table 4.8. Estimate of Nutrient Concentrations in Runoff from Agricultural Fields in the San Jacinto River Watershed (kg/ac/yr = kilograms/acre/year)

Land Use	Pervious Land Runoff (in/yr)[1]	SED (tons/ ac/yr)	Sediment Delivery Ratio	P in Soils (ppm)	TP Export (kg/ac/yr)	TP (mg/L)	TKN in Soils (ppm)	TN Export (kg/ac/yr)	TN (mg/L)
Irrigated	0.66	0.5	5%	1,400	0.03	0.47	1,300	0.03	0.43
Non-irrigated	0.66	2.1	5%	1,100	0.1	1.54	1,400	0.13	1.96
Orchards	0.66	0.5	5%	800	0.02	0.27	550	0.01	0.18
Pasture/ Hay	0.66	2.1	5%	1,400	0.13	1.96	1,300	0.12	1.82

[1] Pervious land runoff estimated from RC = 0.055 and average annual rainfall of 12.0 in/yr (RCFC&WCD Station 186 San Jacinto)

Kinnell (2008) notes that the USLE, and derivations thereof, provide sufficient estimates of event-based soil loss from a specific size of watershed area (1-acre field in case of the nationwide estimates presented above), but that results should not be used for estimating annual soil loss or extrapolating on a per acres basis to larger drainage areas. A scaling factor, commonly referred to as the sediment delivery ratio (SDR), is required to estimate the amount of eroded soil from a typical 1-acre agricultural field that may reach downstream waters such as the San Jacinto River and Salt Creek. One method involves development of a relationship between SDR and total watershed area; several power functions have been developed based on measurements from around the world, synthesized by Ouyang and Bartholic (1997). For the 715 mi^2 watershed to Canyon Lake, these functions give a range in SDR of 5-25 percent. Based on these findings and apparent significant attenuation between ag fields and lake inflows in the San Jacinto River watershed, Table 4-8 incorporates a 5 percent SDR in the estimation of nutrient washoff from agricultural lands to receiving waters in the San Jacinto River watershed.

Nutrient Load Estimates from Watershed

For each referenced monitoring station, the median of collected wet weather samples was computed and served as the nutrient washoff concentration value in the source assessment model. The full range of wet weather TP and TN concentrations are plotted as box/whisker plots in **Figure 4-17** for TP and **Figure 4-18** for TN. These plots show the median (black line through box), 25^{th} and 75^{th} percentiles (lower and upper bounds of box) and minimum and maximum values (whiskers) for the full dataset.

Applying these land use specific washoff concentrations to average annual runoff (see Section 4.1.2 above) provides an estimate of nutrient loads for all model subareas. Taking only model subareas from upstream of USGS gauges on San Jacinto River at Goetz Road and Salt Creek at Murrieta Road and simulating average annual rainfall for the period of 2000-2017 allows for comparison of modeled to measured loads (**Figure 4-19**). Ungauged subareas that are downstream of the monitoring sites and drain directly to the shoreline of Canyon Lake (see Figure 4-12 above) as well as all model subareas upstream of Mystic Lake (no overflows occurred in 2000-2015 period) are excluded from these calibration outputs.

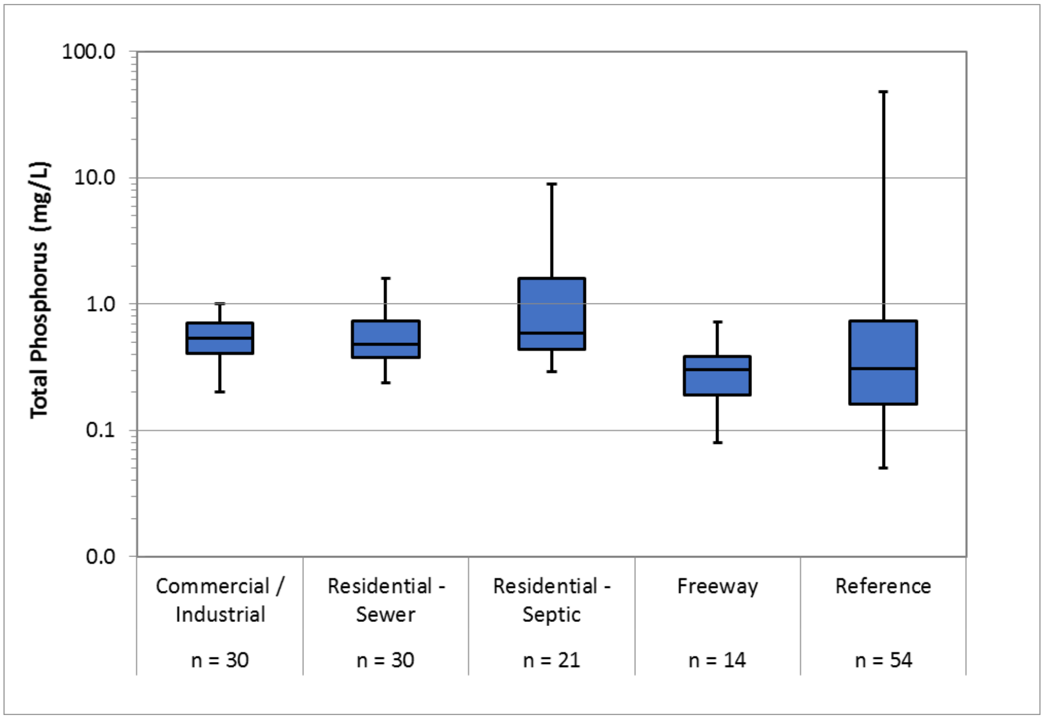


Figure 4-17. Box/Whisker Plots of Wet Weather Total Phosphorus from Land Use-specific Sites

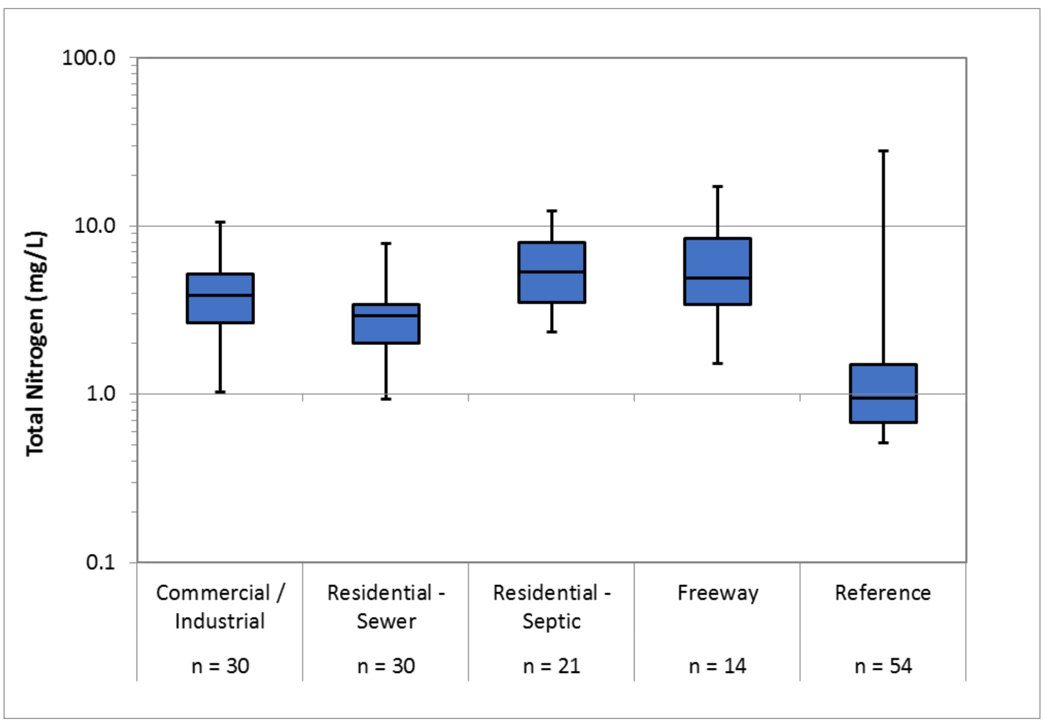


Figure 4-18. Box/Whisker Plots of Wet Weather Total Nitrogen from Land Use-specific Sites

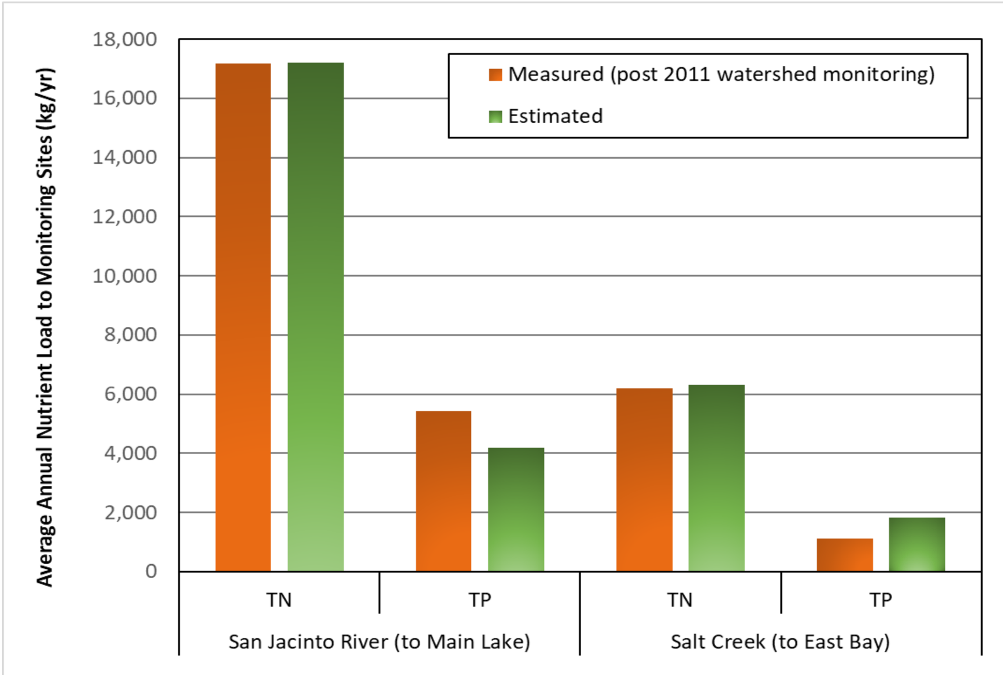


Figure 4-19. Comparison of Measured and Estimated Average Annual Nutrient Loads (2000-2016) to Monitoring Sites for San Jacinto River at Goetz Road and Salt Creek at Murrieta Road

Generally, the model performed well in predicting average annual nutrient loads when compared with estimated loads from measured data at the two downstream monitoring sites. The model did slightly under-predict annual TP loads to the San Jacinto River at Goetz Road. It is possible that another in-stream source is present in this drainage area to account for elevated concentrations (median TP of 0.72 mg/L) at the downstream station.

Table 4-9 provides the results for nutrients loads delivered to the lake segments based on long-term average annual rainfall (1948-2015) and accounting for all model subareas. These results include runoff from ungauged subareas, offsite runoff from CAFOs, and overflows from Canyon Lake to Lake Elsinore and overflows from Mystic Lake to the San Jacinto River and ultimately the Main Lake of Canyon Lake.

Table 4-9. Model Results for Long-Term Average (1948-2017) Annual Runoff and Nutrient Load Delivered to Lake Segments

Receiving Lake Segment	Runoff Inflow (AFY)	TP (kg/yr)	TN (kg/yr)
Canyon Lake Main Lake (Zones 2, 5, 6)	6,855	4,653	18,196
Canyon Lake East Bay (Zones 3, 4)	3,447	2,849	9,616
Local Lake Elsinore (Zone 1)	2,011	923	4,458
Mystic Lake Overflow (Zones 7, 8, 9)	1,974	1,037	3,069
Total (Zones 1-9)	**14,288**	**9,461**	**35,839**

Nutrient loading to lake segments from watershed runoff is summarized by subwatershed zone and by general land use category in **Figures 4-20 and 4-21**, respectively. The results, based on land-use based washoff calculations, show the greatest loading of nutrients originates in subwatershed Zone 5, which comprises the entire drainage area of Perris Valley Channel. Nutrient loads from Zone 4 that are estimated to reach Canyon Lake East Bay are approximately half of washoff from model subareas as a result of significant channel bottom recharge in Salt Creek.

Land use categories with the greatest acreage in the watershed were the largest source of nutrient loading to the lake segments. This includes residential – sewered and commercial / industrial categories as well as forest and open space model subareas. Agricultural land uses in the San Jacinto River watershed have declined significantly since the existing TMDLs were developed. Moreover, with adoption of the Conditional Waiver of Waste Discharge Requirements for Agricultural Discharges (CWAD) in 2017 (Santa Ana Water Board 2017), the acreage of agricultural land use in the watershed is expected to continue to decline. Despite having relatively higher nutrient washoff concentrations, the lower imperviousness and reduction of total agricultural acreage has reduced the source contribution from agricultural land use categories to the lake segments relative to the 2004 TMDL.

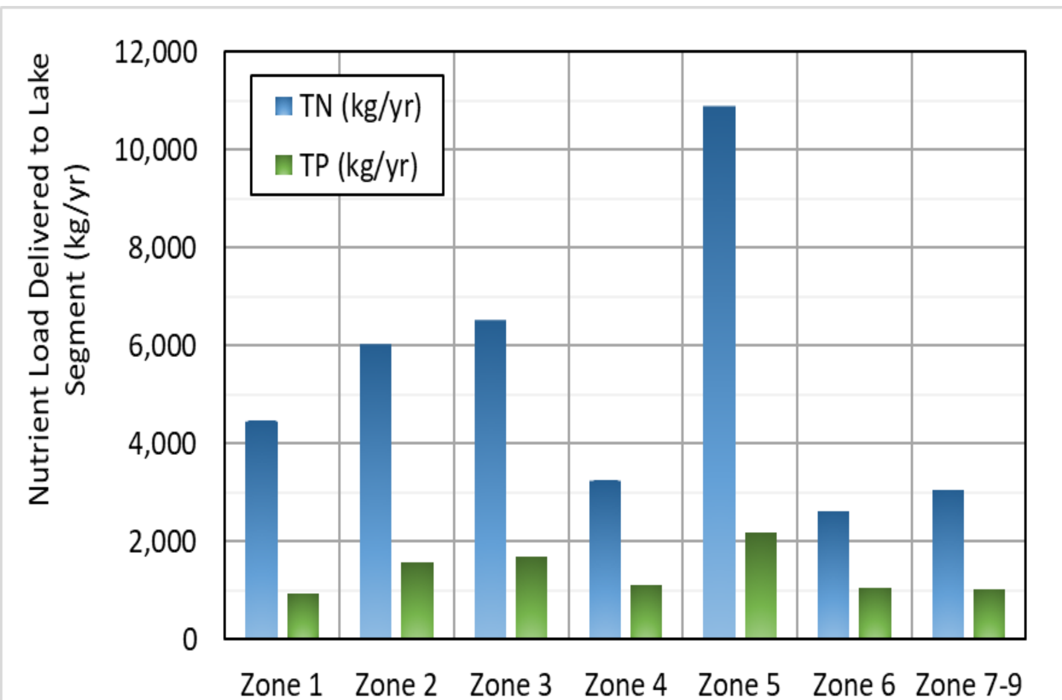


Figure 4-20. Nutrient Loading to Lake Segments by Subwatershed Zone (Note: Data include overflows from subwatershed zones 7-9; Zone 1 delivers load to Lake Elsinore; Zones 2, 5-9 deliver loads to Canyon Lake Main Lake; Zone 3, 4 delivers load to Canyon Lake East Bay)

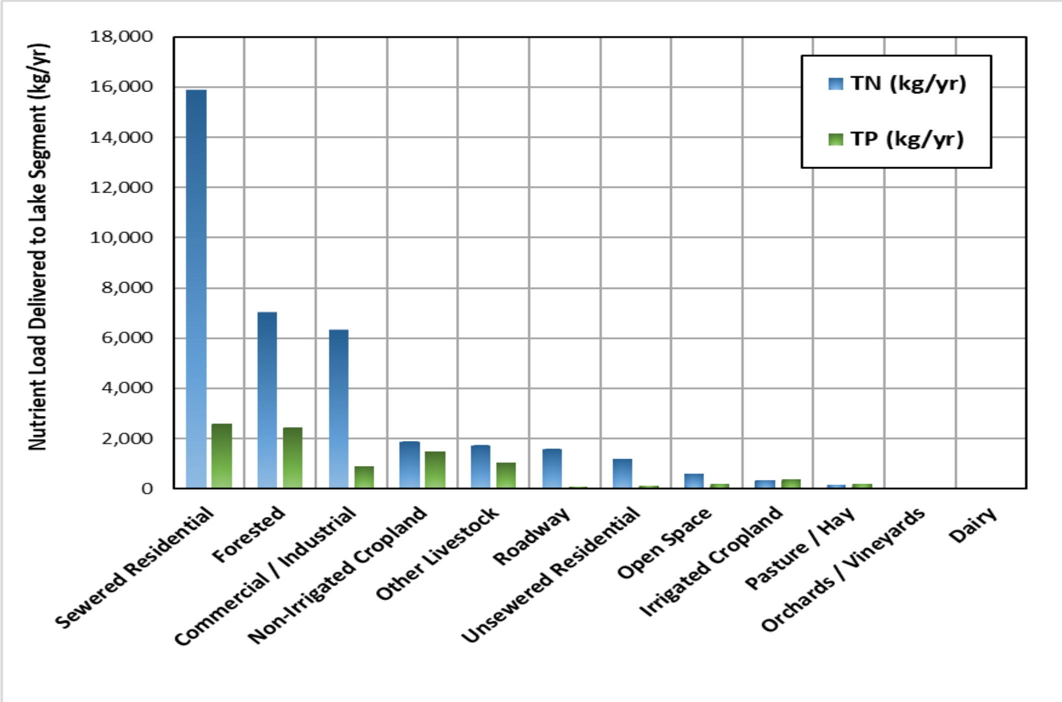


Figure 4-21. Nutrient Loading to Canyon Lake (Main Lake and East Bay Segments) by General Land Use Category

4.2 Supplemental Water

An additional source of volume and nutrient load exists for Lake Elsinore in the form of reclaimed wastewater from EVMWD's regional water reclamation facility (RWRF). Since 2008, EVMWD has added reclaimed wastewater to Lake Elsinore for lake level stabilization. A deeper lake provides multiple benefits including aesthetics, recreational use, and water quality. EVMWD's NPDES permit (Santa Ana Water Board 2013b) for this discharge to Lake Elsinore includes requirements for nutrient loads to the lake as follows:

- *Total Nitrogen* - 12-month running average TN concentration shall not exceed 1 mg/L, and the 5-year running average mass of TN discharged to the lake shall not exceed 16,372 pounds/year (7,442 kg/yr), unless the discharger implements a plan, with the approval of the Santa Ana Water Board or its Executive Officer, to offset TN discharges in excess of the TN limits.

- *Total Phosphorus* - Twelve-month running average TP concentration shall not exceed 0.5 mg/L, and the 5-year running average mass limit for TP discharged to the Lake shall not exceed 8,186 pounds/year (3,721 kg/yr), unless the discharger implements a plan, with the approval of the Santa Ana Water Board or its Executive Officer, to offset TN discharges in excess of the TN limits.

Table 4-10 summarizes the annual volumes of reclaimed water discharged and estimated total phosphorus and total nitrogen loads. The estimated load is based on an average annual concentration in effluent from 2014-2016 of 0.37 mg/L TP and 2.83 mg/L TN. Current treatment mechanisms at the RWRF reduce TP to meet the permitted effluent limit concentration of 0.5 mg/L. Conversely, typical TN concentrations exceed the allowable concentration of 1.0 mg/L. Therefore, EVMWD uses nitrogen offset credits accrued by operation of LEAMS to meet the permit requirements (see Section 7). In years when there is little or no overflow from Canyon Lake, the discharge of reclaimed water to maintain lake levels is the largest source of new external nutrient loads to Lake Elsinore.

Table 4-10. Volume and Estimated Nutrient Load in Supplemental Water Additions to Lake Elsinore

Year	Reclaimed Water (AFY)	Island Wells (AFY)	Total Supplemental Volume (AFY)	Estimated TP Load (kg/yr)	Estimated TN Load (kg/yr)
2007	2,361		2,361	1,078	8,243
2008	5,365	359	5,724	2,613	19,983
2009	5,470	404	5,874	2,681	20,507
2010	6,039	385	6,425	2,932	22,427
2011	1,920	6	1,925	879	6,724
2012	5,499	295	5,794	2,645	20,228
2013	5,843	264	6,106	2,787	21,320
2014	5,778	298	6,075	2,773	21,212
2015	1,930	50	1,981	904	6,912
2016	5,075	90	5,165	2,358	18,032
2017	5,677	175	5,852	2,671	20,430
2007-2017 Average	**4,632**	**211**	**4,844**	**2,211**	**16,911**

4.3 Internal Sources

Several sources of nutrients result from processes that happen within the lake ecosystem, including sediment nutrient flux from diffusive exchange and physical resuspension. An important parameter in CAEDYM is the nutrient flux rate, which accounts for both diffusive and physical mechanisms. Another important internal source of nutrients is wet and dry atmospheric deposition directly onto the lake surface. The following sections describe these processes and provide estimates of the associated nutrient loads.

4.3.1 Sediment Nutrient Flux from Diffusive Exchange

Nutrients that settle to the bottoms of Lake Elsinore and Canyon Lake bound to organic matter or otherwise bound to particles are not immediately available for phytoplankton uptake. Instead, these nutrients undergo processes within the lake bottom to move from being in a bound state to being in a more soluble form (PO_4 and NH_4). This transformation process is referred to as diagenesis.

Anoxic conditions and higher temperatures in the lake bottom sediments increase the rate of diagenesis and nutrient release via chemical reduction of iron-bound phosphorus, dephosphorylation and deamination of organic matter, and other reactions. The flux of these solubilized nutrients from porewater across the sediment-water interface to the water column occurs by diffusion and physical resuspension. This flux is the most significant source of bioavailable nutrients to the water column in Lake Elsinore. This source can be reduced with in-lake controls, an implementation strategy that is already underway in both Lake Elsinore and Canyon Lake.

Prior studies collected intact sediment cores for laboratory incubation experiments to evaluate the diffusive component of sediment nutrient flux. These studies, which were considered in the development of the 2004 TMDL, served as the basis for estimating internal loads for an assumed static lake bottom area of 3,000 acres in Lake Elsinore and 300 acres in Canyon Lake. Key findings from these studies include:

- *Lake Elsinore* - Sediment cores were collected from multiple sites across the lake bottom during four events in 2001 (Anderson 2001). The 2004 TMDL source assessment aggregated the results into lake-wide flux rates for winter (6.6 milligrams/square meter/day [mg/m^2/day] TP; 17.9 mg/m^2/day TN) and summer (8.4 mg/m^2/day TP; 71.0 mg/m^2/day TN) seasons to account for differences in DO and temperature at the sediment water interface (Anderson 2001).

- *Canyon Lake* – Sediment cores collected during five events from multiple sites in 2001-2002 were used to estimate the annual load from sediment nutrient flux (Anderson and Oza 2003). The mean SRP flux rate was somewhat higher for sites in East Bay (12.7 mg/m^2/d) compared with deeper sites in the Main Lake (9.3 mg/m^2/d) due to the cooler temperatures in the hypolimnion present in the Main Lake. Mean NH_4-N flux was also slightly higher in East Bay compared with the Main Lake (32.5 vs. 29.7 mg/m^2/d, respectively) (Anderson and Oza 2003). Averaging spatially and temporally over the whole lake yielded mean flux rates for PO_4-P and NH_4-N of 10.6 and 30.7 mg/m^2/d, respectively.

Subsequent core-flux studies in Lake Elsinore (2010) and Canyon Lake (2006, 2014) provided additional data that was appended to the historical datasets to support a more rigorous estimate of the long-term area-weighted average of flux rates (Anderson 2010). **Table 4-11** provides the update sediment nutrient flux data that provided the basis for revising the TMDLs.

Table 4-11. Average of Area-Weighted Summer Season Sediment Nutrient Flux from Core-Flux Studies in Lake Elsinore (2001, 2010) and Canyon Lake (2001, 2006, 2014)

Period	SRP (mg/m^2/day)	NH_4-N (mg/m^2/day)
Lake Elsinore[1]	7.1	73.0
Canyon Lake[2]	15.5	44.0

[1] Area weighting by acreage of sediment type reported in 2004 TMDL Staff Report (Santa Ana Water Board 2004b); range is from samples collected in August 2001 and August 2010 as reported in Anderson (2010)

[2] See Anderson 2016f

The Linkage Analysis (see Section 5) describes in detail the development of coupled lake water quality-hydrodynamic models to support the revised TMDLs. The model involves a dynamic lake water quality model that simulates daily sediment nutrient flux as a function of DO and temperature at the sediment water interface, accounting for different lake bottom area with changing water levels. While core-flux experiments provide valuable data for a standard condition, actual sediment nutrient flux rates for NH_4-N and PO_4-P are modulated by lakebed area and temperature and DO near the sediment water interface (Hipsey et al. 2006). A key variable in CAEDYM is the nutrient flux rate, which was set to coincide with the ranges reported above in Table 4-11.

4.3.2 Sediment Nutrient Flux from Resuspension

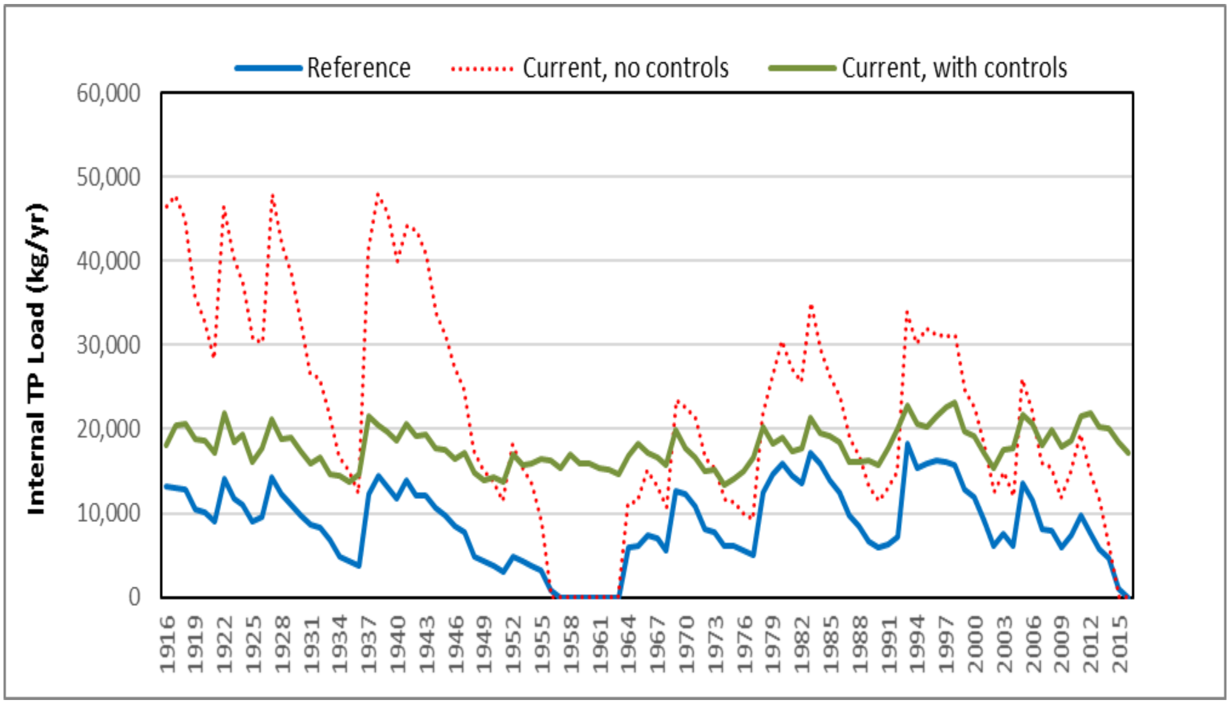
Physical resuspension of lake bottom sediments can release bioavailable nutrients to the water column. Resuspension can be caused by wind, recreation, propeller boats and bioturbation by benthivores (e.g., carp). Physical resuspension is an important nutrient source in Lake Elsinore and to some extent Canyon Lake East Bay as a result of shallower depths and the presence of benthivores. Anderson (2006) estimated sediment bioturbation rates in Lake Elsinore from (a) porewater and loosely sorbed nutrient concentrations; (b) a sediment resuspension rate of 0.24 mg/m^2/day per kilogram/hectare (kg/ha), based on a study of small experimental ponds with varying density of benthivorous fish (Breukelaar et al. 1994); and (c) local carp population density, estimated at ~900 fish per hectare in 2000-2001. Based on this analysis, Anderson (2006) found that the majority of sediment resuspension in Lake Elsinore was attributable to bioturbation, with only 15 percent of flux coming from wind influences. The resulting estimated sediment flux rate was assumed to account for all types of physical resuspension.

Based on Anderson (2006), a concentration of 0.01 milligrams TP/gram (mg/g) sediment resuspended was used to account for both porewater releases (0.005 mg TP/g sediment) and some desorption prior to resettling (0.005 mg P/g sediment). Coupled with the sediment resuspension rate findings, a TP flux of 2 mg/m^2/day was estimated.[4] For TN, only porewater ammonia-N releases play a role in mass flux to the water column from physical resuspension. Ammonia-N flux rates are assumed to be proportional based on an average TN:TP ratio of 4.4 from porewater samples (Anderson 2001), yielding a TP flux of 5 mg/m^2/day.[5] These rates were added to estimates from Table 4-11 above to serve as the baseline nutrient flux rate parameters for CAEDYM, inclusive of releases from physical resuspension as well as diffusive flux described in the Section 4.3.1 above.

The lake water quality models used in the linkage analysis for Lake Elsinore and Canyon Lake developed an estimate of daily internal load estimates for Lake Elsinore and Canyon Lake. **Figure 4-22** shows the modeled annual internal nutrient load from lake bottom sediment in Lake Elsinore for three scenarios: (a) reference (blue line); (b) current no controls (red dotted line); and (c) current with controls (green line). **Table 4-12** provides the long-term annual average internal sediment nutrient load for all three scenarios for both TP and TN. The difference between the "current, no controls" and "current, with controls" results provides an approximation of the load reduction achieved with implementation of in-lake BMPs. The nutrient flux for the reference watershed condition is a rough approximation developed for illustrative purposes. This level of internal load may be expected to occur sometime into the future after external loads are reduced to levels representative of a reference watershed condition.

[4] Based on the following equation/data: 900 kg carp/ha * 0.24 kg sediment/kg carp/ha * 0.01 mg TP/g sediment

[5] Based on the following equation: 900 kg carp/ha * 0.24 kg sediment/kg carp/ha * 0.005 mg TP/g sediment * 4.4 TN:TP



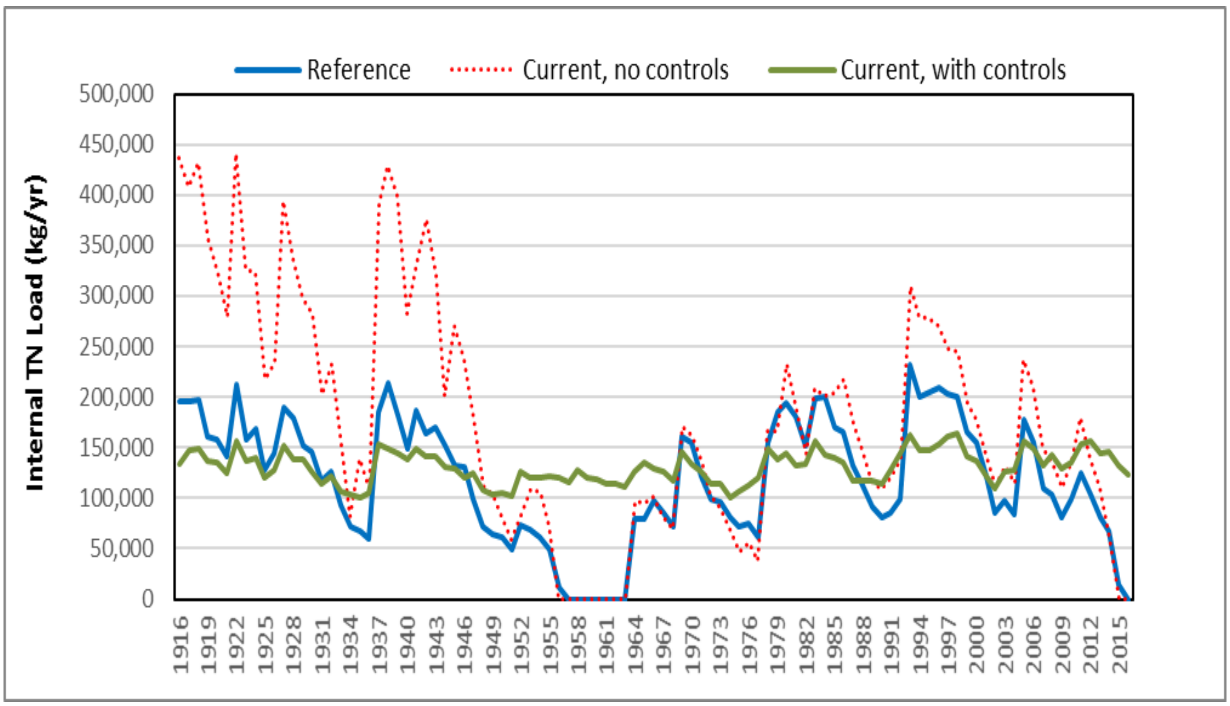


Figure 4-22. Modeled Flux (kg/yr) of PO_4-P (upper) and NH_4-N (lower) from Lake Elsinore Bottom Sediment to Overlying Water Column

Table 4-12. CAEDYM Estimates of Average Annual Nutrient Loads from Lake Bottom Sediments in Lake Elsinore and Canyon Lake for Reference, Current (No Controls), and Current (With Controls) Scenarios

Lake	Reference		Current (No Controls)		Current (With Controls)	
	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)
Lake Elsinore (1916-2016)	9,503	128,315	23,034	184,772	17,731	123,040
Canyon Lake (2007-2011)	1,190	3,955	2,997	11,023	n/a[1]	n/a[1]

[1] No simulation was completed to test the impact of alum additions beginning in September 2013 upon sediment nutrient flux.

For Canyon Lake, a shorter simulation period was evaluated as described in the Linkage Analysis (Section 5). Interannual variability in Canyon Lake sediment nutrient flux was significantly dampened compared with Lake Elsinore, with the greatest yearly deviation from long-term average annual flux rates of less than 30 percent. However, seasonal variability was significant as shown in plots of modeled daily nutrient flux rate over a five-year period from 2007-2001 (**Figure 4-23**). These results are reported above as average annual loads in Table 4-12.

No simulation was completed to test the impact of alum additions beginning in September 2013 upon sediment nutrient flux. While alum additions from 2013-2017 were of sufficient dose to remove more phosphorus than needed to meet WLAs, i.e. representative of a reference watershed condition (see Section 7.2), the impact on internal nutrient flux may not be fully realized due to the presence of a legacy of settled external runoff loads from wet seasons prior to 2013. With ongoing implementation and supplemental core-flux measurements, the model can be updated to estimate sediment nutrient flux with the alum project and other potential in-lake controls.

When employing a reference watershed approach for the TMDL revision, external loads are reduced from current levels to be representative of a reference watershed condition. In theory, a reduction in external load would in turn reduce the pool of nutrients in lake bottom sediments and thereby reduce internal load from sediment nutrient flux. Thus, flux rates could be expected to return to reference rates sometime after WLAs and LAs for external sources are achieved. The length of time that settled nutrients may impact future flux rates from the lake bottom was estimated to have a half-life of 10 years in Canyon Lake and 15 years in Lake Elsinore (Anderson 2011). Given that there may be a lag time associated with a legacy of nutrient enriched sediment, it may take several decades before previously deposited sediment is mineralized and internal loads are returned to reference levels. On the other hand, the LECL Task Force has deployed multiple in-lake controls to reduce sediment nutrient flux for the purposes of offsetting excess external loads (described in Section 7.2), and these may partially address the legacy sediment enrichment.

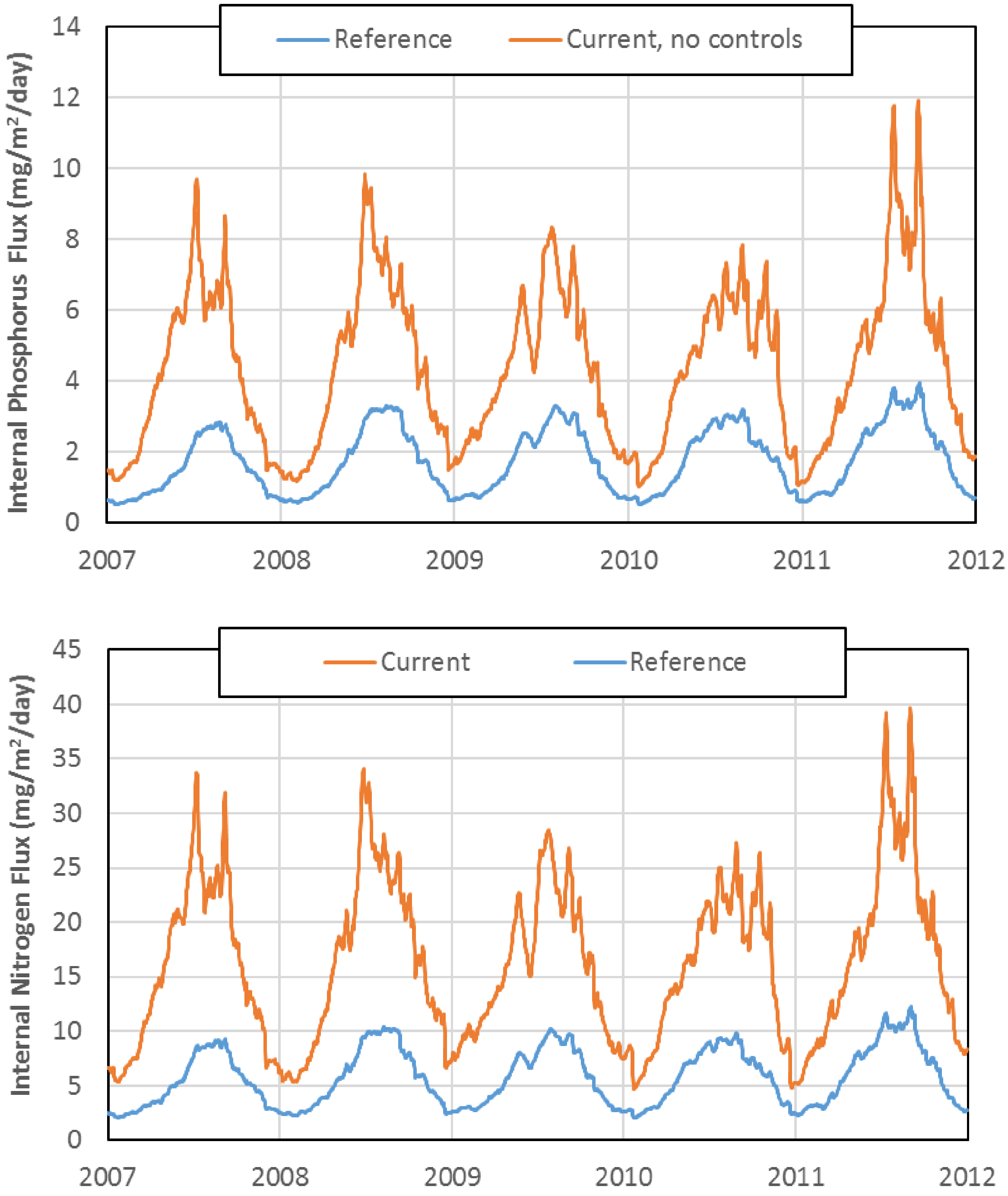


Figure 4-23. Modeled Daily Flux ($mg/m^2/day$) of PO_4-P (Upper) and NH_4-N (Lower) from Canyon Lake Bottom Sediment to Overlying Water Column

It is unknown what the internal load from sediment nutrient flux should be once the allocations in the revised TMDLs are achieved. No data are available for measurements of sediment nutrient flux in Canyon Lake or Lake Elsinore from hundreds or years ago prior to Railroad Canyon Dam construction and land development in the San Jacinto River watershed. Nor is there a comparable lake in the region with an undeveloped watershed that can be used to estimate sediment nutrient flux for a reference condition. Rather than wait to conduct core-flux studies after allocations are met, which would then be followed by years of mineralizing the legacy enrichment, the revised TMDLs developed an approximation of the future internal load from lake bottom sediment. This approximation is based on the following lines of evidence that provide consistent estimates of the enrichment of bottom sediments relative to current conditions:

- Kirby et al. (2005) evaluated the paleolimnology of Lake Elsinore through the collection and dating of 10-meter sediment cores to represent the past 10,000 years. The sediments at very shallow depths (most recent 200 years) were compared with the remainder of the core which represented pre-development (200 – 10,000 year ago). Results showed an enrichment in organic phosphorus and a proxy for nitrogen of ~50 percent (**Figure 4-24**).

- An independent sediment diagenesis model (CDM Smith 2017) was developed for Lake Elsinore to test the impact of changing external nutrient loads from current levels to the reference watershed condition. The flux of nutrients from simulations involving less enriched lake bottom sediments was reduced by 40 percent for TP and 60 percent for TN.

Based on these two lines of evidence, a reference watershed condition scenario was developed that accounts for expected reductions to internal loads that will follow required reductions in external loads.[6] Specifically, the CAEDYM model parameter for sediment nutrient flux rate was adjusted to half of current levels (as shown in Table 4-12) when developing TMDL numeric targets based on a reference watershed condition.

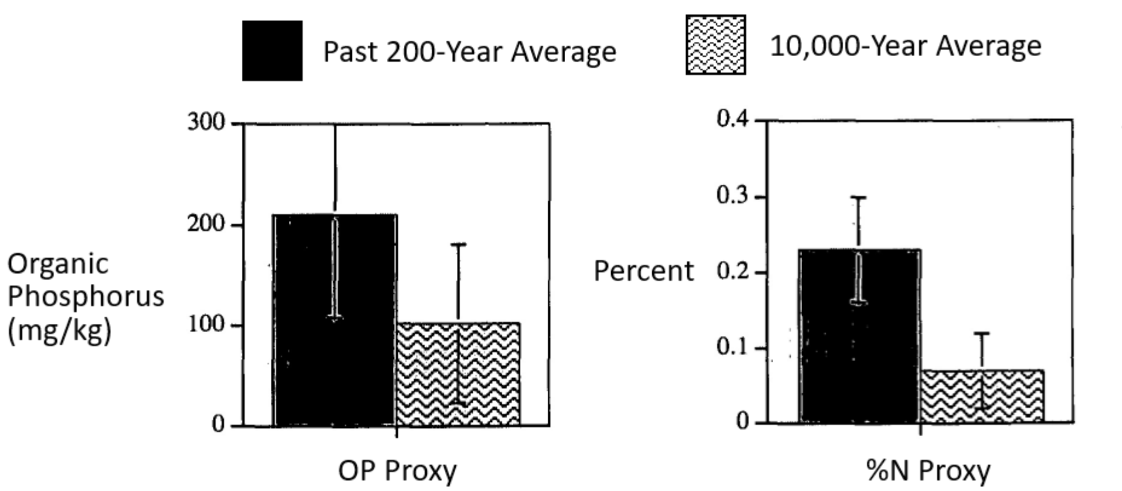


Figure 4-24. Paleolimnology Indicators of Nutrient Enrichment in Lake Elsinore Bottom Sediment Comparing Modern Era (dark grey) to Pre-Historic Era (hatch) Deposits

[6] This approach involving estimation of different sediment flux parameters for current and reference conditions is necessary because the version of CAEDYM used in the TMDL revision does not allow for a dynamic simulation of sediment diagenesis

4.3.3 Atmospheric Deposition

Nutrients within air overlying the surface of the lakes settle onto the lake surface and act as a small source of nutrients to the lakes. Load estimates were developed for direct deposition from the atmosphere to the lake surfaces. Inconsistencies in the approach used to develop estimates for Lake Elsinore and Canyon Lake exist in the 2004 TMDL (Risk Sciences 2017). For example, depositional rates for TN employed for Lake Elsinore and Canyon Lake were based on differing regional literature values. The approach presented below is based on similar data used for the 2004 TMDL but ensures a consistent method for TN and TP is applied to each lake segment

Wet deposition of TP to each lake segment was estimated using literature values for TP wet deposition rates of 30 kilograms/square kilometer/year (kg/km^2/yr) for Keystone Reservoir in Oklahoma (Walker 1996). Adjusting for differences in rainfall, average annual wet deposition for TP in Lake Elsinore and Canyon Lake was assumed to be 13 kg/km^2/yr (0.05 kg/ac/yr). Assuming most TP deposition occurs as wet deposition, load allocations were developed as shown in **Table 4-13.**

Estimates for atmospheric deposition of TN are based on results of a wet and dry deposition sampling conducted as an element of a water quality study for Newport Bay conducted in 2002-2004 (Meixner et. al. 2004). Results from this study showed that dry deposition accounts for most depositional load of TN, with seasonal average rates varying from 2 to 12 pounds/acre/year (lbs/ac/yr) (0.9 to 5.5 kg/ac/yr). The 2004 TMDL used a value of 7.1 lbs/ac/yr (3.2 kg/ac/yr). No significant changes to atmospheric N deposition are expected nor is there any new regional data, therefore the same rates will be used in the TMDL revision. Table 4-13 shows the load allocation for TN in each lake segment.

Table 4-13. Estimated Nutrient Loads from Atmospheric Deposition onto Surface of Lake Elsinore and Canyon Lake

Lake Segment	Estimated TP Load (kg/yr)	Estimated TN Load (kg/yr)
Canyon Lake Main Lake	17	1,077
Canyon Lake East Bay	5	331
Lake Elsinore	156	9,682

4.4 Summary of Nutrient Sources

There are a several key sources of nutrients to Canyon Lake, Main Lake and East Bay, and Lake Elsinore. These sources vary seasonally and according to inter-annual climate patterns in their relative importance to water column nutrients. This source assessment describes the individual sources and quantifies long-term average loading of nutrients to each lake segment. **Table 4-14** presents a summary of all the general nutrient source categories for each lake segment. The relative contribution of each category is also shown as pie charts for Lake Elsinore in **Figure 4-25**, Canyon Lake Main Lake in **Figure 4-26**, and Canyon Lake East Bay in **Figure 4-27**. Two key findings are apparent from the source assessment analysis:

- Internal loads in the form of sediment nutrient flux dominate the long-term nutrient budget for Lake Elsinore

- External loads play a much greater role in the nutrient budgets for Canyon Lake, both in Main Lake and East Bay.

These findings have profound consequences for developing compliance milestones and in specifying the most effective TMDL implementation approaches for each lake segment.

As discussed in Section 3, the basis for setting numeric targets is to create a water quality condition that is equal to or better than what may occur without anthropogenic impacts in the San Jacinto River watershed. This section quantifies nutrient sources for the existing developed condition; however, the same general categories of nutrient sources would exist in a reference, or pre-developed, watershed condition. The difference between the nutrient loads expected from the reference watershed and what is currently occurring represents the reduction in nutrient loads that will be required and that will provide the basis for setting allocations. These allocations are developed in Section 6.

Table 4-14. Summary of Nutrient Loads from All General Source Categories

General Source Category	Canyon Lake Main Lake		Canyon Lake East Bay		Lake Elsinore	
	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)
Watershed Runoff	1,861	7,511	1,139	3,856	6,461	24,593
Sediment Nutrient Flux	2,293	8,433	704	2,590	20,754	166,478
Atmospheric Deposition	17	1077	5	331	156	9,682
Supplemental Water	n/a	n/a	n/a	n/a	2,211	16,911
Total Average Annual Loading	**4,171**	**17,021**	**1,849**	**6,777**	**29,581**	**217,663**

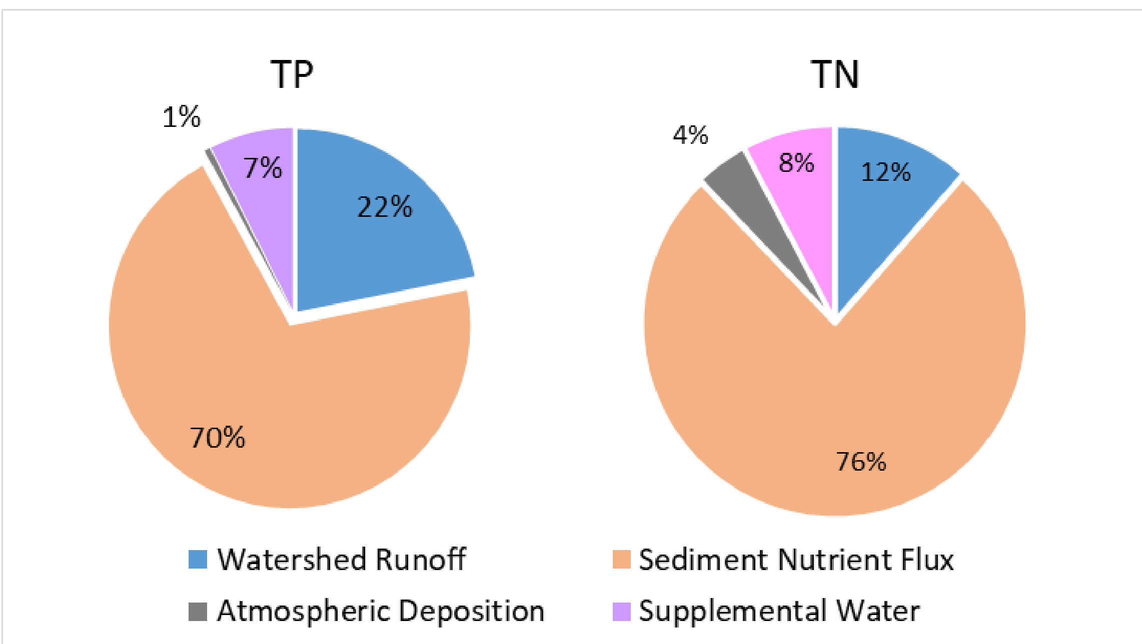


Figure 4-25. Relative Contribution of General Source Categories for Lake Elsinore Long-term Average Annual Nutrient Budget

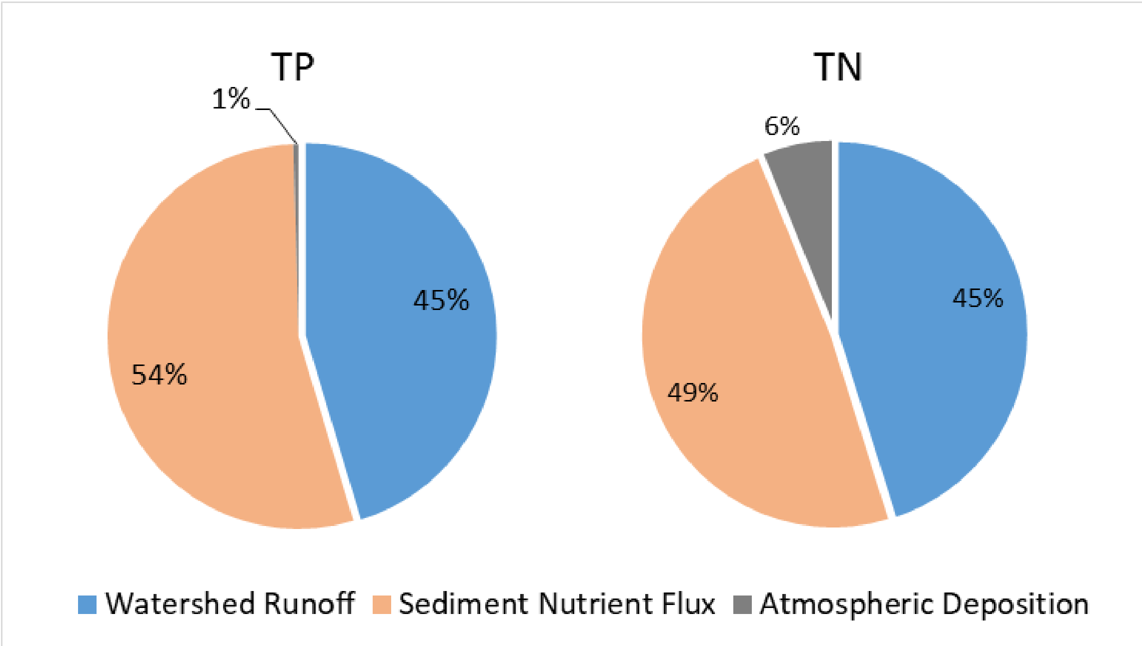


Figure 4-26. Relative Contribution of General Source Categories for Canyon Lake Main Lake Long-term Average Annual Nutrient Budget

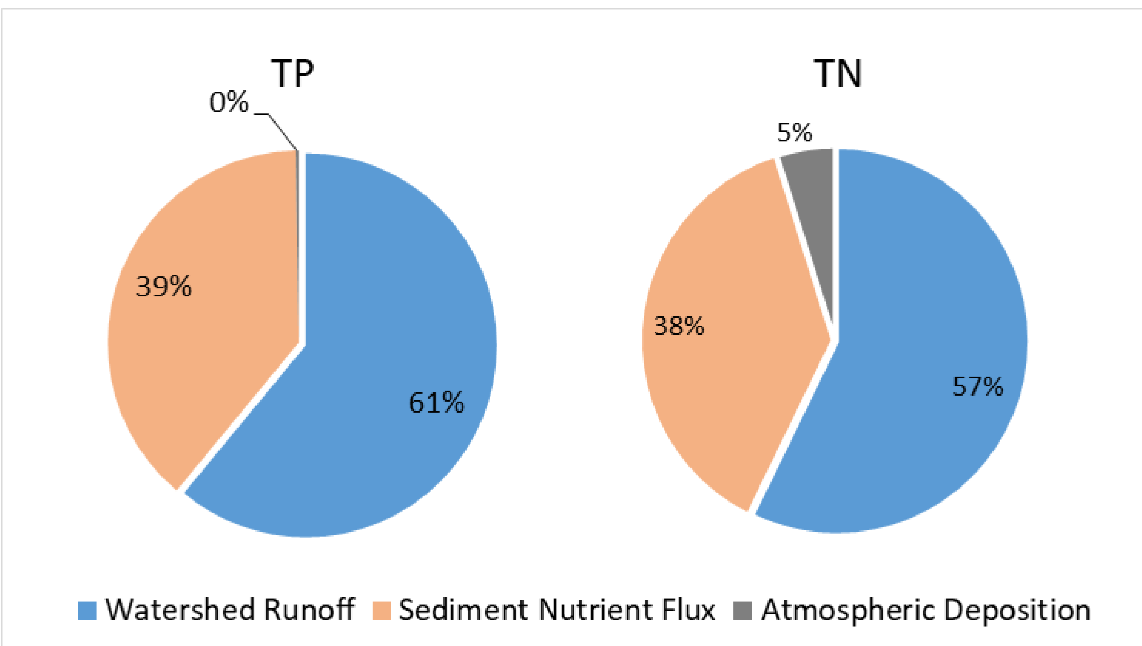


Figure 4-27. Relative Contribution of General Source Categories for Canyon Lake East Bay Long-term Average Annual Nutrient Budget

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Section 5

Linkage Analysis

The primary function of a TMDL linkage analysis is to establish a link between pollutant loading from multiple sources and water quality in receiving waters. The linkage analysis serves as a key step in the use of a reference watershed approach to determine numeric targets for the Lake Elsinore and Canyon Lake nutrient TMDLs. This reference watershed approach and its use to establish numeric targets was presented in Section 3. This section provides the following information:

- *Linkage Analysis Approach (Section 5.1)* - This section describes the role of the linkage analysis in the estimation of numeric targets for Lake Elsinore and Canyon Lake using the reference watershed approach. The basis for the Linkage Analysis involves application of lake models to simulate the biogeochemical processes within each lake segment.

- *Lake Model Descriptions (Section 5.2)* – Describes the lake models employed in developing the linkage analysis. This effort involved coupling of a biogeochemical model with a hydrodynamic model to evaluate spatially and temporally varying water quality in each lake segment. The rationale for selection of CAEDYM to simulate biogeochemical processes in both lakes and use of different hydrodynamic models for each lake (DYRESM for Lake Elsinore; ELCOM for Canyon Lake) is discussed in this section.

- *Application of Lake Models in Lake Elsinore (Section 5.3) and Canyon Lake (Section 5.4)* – These sections are organized in the same way to present the simulation periods, boundary conditions, input data, and key parameter estimates for the Lake Elsinore and Canyon Lake models. It is important to develop a scenario representing current inflows and outflows and associated nutrient loads, to facilitate calibration of models to generate a good fit of hydrologic and water quality results with data measurements. The calibrated models are then subjected to runoff and nutrient loading from a hypothetical reference watershed to serve as the linkage between allowable loading and receiving water quality. Lastly, comparisons of modeled lake water quality for current and reference watershed conditions are presented to illustrate expected benefits within each lake segment anticipated with TMDL implementation.

5.1 Linkage Analysis Approach

The linkage analysis plays an important role in developing a revised TMDL using a reference watershed approach, which differs from a traditional stressor response TMDL. The following subsections describe how the linkage analysis fits into the revised TMDLs and provides a roadmap for the key inputs to the lake water quality models that have been used to conduct the linkage analysis.

5.1.1 Role of Linkage Analysis in TMDL Revision

The linkage analysis estimates water quality response variables, chlorophyll-*a* and DO, for different levels of external nutrient loading representing existing and reference watershed conditions. Results plotted as CDFs allow for an assessment of the difference between existing and reference watershed conditions. The expectation is that with implementation of BMPs to address the TMDLs, existing condition CDF curves will shift to be equal to or better than reference conditions, i.e., achieving the numeric targets (see Section 3).

Existing conditions approximate the current distribution of water quality in each of the three lake segments (Canyon Lake - Main Lake; Canyon Lake - East Bay; Lake Elsinore). A subset of the period of simulation for existing conditions is used to calibrate water quality model parameters to achieve a reasonable goodness-of-fit with measured data collected by the in-lake monitoring program. In the case of Lake Elsinore, the LEMP project was implemented to improve water quality by reducing the surface area of the lake and reclaimed water has been added to maintain water levels (see Section 2.2.2.3). LEMP and the addition of reclaimed water are accounted for as elements of the linkage analysis for existing conditions, but not as part of reference conditions.

The calibrated model developed for existing conditions was modified to evaluate water quality responses for alternative scenarios of reduced external or internal nutrient loads. For setting numeric targets, external nutrient loads to the lake models are reduced to levels expected for a reference nutrient concentration, as described in Sections 5.3.6 for Lake Elsinore and 5.4.6 for Canyon Lake. The lake models are also used to test the water quality benefits that may be achieved with existing and potential supplemental watershed BMPs and lake management scenarios (see Section 7). The only physical structure included in the reference condition linkage analysis is Railroad Canyon Dam, because Canyon Lake would not exist without its presence. Simulation results for chlorophyll-*a* and DO, plotted as CDFs, serve as numeric targets for the revised TMDLs (see Section 3.3).

Lastly, the water quality models used to develop numeric targets for the lake segments will be used to test the potential benefits from existing and potential supplemental in-lake management strategies (see Section 7).

5.1.2 Water Quality Model Development

The Problem Statement in Section 2 describes a unique condition for Lake Elsinore and Canyon Lake resulting from an El Nino-driven climate system within a drought-prone semi-arid region. For Lake Elsinore, climate and presence of upstream retention, including Canyon Lake, have created a natural cycle involving periods of complete lakebed desiccation. Numerical models were developed to characterize a full range of water quality responses for the greatest sources of variability, temporal in Lake Elsinore and spatial in Canyon Lake, as follows:

- *Lake Elsinore* – A 1-D lake model was developed to allow for multidecadal simulation periods needed to capture the full range of hydrologic conditions, including a period of known lakebed desiccation.

- *Canyon Lake* – A 3-D lake model was developed to allow for assessment of temporally and spatially variable water quality response, including vertical stratification and the presence of unique lake segments with limited mixing.

Numerical lake models leverage current scientific understanding of interactions among hydrology, nutrient loading, and resulting water quality in each lake. They also facilitate extrapolation of our current understanding out to hypothetical conditions in a reference watershed, or estimation of benefits from implementation of in-lake water quality control strategies. **Figure 5-1** provides a roadmap for the input data and model boundary conditions used to develop lake water quality models for Lake Elsinore and Canyon Lake.

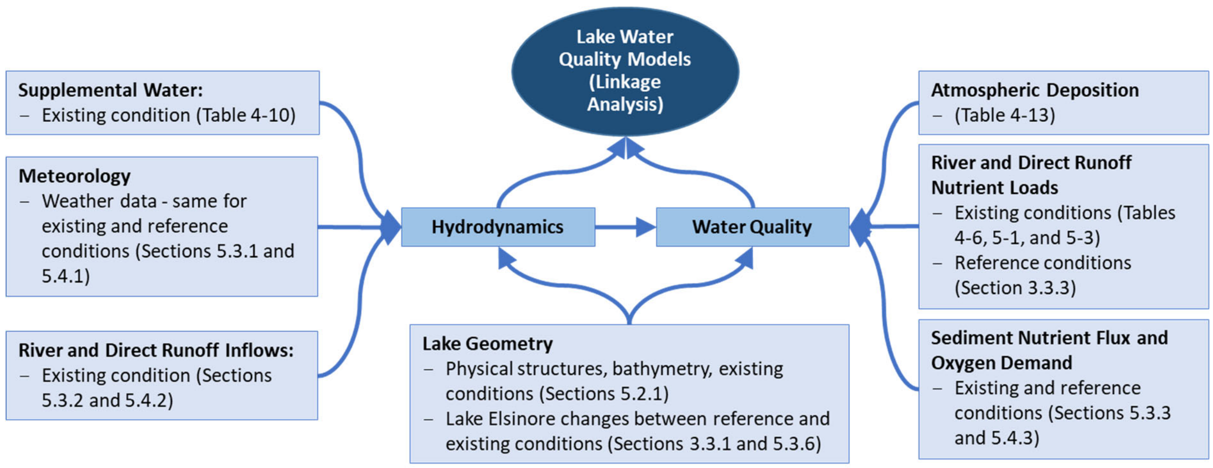

Figure 5-1. Document Location for Key Input Data and Boundary Conditions for Linkage Analysis

5.2 Essential Physical/Biogeochemical Processes and Model Selection

Water quality modeling involves evaluating both hydrodynamics and water quality. Hydrodynamic lake models solve energy, momentum and water budget equations to calculate density stratification, mixing, flow and transport, as well as lake level. Water quality models typically couple with hydrodynamic models, so that they can simulate water quality responses to changes in hydrodynamics. Several models have been developed to simulate hydrodynamics and water quality in lakes and reservoirs, including CE-QUAL-W2, Environmental Fluids Dynamic Code (EFDC), DYRESM-CAEDYM, and ELCOM-CAEDYM. These models vary in sophistication, with varying levels of dimensions represented and water quality processes included. The level of sophistication needed to capture water quality in Lake Elsinore and Canyon Lake depends on the key physical and biogeochemical processes in the lakes, which is discussed in the following sections.

5.2.1 Physical Model Characteristics

Mathematical representation of a lake or reservoir can in some cases be as simple as a 0-D continuous stirred tank reactor (CSTR) model (Thomann and Mueller 1987; Chapra 1997), or as detailed as a finely resolved 3-D model. In the case of a 0-D model, the total volume of a waterbody is considered to exhibit instantaneous, full mixing vertically and horizontally. This can be appropriate for a waterbody that is both shallow enough to show uniform characteristics throughout the water column and also shows little variation in water quality parameters in the horizontal direction.

Lakes and reservoirs tend to be more complex systems than a 0-D model can represent; water column variations in temperature tend to result from light and heat penetration, and this often results in a layering effect in most inland waterbodies. The dynamics of the upper, mixed layer and the deeper, dense layer below are important for hydrodynamic and water quality evaluation, because primary production (and thus oxygen generation, among other things) only occurs where light is present. Buoyant forces derived from the density gradient limit vertical mixing of the water column, often resulting in an anoxic hypolimnion that is elevated in NH_4-N and PO_4-P and potentially also Mn^{2+}, Fe^{2+} and H_2S.

In lakes with relatively simple geometry and little horizontal differences in temperature or water quality, a 1-D model is often utilized. 1-D thermodynamic / hydrodynamic models such as DYRESM thus explicitly assume that the primary gradient in properties is in the vertical direction and treat the waterbody as uniformly mixed laterally. The advantage of a 1-D model is the low computational cost and high speed of simulations, thus allowing simulations of long periods of time and/or a large number of scenarios. As discussed below in more detail, this is the case with Lake Elsinore, which has simple enough geometry that lateral gradients in water quality parameters are not as important to water quality processes as capturing vertical variations.

For lakes and reservoirs with significant horizontal gradients in water column conditions, 2-D or 3-D representations are generally necessary. This is often the case with waterbodies that have complex geometry or spatial variations in water quality loadings. Geometric complexity of Canyon Lake, combined with its vertical stratification, requires a 3-D model such as ELCOM to capture key processes of physical transport and vertical nutrient fluxes.

5.2.1.1 Lake Elsinore

Lake Elsinore is a relatively large lake (approximately 3,000 surface acres at a nominal lake surface elevation (LSE) of 1,240 ft above mean sea level [msl]) that, including the channelized part of the lake linking it to the San Jacinto River, possesses a simple geometry (13.5 mile of shoreline, shoreline development number, D_L of 3.5). The relationship between depth and lake surface area is provided in **Figure 5-2**, where,

- *Current Condition (with LEMP): Volume = (41.01)*(LSE²) – (98,598.10)*(LSE) + 59,257,644.98*
- *Reference Condition (without LEMP): Current Volume + Incremental Volume when LSE > 1,240 ft = (54.94)*(LSE²) – (135,812.9)*(LSE) + 83,935,495.18*

As shown in lake monitoring reports (and summarized in Section 2.2.2.5),[1] measurements of temperature, DO, and TDS generally demonstrate limited lateral variation but stronger variation in the vertical direction. Satellite imagery sometimes demonstrates lateral gradients in chlorophyll-*a* concentrations that result from development and wind movement of algal blooms;

[1] http://www.sawpa.org/collaboration/projects/lake-elsinore-canyon-lake-tmdl-task-force/

but averaging over several days typically damps out short-term variability in chlorophyll-*a* concentrations. Apart from relatively rare large runoff events, pronounced lateral gradients in nutrients, TDS and other water quality properties are generally absent.

While strong lateral gradients are generally not persistent in Lake Elsinore, it is subject to extreme fluctuations in lake level and water quality over annual, decadal, and multidecadal scales (see Section 2.2.2.2 for history of lakebed desiccation). Thus, a long-term simulation that reflects several decades of hydrologic and meteorologic variability is essential in representing the dynamics of lake water quality. Because of the lake's limited horizontal gradients, significant vertical gradients, and extreme response to decade-scale forcings, the 1-D DYRESM Model v.4 for Lake Elsinore was adopted. DYRESM uses a Lagrangian approach in which the thickness of the vertical layer is calculated dynamically based upon heat inputs/losses at each time step, buoyancy/density differences between layers and available mixing energy that allows segregation or combination of adjacent layers.

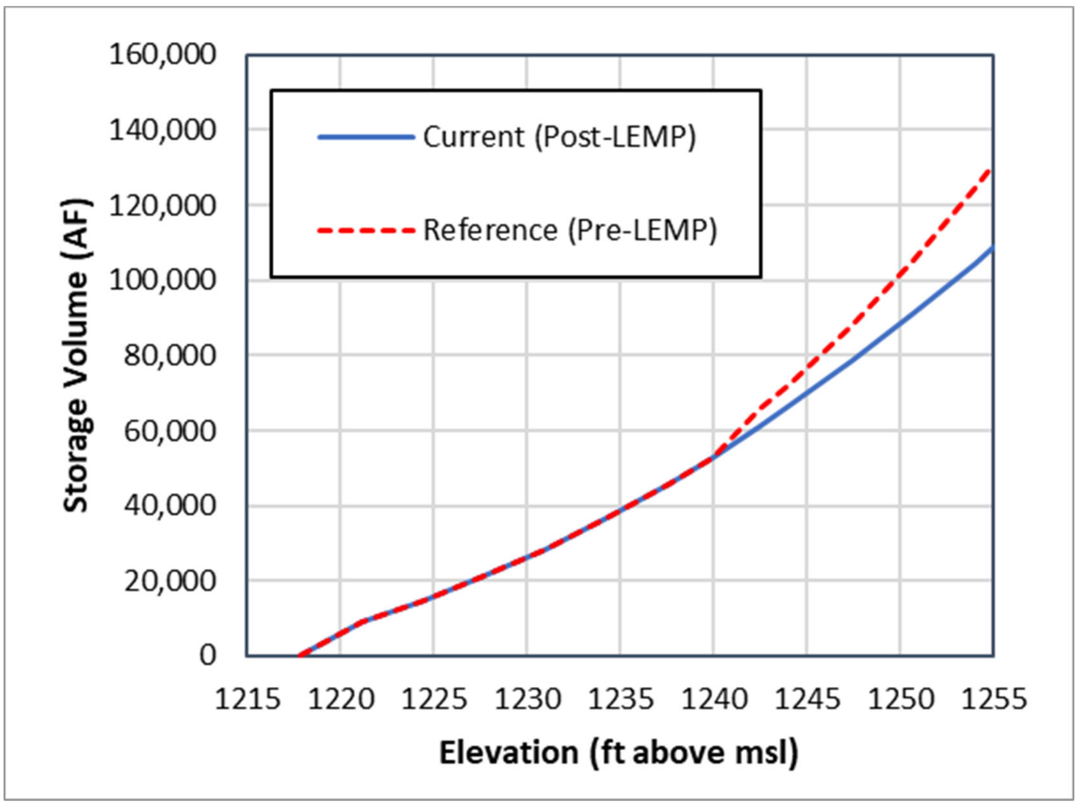

Figure 5-2. Lake Elsinore Elevation-Storage Volume Relationship for the Current Condition and Reference Condition

5.2.1.2 Canyon Lake

The 3-D ELCOM Model v.3 was adopted for use in Canyon Lake because of its more complex, sinuous morphology (D_L=13.5). Strong gradients in properties exist in both vertical and lateral dimensions necessitating a 3-D model for the lake. A 20-m x 20-m lateral grid with 0.3-m vertical layers was developed for the model yielding 247 x 203 horizontal grid with 4,712 horizontal "wet" cells and 92,721 total cells in the simulation domain. To optimize hydraulic continuity and model processing time, a 40-second timestep was used for the simulations. Limitations on availability of USGS streamflow gage data above Canyon Lake and the intensive computational demand of a 3-D hydrodynamic/water quality model restricted the simulations to a 5-year time period. The period from 2007-2011 was selected based upon the wide range of hydrologic conditions and relatively complete water quality dataset over this period.

Canyon Lake is a smaller reservoir (436 acres, 19.7 mile shoreline) with a much more complex, sinuous morphology (D_L=13.5) reflecting impoundment of the San Jacinto River (to the north) near its confluence with Salt Creek (to the east). Lake bathymetry and geometry suggest that strong gradients in properties may exist in both vertical and lateral dimensions, necessitating a 3-D model for the lake (**Figure 5-3**). Thus, the 3-D ELCOM Model v.3 was adopted for use.

The TMDL revision includes separate allocations for Canyon Lake Main Lake and Canyon Lake East Bay. These lake segments have very different tributary drainage areas with San Jacinto River flowing to Main Lake and Salt Creek flowing to East Bay. There is minimal exchange between these two segments of Canyon Lake during dry weather conditions. They also have very different bathymetric characteristics as illustrated in the relationship between depth and lake surface area provided in Figure 5-3.

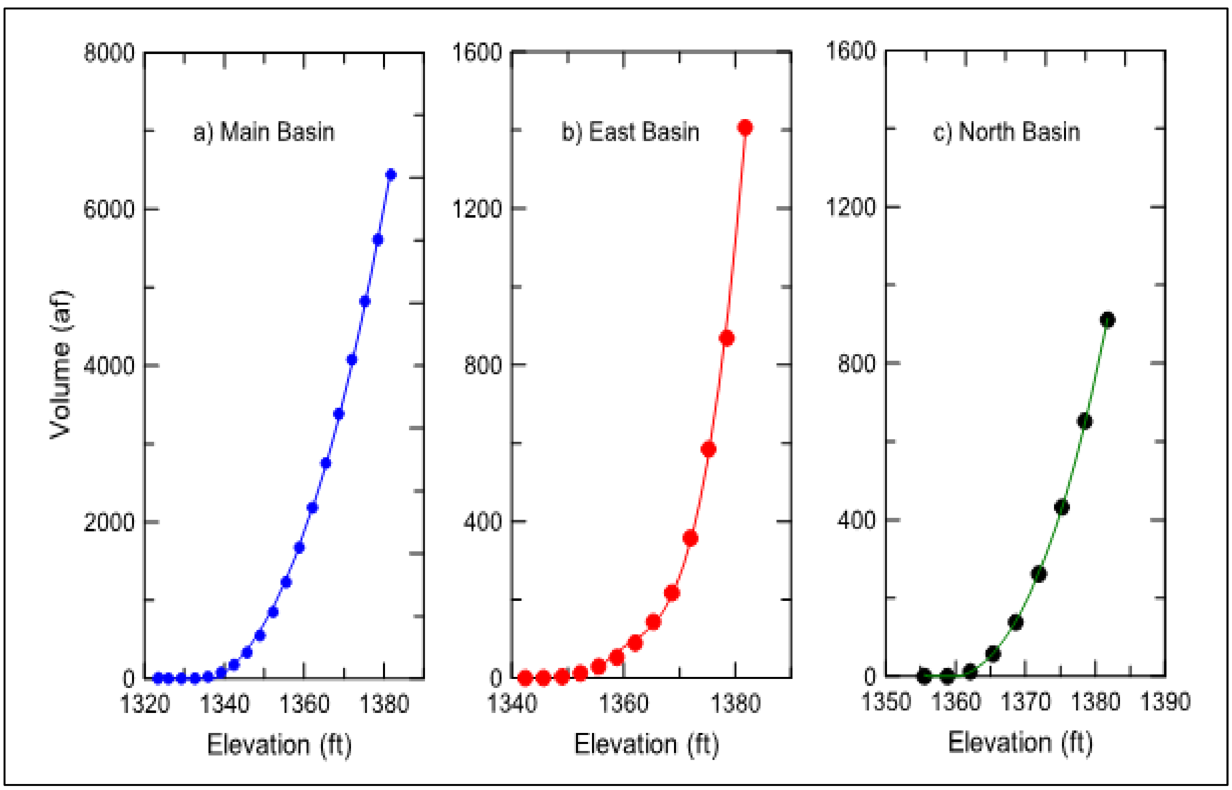

Figure 5-3. Canyon Lake Elevation-Volume Relationship for (a) Main Basin (Main Lake), (b) East Basin (East Bay), and (c) North Basin (North Ski Area)

5.2.2 Water Quality Model Characteristics

Water quality modeling can take many forms, from simple passive scalar transport to eutrophication models involving interactive kinetics and algal growth. A linked biogeochemical-ecological model can include a large number of interacting state variables, as described in Hipsey et al. (2006).

For a linkage analysis to support the development of numeric targets and estimation of nutrient reduction offset credits in Lake Elsinore and Canyon Lake, a eutrophication model is needed to simulate the relationships between nutrients, algae and DO. Nutrient fluxes into the water column from lake bottom sediments in both Lake Elsinore and Canyon Lake have been shown as an important source for water column concentrations (See Section 4.3 for discussion of Internal Sources). It is also critical that sediment fluxes be represented in the water quality model selected.

CAEDYM includes full eutrophication kinetics and can adequately represent water column water quality dynamics in both lakes. Water quality in Lake Elsinore and Canyon Lake was simulated using CAEDYM v.3. This model can be linked to both DYRESM and ELCOM, allowing for a consistent water quality solution between Lake Elsinore and Canyon Lake, while the hydrodynamics are tailored to the specific systems being modeled.

5.3 Lake Elsinore Model Configuration, Calibration and Scenario Simulations

The following subsections describe the meteorological, hydrologic, and water quality input data used to parameterize the DYRESM-CAEDYM model for Lake Elsinore. These subsections also (a) summarize the results after calibration of parameters to yield model simulation results for current conditions that approximate observations; and (b) describe how current condition (2000-2015) simulations used in calibration were modified to represent a reference condition for numeric target setting that account for long-term (1916-2016) lake water quality dynamics.

5.3.1 Meteorological Input Data

Meteorological inputs include the shortwave solar heat flux (300-3,000 nanometers [nm]) that includes photosynthetically available radiation (Photosynthetically Active Radiation [PAR], 400-700 nm), as well as near-ultraviolet (UV) (300-400 nm) and near-infrared (IR) and IR (700-3,000 nm), air temperature and windspeed.

Meteorological conditions for the calibration period were taken from the California Irrigation Management Information System (CIMIS) station #44 at UCR (**Figure 5-4**), which provided shortwave solar heat flux (300-3,000 nm) (Figure 5-4a), air temperature (Figure 5-4b) and windspeed (Figure 5-4c). Values are represented as daily average values in the model. A strong seasonal trend in solar shortwave heat flux is evident in the figure, with daily average shortwave flux values of about 350 watts/square meter (W/m^2) in the summer and 50-100 W/m^2 during the winter (Figure 5-4a). Daily average air temperatures exhibit a similar seasonal pattern, with daily-averaged summer temperatures near 30°C and daily average winter temperatures generally 7-10°C (Figure 5-4b). Daily average windspeeds averaged near 2 meters/second (m/s) and exhibited some seasonality as did daily rainfall rates that also showed annual variability (Figure 5-4c, d).

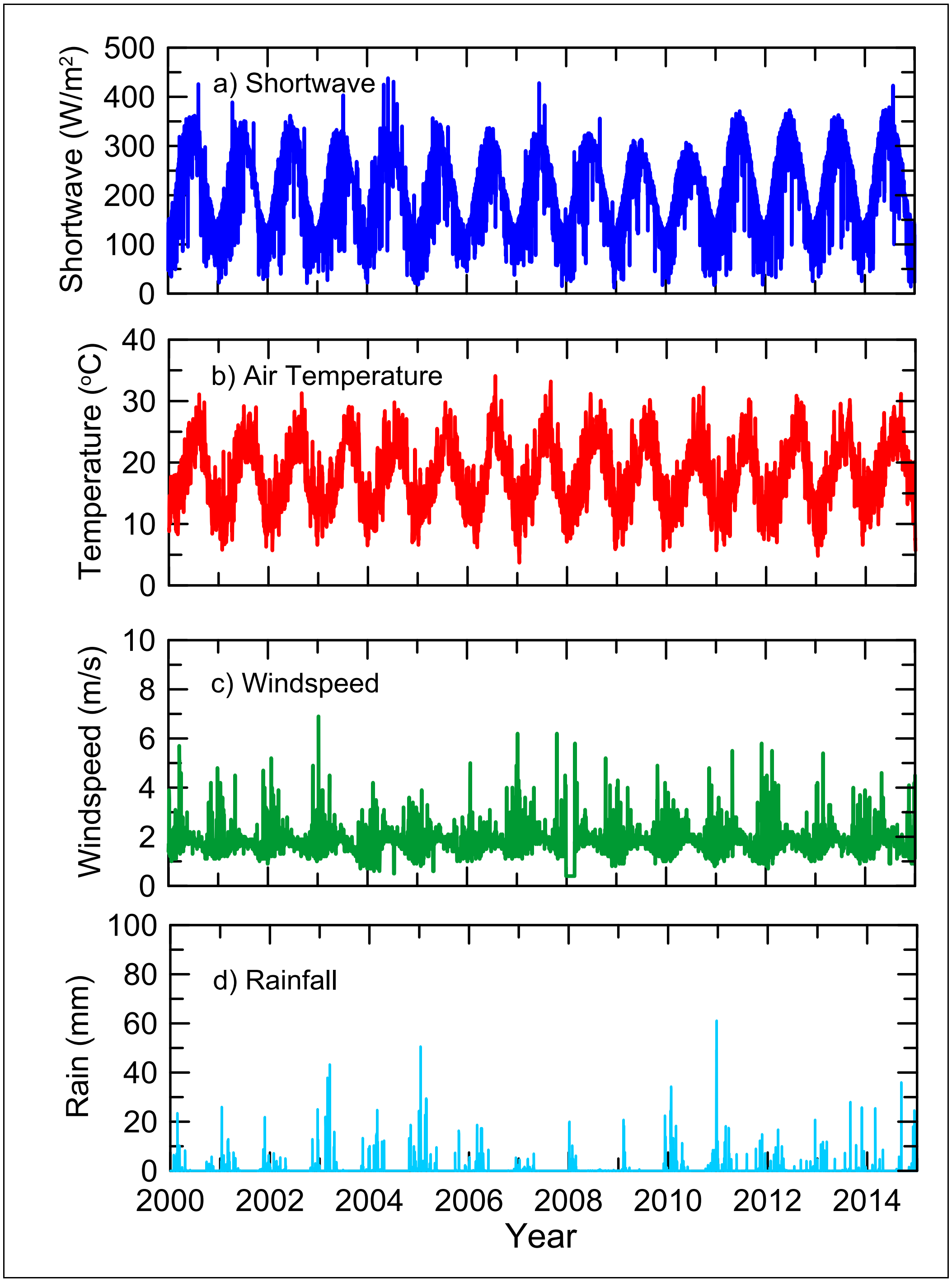

Figure 5-4. Daily Average (a) Shortwave Radiation, (b) Air Temperature, (c) Windspeed and (d) Rainfall Used in Model Simulations for the Calibration Period 2000-2014

5.3.2 Hydrologic Input Data

In addition to direct precipitation on the lake surface, water delivered to the lake included San Jacinto River flows, runoff from the local watershed, and supplemental water that includes reclaimed water from EVMWD and water pumped from island wells in 2003-2004 (collectively represented as recycled water in the model). Lake outflows include a lake outlet channel to downstream Temescal Creek.

The San Jacinto River is the primary watershed runoff inflow to Lake Elsinore and includes all overflow volume from Canyon Lake. Continuous flow data recorded at USGS Station 11070500 are input to the lake model. Daily runoff from the local watershed has been estimated in previous studies (Anderson 2012b), and yields are comparable to long-term average annual volume inflows (see Section 4, e.g., Table 4-4). Reclaimed water discharge to Lake Elsinore has been documented by EVMWD since production went on-line. All modeled inflows are shown in **Figure 5-5**.

A limited number of large runoff events delivered most of the flows from the San Jacinto River during this period, including the very large runoff events at the beginning of 2005, that included daily flow exceeding 8,000 acre-feet. Shorter duration high flow runoff events were also present in January 2010 and December 2011. Precipitation generated runoff from the local watershed contributed as well, although daily flows were much smaller than the very large runoff events noted in 2005, 2010 and 2011. Daily rates of recycled water flow are much lower than periods with wet weather runoff from the watershed. Presented as cumulative flows however, we see that reclaimed water inputs exceeded that of local runoff and contributed about 50,000 AF since inputs began in late 2002 (**Figure 5-6**). Based upon these values, a total of 187,926 AF of water was delivered to Lake Elsinore over this 2000-2014 period, with approximately 53% derived from San Jacinto River flows, 20% from local runoff and 27% from reclaimed water.

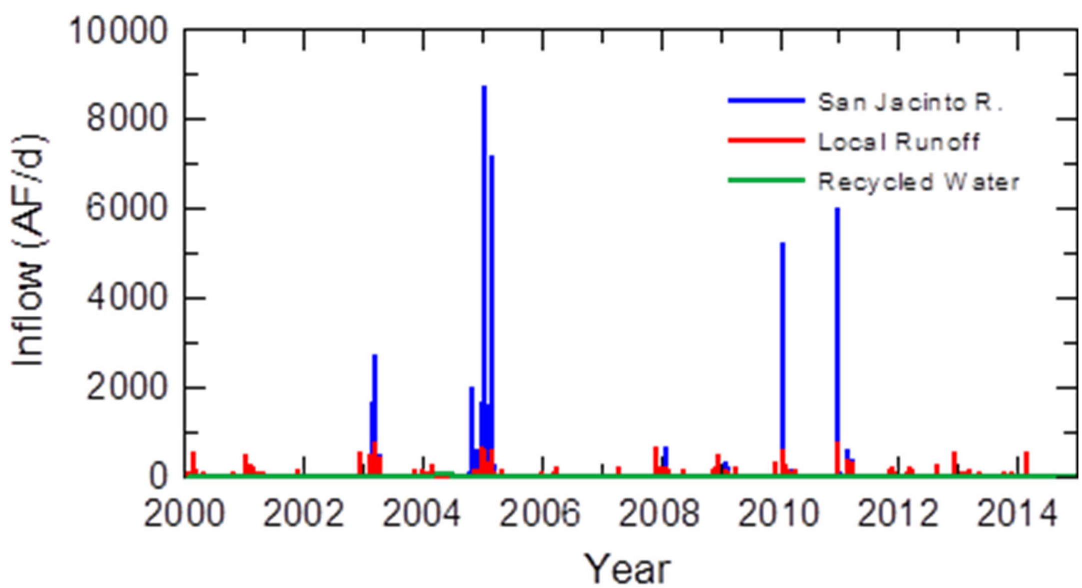

Figure 5-5. Inflows to Lake Elsinore for the Calibration Period 2000-2014

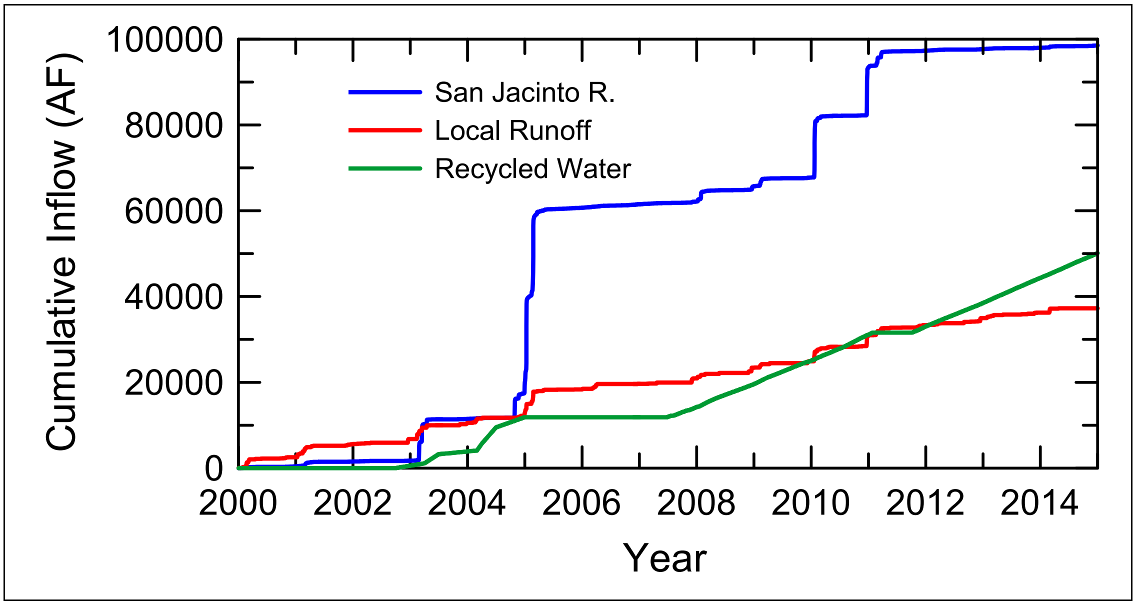

Figure 5-6. Cumulative Inflow to Lake Elsinore from the San Jacinto River, Local Runoff and Recycled Water (Reclaimed Water) for the Calibration Period 2000-2014

5.3.3 Nutrient Water Quality

Concentrations of nutrients in these inflows vary depending upon several factors, including intensity and duration of storms, interval of time between storms and other factors (including treatment plant operation for reclaimed water inputs). Average concentration values derived from storm runoff sampling within the watershed and treatment plant data were used in model simulations (**Table 5-1**). Total external nutrient loading over the calibration period was calculated from flow data (Figure 5-5) and nutrient concentrations (Table 5-1).

Table 5-1. Nutrient Concentrations (mg/L) of Inflows to Lake Elsinore Used in Model Simulations

Source	PO_4-P	Total P	NH_4-N	NO_3-N	Total N
San Jacinto River	0.28	0.51	0.22	0.57	1.89
Local Runoff	0.20	0.48	0.22	0.80	1.82
Recycled Water[1]	0.32	0.41	0.36	1.62	2.87

[1] Recycled water concentrations for EVMWD 2007-present

For internal water quality processes, default water quality parameters were used in CAEDYM (Hipsey et al. 2006) except for key parameters for bioavailable nutrient (soluble reactive phosphorus [SRP] and NH_4) fluxes and sediment oxygen demand (SOD), as follows:

- Internal loading of nutrients, i.e., the bioavailable nutrient flux from lake bottom sediment, is recognized as a very important process in Lake Elsinore, accounting for approximately 85 percent of long-term nutrient load (see Section 4). Measurements of internal loading have been conducted periodically at the lake using the core-flux method (Anderson 2001, 2010). Internal loading rates exhibit significant spatial and temporal variation based on core-flux estimates, largely driven by the non-uniformity of large rainfall events and settling of particulates to the lake bottom. For the TMDL revision, the average flux rates from previously collected core samples (73 milligrams/square meter/day [mg/m^2/d] NH_4-N and 7.1 mg/m^2/d SRP were assumed to approximate long-term average internal loading (see Section 4.3.1). The long-term average sediment nutrient flux rate is a constant input to CAEDYM for simulated nutrients for standard conditions. CAEDYM estimates a daily flux of dissolved nutrients as a function of dynamic changes in water temperature, DO, and pH.

- SOD is also high for this eutrophic lake (Anderson 2010); an average value of 0.8 (g/m^2/d) was used in the model calibration. To accommodate time constraints on modeling efforts, a static internal loading model was used in these simulations that allows internal loading rates to vary with temperature and DO but does not explicitly simulate sediment deposition and associated biogeochemical changes resulting in nutrient recycling and efflux from sediments.

5.3.4 Model Calibration

The Lake Elsinore coupled DYRESM-CAEDYM model was calibrated against available data for 2000-2014. Model calibration was focused on assessing model-data agreement on an annual to decadal scale. For this reason, daily or short-term fluctuations in hydrodynamic and water quality parameters are not the focus of this calibration effort. The adequate representation of long-term trends in this hydrologically and biogeochemically extremely variable water body is thought to be sufficient for the purposes of TMDL development for the lake.

5.3.4.1 Lake Surface Elevation

Figure 5-7 contains a time series comparison between measured and modeled lake surface elevations during the calibration time period. Observations indicate a marked decline in elevation over the years 2000 through 2003, 2005 through 2010, and 2011 through 2014. A dramatic increase in elevation occurs at the end of 2004 and in early 2005 resulting from near-record rainfall and runoff during this time (Figure 5.5). Modeled water surface elevations reflect all of these observed trends and also match closely in magnitude. Absolute model results generally match observations within approximately six inches over this extreme range for the majority of the simulation.

5.3.4.2 Salinity

Salinity in the lake varied from approximately 700 – 2,600 mg/L TDS, with low concentrations following the very large runoff in winter 2005 (**Figure 5-8**, solid circles). The model captured trends in TDS reasonably well, including the high TDS concentrations measured in late fall 2002 and the marked decline in TDS in 2005 (Figure 5-8, line). The only discrepancy was found in 2014, when the model over-predicted TDS in the lake.

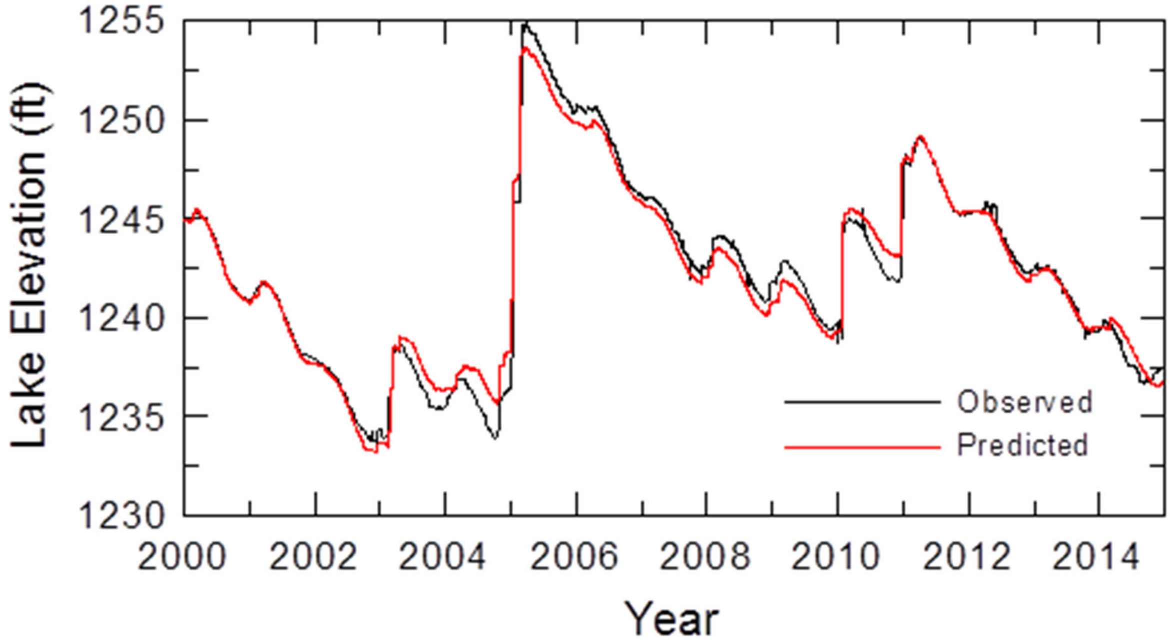

Figure 5-7. Predicted and Observed Lake Surface Elevation for Lake Elsinore for the Calibration Period 2000-2014

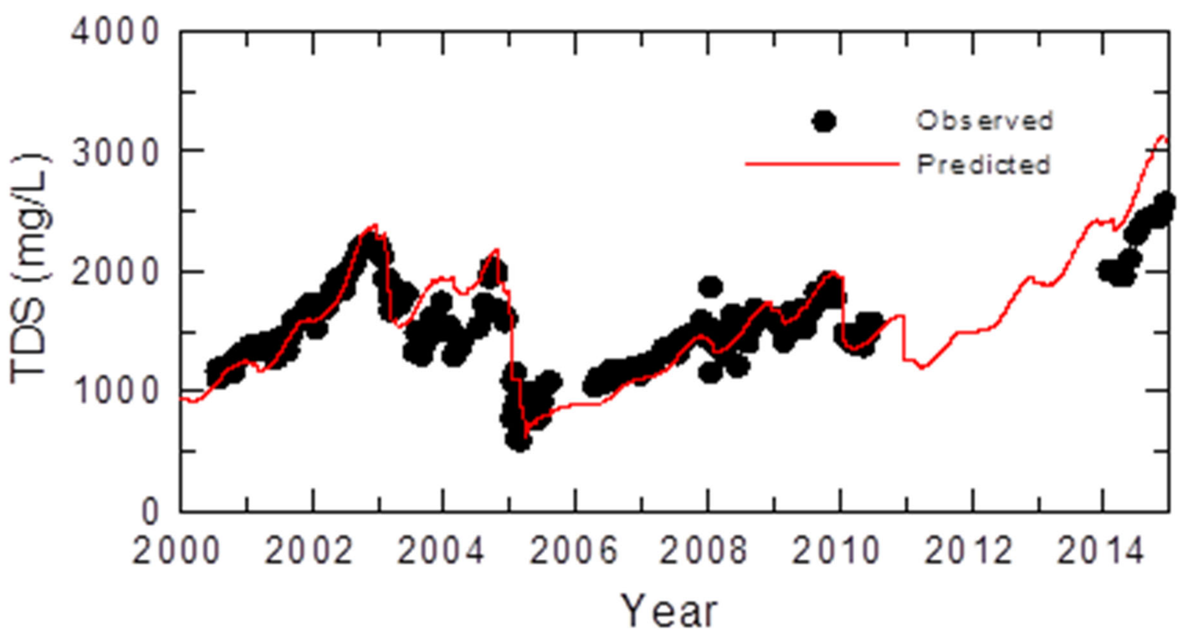

Figure 5-8. Predicted and Observed TDS Concentrations for Lake Elsinore the Calibration Period 2000-2014

5.3.4.3 Temperature

The model reasonably captured measured temperature values in Lake Elsinore (**Figure 5-9**). The model correctly predicted strong seasonal trends in water column temperature that reflects seasonal trends in solar shortwave heat flux (see Figure 5-4a) and air temperature (see Figure 5-4b). The model predicted summer values near 27°C and winter minimum values near 10°C, with little difference between depths reflecting weak stratification or mixed conditions commonly present in the lake (Figure 5-9).

5.3.4.4 Dissolved Oxygen

DO in the lake varied seasonally and with depth (**Figure 5-10**). The temperature effect on oxygen solubility was evident in model predictions for the 2-m depth, with DO values generally near 10 mg/L in the winter and 7-8 mg/L in the summer (Figure 5-10a). At the same time, supersaturation was periodically predicted (e.g., in spring 2011 when concentrations reached 17 mg/L). The model predicted DO concentrations deeper in the water column to be often quite similar to near-surface values and also correctly predicted periods of anoxia in the summer of 2003, 2004, 2006 and 2010 (Figure 5-10b).

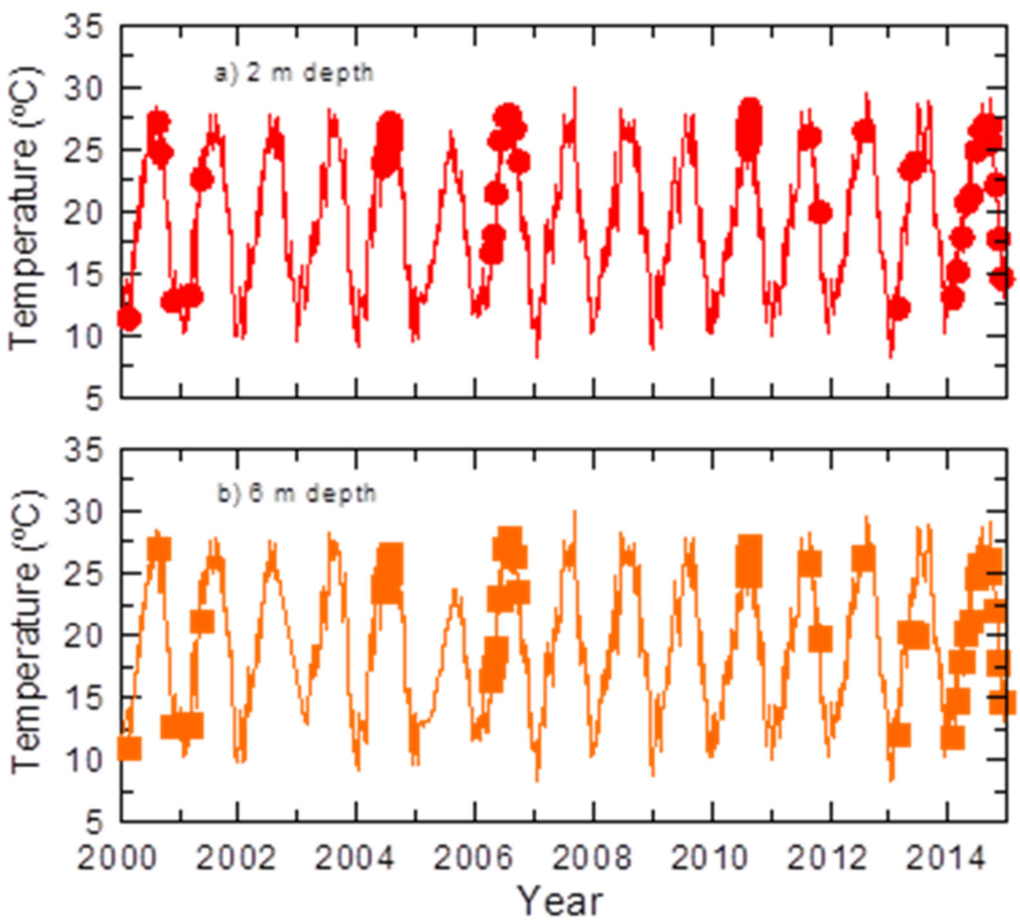

Figure 5-9. Predicted (line) and Observed (● or ■) Temperature at (a) 2-m and (b) 6-m Depths for Lake Elsinore for the Calibration Period 2000-2014

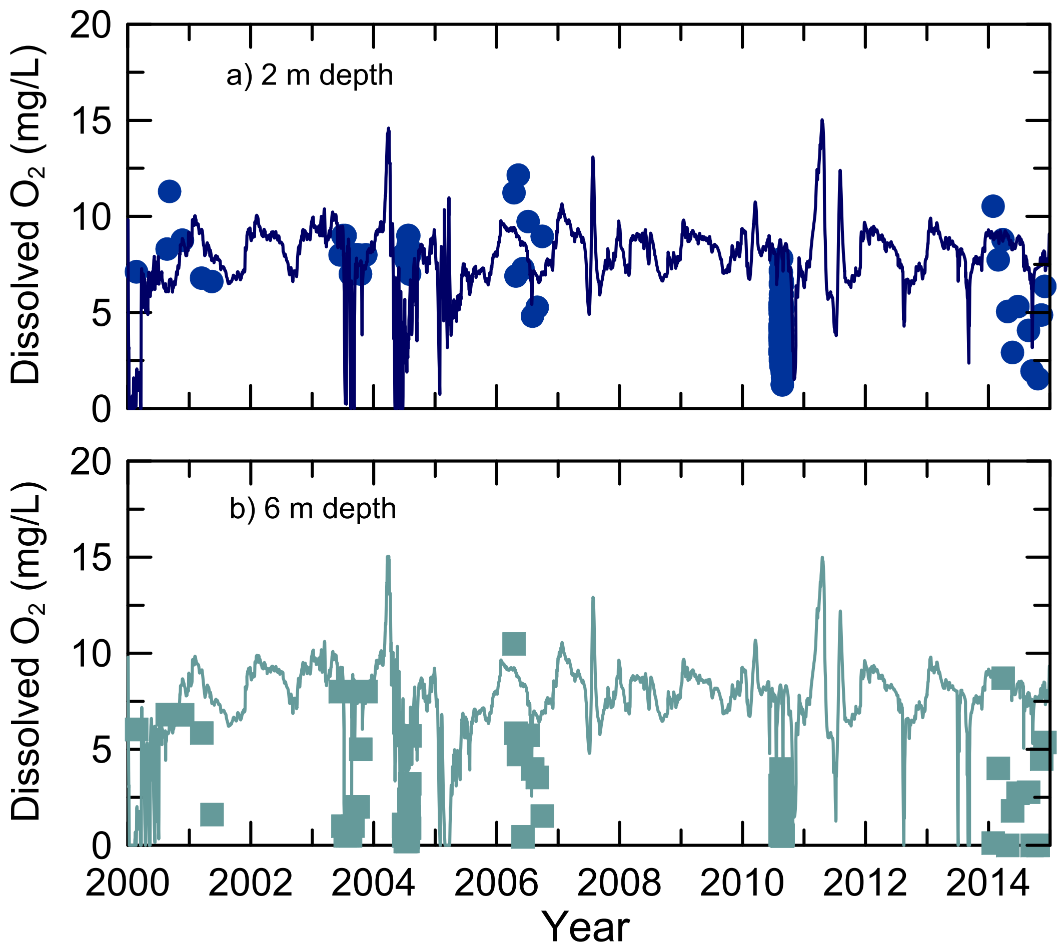

Figure 5-10. Predicted (line) and Observed (● or ■) Dissolved Oxygen Concentrations at (a) 2-m and (b) 6-m Depths for Lake Elsinore for the Calibration Period 2000-2014

5.3.4.5 Total Nitrogen

The model did a fair job of capturing the dramatic trends in concentrations of TN in the lake between 2000 and 2015 (**Figure 5-11**). Concentrations increased from about 2 mg/L in 2000 to greater than 8 mg/L by late 2004, and then declined sharply with the very large runoff volumes delivered in winter of 2005 that quadrupled the volume of the lake. TN concentrations then edged up over several years before declining slightly in 2010 (Figure 5-11). While the model captured trends reasonably well, it did not reproduce the more significant apparent swings observed, e.g., in 2008, when reported concentrations over the period of a few months ranged from < 1 to > 8 mg/L. It may be that sampling bias or analytical challenges crept into the time series data, exaggerating short-term trends.

5.3.4.6 Total Phosphorus

Total P concentrations also varied quite dramatically over this calibration period, from about 0.1 mg/L in 2000 to > 0.6 mg/L in late 2004 before declining to a value near 0.2 mg/L (**Figure 5-12**). The model generally captured trends but under predicted concentrations somewhat in 2003-2004, although it did predict a maximum value of about 0.6 mg/L in late 2004 (Figure 5-12).

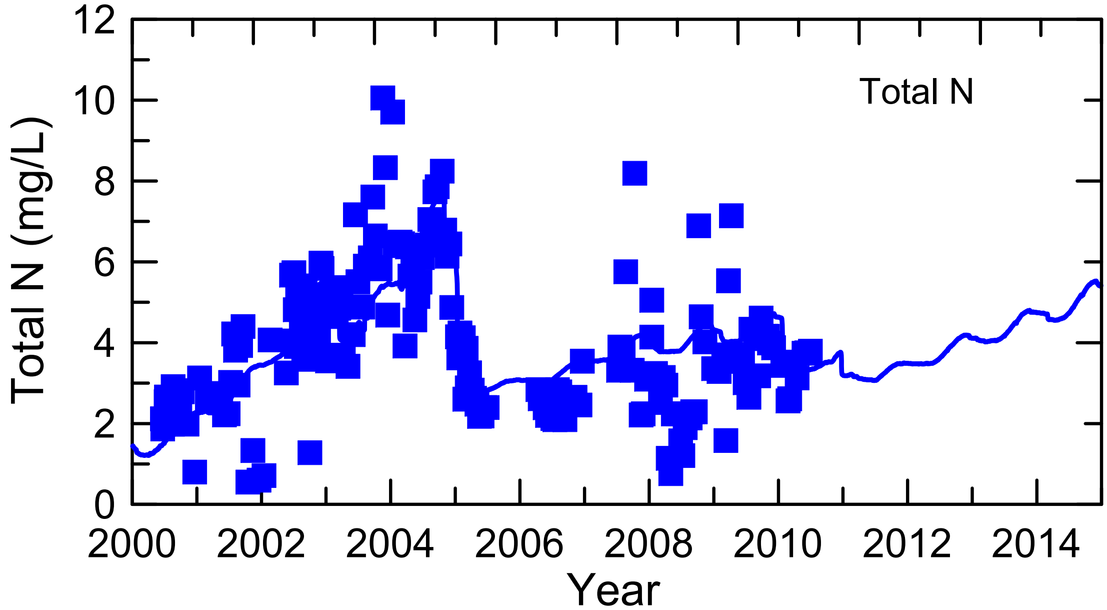

Figure 5-11. Predicted and Observed Total Nitrogen Concentrations for Lake Elsinore for the Calibration Period 2000-2014

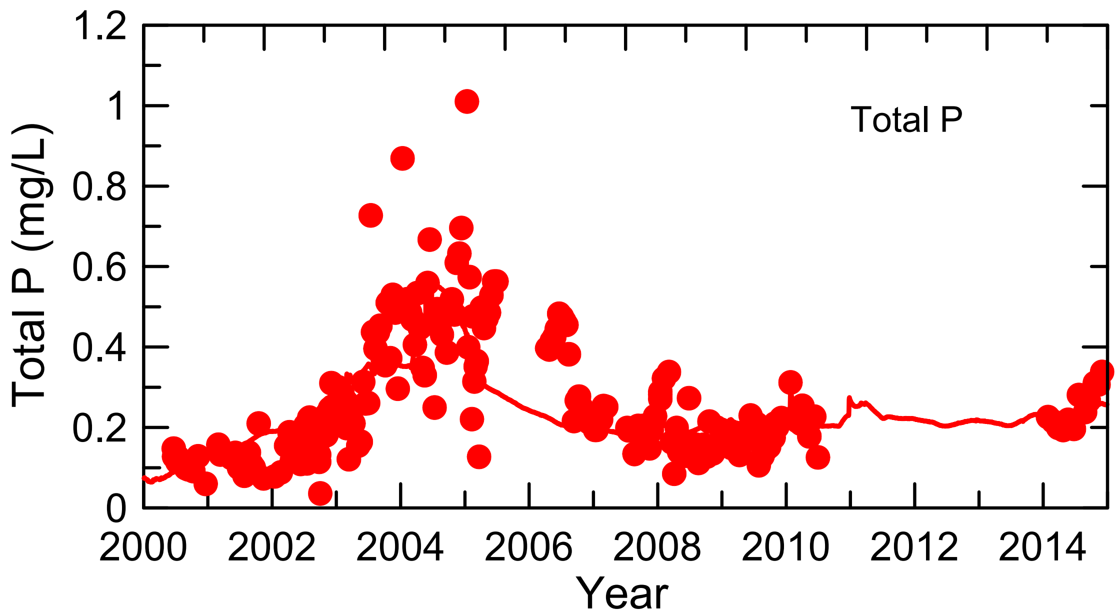

Figure 5-12. Predicted and Observed Total Phosphorus Concentrations for Lake Elsinore for the Calibration Period 2000-2014

5.3.4.7 Chlorophyll-*a*

Measured chlorophyll-*a* concentrations exhibited pronounced seasonal and inter-annual variability, ranging from < 10 µg/L in some winters to > 300 µg/L in 2002, 2004 and 2014 (**Figure 5-13**, solid symbols). The model did a fair job overall in reproducing these complex trends and correctly predicted summer maximum chlorophyll-*a* concentrations in 2000-2004 (Figure 5-13, line). The model did not do as well predicting the winter minimum values, e.g., it missed the particularly high concentrations observed in 2014 (Figure 5-13). Notwithstanding, the agreement between predicted and observed concentrations was considered acceptable given the highly dynamic algal community in the lake and the complex dependence of chlorophyll-*a* concentrations on nutrient availability and ecosystem structure.

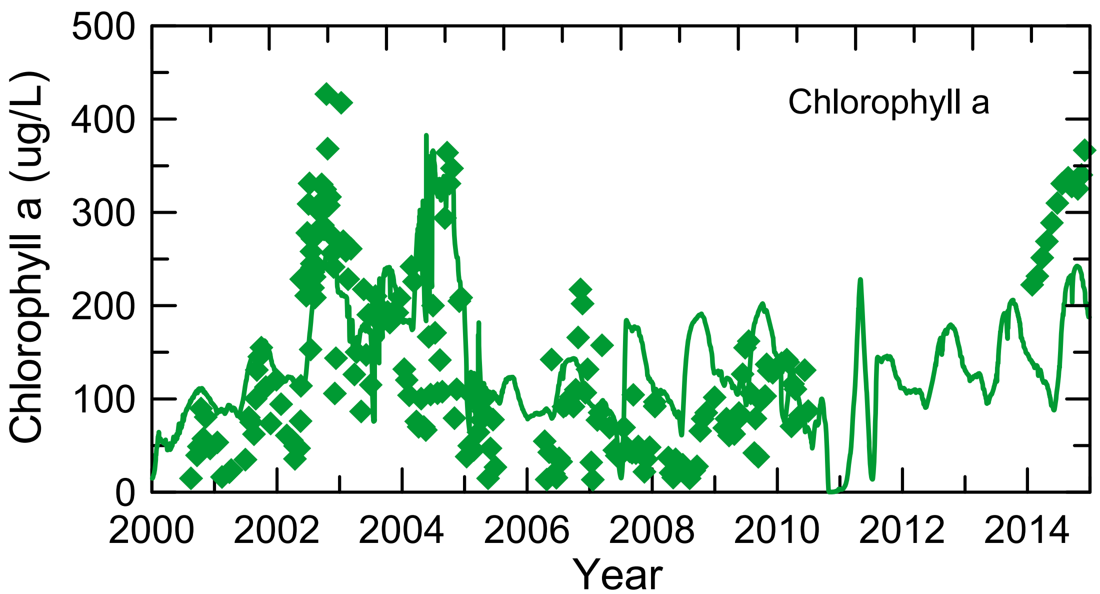

Figure 5-13. Predicted and Observed Chlorophyll-*a* Concentrations for Lake Elsinore for the Calibration Period 2000-2014

5.3.5 Water Quality Model Summary Statistics

The overall goodness-of-fit of the model results to measured values for water column parameters was assessed by comparing overall mean values for the calibration period and from the relative percent error (%RE) between predicted and observed values (**Table 5-2**). The model generally reproduced overall average values reasonably well, although the mean %RE aggregated over specific paired predicted and observed values exhibited greater variance. For example:

- The model reproduced the dramatic variation in lake level reasonably well (see Figure 5-7), yielded a predicted average lake level for this period (1,237.4 ft) in good agreement with the observed value (1,237.7 ft) and also resulted in a low average %RE (1.5%) over the dataset (N = 3020) (Table 5-2).

- Temperature and TDS were also well-represented by the model (see Figures 5-8, 5-9, and Table 5-2).

- The average concentrations of TN and TP over this time period were also well described by the model (< 5% difference), although the %RE averaged from individual paired (predicted-observed) samples varied more widely (23.4 – 29.8%, respectively).

Prediction of algal bloom dynamics in Lake Elsinore proved more challenging. While the average predicted chlorophyll-*a* concentration for the calibration period was within about 16% of the observed value, the %RE averaged over all paired samples (N = 219) was about three times greater. The model as developed, while reproducing trends and mean values with some success, is not capable of predicting algal bloom dynamics in the lake.

The model also had high errors associated with predicting DO concentration. This no doubt is partly due to the challenges predicting algal bloom dynamics in this extremely eutrophic lake but is thought to also arise from non-representative sampling across the calibration period, i.e., sampling intensity was often greatly increased during periods of low DO to quantify duration of hypoxia or anoxia and associated fish kills. More representative sampling across the calibration period is expected to yield improved agreement between predicted and observed DO concentrations.

In summary, given the extreme range in conditions experienced at the lake over this 2000-2014 period, the model is thought to have adequately reproduced water quality in Lake Elsinore under a wide range of hydrologic, chemical and ecological conditions, allowing for comparison of water quality under different conditions and scenarios.

Table 5-2. Mean Observed and Predicted Values and Model Percent Relative Error of Key Water Quality Parameters for Calibration Period (2000-2014) for Lake Elsinore

Variable	Observed	Predicted	% Relative Error
Lake elevation (ft)	1,237.7	1,237.4	1.5% (N = 3020)
Temperature (°C)	24.5	24.1	4.5% (N = 320)
TDS (mg/L)	1,762	1,731	10.4% (N = 229)
DO (mg/L)	8.0	5.1	53.9% (N = 305)
TN (mg/L)	3.98	4.16	23.4% (N = 195)
TP (mg/L)	0.264	0.260	29.8% (N = 226)
Chlorophyll-*a* (µg/L)	140	162	48.8% (N = 219)

5.3.6 Reference Condition Scenario Evaluation

The linkage analysis was used to evaluate the water quality conditions in Lake Elsinore for a scenario where external loads are reduced to levels representative of a reference watershed condition to develop numeric targets for response variables, ammonia-N, DO and chlorophyll-*a*. Section 3.2 describes the water quality input data and lakebed characteristics that define the reference condition for estimating numeric targets. This scenario was developed for a 99-year (1916-2015) simulation period coinciding with available daily flow data for the San Jacinto River near Elsinore USGS gauge 11070500. Watershed runoff from 90 percent of the Lake Elsinore watershed, including all Canyon Lake overflows, are recorded by this gauge. Rainfall records for

Lake Elsinore (RCFC&WCD Station# 067) also go back to 1916, facilitating estimation of daily runoff from the local Lake Elsinore watershed by applying a runoff coefficient model for this same period (Anderson 2016a). Reference watershed nutrient concentrations are assumed to occur in the total (USGS gauge + local runoff model) daily inflow volume to Lake Elsinore.

A 1-D model allows simulation of conditions in the lake over long time periods due to relatively modest computational demands. A minimum layer thickness of 0.25-m and maximum layer thickness of 1.0-m was used for these simulations, with a 2-hr timestep. As discussed in Section 2.2.2.3, the LEMP involved construction of a levee to separate the main lake from the back basin, reducing the lake surface area from about 6,000 to 3,000 acres, thereby reducing evaporative losses and internal loading, and in turn improving water quality. This project is not included in the reference condition for Lake Elsinore, and therefore the much larger natural lake basin is used for the reference condition simulation. The respective elevation volume relationship for the reference condition lake basin is included in the plot of current conditions in Figure 5-2 above. **Figure 5-14** shows the footprint of the lake without the levee.

Results of the reference condition model for Lake Elsinore are plotted as time series in **Figure 5-15** for lake level, TDS, TP, TN, ammonia-N, DO and chlorophyll-*a*. The results for water quality response variables ammonia-N, DO, and chlorophyll-*a* are plotted as CDFs and serve as the basis for numeric targets (see Figures 3-6 through 3-8). The plots clearly show the impact of multidecadal trends in lake level upon TDS and nutrients, and in turn, upon response variables chlorophyll-*a* and DO for a naturally occurring reference watershed condition. While seasonal variability can be detected in the response variables, it is much less significant than longer-term trends, with highly productive periods (as indicated by rising chlorophyll-*a* concentrations and greater diurnal fluctuations in DO) persisting for multiple years or decades.

5.4 Canyon Lake Model Configuration, Calibration and Scenario Simulations

The following subsections describe the meteorological, hydrologic, and water quality input data used to parameterize the ELCOM-CAEDYM model for Canyon Lake. In addition, these subsections summarize the results after calibration of parameters to yield model simulation results for current conditions that approximate observations. Limitations on availability of USGS streamflow gage data above Canyon Lake and the intensive computational demand of the ELCOM 3-D hydrodynamic model restricted the simulation to a 5-year time period for calibration. The 2007-2011 period was selected based upon the wide range of hydrologic conditions and relatively complete water quality dataset over this period of time. The sections below also describe an ELCOM-CAEDYM reference condition scenario for numeric target setting that accounts for a longer simulation period (2000-2016) for lake water quality dynamics.

5.4.1 Meteorological Input Data

The model requires sufficient meteorological data to calculate instantaneous heat budgets for the lake and mixing due to wind shear and convective processes. Hourly meteorological data from the CIMIS station located near UCR, with correction for elevation difference, was used to drive the hydrodynamic-thermodynamic model. A wind-sheltering factor of 0.4 was applied for East Bay to account for the effects of steep topography on wind speed there. The model also requires information for inflows and withdrawals to account for turbulent kinetic energy inputs to the water column via these mechanisms. Flow data for the calibration period were taken from the USGS gaging stations on the San Jacinto River at Goetz Road (USGS gage #11070365) and on Salt Creek (USGS gage #11070465). Water quality measurements for the (limited) flows entering the lake over this period were not available, so average values from previous sampling conducted on the San Jacinto River and Salt Creek were used as inputs (Dyal and Anderson 2003). Information on volumetric withdrawals from the lake over this period were provided by EVMWD (J. Ma, personal communication).

Figure 5-14. Comparison of Current Lake Elsinore Hydrography with Approximate Pre-LEMP Hydrography (shapefile from NHD)

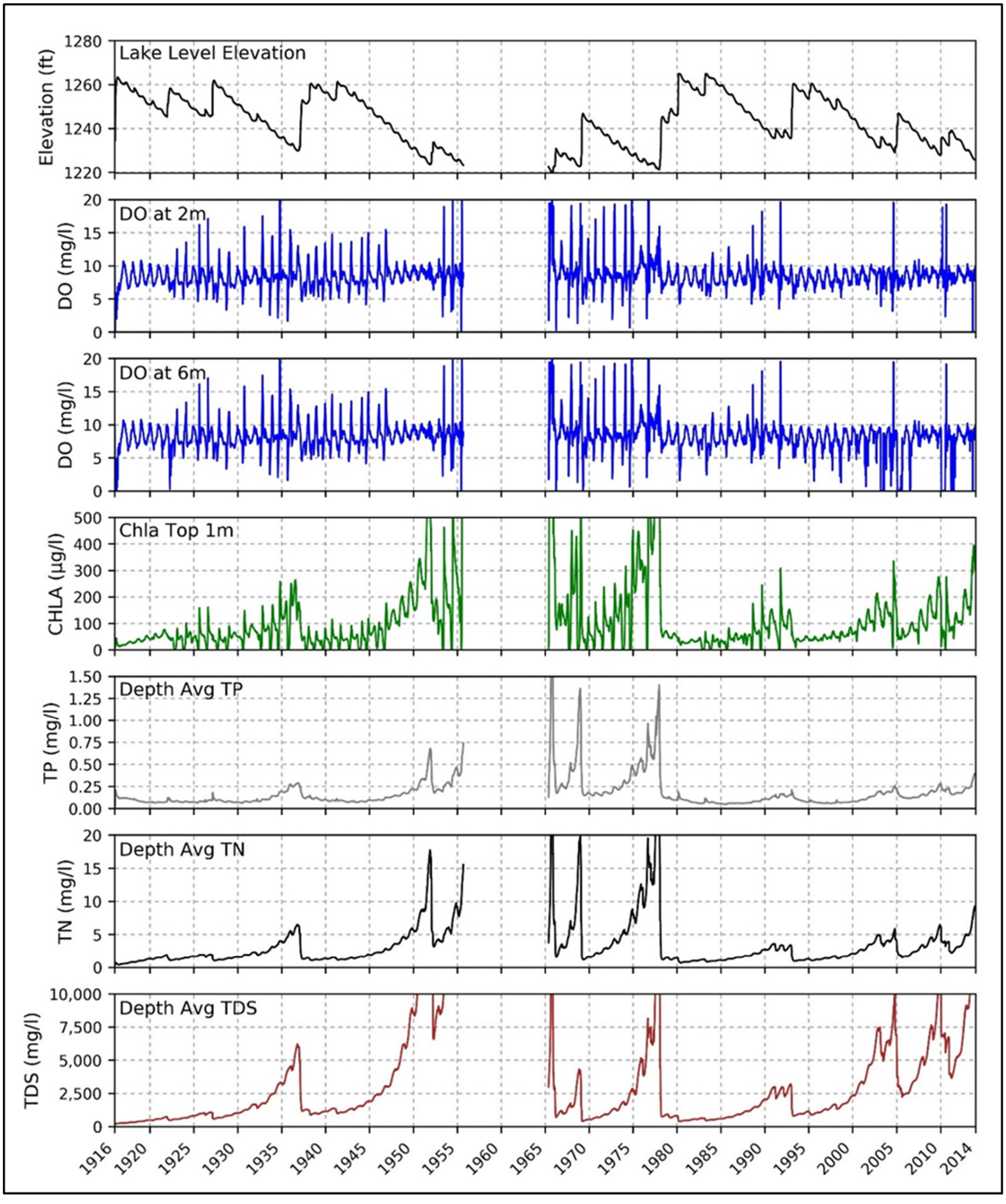

Figure 5-15. Time Series Output of Water Quality Parameters for Reference Condition Simulation for Lake Elsinore (1916-2015)

Daily average meteorological data were calculated from hourly data and presented in **Figure 5-16**. As previously seen for Lake Elsinore, clear seasonal trends are evident in critical meteorological parameters. Daily solar shortwave radiation was low during the winter, with cloud cover during winter storms lowering the daily average flux to < 50 W/m^2 on numerous occasions (Figure 5-16a). Daily shortwave flux reached maximum values of > 300 W/m^2 in the early summer months (Figure 5-16a), although we note that maximum daily air temperatures were reached later in the summer (Figure 5-16b). Daily average wind speeds, while variable, were generally stronger during the winter months (Figure 5-16c), which in many cases coincided with rainfall events (Figure 5-16d).

5.4.2 Hydrologic Input Data

The majority of inflows for the Canyon Lake hydrologic budget involves runoff from the San Jacinto River and Salt Creek (**Figure 5-17**). Inflow data for the calibration period are taken from two USGS gauges; the San Jacinto River at Goetz Rd (Sta#11070365) and Salt Creek at Murrieta Road (Sta#11070465). These gauges measure runoff from 90 percent of the Canyon Lake drainage area, thus a scaling factor of 1.1 was applied to account for flows from the local Canyon Lake watershed (from lakeshore and Meadowbrook and Quail Valley tributaries). Generally, no flow is present during dry weather conditions as measured by USGS gauges. Rainfall driven runoff occurs in the wet season, and volume is dominated by few extremely large events (e.g., with > 2,000 and > 3,000 acre-feet/day (af/d) flows in Salt Creek and San Jacinto River in late December 2010) (Figure 5-17). It was previously noted that these extreme events are responsible for much of the external nutrient loading in a year, with large runoff years in turn dominating loading from the watershed for several years or more (Anderson 2012c).

5.4.3 Nutrient Water Quality

Concentrations of nutrients in watershed runoff inflows vary depending upon a number of factors, including intensity and duration of storms, interval of time between storms and other factors (including retention in upstream lakes or channels). Average concentration values derived from runoff sampling within the watershed were used in model simulations (**Table 5-3**). Total external nutrient loading over the calibration period was calculated from flow data (see Figure 5-17) and nutrient concentrations (Table 5-3).

For internal water quality processes, default water quality parameters were used in CAEDYM (Hipsey et al. 2006) except for key parameters for bioavailable nutrient (SRP and NH_4) fluxes and SOD, as follows:

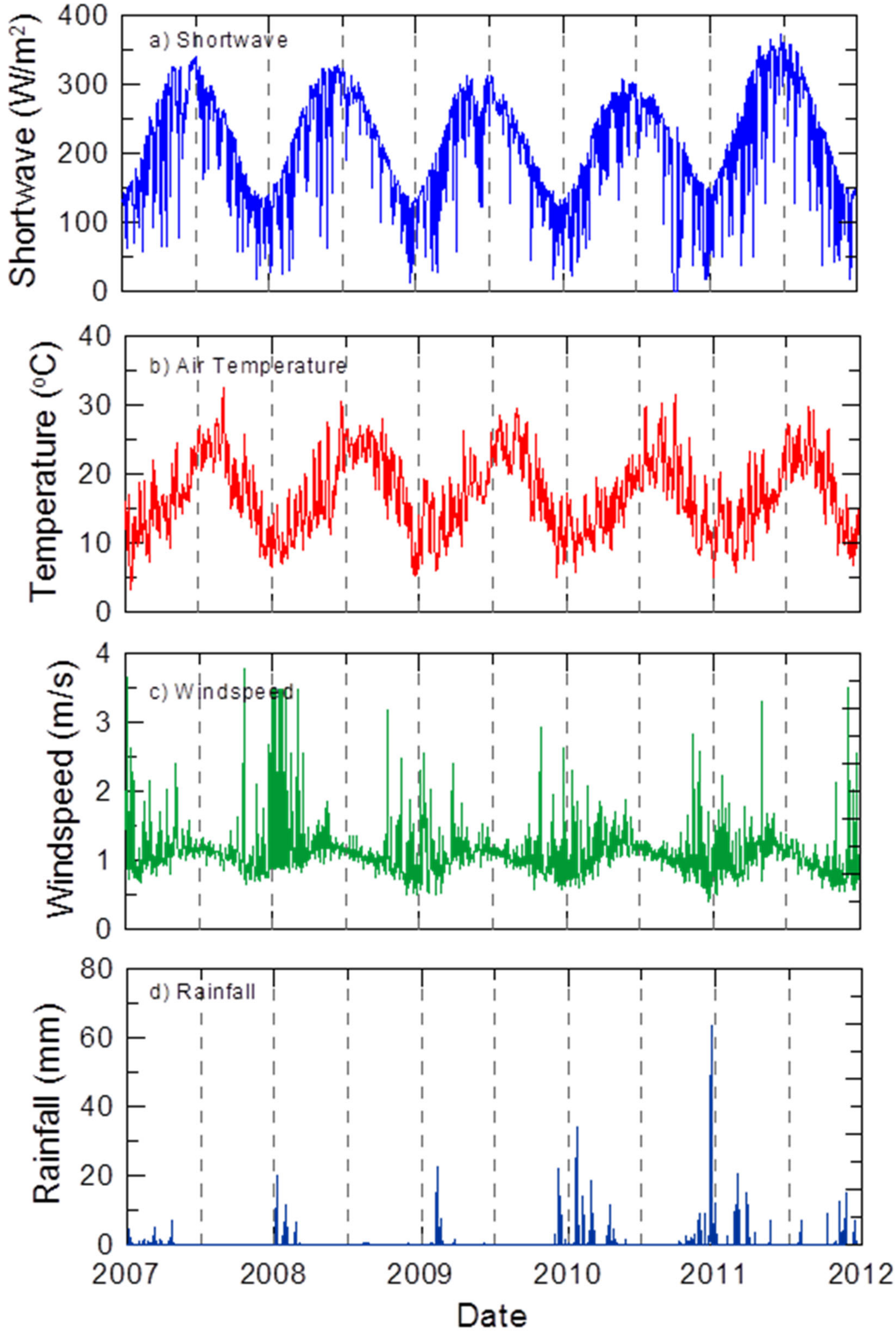

Figure 5-16. Daily Average (a) Shortwave Radiation, (b) Air Temperature, (c) Windspeed and (d) Rainfall Used in Model Simulations for Canyon Lake for the Calibration Period 2007-2011

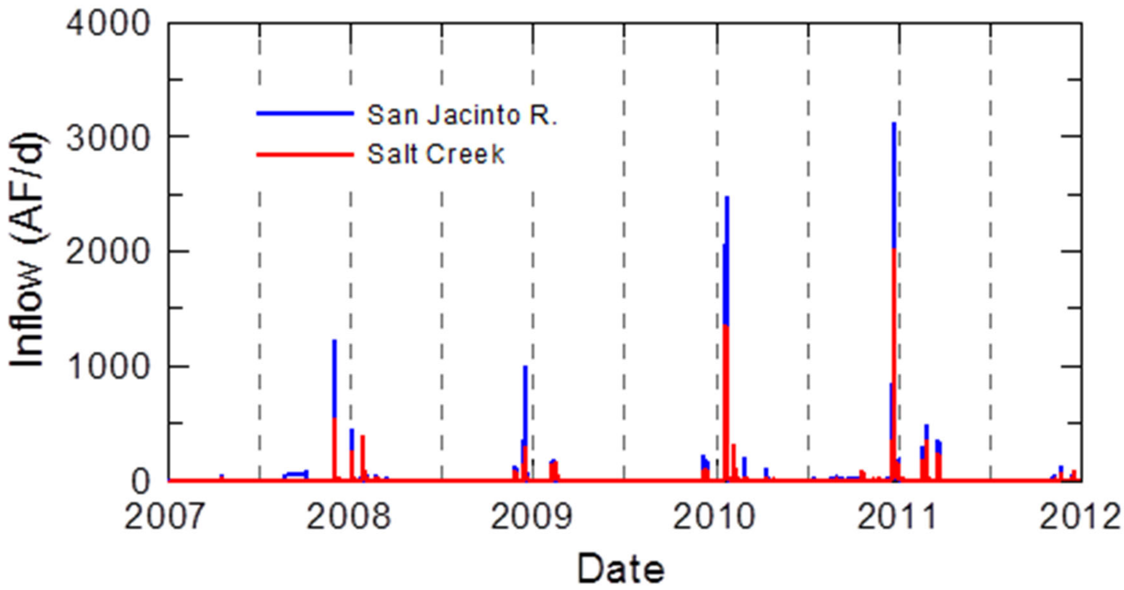

Figure 5-17. Daily Inflows to Canyon Lake for the Calibration Period 2007-2011

Table 5-3. Nutrient Concentrations (mg/L) of Inflows to Canyon Lake Used in Model Simulations

Source	PO_4-P	Total P	NH_4-N	NO_3-N	Total N
San Jacinto River	0.35	0.71	0.31	0.77	2.57
Salt Creek	0.27	0.54	0.29	0.75	2.49

- Rates of internal loading of nitrogen and phosphorus to the water column were separately measured in laboratory core-flux studies (Anderson 2001; Anderson 2007). Samples collected prior to the commencement of alum addition in 2013, had average sediment nutrient flux rates of 43.3 mg/m^2/d for NH_4-N for the 3 main basin sites, with similar average flux rates also found for the two East Bay sites (45.0 mg/m^2/d). Average SRP flux from the sediments was lower than that of N (15.3 and 16.0 mg/m^2/d for the Main Lake and East Bay sites, respectively).

- SOD was determined based on Anderson (2001) and Anderson (2007). Measurement conducted in July 2006 found SOD values of about 0.3 g/m^2/d, with very little difference between any of the sites (Anderson 2007). Additional measurements made in April 2007 found slightly higher short-term SOD values (0.36-0.38 g/m^2/d), although longer-term SOD values were somewhat lower (0.22-0.25 g/m^2/d). An average SOD value of 0.3 g/m^2/d was used for the model calibration.

As with DYRESM, the ELCOM and CAEDYM models require a very large number of parameters; default values were used for almost all thermodynamic and chemical/biological/ecological values.

5.4.4 Model Calibration

The model was calibrated against water column data collected at Canyon Lake from January 2007 – December 2011. Samples were collected at varying intervals but were generally collected monthly to bimonthly. Hydrolab casts were made at five sites on the lake, providing vertical profile measurements of temperature, DO, pH, electrical conductance, oxidation-reduction potential, and turbidity. Depth-integrated surface samples were analyzed for chlorophyll-*a*, total and dissolved nutrients, and other constituents. Discrete samples were also collected at the thermocline, and composited discrete samples from two to three depths within the hypolimnion were also collected (except during the winter when the water column was well-mixed vertically and only a single depth-integrated sample was collected from each site). Section 2.2.3.3 summarizes monitoring program results from Canyon Lake; key data from this program were used for calibration in this section.

A large number of model simulations were conducted for the period January 1, 2007 – December 31, 2011; default model parameters were used in initial simulations and compared visually with observed data. Model parameters were varied to improve goodness-of-fit between observed and predicted values.

5.4.4.1 Lake Surface Elevation

The reported lake surface elevations (symbols) were reasonably well-reproduced in the simulation (solid red line). The model captured the evaporation and drawdown of about six feet that occurred each summer as well as the generally very rapid increase in lake surface elevation each winter to the spillway elevation (**Figure 5-18**).

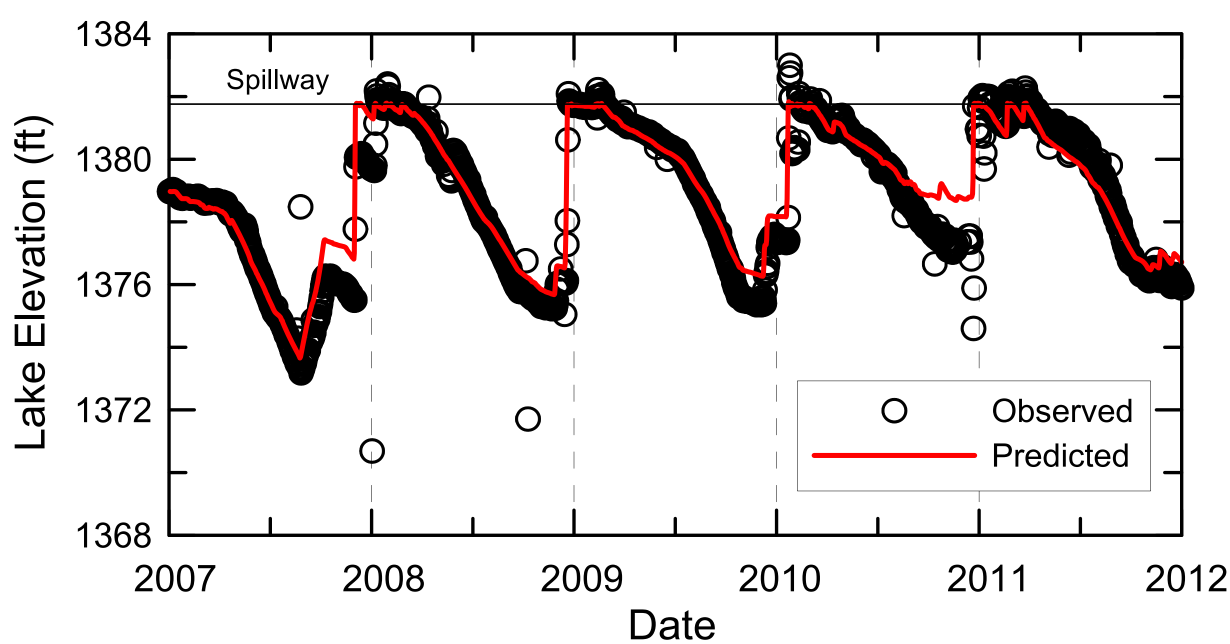

Figure 5-18. Lake Surface Elevation for Canyon Lake the Calibration Period 2007-2011

Excluding some isolated outliers in the reported lake surface elevations, the only significant difference between observed and predicted values was found in late 2010, when the model predicted surface elevations near 1,379 ft., while reported values were closer to 1,377 ft. (Figure 5-18). The source of this discrepancy is not clear. Notwithstanding this anomaly, the model reproduced well the average elevation over this period (1,378.71 vs. 1,378.79 ft, respectively), with %RE of 0.03%.

5.4.4.2 Temperature

As previously noted, temperature is an important property in lakes, regulating stratification and governing rates of chemical and biological reactions. Observed temperature values at depths of 2-m (solid blue circles) and 12-m (open orange circles) for site Main Lake site M1 (and other sites) were reasonably reproduced in the simulation (**Figure 5-19**). The model captured the rapid increase in near-surface (2-m) temperature from about 10-12°C in the winter to nearly 30°C in the summer, as well as the rapid decline in the fall (Figure 5-19) due to reduced solar shortwave radiation inputs and lower air temperatures (Figure 5-16 above). The %RE between predicted and observed temperatures for 2-m depth in the lake was 4.0% (N = 80) with the mean predicted temperature of 21.3°C in good agreement with the observed mean value (21.5°C). The model (orange line) also reasonably reproduced temperatures at 12-m depth (orange symbols) that increased slowly during much of the year before increasing more dramatically in the fall during lake turnover (Figure 5-19). The model predicted a somewhat later turnover date in the fall of 2008 and 2010 compared with available temperature data, but reproduced turnover well in fall 2007 and 2009. The model discrepancy in fall 2010 was carried over somewhat in 2011, with the model predicting somewhat cooler conditions in the hypolimnion in the spring-summer of 2011 than observed. As a result, the %RE in temperature at 12-m depth was slightly higher (%RE of 8.7%), with the mean predicted value (12.6°) slightly lower than the mean observed value (13.3°C).

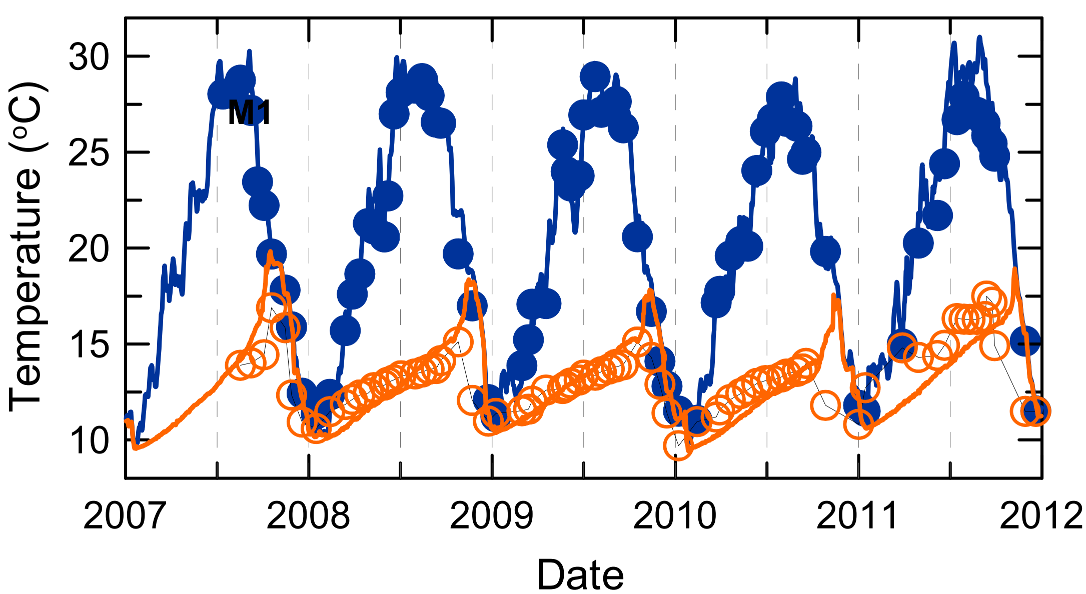

Figure 5-19. Measured and Model-Predicted Temperatures at 2-m (dark blue solid circles) and 12-m (orange open circles) Depths for Canyon Lake for the Calibration Period 2007-2011

5.4.4.3 Dissolved Oxygen

Unlike temperature, which can be simulated using ELCOM alone, prediction of DO requires CAEDYM due to the regulation of DO by biological and chemical processes. DO is specifically a function of photosynthetic production and respiratory loss by algae, sediment oxygen demand, microbial respiration in the water column, chemical demand by reduced substances, and other processes. Dissolved oxygen in Canyon Lake is highly dynamic, with concentrations in the epilimnion often supersaturated in the spring and very low in the fall following turnover. This can be seen in Figure 5-19, where the DO concentration at 2-m depth (solid symbols) reached nearly 14 mg/L or more in early spring in 2008 and late spring in 2009, but also dropped to 2 mg/L or lower in the surface water in the late fall following turnover (**Figure 5-20**). The model (dark red solid line) reproduced the trends reported for DO, with minima in the late fall and maximum values generally seen in the spring (Figure 5-20). The model did not always predict quite as high values in the summer as reported and yielded a slightly lower mean predicted DO concentration at 2-m depth value of 7.28 mg/L compared with the mean observed value of 8.14 mg/L, and a %RE of 22.7%. Considerable effort was dedicated to calibrating the model while also retaining available laboratory measurements of SOD, internal nutrient loading rates, and other factors.

Dissolved oxygen at 12-m depth also exhibited strong seasonal variation, with concentrations often approaching saturation during the winter months when the lake was well-mixed vertically. DO declined rapidly in the early spring and typically being < 0.1 mg/L most of the summer (Figure 5-20). The model reproduced this trend quite well, and yielded a mean DO concentration at 12-m depth of 1.00 mg/L, in good agreement with the observed mean value of 0.99 mg/L, although %RE was high (58.6%) because of numerous very low concentrations where even a modest difference yields a high relative error; this was especially evident, e.g., at turnover, when just a few days difference between predicted and observed timing of turnover yielded high error values. Removal of 5 dates where timing of mixing was responsible for large error estimates lowered the %RE from 58.6% to 37.9% (N = 63). We also note that measurement values are also prone to error at very low concentrations, and concentrations below 1.0 mg/L tend to exert similar biological effects, so this model outcome (Fig. 5-19) is considered adequate.

5.4.4.4 Total Nitrogen

The observed concentrations over time of TN at 2-m depth and ammonium-N at 12-m depth are presented in **Figure 5-21** (solid blue symbols= TN at 2-m; open purple triangles=NH_4-N at 12-m). Most nitrogen in the hypolimnion during periods of stratification is expected be in the ammonia-N form. TN concentrations in the epilimnion tended to range from about 1-3 mg/L, although values < 0.5 and > 4 mg/L were also reported (Figure 5-21). An outlier analysis using an extreme studentized deviate test indicated that the 4 values > 4 mg/L in the summer of 2007 met the statistical criterion for outliers and were removed from mean and error estimates.

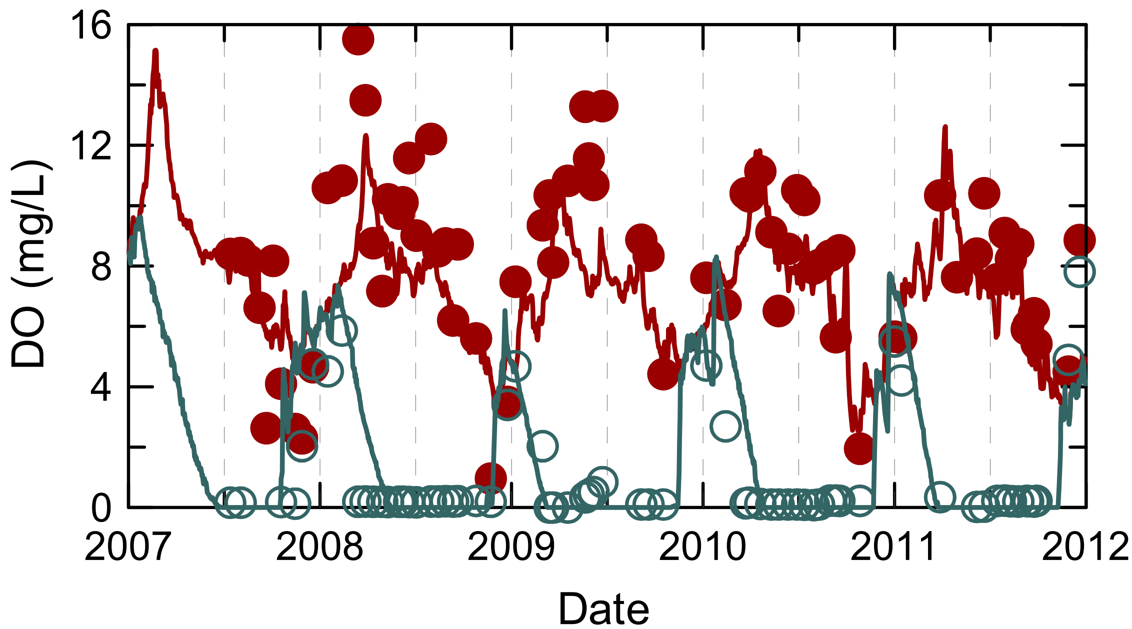

Figure 5-20. Measured and Model-Predicted Dissolved Oxygen at 2-m (dark red solid circles) and 12-m Depths (blue-green open circles) for Canyon Lake for the Calibration Period 2007-2011

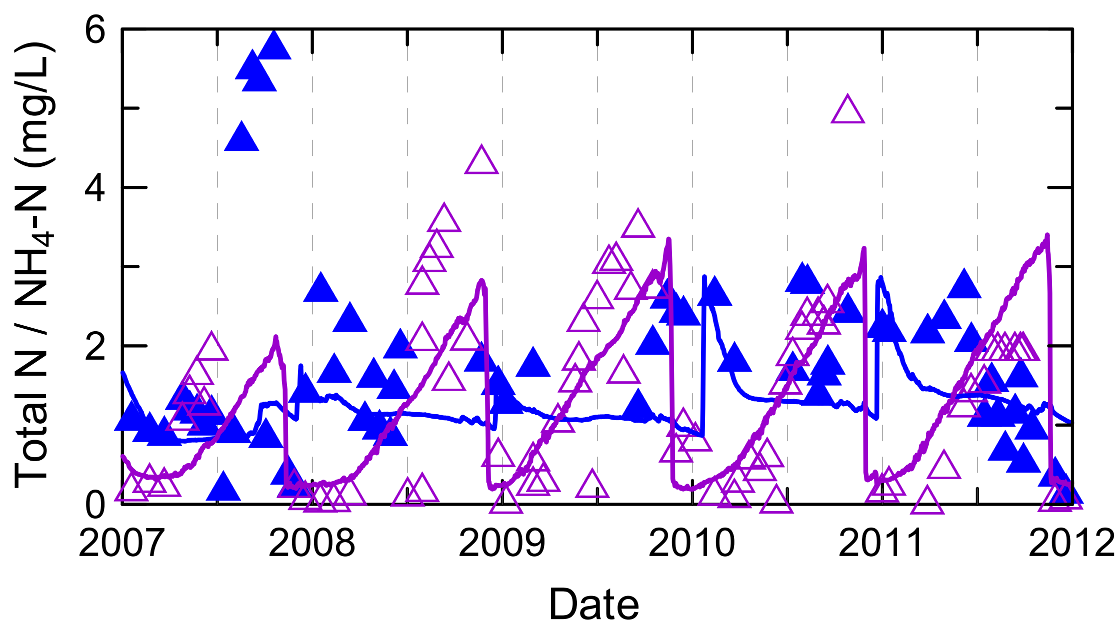

Figure 5-21. Measured and Model-Predicted Total Nitrogen at 2-m (blue, solid triangles) and 12-m Depths (purple, open triangle) for Canyon Lake for the Calibration Period 2007-2011

The data showed seasonal trends in epilimnetic TN involving higher concentrations in the fall following lake overturn and with subsequent external loads from wet season runoff, followed by lower concentrations later in the spring and summer. This trend was difficult to fully reproduce in the model, however (%RE of 36.8% in Main Lake), and the predicted mean concentration of 1.24 mg/L was lower than the mean observed value of 1.57 mg/L for this period. Ammonium-N in the hypolimnion was negligible during the winter following overturn of the water column while NH_4-N increased each spring and summer as a result of internal recycling and accumulation in the bottom waters (Figure 5-21). The model captured these general trends and yielded a mean predicted concentration of 0.85 mg/L in good agreement with the measured values on the same dates (0.81 mg/L) (N = 61). The %RE between predicted and observed values across the available data for 2007-2011 was 41.3%. Observed nutrient concentrations were compared with predicted values at 12-m depth, although actual depth of samples tended to vary somewhat, so some error is thought to arise from that assumption.

5.4.4.5 Total Phosphorus

TP in the epilimnion (2-m depth) exhibited temporal differences although a clearly defined seasonal trend was not readily evident, with concentrations ranging from 0.07 – 1.74 mg/L and a mean of 0.59 mg/L (**Figure 5-22**, solid red circles). The model did an adequate job of reproducing the average concentration of TP (0.66 mg/L); however, the model but did not capture the variability present in the data (modeled range of 0.40 – 1.2 mg/L) (Figure 5-22), with a %RE of 35.4%. Dissolved PO_4-P concentrations at 12-m depth exhibited clear seasonal trends similar to NH_4-N, with concentrations increasing each spring and summer to reach a maximum value in the fall immediately prior to turnover; concentrations often reached or exceeded 2 mg/L before fall sharply with mixing of the water column (Figure 5-22). The model predicted this seasonal trend but tended to underestimate the concentrations somewhat (mean measured and predicted concentrations of 1.12 and 0.74 mg/L, respectively, with a %RE of 44.3%). As with NH_4-N, some error between predicted and observed PO_4-P is also thought to arise from some differences in sampling depth.

5.4.4.6 Chlorophyll-*a*

Chlorophyll-*a* concentrations exhibited strong seasonal differences, with low measured concentrations during the winter and much higher concentrations during the summer (**Figure 5-23**, solid symbols). Sampling was limited to a few dates in the winter of 2008 and 2009, so sampling in 2010 and 2011 offered the most complete sets of annual trends in chlorophyll-*a*. Model predictions reflected these seasonal trends in chlorophyll-*a*, with temporally-averaged concentrations in relative agreement between observed and predicted values (31.2 and 38.8 µg/L, respectively), similar minimum values (2.0 and 3.1 µg/L, respectively), and similar maximum values as well (73.1 and 77.6 µg/L, respectively). Notwithstanding, the timing of the phytoplankton blooms varied in some years, with a high %RE (66.8%). Given the complexity of reproducing the phytoplankton community in such a dynamic lake environment, the capacity to reproduce mean, minimum and maximum values suggests that the model can nonetheless be useful in describing water quality trends but is not capable of predicting the specific timing of the blooms.

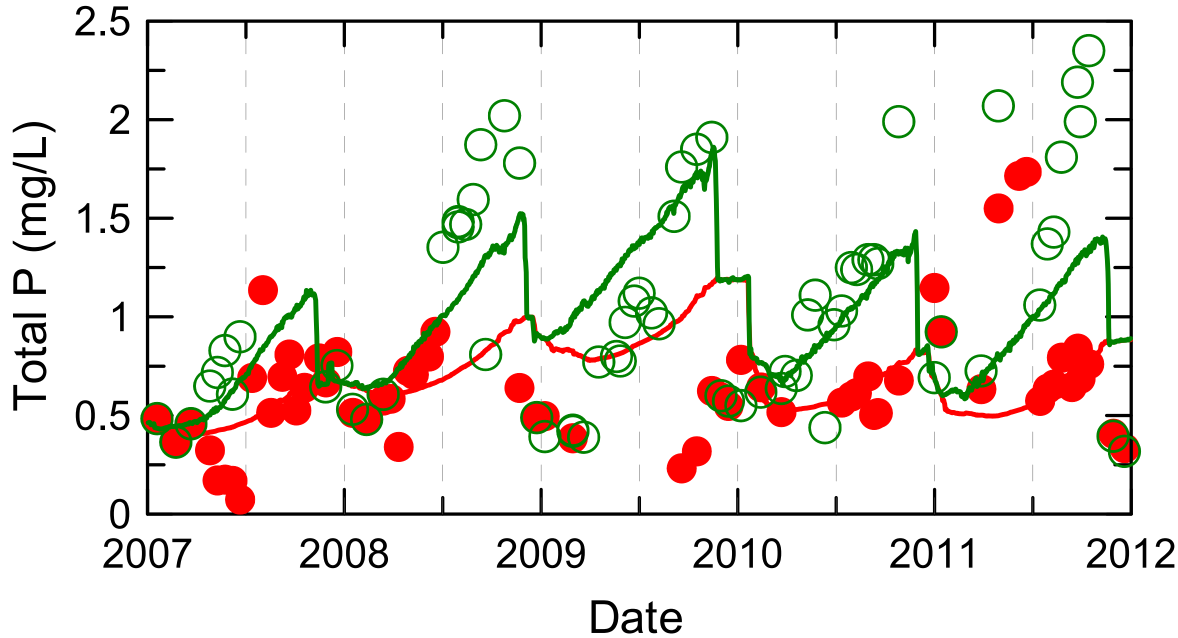

Figure 5-22. Measured and Model-Predicted Total Phosphorus at 2-m (red solid circles) and 12-m Depths (dark green open circles) for Canyon Lake for the Calibration Period 2007-2011

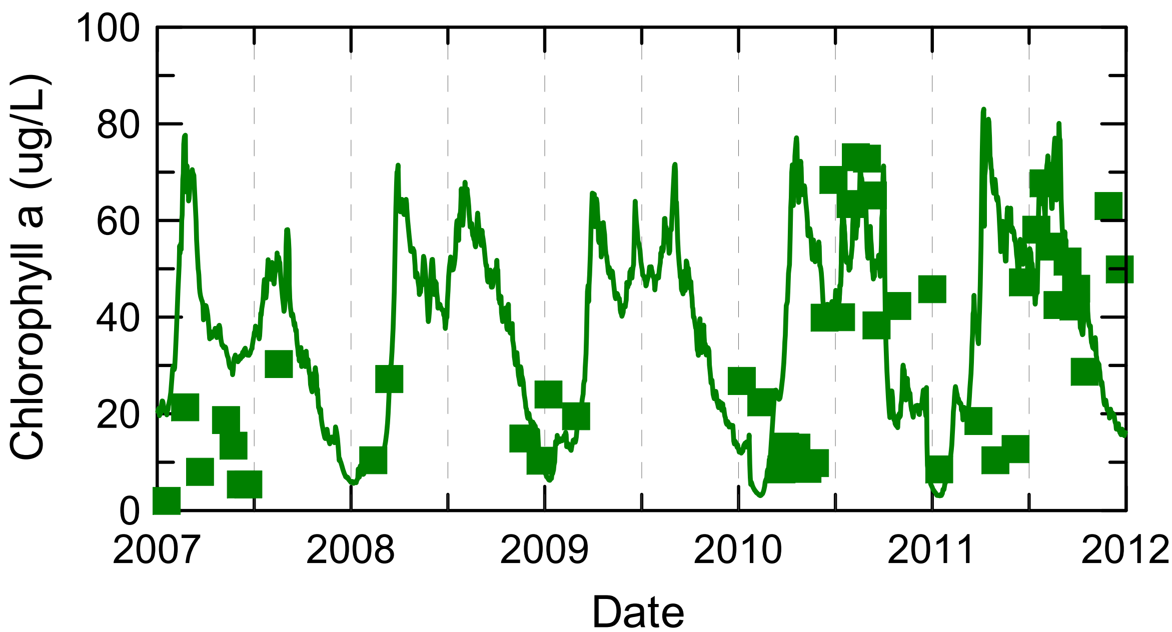

Figure 5-23. Measured and Model-Predicted Chlorophyll-*a* at 2-m Depth (green solid squares) for Canyon Lake for the Calibration Period 2007-2011

5.4.5 Water Quality Model Summary Statistics

The model could be calibrated to reproduce water quality for a single year, but disparities between predicted and observed properties generally increased when using a five-year calibration period (2007-2011). The comparatively long simulation period (5-yrs) with markedly different hydrology created extra challenges in simulating water quality in the lake. However, when looking at the five year means for water quality parameters, model results matched well with observed data in both Canyon Lake Main Lake (M1) and Canyon Lake East Bay (E2) (**Table 5-4**). On average, the model predicted similar mean DO and temperature within the hypolimnion of the Main Lake, based on results collected from 12-m depth below the lake surface.

Table 5-4. Mean Values for Observed and Predicted Water Quality Parameters in Canyon Lake (Observed/Predicted)

Site	Depth (m)	Temperature (°C)	DO (mg/L)	Chlorophyll-*a* (µg/L)	Total N (mg/L)	Total P (mg/L)
Main Lake (M1)	Epilimnion (2-m)	21.5 / 21.3	8.1 / 7.3	31.2 / 38.8	1.57 / 1.24	0.59 / 0.66
	Hypolimnion (12-m)	13.3 / 12.6	1.0 / 1.0	-	-	-
East Bay (E2)	Epilimnion (1-m)	-	-	50.8 / 53.7	1.80 / 1.35	0.50 / 0.64

The goodness-of-fit for trends in water quality parameters was assessed by computing the RE of model results with observed data on days when water quality samples were collected for TN, TP and chlorophyll-*a*. The average of REs for all discrete pairs of modeled and measured results for all water quality parameters ranged from 22.7 to 75.6 percent (**Table 5-5**). Discussion is provided above related to the goodness-of-fit for each parameter. Overall, the lake model calibration is considered acceptable given that a reference watershed approach, and not the linkage analysis, is used for estimating allowable external nutrient loads in the revised TMDL.

Table 5-5. Average of Percent Relative Errors Between Discrete Pairs (Sampled Days) of Predicted and Observed Water Quality in Canyon Lake

Site	Depth (m)	Temperature (% error)	DO (% error)	Chlorophyll-*a* (% error)	Total N (% error)	Total P (% error)
Main Lake (M1)	Epilimnion (2-m)	4.0 (N = 80)	22.7 (N = 73)	66.8 (N = 47)	36.8 (N = 57)	35.4 (N = 60)
	Hypolimnion (12-m)	8.7 (N = 77)	58.6 (M = 68)	-	-	-
East Bay (E2)	Epilimnion (1 m)	-	-	59.5 (N = 65)	37.8 (N = 72)	61.1 (N = 69)

5.4.6 Reference Condition Scenario Evaluation

The linkage analysis evaluated water quality conditions in Canyon Lake for a scenario where external loads are reduced to be representative of the reference watershed condition to develop numeric targets for ammonia-N, DO and chlorophyll-*a* (see Section 3.2.2 for water quality input data). This scenario was developed for a 15-year (2001-2016) simulation period coinciding with available daily flow data from USGS gauges for the San Jacinto River at Goetz Rd (Sta#11070365) and Salt Creek at Murrieta Road (Sta#11070465). Reference watershed nutrient concentrations are assumed to occur in the total daily inflow volume to Canyon Lake.

No changes were made to the Canyon Lake bathymetry or model resolution to run a reference condition scenario. Results of the reference condition model are plotted as time series in **Figure 5-24** for Canyon Lake Main Lake and **Figure 5-25** and Canyon Lake East Bay. Results include lake level, TDS, TP, TN, ammonia-N, DO and chlorophyll-*a*. The following observations were noted from these results:

- For both Main Lake and East Bay, algal productivity follows a seasonal pattern with an initial bloom toward the end of the wet season (February/March) that extends until the fall when days get shorter and wet weather provides some flushing of algae.
- Limited inter-annual variability exists in the magnitude of chlorophyll-*a* in both lake segments for a reference watershed condition.
- Apparent differences in nitrogen and phosphorus patterns can be attributed to both internal and external loading. Flux rates for nitrogen are about three times greater than for phosphorus, and this same proportion is reflected when comparing modeled depth average concentrations for nitrogen and phosphorus during dry seasons.
- Water column TP concentration resulting from sediment flux over the dry season is similar to the assumed concentration for external runoff inflows in a reference watershed condition; therefore, variability in phosphorus is much lower over the simulation period.
- Ammonia-N flux rates support a dry season depth average of about 0.5 mg/L, which is half of the TN assumed for external runoff inflows in a reference watershed condition. Therefore, external watershed runoff provides a considerable rise in water column TN concentration, especially for storm events with volumes in excess of the storage capacity (i.e., flushing the entire standing volume one or more times over a single storm).

Figures 5-26 through 5-29 illustrate vertical profiles of the ELCOM-CAEDYM Model results for DO, nutrients, and chlorophyll-*a* comparing existing with reference watershed conditions based on output from Station M1 in the Main Lake. Note the difference in magnitudes for the color ramps between existing and reference watershed conditions. One key observation is the persistence of low DO (below 5 mg/L) in the hypolimnion of Main Lake for both existing and reference watershed conditions. For nitrogen and phosphorus, the model estimated the greatest fluxes to occur in different years, with nitrogen fluxes increasing in dry seasons immediately following wet years and phosphorus fluxes greatest in drought years. Chlorophyll-*a* was found to grow deeper in the water column toward the end of the growing season which served to reduce the area of anoxia.

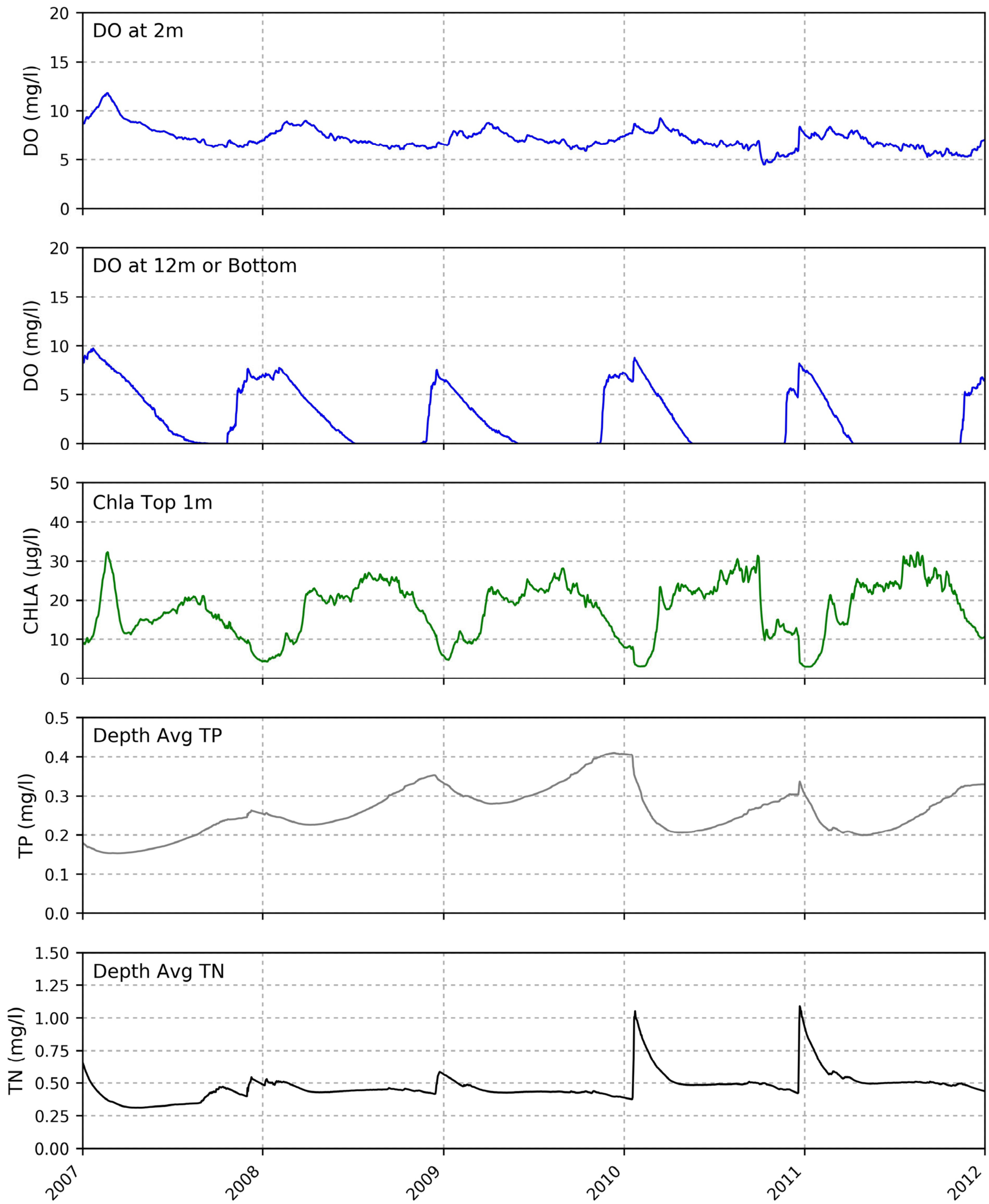

Figure 5-24. Time Series Output of Water Quality Parameters for Reference Condition Simulation for Canyon Lake Main Lake (2007 - 2011)

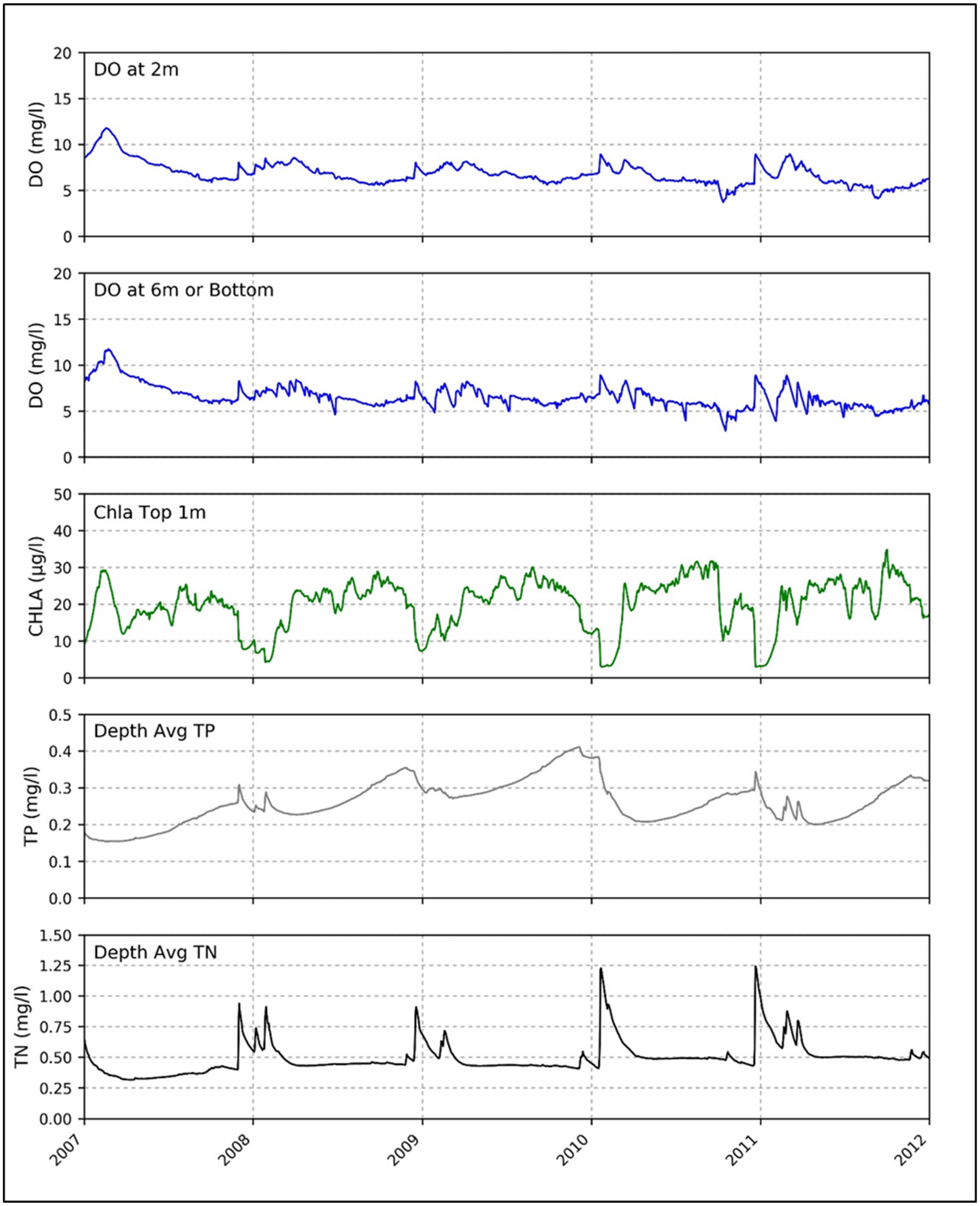

Figure 5-25. Time Series Output of Water Quality Parameters for Reference Condition Simulation for Canyon Lake East Bay (2007 - 2011)

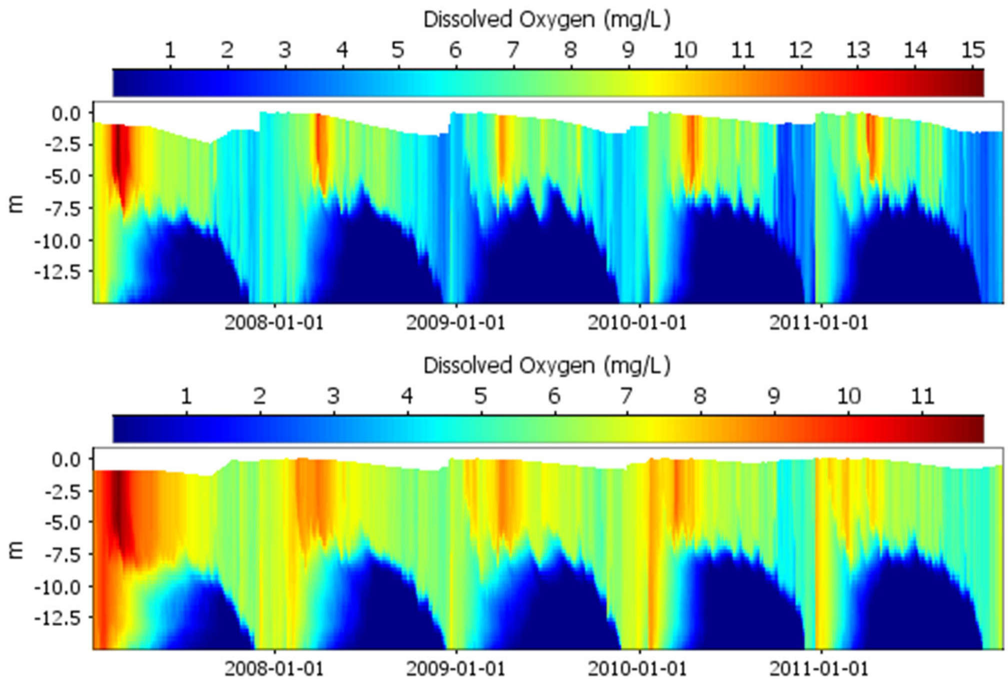

Figure 5-26. Vertical Profiles of ELCOM-CAEDYM Model Results for Dissolved Oxygen Comparing Existing Conditions (top) with Reference Watershed Conditions (bottom) Based on Output from Station M1 in Main Lake of Canyon Lake

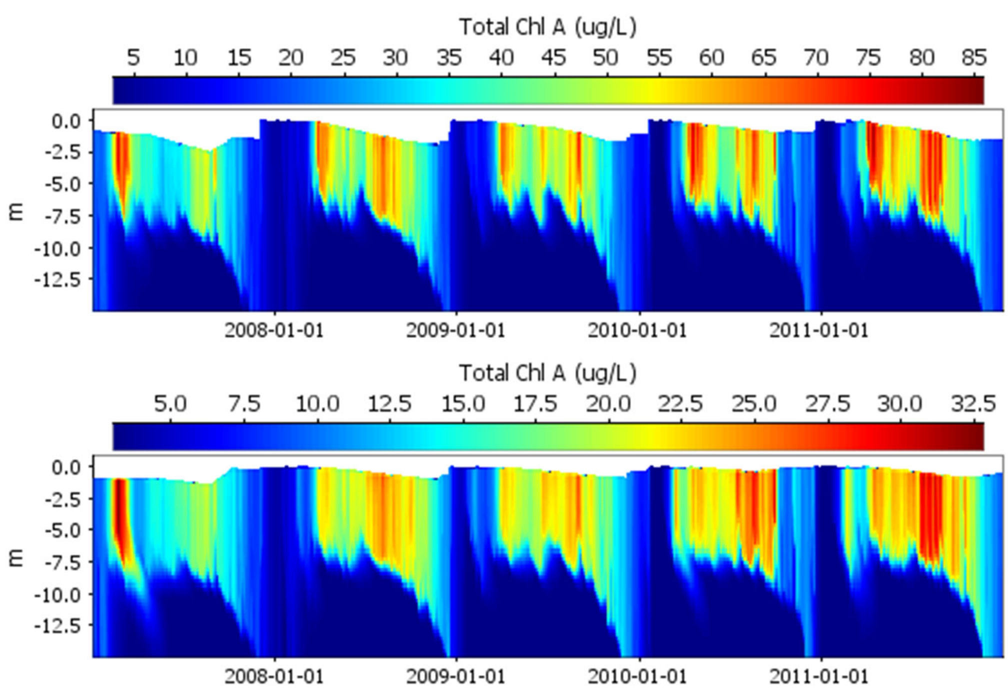

Figure 5-27. Vertical Profiles of ELCOM-CAEDYM Model Results for Chlorophyll-*a* Comparing Existing Conditions (top) with Reference Watershed Conditions (bottom) Based on Output from Station M1 in Main Lake of Canyon Lake

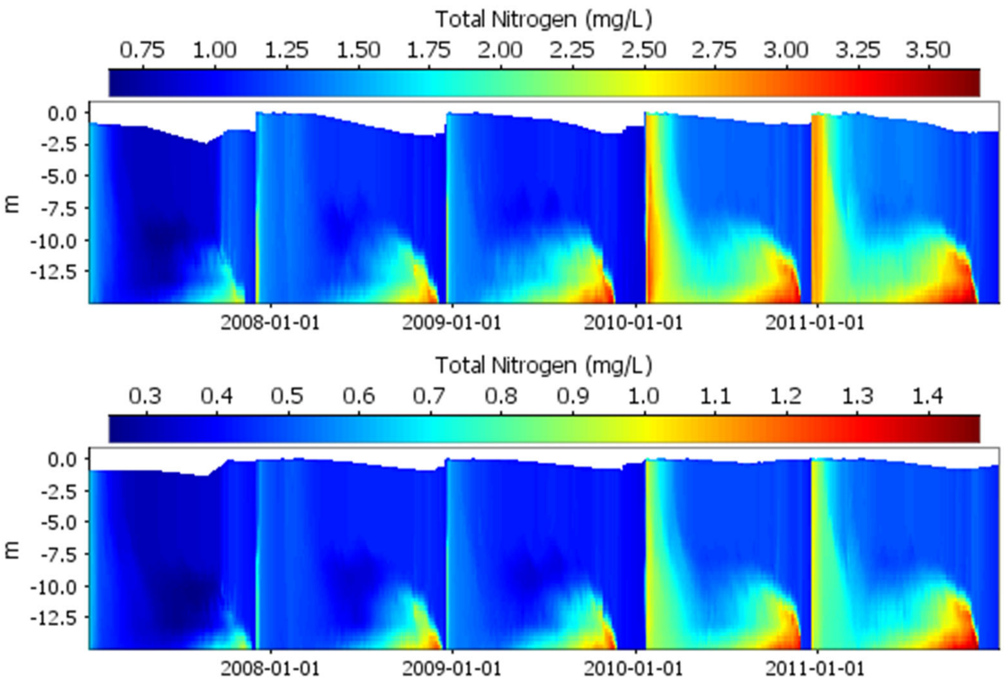

Figure 5-28. Vertical Profiles of ELCOM-CAEDYM Model Results for Total Nitrogen Comparing Existing Conditions (top) with Reference Watershed Conditions (bottom) Based on Output from Station M1 in Main Lake of Canyon Lake

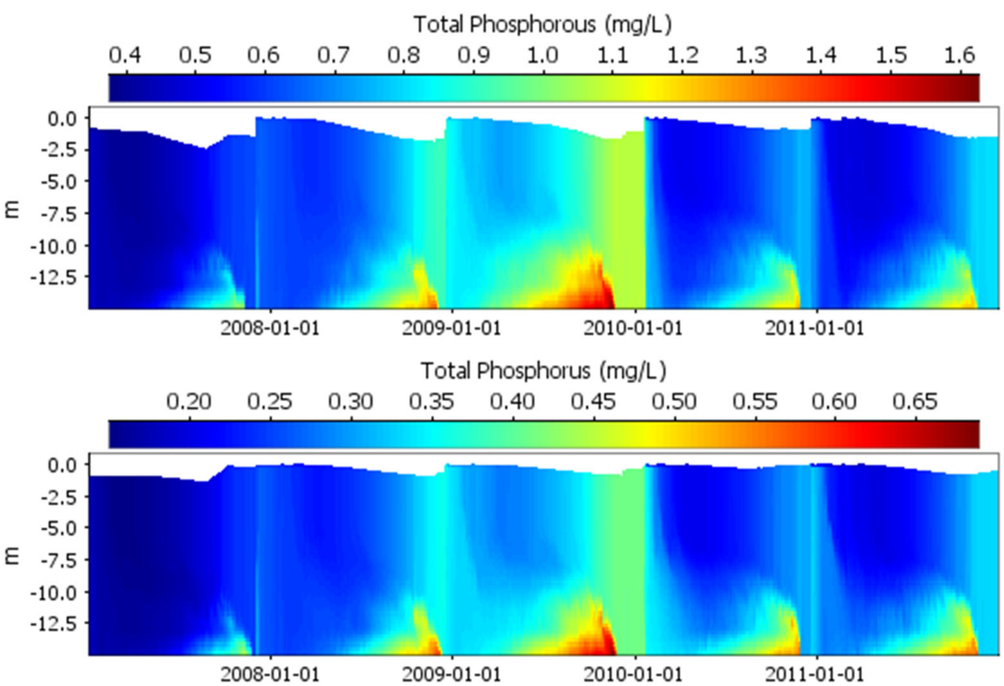

Figure 5-29. Vertical Profiles of ELCOM-CAEDYM Model Results for Total Phosphorus Comparing Existing Conditions (top) with Reference Watershed Conditions (bottom) Based on Output from Station M1 in Main Lake of Canyon Lake

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Section 6

Total Maximum Daily Load, Wasteload Allocations and Load Allocations

The allowable nutrient loading to three lake segments, Canyon Lake Main Lake, Canyon Lake East Bay and Lake Elsinore, is determined from analysis of the hydrology and water quality for the hypothetical reference watershed based on pre-development conditions (see Section 3.2 for description of the reference watershed condition). Specifically, this information was developed in the following sections:

- Reference watershed conditions were approximated from modeling the watershed subareas by reducing washoff concentrations to natural background levels (see Section 3, Numeric Targets).
- The loading of nutrients to the lakes under reference conditions was simulated by evaluating reference watershed conditions using the watershed runoff model developed to assess existing sources of nutrients from the watershed (Section 4, Source Assessment).
- Section 5 (Linkage Analysis) documents for a reference watershed condition, approximations of internal loads associated with sediment nutrient flux, which comprises the single greatest source of TP and TN in Lake Elsinore.

This section partitions the total allowable loads of TP and TN from point sources into WLAs and non-point sources into load LAs for individual jurisdictions as follows:[1]

- *Section 6.1 – Total Maximum Daily Load*: The total allowable load of nutrients from external sources, plus a MOS, equals the TMDL for Lake Elsinore and Canyon Lake. For these waterbodies, the TMDL is based on estimated nutrient concentrations in washoff from a hypothetical reference condition over the entire watershed. Due to the water quality benefits realized with increased lake volume, current volumes of runoff and supplemental water additions are allowed for in the WLAs and LAs.
- *Section 6.2 – Watershed Runoff*: Nutrient loads delivered to the lakes from watershed runoff are allocated to upstream jurisdictional areas in this section. A key element of this allocation involves allocation of watershed nutrient loads to Lake Elsinore from upstream of both Canyon Lake by way of overflows from Canyon Lake. The difference between current loads (as determined in Section 4) and allowable loads is reported. This difference represents the reduction in TP and TN loads that must be achieved to meet WLAs and LAs.

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[1] The WLA is the portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. The LA is the portion of a receiving water's loading capacity that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources.

- *Section 6.3 – Supplemental Water*: Allowable loads from the addition of supplemental water to the lakes is described in this section. While the addition of supplemental water to the lakes represents a discharge, it is important to recognize that the addition of supplemental water also represents a water quality management strategy. The WLA for supplemental water is based on a reference watershed runoff nutrient concentration (See Section 3.2.2.3) and does not consider additional water quality benefit for response targets that may be achieved with a deeper lake. Potential offset credits from supplemental water addition are described in Section 7 that describes TMDL implementation.

- *Section 6.4 – Internal Loads:* Estimates of allowable internal loads for atmospheric deposition and sediment nutrient flux are described in this section. Implementation of the TMDL will eventually return sediment nutrient flux rates to reference levels, but a significant lag time exists to account for legacy nutrient enrichment to cycle through the system.

- *Section 6.5 – Summary of Allocated Loads.* This section summarizes the WLAs and LAs described in previous sections. In addition, this section discusses how compliance with allocations will be evaluated. As described in other chapters, the temporal variability associated with naturally occurring weather patterns results in significant variability in the delivery of nutrient loads to the lakes. Use of a 10-year averaging period for setting allocations in the revised TMDLs provides a more appropriate measure of progress toward TMDL compliance by reducing the influence of naturally occurring annual fluctuations.

6.1 Total Maximum Daily Load

A TMDL is the sum of allowable nutrient loads from point (WLA) and non-point (LA) sources that can be delivered to Lake Elsinore and Canyon Lake to achieve the numeric targets, accounting for a MOS:

$$TMDL = WLA + LA + MOS$$

For the Lake Elsinore and Canyon Lake TMDLs, allowable loads are allocated based on nutrient washoff concentrations expected for a reference watershed condition. As such, the allowable loads are concentration-based. By setting a concentration-based allocation for the revised TMDLs, increases in volume (and thereby load) of discharges would be accompanied by proportionate increases in the allowable loading. Thus, the required load reduction (excess above the reference condition) remains the same percentage with a change in runoff volume. The LECL Task Force decided to use a concentration basis for allocations to support the objective of increasing the volume of clean water that reaches the lakes.

Since a TMDL is a measure of mass by definition, there must be a term for volume in the calculation of the TMDL and in-turn allocations for external sources. The following sections employ model estimates of long-term average runoff for existing watershed conditions (based on 2014 land use mapping) and near-term projections of long-term average supplemental water additions to convert reference concentrations into 10-year average allocations for loads delivered to three lake segments, Canyon Lake Main Lake, Canyon Lake East Bay, and Lake Elsinore. These mass allocations are expected to change as land use and jurisdictional areas in the watershed change, generally with a trend of declining agricultural land use and increasing urbanization.

The MOS provides additional assurance that the TMDLs will be achieved if programs are implemented to attain the required reduction to meet allocated nutrient loads. For these TMDLs, a MOS much greater than 10 percent has been accounted for by using the median TP and TN values (0.32 mg/L and 0.92 mg/L, respectively) of water quality observations from the San Jacinto River Cranston Guard Station reference site. The median was used rather than the geometric mean (TP: 0.4 mg/L, TN: 1.24 mg/L), arithmetic mean (TP: 2.43 mg/L, TN 2.60 mg/L) or median of event averages (TP: 0.39 mg/L, TN: 1.35 mg/L) (see additional discussion in Section 3.2.2.3).

6.2 Watershed Runoff

6.2.1 Allowable Runoff Loads

Nutrient loads estimated for watershed runoff under a reference watershed condition represent the total allowable load to each lake segment from external watershed runoff sources. Allowable nutrient loads are determined as the product of average annual runoff volume (V_{annual}) and reference nutrient concentration ($C_{reference}$) at the point of discharge into each lake segment, as follows:

$$Load_{allowable} = V_{annual} * C_{reference}$$

Section 3.2 describes how nutrient concentrations are estimated for a reference watershed condition. The numeric targets in the revised TMDLs are expressed as CDFs for the estimated water quality response targets that are expected with external loads representative of a reference watershed condition. Allowable loads are calculated to determine the total allowable load from each of the individual nine subwatershed zones in the watershed (**Figure 6-1**).

6.2.2 Allocations of Allowable Nutrient Loads to Lake Segment TMDLs

Allocations for nutrient loads were developed for each of the following: Canyon Lake Main Lake; Canyon Lake East Bay; overflows from Canyon Lake to Lake Elsinore; and Local Lake Elsinore. Although each of these lake segments is given an allocation, there are only three TMDLs since Canyon Lake Overflows to Lake Elsinore and Local Lake Elsinore comprise the Lake Elsinore TMDL (**Table 6-1**). Subwatershed zones upstream of Canyon Lake may contribute to multiple downstream waters and therefore will have allocations defined for more than one of the lake segments (see Figure 6-1).

Naturally occurring recharge losses between jurisdictional areas and lake inflows (by channel bottom recharge downstream of Zones 4, 5, and 6 and by Mystic Lake retention of runoff from Zones 7-9) are accounted for in the allocation of loads arriving at the lakes and in the remaining load reductions which is equal to excess loads estimated to arrive at the lakes. Appendix B provides the allowable loads expressed as washoff from upstream jurisdictional areas before accounting for naturally recharge losses.

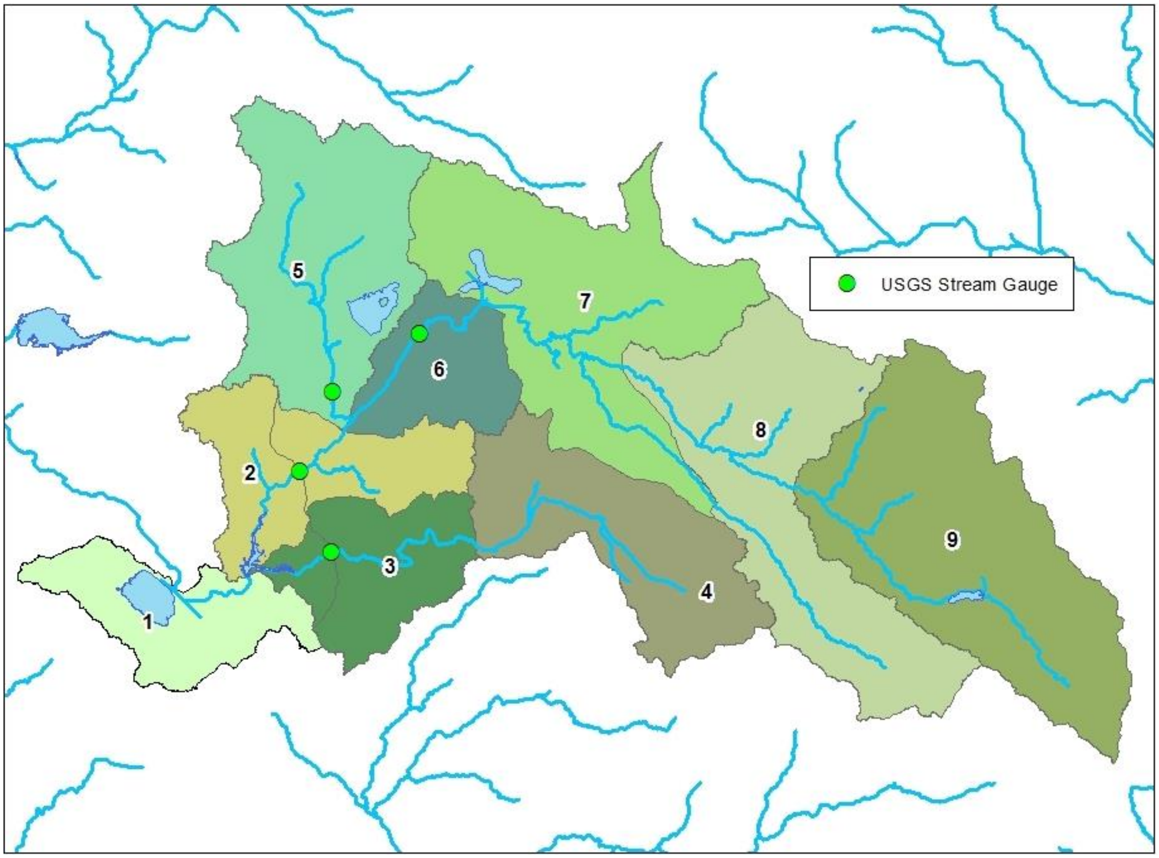

Figure 6-1. Location of Subwatershed Zones in the San Jacinto River Watershed (Zones 2, 5-9 drain to Canyon Lake – Main Lake [except note that Zones 7-9 may be intercepted by Mystic Lake]; Zones 3-4 drain to Canyon Lake – East Bay; and Zone 1 drains to Lake Elsinore)

Table 6-1. Matrix Showing Three TMDLs and Allocation of Allowable Nutrient Loads by Subwatershed Zone (see Figure 6-1 for location of zones)

Subwatershed Zone	Canyon Lake		Lake Elsinore	
	Main Lake	East Bay	Canyon Lake Overflows	Local Watershed
1	--	--	--	100%
2	40%	--	60%	--
3[1]	--	40%	60%	--
4[1]	--	40%	60%	--
5	40%	--	60%	--
6	40%	--	60%	--
7	--	--	100% [2]	--
8	--	--	100% [2]	--
9	--	--	100% [2]	--

[1] East Bay volume is transferred to Main Lake via a culvert under the Canyon Lake Drive causeway. The residence time for volume originating in East Bay that transfers to the Main Lake is limited prior to overflowing to Lake Elsinore and is considered negligible for the TMDL revision. Thus, no allocations are given to jurisdictions in subwatershed Zones 3 and 4 (East Bay subwatershed) for Canyon Lake Main Lake.

[2] Allowable loads are reduced to account for naturally occurring retention in Mystic Lake (see Section 4.1.3.4)

The Source Assessment (Section 4) applied USGS gauge records and long-term watershed monitoring data to estimate nutrient mass inflow to Canyon Lake from two key stations on San Jacinto River at Goetz Rd and Salt Creek at Murrieta Rd as well as nutrient mass overflow to Lake Elsinore from the San Jacinto River downstream of Railroad Canyon Dam (see Figures 4-14 and 4-15). The retention of nutrient loads was estimated as the difference between the summed annual loading for stations upstream and downstream of Canyon Lake for years when Canyon Lake overflows occurred. This analysis shows an average of 40 percent of nutrient loads that reach Canyon Lake are retained in the lake and 60 percent of the loads overflow to Lake Elsinore. Therefore, allowable loads from the Canyon Lake watershed are converted into WLAs and LAs involving a 40/60 split to Canyon Lake (either East Bay or Main Lake) or Lake Elsinore TMDLs, respectively (see Table 6-1).

Allocations of nutrient loads were parsed by using current (2014 mapping) estimates of the land use areas within jurisdictional boundaries (**Figure 6-2**). Estimates of runoff and nutrient loading from these areas was done by reducing nutrients to reference concentrations in the watershed model. The subwatershed zone for jurisdictional areas plays a role in reference loading, due to a number of factors specific to each subwatershed (i.e., variations in annual rainfall and levels of downstream retention in Mystic Lake and in channel bottom characteristics). Distributions of allowable load by subwatershed were converted to allocations to each TMDL and jurisdiction based on the factors presented in Table 6-1. These allocations represent the nutrient load estimated to be delivered to each lake segment from upstream runoff under the reference watershed condition.

Table 6-2 provides the results of the allocation analysis for each jurisdiction or responsible agency. These results represent a snapshot of allocations at lake inflows for each of the lake segments based on 2014 jurisdictional boundaries. As jurisdictional areas change, anticipated to be largely from conversion of undeveloped or agricultural land uses to urban land uses, the allowable loads and need to reduce existing loads is transferred to the jurisdiction that is taking ownership. For example, for an agricultural field in Hemet that is converted to a commercial development, the City of Hemet would receive an increased allowable load to accommodate the increase in existing load.

6.2.3 Watershed Runoff Load Reductions to Meet TMDL Allocations

The incremental load above the allocations (see Table 6-2) represents the nutrient load attributable to anthropogenic watershed development. Thus, the difference between existing nutrient loads delivered at the lake inflow and allocations at the lake inflows is the reduction needed for each watershed jurisdiction to comply with the TMDLs (**Table 6-3**). This same mass reduction would be needed if watershed BMPs were used to reduce excess load from an individual jurisdictional area.

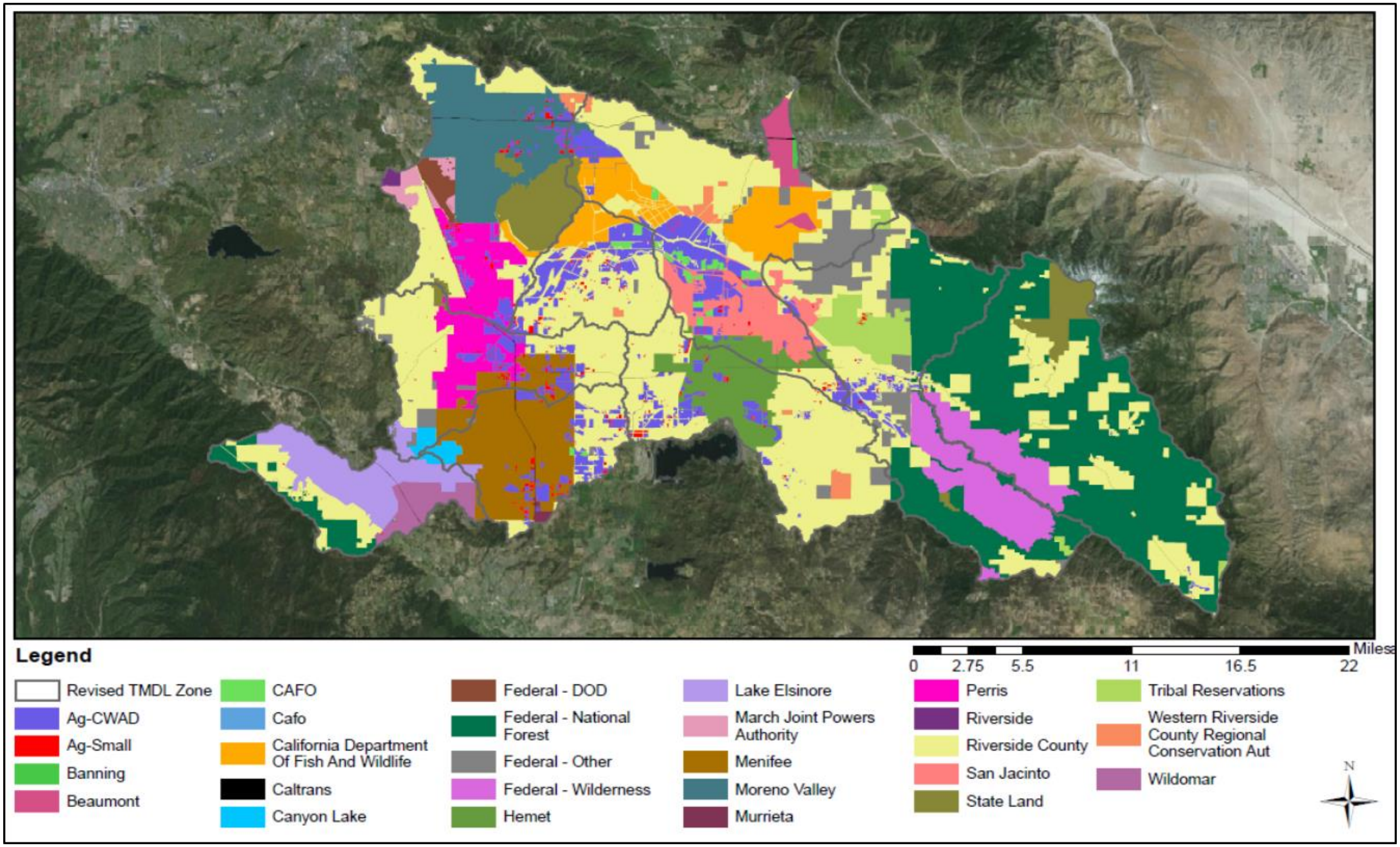

Figure 6-2. Jurisdictional Boundaries in the Lake Elsinore and Canyon Lake Watershed

Table 6-2. Allocations for Watershed Runoff into Lake Elsinore and Canyon Lake Nutrient TMDLs

Responsible Agency	Canyon Lake Main Lake		Canyon Lake East Bay		Local Lake Elsinore[1]		Canyon Lake Overflow to Lake Elsinore[1]	
	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)
Wasteload Allocations								
Banning	-	-	-	-	-	-	1	4
Beaumont	-	-	-	-	-	-	11	31
CAFO	n/a	n/a	n/a	n/a	0	0	10	30
Caltrans	12	36	4	13	9	27	30	87
Canyon Lake	13	39	17	49	11	32	46	132
CR&R	-	-	-	-	-	-	0.4	1
Federal – Dept. of Defense	23	66	-	-	-	-	35	99
Hemet	-	-	64	184	-	-	112	323
Lake Elsinore	15	43	4	10	381	1,095	28	80
March Joint Powers Authority	19	55	-	-	-	-	29	82
Menifee	56	162	240	691	9	25	445	1,280
Moreno Valley	281	807	-	-	-	-	422	1,214
Murrieta	-	-	6	18	-	-	9	27
Perris	165	473	0	1	-	-	248	712
Riverside	9	25	-	-	-	-	13	38
Riverside County	360	1,036	158	454	149	428	957	2,752
San Jacinto	0	1	1	2	-	-	36	103
Wildomar	-	-	0	0	128	367	0.1	0.2
Load Allocations								
Agriculture-CWAD: Irrigated	66	190	22	63	-	-	153	441
Agriculture-CWAD: Non-irrigated	40	114	28	80	0	1	109	313
Agriculture (Small)	16	46	9	25	1	4	39	112
CA Dept. of Fish and Wildlife	28	80	-	-	-	-	73	209
Federal - National Forest	-	-	1	4	106	304	328	944
Federal – Other	19	55	5	14	-	-	67	194
Federal – Wilderness	-	-	-	-	-	-	64	183
State Land	22	64	-	-	-	-	59	170
Tribal Reservations	-	-	-	-	-	-	18	52
Western Riverside County Regional Conservation Authority	5	13	3	9	-	-	15	42
Total Allowable Watershed Load (WLAs and LAs)	**1,149**	**3,304**	**562**	**1,617**	**794**	**2,283**	**3,358**	**9,656**

[1] Allocations for Local Lake Elsinore and Canyon Lake Overflow to Lake Elsinore are combined into a single Lake Elsinore TMDL. However, the allocations are reported separately here since source controls in the Canyon Lake watershed can be used to estimate credits toward reducing loads in Overflows from Canyon Lake to Lake Elsinore.

Table 6-3. Nutrient Load Reduction Required for Watershed Jurisdictions to Comply with Lake Elsinore and Canyon Lake Nutrient TMDLs

Responsible Agency	Canyon Lake Main Lake		Canyon Lake East Bay		Local Lake Elsinore		Canyon Lake Overflow to Lake Elsinore	
	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)
Point Sources with NPDES Permits								
Banning	-	-	-	-	-	-	1	7
Beaumont	-	-	-	-	-	-	3	43
CAFO	n/a	n/a	n/a	n/a	0	(0)	31	31
Caltrans	1	130	0	45	1	81	-	280
Canyon Lake	5	55	6	90	3	48	16	217
CR&R	-	-	-	-	-	-	0	0
Federal – Dept. of Defense	4	158	-	-	-	-	7	237
Hemet	-	-	37	332	-	-	68	603
Lake Elsinore	4	49	1	15	26	1,038	8	96
March Joint Powers Authority	4	54	-	-	-	-	6	81
Menifee	45	297	146	1,204	4	24	286	2,252
Moreno Valley	125	1,604	-	-	-	-	187	2,407
Murrieta	-	-	3	37	-	-	4	56
Perris	59	809	0	-	-	-	89	1,213
Riverside	4	55	-	-	-	-	6	82
Riverside County	210	1,093	162	402	50	466	666	2,621
San Jacinto	-	-	0	2	-	-	22	167
Wildomar	-	-	-	-	40	525	-	-
Nonpoint Sources								
Agriculture (CWAD)	30	-	10	-	-	-	66	-
Agriculture (Non-irrigated)	237	285	155	176	1	1	665	801
Agriculture (Small)	37	24	27	24	0	-	98	70
CA Dept. of Fish and Wildlife	0	0	-	-	-	-	0	0
Federal - National Forest	-	-	-	-	1	2	1	6
Federal – Other	-	-	1	1	-	-	0	-
Federal – Wilderness	-	-	-	-	-	-	0	0
State Land	2	5	-	-	-	-	3	9
Tribal Reservations	-	-	-	-	-	-	0	6
Western Riverside County Regional Conservation Authority	0	0	0	0	-	-	2	2
Total Watershed Load Reduction Required	**767**	**4,516**	**548**	**2,293**	**127**	**2,186**	**2,220**	**11,049**

6.3 Supplemental Water

Supplemental water is added to Lake Elsinore to maintain lake levels, as authorized by the Santa Ana Water Board (Santa Ana Water Board 2013b). The DYRESM-CAEDYM model for Lake Elsinore showed that without supplemental water additions since 2002 (as authorized by Santa Ana Water Board 2002), lakebed desiccation would have likely occurred in 2014 under reference conditions (**Figure 6-3**). A WLA for supplemental water additions to Lake Elsinore based on projected effluent rates for EVMWD reclaimed water is provided in **Table 6-4**. Additional sources of supplemental water for the lakes are provisionally allowable, as long as the concentration of nutrients is equal to or less than the reference watershed runoff. Further, the increased lake level that results from supplemental water addition may also provide water quality benefits of increased habitat for littoral zone aquatic communities and reducing bioavailable nutrient concentrations in the water column. These benefits will be translated into estimated nutrient offsets in Section 7, Implementation.

6.4 Internal Loads

This information, which was first presented in Section 4.3, is also incorporated here to support the discussion of allocations applicable to the revised TMDLs.

6.4.1 Sediment Nutrient Flux

When employing a reference watershed approach, external watershed loads are reduced from current levels to be representative of a reference watershed condition. A reduction in external load from current levels would in turn reduce the pool of nutrients settled to the lake bottom sediments and thereby reduce internal load from diffusive sediment nutrient flux. No data are available for measurements of sediment nutrient flux in Lake Elsinore or Canyon Lake prior to land development in the San Jacinto River watershed. Nor is there a comparable lake in the region with an undeveloped watershed that could be used to estimate sediment nutrient flux for a reference condition. However, multiple lines of evidence provide consistent estimates, as described below:

- Paleolimnology of Lake Elsinore collected and dated 10-m sediment cores to represent the past 10,000 years (Kirby et al. 2005). Sediment from shallow depths (most recent 200 years) were compared with sediment in the remainder of the core (200 – 10,000 years ago). Results showed higher total organic matter, higher nitrogen levels, lower carbon to nitrogen (C:N) ratios (measure of the relative contribution of terrestrial vs. aquatic organic matter with lower values indicating increased contributions from aquatic sources), and higher organic phosphorus (OP) values (Kirby et al. 2005) (**Figure 6-4**).

- An independent sediment diagenesis model was developed for Lake Elsinore and Canyon Lake to test the impact of changing external nutrient loads from current levels to the reference watershed condition. The flux of nutrients from simulations involving less enriched lake bottom sediments was reduced by ~50 percent.

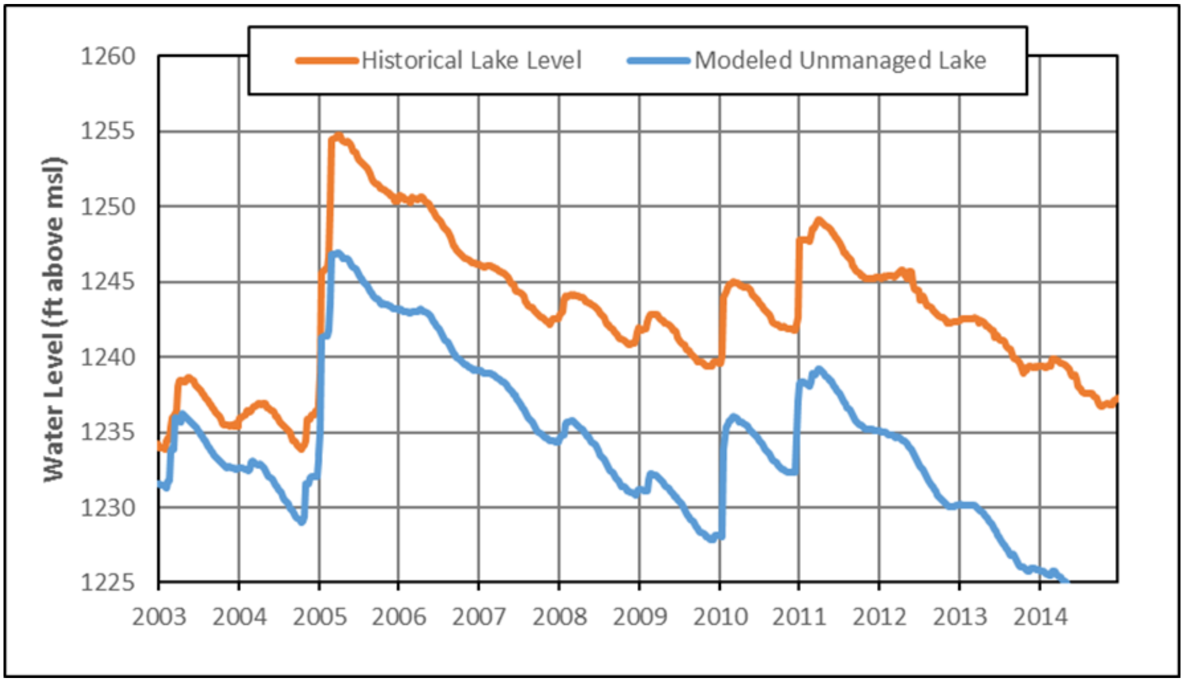

Figure 6-3. Actual Lake Level Compared to Reference Condition (without supplemental water and without LEMP basin)

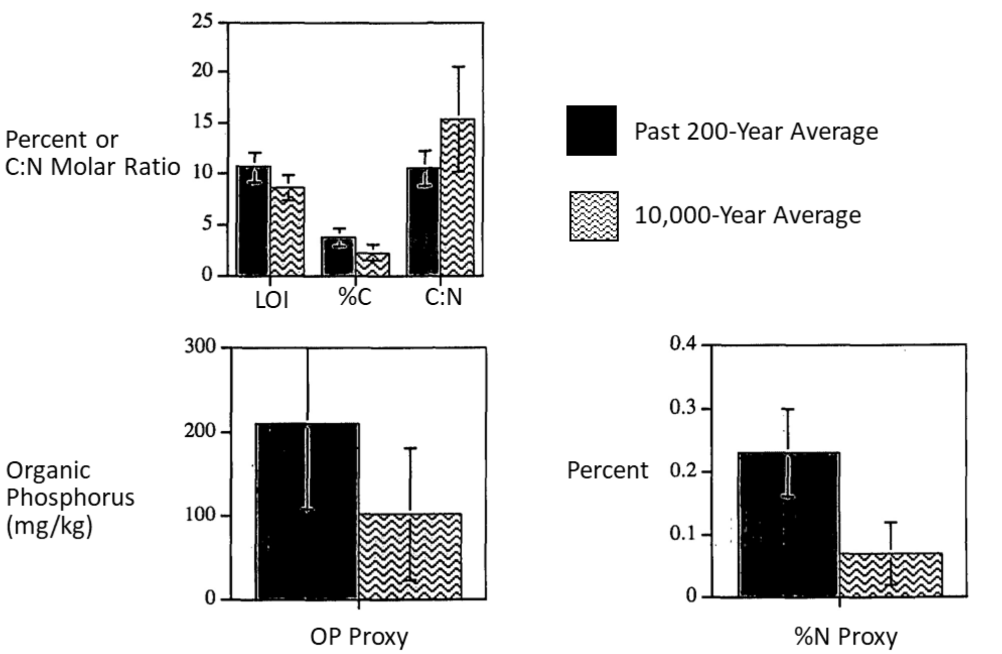

Figure 6-4. Comparison of Nutrient Levels and Lake Productivity Level Proxies for the Past 200 Years Versus the 10,000 Year Historic Record (Dark shaded area = past 200-year average; hatched area = 10,000-year average; bars represent 1 standard deviation from mean) (adapted from Figure 22 in Kirby et al. 2005).

Table 6-4. WLAs for EVMWD Reclaimed Water Additions to Lake Elsinore

EVMWD Reclaimed Water Additions	Flow		Concentration		Nutrient Load	
	mgd	AFY	TP (mg/L)	TN (mg/L)	TP (kg/yr)	TN (kg/yr)
Current Permit	8.0	6,037	0.50	1.00	3,721	7,442
TMDL Revision	9.5	10,642	0.32	0.92	4,198	12,069

A model scenario was implemented for Lake Elsinore and Canyon Lake to characterize lake water quality for a reference watershed condition and estimate numeric targets. This model scenario involved use of a nominal diffusive sediment nutrient flux rate at half of current levels as measured by core-flux studies (see Section 4.3.1) as supported by the lines of evidence above. The dynamic simulation for this scenario approximates the naturally occurring sediment nutrient flux modulated by daily fluctuations in temperature and pH, which serves as the basis for a load allocation in the TMDLs (**Table 6-5**). Over time, these load allocations from the lake bottom sediment are expected to be achieved by reducing/offsetting external loads to levels equal or better than a reference watershed condition. Once reference watershed conditions are achieved, it may take several decades for internal loads to return to the load allocation, depending mostly upon future hydrologic conditions.

6.4.2 Atmospheric Deposition

Load allocations were developed for direct deposition from the atmosphere to the lake surfaces. Inconsistencies in the approach used to develop estimates for Lake Elsinore and Canyon Lake exist in the 2004 TMDL (Risk Sciences 2017). For example, depositional rates for TN employed for Lake Elsinore and Canyon Lake were based on differing regional literature values. The approach presented below is based on similar data used for the 2004 TMDL but ensures a consistent method for TN and TP is applied to each lake segment.

6.4.2.1 Total Phosphorus

Wet deposition of TP to each lake segment was estimated using literature values for TP wet deposition rates of 30 kg/km^2/yr for Keystone Reservoir in Oklahoma (Walker 1996). Adjusting for differences in rainfall, average annual wet deposition for TP in Lake Elsinore and Canyon Lake was assumed to be 13 kg/km^2/yr (0.05 kg/ac/yr). Assuming most TP deposition occurs as wet deposition, load allocations were developed as shown in **Table 6-6**.

6.4.2.2 Total Nitrogen

Estimates for atmospheric deposition of TN are based on results of a wet and dry deposition sampling conducted as an element of a water quality study for Newport Bay conducted in 2002-2004 (Meixner et. al. 2004). Results from this study showed that dry deposition accounts for most depositional load of TN, with seasonal average rates varying from 2 to 12 lbs/ac/yr (0.9 to 5.5 kg/ac/yr). The 2004 TMDL used a value of 7.1 lbs/ac/yr (3.2 kg/ac/yr) based on this study. No significant changes to atmospheric N deposition are expected nor is there any new regional data, therefore the same rates will be used in the TMDL revision. Table 6-6 shows the load allocation for TN in each lake segment.

Table 6-5. Load Allocations for Sediment Nutrient Flux

Lake Segment	Acres	Sediment Nutrient Flux ($mg/m^2/d$)		Load Allocation (kg/yr)	
		TP	TN	TP	TN
Canyon Lake (Main Lake)[1]	334	1.6	5.4	910	3,023
Canyon Lake (East Bay)	103	1.6	5.4	280	932
Lake Elsinore	3,000	1.7	26.2	9,503	128,315

[1] Includes North Ski Area, the portion of the Lake north of the causeway, but no sediment data has been collected to date to characterize flux rates from this zone.

Table 6-6. Load Allocations for Atmospheric Deposition

Lake Segment	Acres	Atmospheric Deposition Rate (kg/ac/yr)		Load Allocation (kg/yr)	
		TP	TN	TP	TN
Canyon Lake (Main Lake)[1]	334	0.05	3.23	17	1,077
Canyon Lake (East Bay)	103	0.05	3.23	5	331
Lake Elsinore	3,000	0.05	3.23	156	9,682

[1] Includes North Ski Area portion of Canyon Lake, north of causeway

6.5 Summary of Allocated Loads

6.5.1 Total for Point and Nonpoint Source Allocations

Table 6-7 presents the total allocated load, considering both point and nonpoint sources of nutrients, to each lake segment. These total loads are also shown by the major categories of nutrient sources contributing to the total load. **Table 6-8** compares these allocations with the 2004 TMDL, showing a reduced allowable loading with the reference watershed approach for TP and TN in all but the local Lake Elsinore watershed.

6.5.2 Consideration of Averaging Periods

The nutrient load from the reference watershed to each lake segment will vary significantly from year to year because of prevailing climate patterns. In southern California, annual rainfall is influenced by water temperature patterns in the Pacific Ocean, which cause most rainfall and runoff from the San Jacinto River watershed in 'El Nino' years and droughts with limited runoff to the lakes in 'La Nina' years. Thus, mass-based allocations of allowable nutrient loads cannot be imposed based on the expected nutrient load in a single hydrologic year. To address this reality, the existing 2004 TMDLs used a 10-year period to determine whether annual average nutrient loads are being reduced to allowable levels. This approach allowed for consideration of fluctuations in rainfall and runoff above and below the 10-year average in any given year. The same averaging period applied to the original TMDLs is used in the revised TMDLs.

Table 6-7. Summary of WLAs and LAs for Major Categories of Nutrient Sources to Each Lake Segment

Lake Segment	Wasteload Allocation (kg/yr)		Load Allocation (kg/yr)	
	TP	TN	TP	TN
Canyon Lake (Main Lake)				
Watershed Runoff	954	2,743	195	562
Supplemental Water	As needed		NA	
Atmospheric Deposition	NA		17	1,077
Sediment Nutrient Flux	NA		910	3,023
Canyon Lake (East Bay)				
Watershed Runoff	494	1,422	68	195
Supplemental Water	As needed		NA	
Atmospheric Deposition	NA		5	331
Sediment Nutrient Flux	NA		280	932
Lake Elsinore				
Watershed Runoff (Canyon Lake Overflows)	2,433	6,994	926	2,661
Watershed Runoff	687	1,974	107	309
Supplemental Water	4,198	12,069	NA	
Atmospheric Deposition	NA		156	9,682
Sediment Nutrient Flux	NA		9,503	128,315

Table 6-8. Comparison of Allocations Between the Proposed Revised TMDLs and Existing 2004 TMDLs

Total Allowable Loads	Total Phosphorus		Total Nitrogen	
	2004 TMDL	TMDL Revision	2004 TMDL	TMDL Revision
Main Lake	NA[1]	2,076	NA[1]	7,404
East Bay	NA[1]	848	NA[1]	2,880
Total Canyon Lake	8,691	2,924	37,735	10,284
Overflow from Canyon Lake to Lake Elsinore	2,770	3,358	20,774	9,656
Lake Elsinore	25,814	14,651	218,251	152,349

[1] NA = Not Applicable; 2004 TMDL established allocations for the entire Canyon Lake rather specific lake segments.

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Section 7

Implementation

The revision of the Lake Elsinore and Canyon Lake nutrient TMDLs includes implementation requirements designed to continue progress toward returning water quality to a reference condition for each lake segment. For almost two decades, a combination of watershed and in-lake controls have been implemented by individual organizations or through collaboration by multiple agencies. This section evaluates water quality improvements achieved from implementation of these controls and compares them with potential nutrient reductions from different sources to determine whether enhancements to existing measures and/or supplemental projects are needed for each lake segment to comply with WLAs and LAs or in-lake response targets established in the revised TMDL. Based on the outcome of this analysis, a TMDL implementation program was developed as described in the following sections:

- *Section 7.1 – Reasonable Assurance Analysis (RAA) Approach*: Implementation of water quality controls is needed to return each lake segment to a condition approximated for a reference watershed. This section provides the framework for demonstration of compliance with the revised TMDL through ongoing implementation of existing controls and incorporation of supplemental projects as needed. Specific measures of compliance are described in Section 9.

- *Section 7.2 – Review of Past and Present Water Quality Control Efforts*: Water quality control activities and studies have been ongoing in the San Jacinto River watershed for many years. The outcomes from these varied efforts have led to a comprehensive scientific understanding of the characteristics and dynamics of Lake Elsinore and Canyon Lake. This section summarizes findings from prior water quality studies and describes existing projects that have been implemented to date. In addition, the models developed for the TMDL's source assessment and linkage analysis (Sections 4 and 5, respectively) are used here to quantify expected load reductions and the in-lake water quality response from ongoing implementation of existing projects. Based on the outcome of this analysis, this section presents the scientific basis for estimating future water quality benefits that will be accrued from the continued implementation of existing water quality control efforts.

- *Section 7.3 – Supplemental Project Concepts:* The RAA shows that enhancements to existing controls or new supplemental projects may be needed in all three lake segments to meet the revised TMDL numeric targets. This section provides an overview of potential supplemental projects for water quality improvement that will be considered for implementation in the future as part of the development of TMDL implementation plans. Project concepts are described briefly and evaluated based on the type of benefits expected, applicability to each lake segment, technical feasibility, and order of magnitude cost. Additional cost information is provided in Section 11.

- *Section 7.4 - Program of Implementation:* This section describes the phased implementation framework that began with the adoption of the original nutrient TMDLs and continues under the revised TMDLs. Moving forward, the program of implementation includes a list of implementation actions, milestones for completion and entity (ies) responsible for their implementation. The program of implementation is intended to ensure continued application of existing water quality controls (modified as needed), timely implementation of supplemental projects (where needed), completion of targeted studies recommended to further validate the scientific basis for the TMDL revision, required revisions to existing waste discharge requirements and management plans, and execution of an appropriate surveillance and monitoring program.

7.1 Reasonable Assurance Analysis Approach

7.1.1 Framework

Implementation actions are required to return water quality in Lake Elsinore and Canyon Lake (Main Lake and East Bay) to conditions representative of a reference watershed condition. The TMDL numeric targets are expressed as CDFs of expected chlorophyll-*a*, DO, and total ammonia in each lake segment for a reference watershed condition (see Section 3.3). Multiple pathways exist to achieve a range of lake water quality in the future; however, two general strategies are being employed: either (1) reduction of external nutrient loads from the watershed to achieve WLAs and LAs and in turn response targets, or (2) implementation of water quality controls that directly affect the response targets in the lakes.

Figure 7-1 illustrates the two general implementation strategies employed to achieve water quality that meets the TMDL numeric targets. Existing and ongoing implementation activities for each lake and their respective watersheds have spanned both of these strategies, including (1) implementation of external nutrient controls; and (2) application of direct controls to manage algae, nutrients, oxygen, and/or hydrology within the lakes, where it is infeasible, impracticable or unreasonable to rely on source control as the primary water quality management tool.

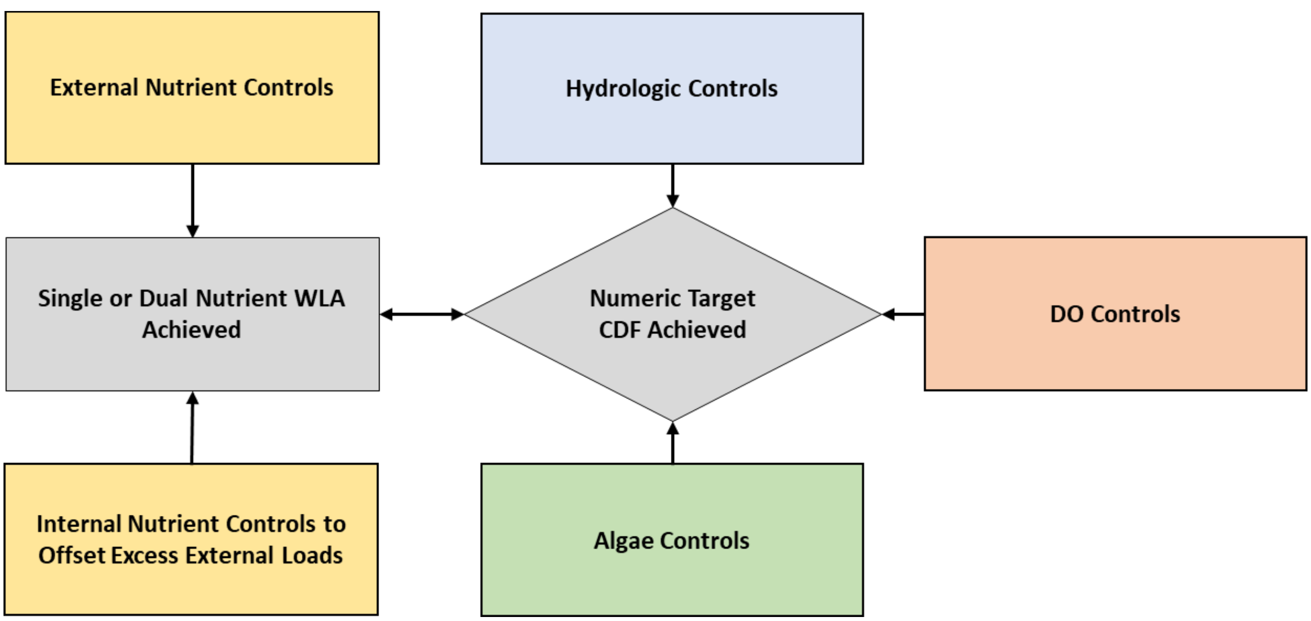

Figure 7-1. Alternative Pathways for Implementation Actions (colored boxes) to Achieve Compliance with TMDL Numeric Targets

7.1.2 Canyon Lake RAA Approach

Numeric targets have been developed separately for the Main Lake and East Bay portions of Canyon Lake (see Section 3.3.2). For both lake segments, the RAA compares current nutrient loads from the watershed (see Section 4) with allocations applicable to a reference watershed (see Section 6) to determine the excess nutrient loading to the lakes that should be reduced by either source controls or by offsetting internal loads. This nutrient mass-based RAA strategy is sufficient to prevent "excess algae growth" in Canyon Lake. Section 7.2.4.1 below establishes a nutrient-focused RAA for phosphorus in Canyon Lake as the means to estimate the amount of alum that may be applied to effectively reduce internal loads to offset watershed phosphorus loading in excess of the allowable allocation.

7.1.3 Lake Elsinore RAA Approach

For Lake Elsinore, the RAA must account for the collective benefit accrued from the implementation of multiple water quality control strategies that have been employed to improve water quality in the lake. For example, construction of the levee and the ongoing addition of reclaimed water collectively alter the natural hydrology of the lake. These water quality benefits are evaluated using the Linkage Analysis (see Section 5), which is comprised of lake water quality and hydrodynamic models equipped to evaluate the collective water quality benefit from different types of implementation strategies. The results of these analyses are expressed in the form of CDFs for response targets chlorophyll-a, DO, and ammonia.

7.1.4 Climate Change

Climate change predictions for the next 100 years estimate an increased frequency and duration of extended droughts and severity of extreme wet weather events in southern California (EPA and CDWR 2011). These predicted climate change impacts have the potential to influence water quality in Lake Elsinore and Canyon Lake as follows:

- Increased evaporative losses from the lake surface and associated stressors to water quality including water level decline and increased concentration of TDS.
- Warmer water temperatures and associated stressors including more rapid phytoplankton growth rates and a greater fraction of total ammonia that is in unionized form.
- More extreme wet weather events which may results in increased erosion of soil from the watershed and flooding on lakeshore and downstream waters.

The State Water Board adopted a resolution requiring consideration of potential climate change impacts in all Water Board actions (State Water Board 2017b). The resolution contains actions for the Water Boards to take to mitigate greenhouse gas emissions, prepare for and adapt to impacts of climate change, account for climate change in modeling and analysis, and provide for public education and engagement. Specific elements of this resolution that apply to the protection of beneficial uses in Lake Elsinore and Canyon Lake in the context of the revisions to the nutrient TMDLs include:

- Permitting of projects that develop new or underutilized water resources

- Addition of operational flexibility to build and enhance resilience to impacts of climate change
- Restoration and maintenance of healthy watersheds
- Reduction of vulnerability to catastrophic fires
- Reduction of vulnerability of water and wastewater infrastructure to flooding
- Account for and address impacts of climate change in permits, plans, policies, and decisions

Many of the existing water quality controls that are being implemented in Lake Elsinore and Canyon Lake support the implementation of these required elements of the above adopted resolution, e.g., addition of supplemental water to Lake Elsinore and forest land management activities. Water agencies in the San Jacinto River watershed are also implementing projects that support the resolution, including extensive water recycling for indirect potable reuse (IPR), capture of stormwater for groundwater basin recharge or direct delivery, and deployment of water conservation BMPs to levels that are achieving Senate Bill X7-7 requirements (California Legislature 2009; EMWD 2016; EVMWD 2016).

In addition, some of the potential supplemental projects that have been identified may also improve resiliency to climate change impacts, such as increases in reclaimed water deliveries to Lake Elsinore to maintain lake levels at 1,240 ft under all hydrologic conditions and EVMWD IPR (EVMWD 2017) to reduce reliance on imported water.

7.1.5 Adaptive Implementation

The process of "adaptive implementation" makes best use of scarce public resources and reduces the risk of unforeseen consequences by emphasizing incremental changes (LECL Task Force 2007). Future planning efforts may consider enhancements to existing projects, prioritization of water quality management efforts, and encouragement of additional technical studies. These planning efforts must also account for the timeframe required for in-lake controls to address legacy internal loads and potential impacts from climate change.

The RAAs for Lake Elsinore and Canyon Lake (Main Lake and East Bay) quantify the expected need for enhancements to existing projects or implementation of supplemental projects based upon the best available science regarding water quality benefits that may be expected in these highly dynamic, managed aquatic ecosystems. Additional studies may still be needed to improve current understanding of the science both in the watershed and in the lakes, including, but not limited to (1) water quality of runoff from undeveloped hillsides of the San Jacinto watershed, (2) role of rising TDS in zooplankton and algal population dynamics, (3) effectiveness of existing controls, (4) cyanotoxin occurrence and controllability, and (5) impacts of potential changes to the hydrology of upper watershed and Mystic Lake. The need for additional investigations in these areas or others will be considered as part of the program of implementation.

7.2 Review of Past and Present Water Quality Control Efforts

Numerous project planning studies have been completed for Lake Elsinore and Canyon Lake, especially since completion of the LEMP Project in the 1990s. This section provides a brief summary of the LEMP Project (see additional discussion in Section 2.2.2.3), an overview of the findings from key planning studies completed since implementation of LEMP, and a summary of existing water quality control efforts ongoing in the lakes and the watershed.

7.2.1 Lake Elsinore Management Plan

In the early 1980s new efforts were initiated to resolve concerns with Lake Elsinore's dynamic behavior which resulted in significant fluctuations in lake elevation and associated shoreline variability, flooding and water quality problems (Engineering-Science 1984). While LEMP was developed to address these concerns, Engineering-Science (1984) notes that the search for solutions had been the subject of evaluation for some time:

> *"The development and evaluation of options for the long-term solution to the problems associated with Lake Elsinore has been nearly a constant activity during the past two decades. In the 1960s, deep wells were installed to provided replenishment water to Lake Elsinore during periods of drought. In the early 1970s, plans for establishing a permanent lake were formulated. In the early 1980s, programs for minimizing flood damage were investigated following the disastrous floods in 1979 and 1980."*

The implementation of the LEMP project led to the construction of the levee on the southeast side of Lake Elsinore (see Section 2.2.2.3 and Figure 3-5). This project demarcates the decision to manage Lake Elsinore to maintain minimum water levels even during periods of extended drought when complete lakebed desiccation may have otherwise occurred under natural conditions (i.e., reference conditions as defined in Section 3.2.2). From a regulatory standpoint, the decision to construct LEMP supported efforts to preserve recreational use of the lake, regardless of the occurrence of natural wet and dry cycles. After LEMP construction water quality impairment concerns continued resulting in the development of a number of planning studies to evaluate options for implementation of additional water quality controls in the watershed. The findings from these studies and others are summarized below.

7.2.2 Overview of Previous Water Quality Planning and Management Efforts

Since the 1990s numerous water quality planning and management studies have been completed in the San Jacinto River watershed, including studies specific to the San Jacinto River watershed and Lake Elsinore and Canyon Lake. While the objectives and outcomes varied for each study, the primary focus of this work was to support efforts to identify and evaluate projects or BMPs designed to improve water quality in the watershed or lakes. **Table 7-1** provides a summary of the objectives and key findings from these studies. Projects implemented as a result of the findings from these studies are described in the next section.

Table 7-1. Summary of Lake Elsinore and Canyon Lake Water Quality Planning and Management Studies Since the 1990s

Study	Objectives	Relevant Findings
Lake Elsinore Water Quality Management Plan (SAWPA 1994)	▪ Define lake hydraulic features, including flows discharging into tributary rivers, points of stormwater runoff to the lake, and evaporation losses ▪ Conduct a year-long monitoring program to examine water quality in the lake and tributary rivers during wet and dry periods ▪ Compile data from the monitoring program and identify major nutrient processes in the lake during wet and dry periods ▪ Define baseline conditions, describing hydrologic conditions and lake water quality during wet and dry periods ▪ Define expected lake uses and establish appropriate water quality criteria to attain each use. ▪ Develop alternative plans to optimize conditions for Lake Elsinore during wet and dry periods	▪ Areas Evaluated – Three levels of reclaimed water addition (up to 8,500 AFY; up to 19,500 AFY; up to 30,000 AFY) with three different concentrations of effluent quality (0.05 mg/L TP; 0.5 mg/L TP; 3.5 mg/L TP) – Septic system management ▪ Key Findings: – Analysis of data collected in the early 1990s revealed several important lake water quality characteristics, including (1) taxonomic analysis confirmed algae were predominantly blue-green types; (2) very high TDS and pH coincide with dry conditions; (3) weak thermal stratification; and (4) sufficient SOD to create anoxic conditions throughout the lake bottom. – Identifies an achievable water quality target of 50-100 µg/L chlorophyll-a and 100-250 µg/L TP with implementation of an in-lake aeration system to control internal loads. Septic systems found to be an insignificant source of nutrients. – Plan suggests further consideration or piloting of a submerged macrophyte system in back basin for treatment of effluent prior to discharge, algae harvesting, and alum addition.
Restoration of Canyon Lake and Benefits to Lake Elsinore (Horne 2002)	▪ Evaluate potential benefits of in-lake water quality controls in Canyon Lake	▪ Water quality controls evaluated – Hypolimnetic oxygenation – Dredging – Mixing during de-stratified period using existing air compressor – Local wetland filtration – Biomanipulation by improving conditions for Daphnia, including hypolimnetic oxygenation and the selective removal of small fish ▪ Key Findings: – Recommendations included design and construction of Hypolimnetic Oxygenation System (HOS), pilot dredging, collection of additional sediment samples, and further estimation of benefits of mixing, biomanipulation, and offline wetlands
Lake Elsinore Nutrient Removal Study (LESJWA 2004)	▪ Adopt short-term and long-term water quality goals for Lake Elsinore and nutrient loading criteria to support lake water quality goals ▪ Evaluate treatment technologies for phosphorus removal in potential supplemental water sources ▪ Establish phosphorus removal efficiencies for treatment technologies ▪ Develop construction, capital, operation and maintenance costs for alternatives, and identify best alternative	▪ Nutrient removal options evaluated: – Supplemental water addition and enhanced effluent treatment – Back basin treatment wetlands ▪ Key findings: – Recommendations included recycling pump station to bring lake water to old San Jacinto River channel and through back basin treatment wetlands, capture of 8,500 AFY of supplemental water from island wells, and effluent from EVMWD and EMWD, and construction of additional chemical phosphorus treatment for effluent from EMWD.

Table 7-1. Summary of Lake Elsinore and Canyon Lake Water Quality Planning and Management Studies Since the 1990s

Study	Objectives	Relevant Findings
San Jacinto Nutrient Management Plan (SAWPA 2004)	Identify existing and planned nutrient controls and recommend additional projects	▪ Nutrient controls evaluated: – Lake Elsinore aeration – Canyon Lake aeration/destratification in deep water – Canyon Lake dredging in East Bay – Structural urban BMPs – Sewer and septic improvements – Interception and treatment of nuisance urban runoff – Riparian habitat restoration and development of agricultural buffers – Determination of crop-specific agronomic rates for guidance in fertilizer and manure application management – Assessment of nutrient loads to San Jacinto River watershed from flooding of agricultural areas – Regional organic waste digester ▪ This planning report supplemented the models developed to understand sources and allowable loads for the development of the 2004-adopted TMDL. No quantitative water quality benefit estimates were developed for the listed existing and potential projects.
Fisheries Management Plan for Lake Elsinore Riverside, County, California (LESJWA 2005a)	Objective of the study was to develop a fisheries enhancement and maintenance program that will create a balanced, self-sustaining and valued sport fishery that will complement the Lake Elsinore and San Jacinto Watershed Authority's lake water quality rehabilitation efforts."	▪ Study identified several factors that contribute to impairment of the fish community in Lake Elsinore: – Hypereutrophic (excessively productive and fertile) system; – High productivity contributes to algal growth, chemical imbalances and depletions, and conditions where only very tolerant aquatic species can exist; less tolerant species (for example, many sport aquatic fishes) cannot prosper in such a highly productive aquatic system. – To change the lake environment so that it will be more favorable to a sport fish community, the following factors must be addressed: (1) Lake level fluctuations; (2) Poor water quality; (3) Carp predation and competition; (4) Poor food supply; (5) Poor feeding conditions; (6) Poor habitat; and (7) Poor reproduction. ▪ To support a viable sport fish community, control of lake level fluctuations and poor water quality is critical; without control of these factors, management to improve other conditions will not be successful. ▪ Study identified five major enhancement objectives to address impairment and provide a reasonable framework for implementation: (1) carp control; (2) zooplankton enhancement; (3) aquatic and emergent vegetation restoration; (4) fish habitat improvement; and (5) fish community structure improvement. These objectives are listed in order of priority, e.g., without carp control, other objectives will not be attainable. Others may be implemented concurrently as they may be necessary to support other objectives (e.g., aquatic vegetation restoration is necessary for both zooplankton enhancement and fish habitat improvement).

Table 7-1. Summary of Lake Elsinore and Canyon Lake Water Quality Planning and Management Studies Since the 1990s

Study	Objectives	Relevant Findings
Lake Elsinore Stabilization and Enhancement Project, Final Program Environmental Impact Report (LESJWA 2005b)	▪ Project evaluated alternatives to: – Stabilize the water level of Lake Elsinore, by maintaining the lake elevation within a desirable operating range (minimum of 1,240 ft to a maximum of 1,247 ft msl) – Improve lake water quality – reduce algae blooms, increase water clarity, increase dissolved oxygen concentrations throughout the water column, and reduce or eliminate fish kills – Enhance Lake Elsinore as a regional aesthetic and recreational resource	▪ Proposed Project included following elements: – Supplemental water addition to Lake Elsinore for lake stabilization and enhancement – the proposed source of supplemental water to stabilize lake water elevations is reclaimed water from the EVMWD Regional Water Reclamation. – Nutrient removal facilities to reduce nutrient concentrations in discharges to the lake from the EMVWD facility, including: • Installation of facilities at EVMWD facility for chemical removal of phosphorus (near-term element) • Reconfiguration of a portion of existing wetlands in the Lake Elsinore Back Basin into treatment wetlands (long-term potential element) – Subsurface, diffused air in-lake aeration system – The proposed aeration system included aeration buildings (compressed air facilities) at the north and south sides of the lake, from which piping would extend onto the lake bottom and bubble air into the water column. This subsurface aeration system was envisioned to supplement the surface axial flow pump aeration system already in place in the lake.
In-Lake Nutrient Reduction Plans (LECL Task Force 2007)	Develop implementation plan to meet the 2004 TMDL numeric targets in Lake Elsinore	▪ Implementation Plan Elements: – Phase 1: • Lake level stabilization with levee and reclaimed water additions • Destratification with axial flow pumps • Large scale in-lake aeration system • Fishery management including carp netting and stocking of sport fish to control shad population – Phase 2: Supplemental projects – if needed • Enhanced aeration system - more frequent operation or additional pipelines/aerators • Enhanced treatment of reclaimed water to < 0.5 mg/L • Direct application of alum or other chemical P treatment • Targeted suction dredging • Constructed wetlands in back basin • Active aquatic plant management • Enhanced fishery management • Enhanced lake stabilization (groundwater or reclaimed water) ▪ Key Findings – Continued monitoring recommended to determine whether a supplemental Phase 2 project would be needed. – Additional special studies recommended including (1) in-lake measurements of sediment organisms as a living sink for nitrogen; (2) estimation of sediment denitrification as an atmospheric sink for nitrogen; and (3) in-lake samples of nitrogen fixing potential of lake as source for nitrogen.

Table 7-1. Summary of Lake Elsinore and Canyon Lake Water Quality Planning and Management Studies Since the 1990s

Study	Objectives	Relevant Findings
Integrated Regional Watershed Management Plan for the San Jacinto River Watershed (San Jacinto River Watershed Council 2007)	San Jacinto River Watershed stakeholders identified 10 resource management strategies and associated sub-objectives. The 10 strategies included: ▪ Improve surface and ground water quality ▪ Ensure the long-term viability of water supplies ▪ Provide adequate stormwater and flood control ▪ Protect, enhance and create habitat for wildlife ▪ Manage land use to protect natural resources and watershed character ▪ Promote water recycling ▪ Expand water conservation programs ▪ Enhance opportunities for parks, recreation and open space ▪ Weigh environmental justice concerns in watershed decision-making ▪ Explore opportunities to address climate change issues in watershed projects	▪ 110 water management projects were submitted for inclusion in the Plan. These projects (conceptual and ready for implementation) ranged from localized to watershed-wide with estimated costs ranging from $40,000 to more than $500 million. The broad range of projects span the resource management strategies and address a variety of the watershed challenges described in the report. Of the projects submitted, 95 percent address more than one of the plan's resource management strategy, and nearly 54 percent addressed four or more strategies. ▪ The San Jacinto River Watershed Council will take a lead role in implementation of the Plan ▪ The Plan is a "living" documents that will guide watershed priorities and objectives; it will be updated every five years or earlier if necessary.
San Jacinto Watershed Integrated Regional Dairy Management Plan (San Jacinto Basin Resource Conservation District 2009)	Develop an integrated regional plan for the dairy industry in the San Jacinto River watershed to address regulatory requirements and issues of concern for dairy operators	▪ Key elements of the plan: – Manure Manifest System to track manure generation, transport and use in the watershed – Management practices including: source reduction, manure export, structural BMPs, and specialized salt/nutrient load reduction practices, such as a Vibratory Shear Enhanced Processing system – Reclamation of manure nutrients for crop production within the watershed – Implement practices on a watershed scale, such as treatment of raw manure and wastewater, a regional digester, a centralized/cooperative composing facility, an organized manure export operation, cooperation with EMWD on salt issues, coordination with Santa Ana Water Board to develop a nutrient management plan template ▪ Additional findings: – The use of manure in agricultural operations is not regulated under the CAFO permit. The impact of manure spreading practices in the San Jacinto River watershed on downstream watershed loads was not quantified in this plan. Various control strategies to manage all manure in the watershed were considered in this plan. Ultimately, the spreading of manure within the watershed was prohibited resulting in exportation from the watershed

Table 7-1. Summary of Lake Elsinore and Canyon Lake Water Quality Planning and Management Studies Since the 1990s

Study	Objectives	Relevant Findings
Assessment of Best Management Practices to Reduce Nutrient Loads (UCR 2011)	Overall objective was to determine, demonstrate, and compare selected BMPs for mitigating nutrient movement caused by rainfall/irrigation runoff from citrus orchards, dryland winter wheat fields, vegetable row crop fields, and turf grass; and to develop a comprehensive nutrient management manual for the watershed	▪ Conducted a field studies over three wet seasons in the san Jacinto River watershed to evaluate various BMPs ▪ Effective BMPs for reducing nutrients in runoff were found to be in place; researchers did not observe problems being caused by runoff from the fields of growers. ▪ Specific outcomes included: – All selected agricultural BMPs were found to be effective in reducing nitrogen and phosphorus carried by storm/irrigation generated runoff; – Outreach education to residents and golf course professionals about turf-related BMPs and their value; and – Informed growers and stakeholder groups about agricultural BMPs and their value。 ▪ Load reductions were quantified from the adoption of BMPs in citrus, dryland wheat and vegetables, and it was demonstrated that these BMPs are effective in reducing nutrient loads to surface waters.
Comprehensive Nutrient Reduction Plan (CNRP) (RCFC&WCD 2013)	Develop an implementation plan for MS4 permittees to reduce urban watershed runoff loads to meet WLAs or meet in-lake numeric response targets. Analysis included the findings from Anderson (2012d) that showed that Canyon Lake would not meet chlorophyll-*a* targets even if watershed runoff met the WLA and LA established in the 2004 TMDL.	▪ CNRP implementation elements – Watershed-based BMPs – Ordinance development – Street sweeping – Low impact development – Septic system management – Public education and outreach – Canyon Lake in-lake remediation projects: (a) Alum additions; (b) HOS – Lake Elsinore in-Lake remediation projects: (a) LEAMS; (b) Fishery management ▪ Additional considerations: – The CNRP includes a quantitative analysis to demonstrate the expected compliance with the 2004-adopted TMDL once implemented: • Canyon Lake - Compliance analysis involved use of a DYRESM-CAEDYM model of lake water quality to show how combination of watershed BMPs and planned alum additions would result in water quality conditions that meet the numeric targets for chlorophyll-a and make significant progress toward bringing DO levels to an estimated natural background condition (Anderson 2012d). • Lake Elsinore - Compliance demonstrated by reducing (with watershed BMPs) or offsetting (with in-lake controls) nutrient loads from urban and septic sources to meet WLAs. – CNRP described the importance of adaptive implementation, with an iterative process of ongoing implementation of BMPs/in-lake remediation projects and monitoring to assess progress and consider modifications.

Table 7-1. Summary of Lake Elsinore and Canyon Lake Water Quality Planning and Management Studies Since the 1990s

Study	Objectives	Relevant Findings
Agricultural Nutrient Management Plan (AgNMP) WRCAC (2013a)	Develop an implementation plan for agricultural operators to reduce urban watershed runoff loads to meet WLAs or meet in-lake numeric response targets	▪ AgNMP implementation elements: – Watershed-based BMPs – Manure management – Cover crop – Tilling practices – Soil binders – Canyon Lake in-lake remediation projects: • Alum additions • HOS – Lake Elsinore in-lake remediation projects: • LEAMS • Fishery management ▪ Additional considerations: – The AgNMP includes a quantitative analysis to demonstrate the expected compliance with the 2004-adopted TMDL once implemented. The AgNMP was developed in parallel with the CNRP and employs the same tools for demonstration of expected compliance (see above).
Mystic Lake Studies (Hamilton and Boldt 2015a and 2015b)	Re-evaluate potential contribution of nutrients to Canyon Lake from non-point sources located in the eastern San Jacinto River subwatersheds, represented by Zones 7, 8, and 9 (see Section 4).	▪ Hydrologic changes throughout the watershed, both ongoing and historic, make existing TMDL wet year accounting and prediction erroneous. Defining a wet hydrologic scenario—that is, years when Mystic Lake overflows—based on the outflow from Canyon Lake results in an unnecessary financial burden on stakeholders in the zones upstream of Mystic Lake. ▪ In the future, changes in Mystic Lake storage capacity as well as land use changes and water management practices, will change the amount and pattern of precipitation runoff and infiltration. The likelihood of Mystic Lake overflowing decreases every year due to hydrologic changes in the watershed and, therefore, diminishes responsibility for stakeholders in subwatershed Zones 7, 8, and 9.
San Jacinto River Watershed Land Use Projects (WRCAC 2008, 2011, 2012, 2015a, 2018a; San Jacinto River Watershed Council 2015)	Periodic updates to the land use dataset for the entire San Jacinto River watershed, including the Lake Elsinore and San Jacinto Mountain Regions.	▪ These reports document changing land use in the San Jacinto River watershed and provide a foundation for the development of the revised TMDLs. ▪ Originally focused on only agricultural land uses within the watershed, the 2014 analysis (WRCAC 2015a) was performed for the entire watershed.

7.2.3 Review of Existing Water Quality Control Activities

7.2.3.1 Overview

Stakeholders in the San Jacinto River watershed have actively planned and implemented watershed and in-lake water quality controls since the 1980s beginning with the LEMP project and followed by a diverse set of projects in the watershed and in each lake. Currently, the LECL Task Force or its member agencies implement BMPs, oversee operations required for many existing water quality controls, direct routine watershed and in-lake monitoring, and conduct important water quality studies to assess the effectiveness of existing controls. The various watershed and in-lake management activities are discussed below.

7.2.3.2 Watershed Best Management Practices

MS4 permittees in Riverside County within the San Jacinto River watershed have been implementing BMPs within their respective jurisdictions as part of the implementation of the CNRP (RCFC&WCD 2013). The agricultural community is also actively implementing BMPs through requirements established in the CWAD (Santa Ana Water Board 2017), which includes implementation of an AgNMP (WRCAC 2013a) and the General Waste Discharge Requirements for CAFOs applicable to the area (Santa Ana Water Board 2013c). The subsections below describe the existing water quality control activities that are being implemented under these various programs and the water quality benefits provided with regards to nutrient load reductions. Estimates of existing watershed runoff loads from jurisdictions in the watershed were developed using a simple model (see Section 4.1.4.3) that computes downstream annual nutrient loads as a function of average annual runoff and generalized land use nutrient washoff concentrations over spatially lumped jurisdictional areas. Reductions in loading from the MS4 program or agricultural BMPs deployed at varying levels by each jurisdiction were not accounted for in the estimation of jurisdictional loads for the revised TMDLs. It is anticipated that the CNRP and AgNMP updates (see Section 7.4.2.3) will assess the effectiveness of existing watershed BMPs and focus plans for future load reductions in areas that are not already being treated by existing controls.

MS4 Program

The Riverside County MS4 program is currently implementing the following BMPs within the portions of the San Jacinto River watershed subject to the LECL TMDL:

- *Street Sweeping and Debris Removal* - Street sweeping and MS4 facility debris removal activities reduce a significant source of nutrients in urban environments. Nutrient load reductions from street sweeping and debris removal activities were included in the CNRP compliance analysis. A continuous simulation model of exponential pollutant buildup and washoff was employed to estimate the nutrient load reduced as a result of street sweeping and debris removal program implementation (RCFC&WCD 2013). The model provides an estimate of 0.15 kg/yr TP and 0.5 kg/yr TN of nutrient load avoided for every metric ton of sediment removed from streets or drains by the MS4 program.

  Assuming these programs continue to be implemented at similar levels in the future, reductions in watershed loads are considered existing controls and reflective of current conditions (as reported in RCFC&WCD 2013) (**Table 7-2**). MS4 permittee jurisdictions may enhance existing programs to yield significant increases of sediment removal from street sweeping, catch basin cleaning, or other measures. If implemented, increased sediment removal from the estimates reported in Table 7-2 (see RCFC&WCD 2016 for jurisdiction specific sediment removals) would be accounted as a load reduction credit toward meeting the WLAs in the revised TMDLs.

Table 7-2. Existing Watershed Load Reduction from Street Sweeping and MS4 Facility Debris Removal by MS4 Permittees

Drainage Area	Sediment Removal (Metric Tons/yr)		Nutrient Load Reduction	
	Street Sweeping	Catch Basin Cleaning	TP (kg/yr)	TN (kg/yr)
Canyon Lake Main Lake - San Jacinto River[1]	540	3,712	638	2,126
Canyon Lake East Bay – Salt Creek[1]	1,553	142	254	848
Local Lake Elsinore	883	299	177	591

[1] Nutrient load reduction credit is apportioned to RAAs for Canyon Lake and Lake Elsinore in overflows from Canyon Lake

- *Septic System Management* - Properly functioning septic leachfields capture and treat nitrogen and phosphorus in residential sewage within the vadose zone prior to reaching saturated groundwater or lateral discharge to surface waters. Malfunctioning septic systems in the San Jacinto River watershed are a potential source of nutrients to the downstream lakes. Given that there are 4,000 septic systems dispersed throughout the watershed and using a potential failure rate of 30% (SAWPA 2003), the potential exists for a significant number of failing systems.[1]

  An empirical approach (based on observations) was used to approximate nutrient loads attributable to failing septic systems. During six runoff events between 2001-2004, multiple grab samples were collected at a site downstream of the Quail Valley unsewered residential neighborhood (RCFC&WCD Station 834). These water quality data were compared with data from samples collected from the same period at a nearby site just downstream of a sewered residential watershed (Sunnymead Channel - RCFC&WCD Station 316) to estimate the incremental difference attributable to septic systems (**Table 7-3**). For an unsewered residential land area with an estimated average annual runoff of 1.22 in/yr, a nutrient reduction credit of 0.01 kg/ac/yr TP and 0.30 kg/ac/yr TN was estimated for watershed acres converted from unsewered to sewered by replacing neighborhoods on septic with sewer service.

[1] The Santa Ana Water Board established a moratorium on septic systems in the Quail Valley area in 2006 (Santa Ana Water Board 2006b).

Table 7-3. Estimate of Load Reduction Achieved with Elimination of Septic Systems

Variables	Phosphorus	Nitrogen
Unsewered Residential (RCFC&WCD Station 834)	0.59	5.30
Sewered Residential (RCFC&WCD Station 316)	0.48	2.93
Septic Signal (Unsewered – Sewered)	0.11	2.37
Runoff (in/yr)	1.22	1.22
Load Reduction (kg/ac/yr)	0.01	0.30

- *Structural BMPs in New Development Water Quality Management Plans (WQMP)* – Section XII of the 2010 MS4 permit includes requirements for certain development projects to manage stormwater with post-construction BMPs (Santa Ana Water Board 2010). Thus, as urban development in the San Jacinto River watershed continues, new stormwater BMPs will be implemented that are expected to reduce downstream nutrient loads to Lake Elsinore and Canyon Lake from current levels.

  The net reduction of nutrient loading to the downstream lakes because of a development project incorporating stormwater BMPs must account for the predeveloped condition of a site. For example, if a project involves redevelopment of an existing commercial property, there will be a net reduction in load from site modernization and stormwater capture. Conversely, if the project site was previously undeveloped, then there may be an increase or decrease in nutrient load after accounting for both increases in nutrient washoff and increases in runoff capture within stormwater BMPs.

  Generally, projects that incorporate infiltrating stormwater BMPs will provide a net reduction in nutrient loads to downstream lakes by way of eliminating ~80 percent of runoff volume and associated nutrients that would otherwise be mobilized regardless of the pre-existing land use. The CNRP update will include a tool for tracking and reporting deployment of existing and future development WQMP projects to facilitate proper accounting of nutrient load reduction credits by subwatershed zone needed to support compliance demonstrations (see Section 7.4.2.3).

Agricultural Lands

WRCAC has been implementing various programs and studies to support the reduction of nutrient loads from agricultural lands in the watershed. This work has been documented through periodic organization reports (WRCAC 2010, 2014, 2015b, 2016, 2018b) and findings from various watershed-related studies (e.g., Hamilton and Boldt, 2015a, 2015b; UCR 2011; and WRCAC 2013c). In addition, as noted in Table 7-1, WRCAC has overseen efforts to regularly update agricultural land use data for the watershed (San Jacinto River Watershed Council 2015; WRCAC 2008, 2011, 2012, 2015a, 2018a). The outcomes from these efforts have provided critical input to the AgNMP and CWAD as described below.

The CWAD requires agricultural operators in the San Jacinto River watershed to "implement reliable and effective Management Measures and Management Practices, collectively termed

BMPs, to control minimize or eliminate pollutant discharges from their agricultural operations to surface and ground waters of the State" (Santa Ana Water Board 2017). WRCAC voluntarily developed an AgNMP in 2013 to identify early actions that may be taken pending development of the CWAD and the revised TMDLs (WRCAC 2013a). BMPs included in the AgNMP, that are consistent with the CWAD requirements and serve to reduce nutrient loads to the downstream lakes, include elimination of all manure spreading in the watershed, implementation of vegetative buffers, use of cover crops during wet season, and on-site runoff retention using berms or levees on fields.

A study of alternative agricultural land BMPs by UCR (2011) provided a basis for AgNMP estimates of projected reductions in nutrient washoff from irrigated and non-irrigated croplands, and orchard/vineyards. The study showed that BMPs such as vegetative buffers, cover crop, soil binders, or mulching can reduce TP and TN by 33-59 percent in runoff from agricultural fields. When the AgNMP was developed in 2013, the analysis projected that 100 percent of parcels subject to the CWAD would incorporate BMPs by 2020.

The UCR agricultural field scale experiments and associated load reduction projections in the AgNMP did not account for reductions in runoff generation that may be achieved with well managed irrigated agricultural fields. The Natural Resources Conservation Service is currently investigating the extent to which increases in soil organic matter (SOM) from irrigation and use of cover crops can increase infiltration of runoff and percolation to groundwater, thereby reducing overland flow runoff (NRCS 2017). In the San Jacinto River watershed, soil samples collected from agricultural fields contained 1.9 to 3.4 percent SOM (Kieser and Associates 2017). As of the development of this TMDL revision, a NRCS Conservation Innovation Grant (CIG) for the San Jacinto River watershed is underway to collect additional data needed to compare SOM in irrigated agricultural fields with non-irrigated agriculture and undeveloped lands. If runoff generation is shown to be less than a reference watershed, then future updates to the AgNMP may quantify load reductions from farming practices that increase SOM. The CIG study is also collecting information on spatial variability and management factors that influence nutrient concentrations in agricultural field soils that could be mobilized to the downstream lakes.

Dairies (aka Confined Animal Feeding Operations or "CAFOs")

Dairy operators have an NPDES permit which requires strict adherence to manure management practices including: recordkeeping, annual reporting and compliance with the TMDL (Santa Ana Water Board 2013c). Nutrient Management Plans are also required for dairies growing forage crops for their farms. The CAFO permit has provisions prohibiting discharge in all but the most extreme storm events (e.g., a 24-hr storm expected to occur no more than approximately once every 25 years). Importation of manure into the watershed from outside the San Jacinto River watershed is now prohibited. In addition, nearly all of the dairies are located in an area of the watershed upstream of Mystic Lake. Discharges from these dairies rarely make it all the way down to Canyon Lake or Lake Elsinore, except in the most extreme El Niño winters when Mystic Lake overflows into the San Jacinto River (see Section 4.1.3.4 for discussion of influence of Mystic Lake).

In 2007, WRCAC completed a comprehensive review of dairy management practices, available technologies and BMPs in the San Jacinto River watershed (San Jacinto Basin Resource

Conservation District 2009). Many of the best practices identified during that review were subsequently implemented at a number of other dairies in the region. A good example of a cost-effective BMP is "backhauling" - a practice of trucking manure out of the watershed and bringing feed back to the farm (usually from the same source). In 2000, only two dairies hauled manure out of the watershed. Today, most manure generated by local dairies is hauled out of the San Jacinto River watershed. Detailed data is currently being developed to demonstrate this condition. The Scott Brothers Dairy Farm has invested in a multi-million-dollar gasification project which creates Biodiesel SynFuel and biochar (Risk Sciences 2016). The project has been funded through various grants and the Scott Brothers. The treatment system for the project, which received the 2016 Nutrient Challenge Honoree Award from EPA, is designed to remove 98% of Total Suspended Solids (TSS), 40% of TDS, 90% of the Phosphorous, 67% of the Nitrogen, and 40% of the Potassium from dairy wastes retained on site.

Watershed Monitoring Activities

Watershed monitoring data for inflows to the lakes were used to estimate current (2011-2017) nutrient loads to the lake segments. This approach facilitated current loading estimates that capture water quality improvements in the upstream drainage areas from implementation of watershed BMPs deployed since the adoption of the 2004 TMDL. Notable changes to nutrient concentrations were detectable for some of the downstream monitoring stations when parsing the data from 2001-2010 and 2011-2017 (**Table 7-4**). These changes may reflect benefits achieved from the deployment of watershed BMPs, assumed to be more extensively implemented following the adoption of the 2010 MS4 permit (Santa Ana Water Board 2010).

Table 7-4. Change in Median Total Phosphorus and Total Nitrogen Concentrations in Monitored Events from Before and After 2010-2011 Wet Season

Period	San Jacinto River at Goetz Road		Salt Creek at Murrieta		San Jacinto River near Elsinore (Canyon Lake Overflow)	
	TP (mg/L)	TN (mg/L)	TP (mg/L)	TN (mg/L)	TP (mg/L)	TN (mg/L)
Median (Pre-2011)	0.68	2.93	0.62	2.68	0.46	1.95
Median (Post-2011)	0.73	2.22	0.39	2.12	0.46	1.78
Difference	+ 0.05	- 0.71	- 0.22	- 0.56	--	- 0.17
Percent Change	+ 7.4%	- 24.2%	- 37.1%	- 20.9%	0%	-8.7%

[1] Nutrient load reduction credit is apportioned to RAAs for Canyon Lake and Lake Elsinore in overflows from Canyon Lake

With regard to the observations in the San Jacinto River at Goetz Road monitoring site, the apparent increase in the median TP concentration should not be interpreted as a lack of improvement (Table 7-4). Assessment based on downstream concentration alone does not account for load reduction because of increased volume retention in stormwater BMPs. Other factors such as changing land use and soil erosion from burned undeveloped hillsides may have yielded even higher post-2011 nutrient concentrations without any deployment of watershed BMPs. Other factors such as changing land use and soil erosion from burned undeveloped hillsides may have yielded even higher post-2010/11 wet season nutrient concentrations without any deployment of watershed BMPs. For example, RCFC&WCD collected samples from the undeveloped portion of the Ortega Channel drainage area in the 2014-15 wet season following the Falls Fire in August 2013. Results showed TP and TN concentrations over one orders of magnitude greater than measured in an experimental forest in Colorado (**Table 7-5**). Thus, forest land management by the US Forest Service to prevent and contain fires may be an important nutrient control measure in the San Jacinto River watershed.

Table 7-5. Comparison of Nutrient Concentration from Undeveloped Ortega Canyon Burned Drainage Area with Ecoregion 2 Western Forest Sites[1]

Site	TP (mg/L)	TN (mg/L)
Western Forests[1]	0.11	0.66
Ortega Canyon	5.81	12.24

[1] Average concentration from Western Forests in Ecoregion 2 (Santa Ana Water Board 2004c)

7.2.3.3 In-Lake Best Management Practices

Several existing in-lake BMPs have been working to accrue water quality benefits since adoption of the 2004 TMDL. In-lake water quality data analyses have evaluated the effectiveness of these controls on water quality in the lakes (Risk Sciences 2016; Horne 2015, 2018). These analyses generally have concluded that water quality improvements have been achieved; however, the post-implementation period is insufficient to develop representative CDFs to assess progress toward compliance with in-lake response targets. In the interim, progress toward achieving CDF numeric targets is estimated with the Linkage Analysis lake water quality models. The sections below provide specific effectiveness assessments for in-lake water quality control projects.

Canyon Lake Activities

Alum addition, an in-lake nutrient control BMP, has been implemented in Canyon Lake since 2013. When added to water, alum forms an aluminum hydroxide floc, which then binds with phosphorus in the water column and settles to the lake bottom. Once on the lake bottom, any remaining binding capacity is used to sequester a portion of phosphorus in porewater. The portion of phosphorous bound with aluminum on the lake bottom is inert and insoluble. It is no longer available for cycling back to the water column by processes of desorption and diffusive flux.

The LECL Task Force, with partial support from a Proposition 84 grant, implemented a pilot project to demonstrate the efficacy of alum addition for reducing bioavailable phosphorus as an algae control strategy in Canyon Lake. To satisfy California Environmental Quality Act (CEQA) requirements, a review of the planned project was completed in the summer of 2013. Carefully controlled doses of alum have been applied via surface spreading twice per year in Canyon Lake since September 2013 (**Table 7-6**).

Table 7-6. Dates of Alum Application and Kilograms of Dry Alum Applied by Lake Segment since September 2013

Date	Main Lake	East Bay	North Ski Area	Total
9/15/2013	140,000	50,000	0	190,000
2/10/2014	70,000	50,000	0	120,000
9/22/2014	140,000	50,000	0	190,000
4/9/2015	0	50,000	0	50,000
9/8/2015	169,900	42,100	0	212,000
5/9/2016	80,300	50,700	11,200	142,200
9/26/2016	142,000	35,800	8,400	186,200
2/22/2017	80,600	51,400	11,300	143,300
9/25/2017	131,600	28,700	7,000	167,300
2/12/2018	72,300	37,800	8,800	118,900
Total Kilograms (through February 2018)	**1,026,700**	**446,500**	**46,700**	**1,519,900**

Routine water quality monitoring is performed at four lake stations before and after each alum application. Two of the sampling sites are located in the main body of Canyon Lake and two are located in the East Bay. **Figure 7-2** shows the decline in TP concentrations at all stations immediately following each alum application. Since December of 2014, samples collected in Canyon Lake – Main Lake show that phosphorus concentrations are consistently at or below 0.1 mg/L, with exception of the spring 2017 application which effectively reduced water column TP from 0.77 mg/L to 0.24 mg/L in Main Lake and from 0.83 mg/L to 0.14 mg/L in East Bay. The binding capacity in this event was not observed in the first seven events because TP concentrations were low prior to alum addition, partially caused by the extended drought. In such cases, most of the alum floc that settles to the lake bottom continues to bind porewater phosphorus. This is apparent from sediment nutrient samples collected in 2014 after the first four alum applications in Canyon Lake, which showed a significant increase in aluminum bound phosphorus and a decline in mobile (labile and iron bound) partitions (**Figure 7-3**).

For waters with pH between 6-8, the binding capacity of alum floc was estimated based on a ratio of 150 parts alum for every 1 part of sequestered phosphorus, which is conservatively high relative to ranges reported for other lakes (Huser 2012; Little St. Germain Lake Protection and Rehabilitation District 2009; Berkowitz et al. 2006; Rydin et al 2000). The RAA for Canyon Lake estimates average annual TP reduction achieved from alum additions, separately to Main Lake and East Bay, to assess whether current TP loads in excess of WLAs and LAs are effectively offset by reductions achieved within Canyon Lake (see Section 7.2.4.1 below).

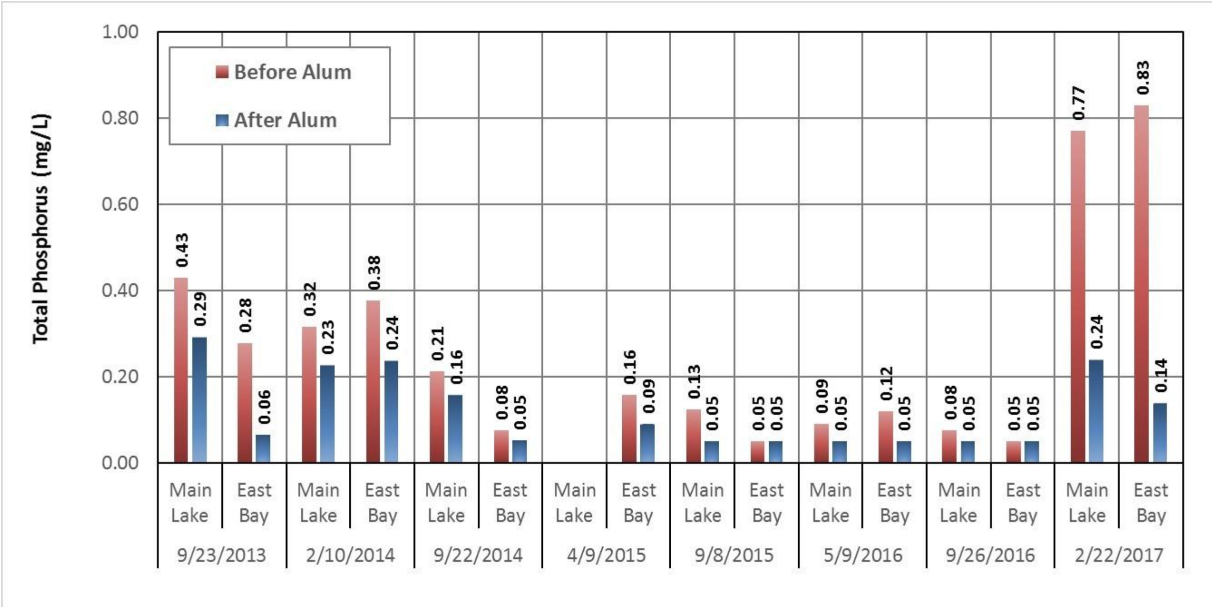

Figure 7-2. Depth-Integrated Total Phosphorus Concentration in Canyon Lake Before and After Alum Applications

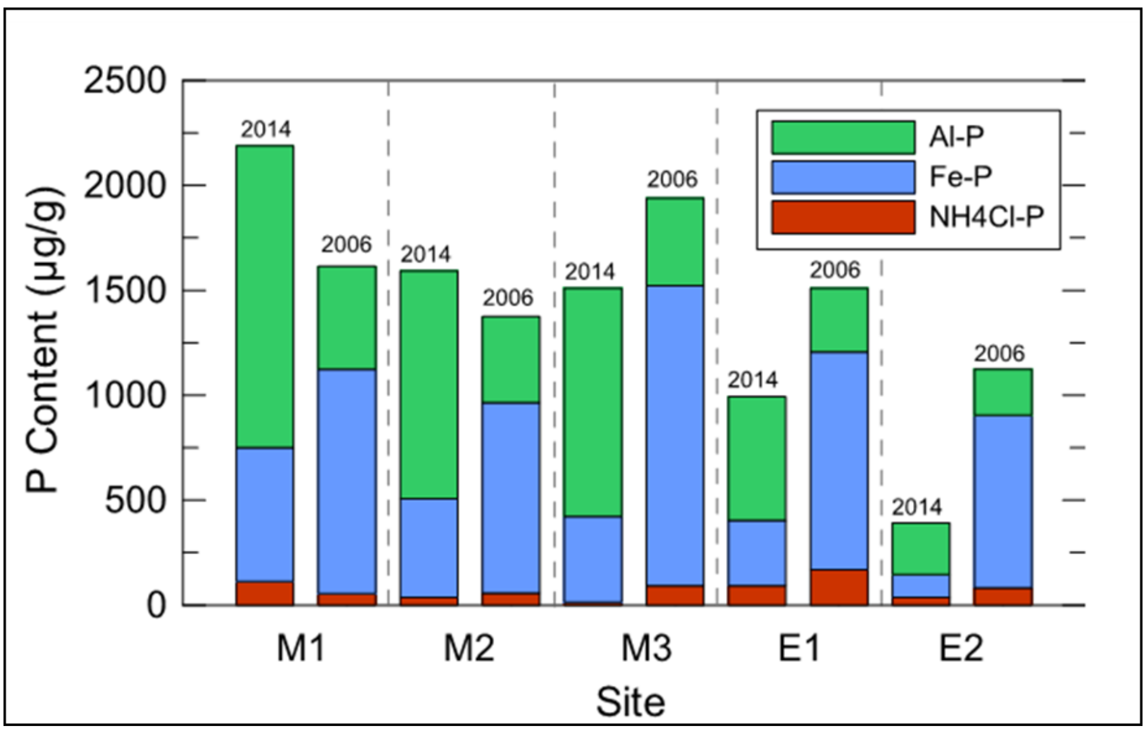

Figure 7-3. Comparison of Canyon Lake Bottom Sediment Samples Showing Changing Partitions of Phosphorus (Figure from Anderson 2016f) (M = Main Body; E = East Bay)

Lake Elsinore Activities

For more than 10 years multiple in-lake BMPs have been implemented to improve water quality in Lake Elsinore:

- Lake Elsinore Management Project (LEMP)
- Supplemental water addition
- Lake Elsinore Aeration and Mixing System (LEAMS)
- Fishery management

The collective water quality benefits from each of these projects, which serve as the basis for the RAA for Lake Elsinore, are estimated using the Linkage Analysis lake water quality models (see Section 5).

Lake Elsinore Management Plan (LEMP)

According to the Environmental Assessment for the LEMP project, the construction of a levee to reduce the surface area of the lake would serve to improve water quality as well as provide sustained recreation opportunities (Engineering-Science 1984, see Table 2-6). A managed lake condition was created when the levee was constructed. Construction of a levee was intended to provide better protection of the recreational and aquatic life beneficial uses than would otherwise occur under natural reference conditions.

The location of the levee within Lake Elsinore constrains the relationship between volume and surface area when the lake elevation exceeds ~1,240 ft and maintains the same hypsography as the historical lake basin at an elevation below 1,240 ft (see Figure 5-2). As a result, the levee today only provides water quality benefits when water levels are above 1,240 ft (**Figure 7-4**). In conjunction with supplemental water addition, the levee is a key component to a managed lake condition by helping to maintain lake levels at or above 1,240 ft in all hydrologic years by reducing the surface area that would otherwise be subject to increased evaporative losses.

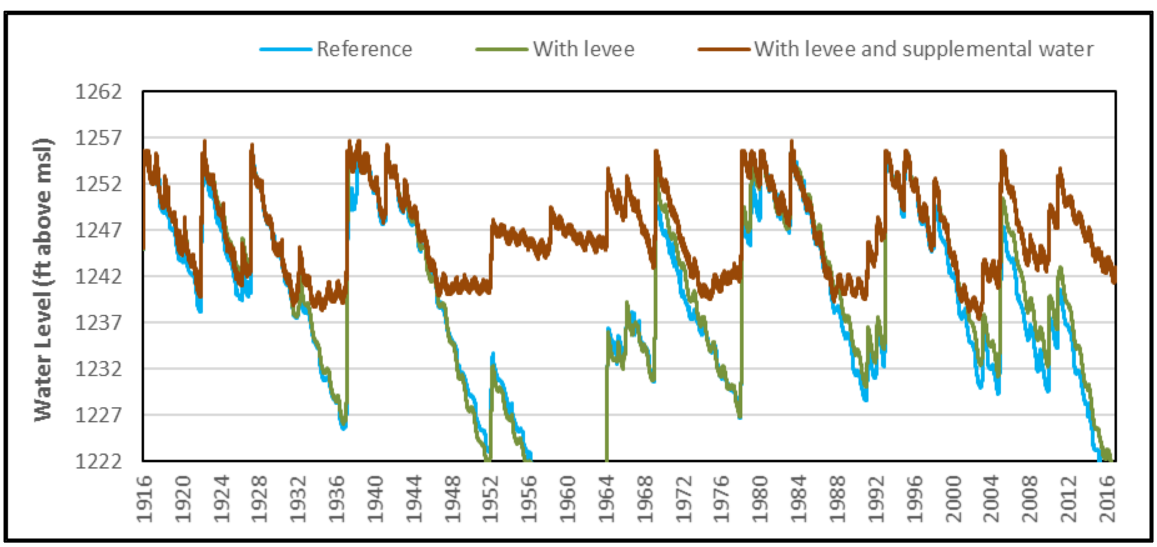

Figure 7-4. Lake Elsinore DYRESM-CAEDYM Model Results for Lake Levels Given 1916-2016 Hydrology, for Conditions with and without the Presence of the Levee, and with Additions of Supplemental Water

Addition of Supplemental Water

While the implementation of LEMP was expected to stabilize lake water levels and improve water quality, variations in the lake level and water quality can still be substantial in Lake Elsinore. This is partly due to the location of the levee (described above), climate patterns, but also as a result of runoff retention within Canyon Lake. The construction of Railroad Canyon Reservoir (completed in 1929) had the potential to significantly impact downstream Lake Elsinore, especially given that 90 percent of Lake Elsinore's drainage area is upstream of Canyon Lake. This was the subject of the Tilley Agreement in 1927[2] and Fill and Operate Agreement in 1991.[3] These agreements were superseded by the 2003 agreement between the City of Lake Elsinore and EVMWD, which requires EVMWD to maintain water levels in Lake Elsinore at 1,240 ft in order to divert water from Canyon Lake for municipal drinking water supply.[4] Water is diverted from Canyon Lake rather than Lake Elsinore to assure the quality of water required to meet the MUN beneficial use is met. If the water were allowed to flow downstream to Lake Elsinore and commingle with the high TDS water in Lake Elsinore, it would be too salty (often > 2,000 mg/L TDS) to support the MUN use.[5]

Since 2002, EVMWD has provided supplemental makeup water to maintain lake levels in Lake Elsinore. Sources of supplemental water include EVMWD's highly treated reclaimed water (~95 percent of total supplemental water) and production from non-potable wells on islands in the lake (~5 percent of total supplemental water) (see Table 4-10).

The lake model assumes reclaimed water will be discharged at 7.5 million gallons/day (mgd) on all days (1916-2016) when the lake levels dropped below 1,240 ft. This represents the currently available capacity of EVMWD's treatment plant and the water level conditions at which the local stakeholders have agreed reclaimed water can be added to Lake Elsinore.[6] Over the 100-year linkage analysis simulation period (1916-2016), the average annual volume of reclaimed water added to Lake Elsinore under these existing constraints amounted to ~3,600 AFY, with up to ~8,400 AFY in periods of extended drought (such as 2016). During the most recent dry period prior to the winter of 2016-2017, modeling analyses indicate that Lake Elsinore would have been completely dry for more than two years (2015-2016) without the collective hydrologic control achieved from implementation of LEMP and supplemental water additions (Figure 7-4). As such, the managed lake condition including both LEMP and supplemental water addition clearly provided better protection of recreational uses than would be realized in a reference condition

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[2] Agreement entered on October 29, 1927, among George H. Tilley and Samantha Tilley, his wife, James Alexander and Anna Alexander, his wife, A.R. Anderson and Clarice Anderson, his wife, South Elsinore Development Company, a corporation, the Mariposa Company, a corporation, D.W. Harvey and F. Mae Harvey, his wife, Clevelin Realty Corporation, a corporation, S.H. Burton and Ellen W. Burton, his wife, Lake-Shore Beach Company, a corporation, Charles H. Rippey, Jr. and A. Marie Rippey, his wife, R.J. Hadsell and Sadie J. Hadsell, his wife, J.L. Cope, South Elsinore Mutual Water Company, a corporation, Alexander Muhlberg and Emilie E. Muhlberg, his wife, and City of Lake Elsinore, a municipal corporation, and Temescal Water Company, a corporation.

[3] Agreement entered by and between the City of Lake Elsinore, Lake Elsinore Redevelopment Agency and the Elsinore Valley Municipal Water District on December 19, 1991.

[4] Lake Elsinore Comprehensive Water Management Agreement between City of Lake Elsinore, Lake Elsinore Redevelopment Agency and the Elsinore Valley Municipal Water District, March 1, 2003.

[5] Lake Elsinore has been exempted from the MUN designation in accordance with State Water Board Resolution No. 88-63 (Sources of Drinking Water Policy) (see Table 3-1, Santa Ana Water Board 2016)

[6] Stakeholders intend to investigate the potential for revising the 1,240 ft lake level threshold if subsequent studies confirm more supplemental reclaimed water would be beneficial to the lake and adjoining property owners.

(Fortnight: The Magazine of California 1954). DYRESM-CAEDYM results showed that Lake Elsinore would be dry about 9% of the time under reference conditions, but lake levels would not be expected to have fallen to 1,235 ft with the current managed lake condition even during a prolonged period of drought. In 2015-2016, actual lake levels were ~15 ft higher than they otherwise would have been under reference conditions involving a dry lakebed. Moreover, other public health issues associated with periods of lakebed desiccation, such as severe gnat infestations and dust, were effectively prevented by these existing controls. In recent years, dust suppression has been identified as a critical need to address significant potential public health concerns in other southern California waterbodies, including the Salton Sea and Owens Lake (e.g., see CNRA 2017 for Salton Sea).

While the addition of EVMWD supplemental water to Lake Elsinore supports the recreation beneficial uses of the lake, reclaimed water represents an additional external source of nutrient loads in excess of reference conditions, despite the Wastewater Treatment Plant (WWTP) achieving relatively low effluent nutrient concentration. Thus, there is a potential for increased eutrophication relative to the reference watershed condition. The linkage analysis was used to evaluate the balance of increased nutrient loads against the benefits of increased water volume in Lake Elsinore, including reducing wind driven sediment resuspension, facilitating aquatic vegetation on shorelines, and diluting TDS under most conditions. **Figure 7-5** shows model results for TDS under reference and managed conditions (with 100 years of implementing existing controls) as time series histories over the simulation period. Under most circumstances, the addition of reclaimed water with a TDS of 700 mg/L serves to dilute ambient TDS in the lake (Figure 7-5) (Note: the water quality objective is 2,000 mg/L TDS, about the same as the median TDS concentration observed under the reference condition).

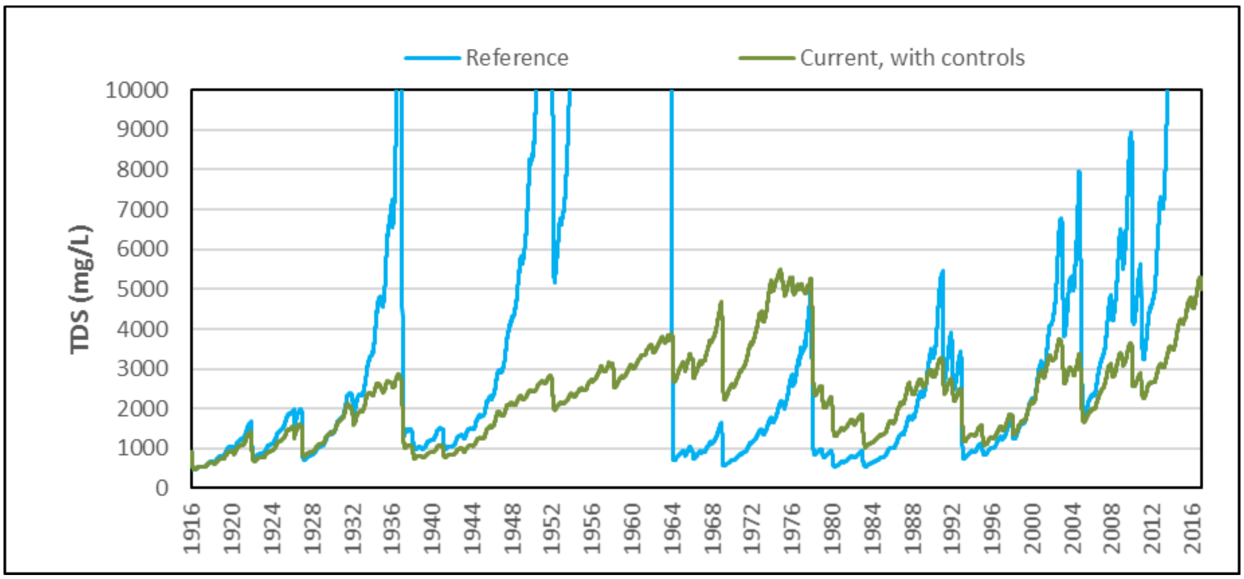

Figure 7-5. Lake Elsinore DYRESM-CAEDYM Model Results for Total Dissolved Solids Concentration Given 1916-2016 Hydrology, for Reference Conditions and with the Levee and Additions of Supplemental Water

One exception to the model findings occurs during the period beginning in 1964 - immediately following lakebed desiccation in the early 1960s. If the lake is allowed to dry out, TDS is mineralized in lake bottom sediments and can even be exported from the lake basin as wind-blown dust. When runoff again begins to refill the lake, a TDS lower than reclaimed water is observed, as occurred in 1964. This historical process of drying and refilling provides a natural reset of ambient TDS in Lake Elsinore. Because reclaimed water is now used to manage lake levels to prevent desiccation and support recreational uses, this managed lake condition is expected to yield higher TDS in some climatic cycles, which can result in less effective zooplankton population for grazing upon algae.

The development of this revised TMDL is based on a common desire of all watershed stakeholders to support recreational uses applicable to Lake Elsinore by maintaining minimum water levels in Lake Elsinore and preventing any future lakebed desiccation events from occurring. Thus, the natural reset process described above cannot be relied upon as a water quality improvement mechanism, nor would it be prudent to allow the lake to dry out as it causes a complete extinction of aquatic life before water quality improvement begins to occur. Thus, numeric target CDFs developed for Lake Elsinore represent periods of lakebed desiccation as having maximum concentrations for chlorophyll-*a* and ammonia, and zero lake volume above 5 mg/L DO (see Section 3).

Lake Elsinore Aeration and Mixing System

The 2004 TMDL set WLAs for EVMWD's reclaimed water discharge. These WLAs provided the basis for effluent limits in the wastewater facility's NPDES permit. EVMWD's permit allows for these limitations to be met directly at the point of discharge and/or indirectly through offsets of excess internal nutrient loads by reducing the flux of nutrients from the lake bottom with the construction and operation of LEAMS.

LEAMS was constructed in 2007 as a joint project developed by LESJWA and co-sponsored by EVMWD, the City of Lake Elsinore and Riverside County. LEAMS relies on a combination of slow-turning propellers submerged in the lake and shoreline compressors that disperse air from pipelines anchored to the bottom of the lake to circulate water in Lake Elsinore (**Figure 7-6**).

Water near the bottom of the lake is low in DO. LEAMS is designed to push this bottom water toward the surface where it will be re-aerated, naturally by wind and wave action. Higher DO levels are essential to support fish and other aquatic organisms living in the lake. Stirring the lake to increase DO concentrations also helps improve water quality. Higher DO concentrations also help prevent chemical reduction of iron that releases bound phosphorus to a soluble form that may be released to the water column by diffusive exchange. LEAMS may also facilitate coupled nitrification-denitrification, a process that converts ammonia to nitrate in oxygenated waters and then converts nitrate to nitrogen gas when anoxic conditions return. This process requires water to shift from oxic to anoxic conditions, achieved thought intermittent operation of the system as well as by the non-uniform nature of the aeration lines (Horne 2015).

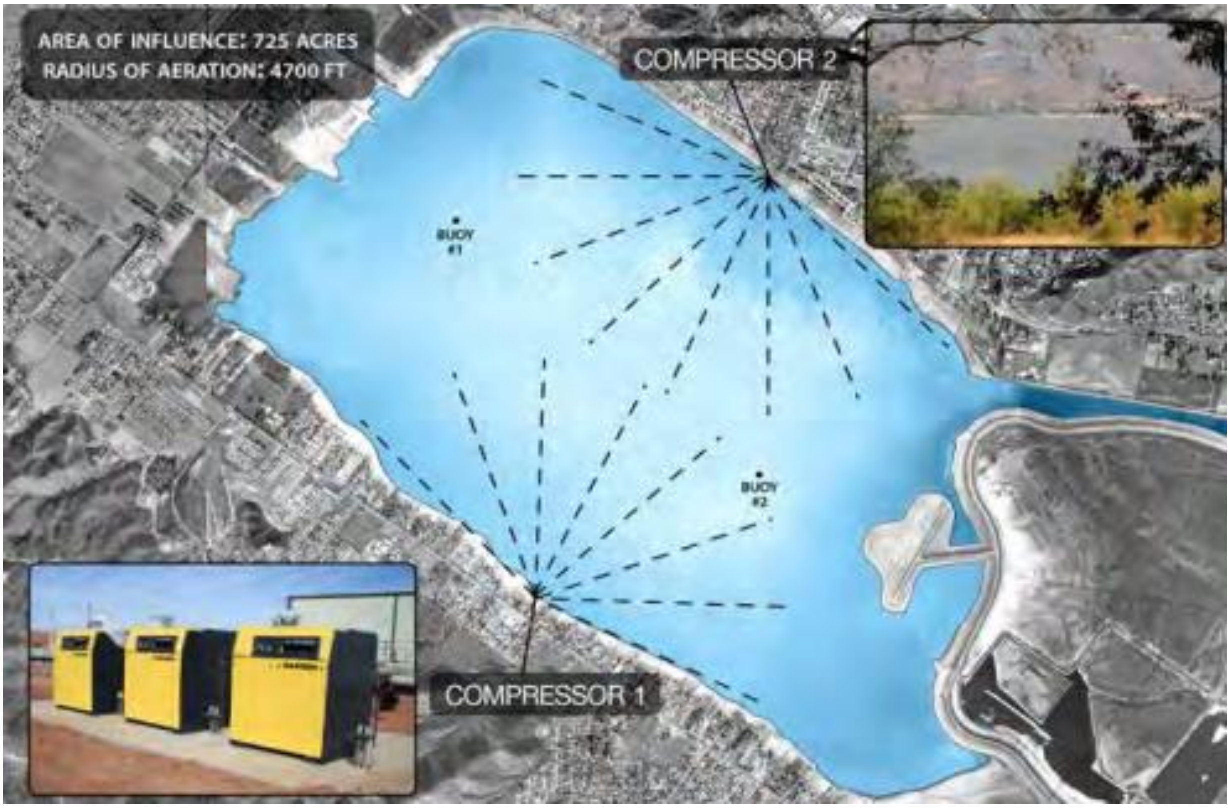

Figure 7-6. Diagram of the Lake Elsinore Aeration and Mixing System

EVMWD has submitted required technical analyses demonstrating the achievement of required offsets with LEAMS operation (Horne 2015, 2018). Some corroboration of these offsets has been found in the DYRESM-CAEDYM model used to complete a RAA to demonstrate water quality benefits achieved from deployment of existing controls including LEAMS (see Section 7.2.4.2 below). The LECL Task Force is currently working to update the offset demonstration approach to consider multiple estimation methods, increase reporting frequency, and coordinate monitoring activities and effectiveness analysis with the Task Force.

Fishery Management

Table 7-1 summarized planning studies that have been completed for Lake Elsinore and Canyon Lake. These studies included development of a proposed fishery management program that included a range of potential implementation strategies, e.g., carp removal, zooplankton enhancement and fish habitat/community structure improvement (including stocking of predator fish) (LESJWA 2005a). The highest priority management strategy identified in was carp removal, given the impact carp can have on the aquatic environment, including (1) increasing nutrient loadings to the water column, thus enhancing algal production; (2) competing with desirable sport fish for food; (3) preventing many species of sport fish from successfully reproducing; and (4) preventing rooted aquatic vegetation from becoming established (LESJWA 2005a).

Increased nutrient loading to the water column can be caused by benthivorous fish such as carp that resuspend lake bottom sediments as a result of their foraging behavior, a process referred to as bioturbation. Resuspended sediments can cause releases of bioavailable nutrients to the water column. Bioturbation rates in Lake Elsinore are estimated to account for a lake-wide average of approximately 2 $mg/m^2/day$ TP and 5 $mg/m^2/day$ TN in Lake Elsinore (see Section 4.3). Studies have shown that reductions in carp populations would be expected to provide corresponding reductions in TP. For example, a 2/3 reduction in the 2000-2001 carp population to less than 125 fish/ac (309 fish/ha) may have reduced bioturbation TP loading rates by 1.3 $mg/m^2/day$ TP and 3 $mg/m^2/day$ TN (Anderson 2006). These estimated reductions in TP and TN loading rates, resulting from reductions in carp populations. were incorporated into the revised TMDL lake water quality model.

In 2002, LESJWA and the City of Lake Elsinore initiated a multi-year demonstration project to reduce the carp population in Lake Elsinore. From 2003 to 2008, a total of 1.3 million pounds of carp was removed from the lake and by the end of 2008, the estimated carp population was 138 fish per acre (City of Lake Elsinore 2008). The carp removal program was so successful that it was suspended in 2008 because the carp population was so low that the carp could no longer be captured efficiently. The LECL Task Force periodically conducts fish surveys to determine if the carp population has increased enough to again implement the carp removal program. However, as recently as 2015, an assessment of the lake showed that the number of fish >20 cm in length, a surrogate indicator for carp, remained < 6 per acre (Anderson 2016b), indicating that there were still 90% fewer carp than there were when the carp removal program was suspended in 2008. Fish surveys will continue periodically and if the carp population increases to a sufficient level of concern, the carp removal program will be re-initiated.

In addition to restarting the carp removal program, fishery management as an existing supplemental project could also be enhanced to implement other fishery objectives originally identified previously identified (LESJWA 2005a), e.g., stocking of predator fish and improving fish habitat. Any such enhancements would be considered as part of the evaluation of the need for additional supplemental projects during Phase 2 (see Section 7.3 below).

7.2.4 Estimated Water Quality Benefits

7.2.4.1 Canyon Lake

The RAA for Canyon Lake Main Lake and East Bay focuses on reduction of phosphorus to offset additional nutrient loads from external sources. Current surface spreading of alum twice per year in Canyon Lake is sufficient to sequester all excess (above reference condition) phosphorus loading estimated to be retained within Canyon Lake Main Lake and East Bay for long-term average rainfall conditions and accounting for watershed BMPs deployed as of the development of this TMDL revision (**Table 7-7**). The addition of alum to Canyon Lake is expected to continue to be a primary mechanism for achieving compliance in Canyon Lake as it has been proven to be effective. However, as part of the revision to the CNRP and AgNMP (see Section 7.4.2.3 below) in the next phase of TMDL implementation, the overall effectiveness of the alum program will be evaluated to determine if the program should be refined moving forward.

The use of alum within the lake segments to offset excess phosphorus is designed to cause phosphorus limitation of algae growth (i.e., a single nutrient control strategy). The role nitrogen may play in algae growth was not included in this RAA. Section 9 provides additional requirements related to the use a single nutrient control in future compliance demonstrations by dischargers.

Table 7-7. Current Estimates of Benefits Obtained from Alum Additions to Canyon Lake

Site	TP (kg/yr)	
	Main Lake	East Bay
1. Average External Load (1948-2017) (with existing watershed BMPs)[1]	1,916	1,110
2. Allowable Load[2]	1,149	562
3. Load Reduction Required (1 minus 2)	767	548
4. Average Annual Alum Additions (as dry alum)	215,000[2]	90,000
5. Estimated Nutrient Reduction from Alum Additions[3]	1,433	600
6. Unmet Load Reductions (3 minus 5)	-667	-52

[1] Load expressed as portion retained within Canyon Lake
[2] Includes alum additions to the North Ski Area
[3] Based on alum to sequestered P ratio of 150:1

7.2.4.2 Lake Elsinore

The RAA for Lake Elsinore involves a simulation of water quality response targets over a 100-year hydrologic period (1916-2016) for the managed lake condition (with existing controls). Existing controls were incorporated into the managed lake condition simulation over the entire simulation period, even though controls were only implemented over the past 20 years. Thus, the 100-year simulation results should not be compared to measured data, but rather serve to estimate the water quality response in the future if hydrology similar to the 1916-2016 period were to occur going forward. Results are compared with the numeric targets, which are based on model results for a reference watershed condition (pre-development era) over the same 100-year hydrologic period. The impact of urban and agricultural development in the watershed is also evaluated for a condition with no water quality controls to quantify progress made with implementation of in-lake BMPs. Parameters are adjusted to represent three linkage analysis scenarios as described below and summarized in **Table 7-8**:

- *Scenario 1*: This scenario represents the reference watershed condition and the results were used to develop the numeric targets reported in Section 3. Nutrient concentrations were reduced to reference concentrations for the San Jacinto River watershed (see Section 3.2.2) and it was assumed that no in-lake water quality controls exist.

- *Scenario 2*: This scenario relies on the pre-2011 concentrations of nutrients in watershed runoff inflows (see Table 7-2 above) with no in-lake controls. Results portray water quality conditions that may have occurred without the implementation of multiple in-lake controls.

- *Scenario 3*: This scenario relies on (a) post 2011 concentrations of nutrients in watershed runoff inflows (see Table 7-2 above); and (b) includes the implementation of existing in-lake water quality controls. The results over the past ten years since all in-lake controls have been implemented most closely represent actual conditions. The simulation, which was run for 100 years of hydrology (1916-2016), provides an estimate of the long-term water quality condition that may be achieved with continued operation of existing controls. The Linkage Analysis model takes into account water quality controls as follows:

- *Watershed BMPs* – The benefits from the BMPs are captured in recent data used for assumed inflow TP and TN concentrations. This approach also accounts for any benefits from nutrient control within Canyon Lake.
- *LEMP* – Linkage analysis employs the revised lake hypsography.
- *Supplemental Water* – Linkage analysis includes additions of supplemental water at 7.5 mgd on all days (1916-2016) when the modeled lake level drops below 1,240 ft. Over the 100-year simulation period an average annual addition of supplemental water amounted to ~3,600 AFY. The assumed quality of supplemental water for relevant constituents includes: 700 mg/L TDS, 0.5 mg/L TP, and 3.0 mg/L TN.
- *LEAMS* – Linkage analysis simulates the influence of increased DO (or reduced anoxia) on daily sediment nutrient flux near the lake bottom achieved from operation of LEAMS. DYRESM-CAEDYM variables that control hydraulic mixing energy are increased to account for LEAMS and cause an increased DO.
- *Fishery Management* – Linkage analysis employs a reduced flux rate based on estimates of bioturbation and effectiveness of fishery management program.

Table 7-8. Scenarios Evaluated with Linkage Analysis to Support Lake Elsinore RAA

Parameter	Scenario 1: Reference Conditions	Scenario 2: Current Development; No Water Quality Controls	Scenario 3: Current Development; With Existing Water Quality Controls
Lake Elsinore Spill Elevation (ft msl)	1,255	1,255	1,255
Hypsography	Without levee	Without levee	With levee
Inflow TP (mg/L) in Runoff	0.32	0.46	0.51
Inflow TN (mg/L) in Runoff	0.92	1.95	1.78
Internal TP Flux ($mg/m^2/day$)[2]	5.4	9.0	7.7
Internal TN Flux ($mg/m^2/day$)[2]	37	75	72
EVMWD discharge	None	None	Reclaimed water[1]
Runoff Flow	USGS gauge + local runoff estimate (1916 - 2016)		

[1] Reclaimed water addition assumed at 7.5 mgd when water level is below 1,240 ft with TDS 700 mg/L, TP 0.5 mg/L, TN 3.0 mg/L

[2] Assumes a 2/3 reduction in the 2000-2001 carp population to less than 125 fish/ac (309 fish/ha) and an estimation reduced bioturbation flux of 1.3 $mg/m^2/day$ TP and 3 $mg/m^2/day$ TN (Anderson 2006) (see Section 7.2.3.3)

A simplifying assumption made for all three scenarios is that hydrologic inflows to Lake Elsinore are functionally equivalent. This assumption neglects the expectation of increased watershed runoff as a result of urban development in the watershed; however, it was determined that any such runoff would be minor relative to the impact to Lake Elsinore inflows from the construction of Railroad Canyon Reservoir. Railroad Canyon Dam reduces watershed runoff inflow to Lake Elsinore by capture and use of stored water by EVMWD (reclaimed water addition to maintain water levels in Lake Elsinore mitigates this water diversion in Canyon Lake per the 2003 Lake Elsinore Comprehensive Water Management Agreement). Conversely, long-term sedimentation in Canyon Lake may give rise to an increase in overflows regardless of the upstream watershed condition. Recognizing the value of increased water in Lake Elsinore, no estimate of hydrologic change as a result of watershed development is included in the TMDL revision. While not directly addressed in the 2004 TMDL Staff Report, this assumption is consistent with the modeling conducted for the original TMDL (Santa Ana Water Board 2004b).

CDF plots of daily modeling results for each of the three linkage analysis scenarios show that the collective implementation of existing watershed and in-lake BMPs in Lake Elsinore yield water quality conditions for response targets (chlorophyll-*a* and DO) that are approaching the range of conditions estimated for a reference watershed during most years (i.e., the numeric targets) and providing relatively better water quality (lower chlorophyll-*a* and greater lake volume with DO over 5 mg/L) during periods of extended drought (**Figures 7-7** and **7-8**).

At the time of this TMDL revision (beginning in 2015), modeling results show that the lakebed would currently be dry under a reference condition. Accordingly, implementation of existing controls has yielded better than reference condition support for beneficial uses. It is important for existing projects to continue to operate and for their effectiveness to be evaluated against reference conditions over varying hydrologic periods. Ultimately, monitoring data will demonstrate whether sufficient progress toward numeric targets is achieved or if supplemental projects will be necessary in Lake Elsinore. Section 9 provides additional requirements related to the use of response target CDFs in future compliance demonstrations by dischargers.

The RAA results also provide an estimate of reduced internal nutrient loads that are attributable to potential long-term implementation of existing water quality controls (**Table 7-9**). These nutrient offsets are not solely responsible for in-lake water quality improvements, but rather work in concert with hydrologic controls to provide reductions in algae growth (see Figure 7-7).

7.3 Supplemental Project Concepts

As part of implementation of the revised TMDLs, the responsible entities with WLAs and LAs will evaluate the need for implementation of supplemental projects to provide additional water quality improvements. At this time, potential supplemental projects could include:

- Mystic Lake drawdown
- Alum addition to wet weather inflows
- Increased reclaimed water additions
- Oxygenation
- Dredging in East Bay Canyon Lake
- Indirect potable reuse
- Enhanced fishery management
- Vegetation management
- Artificial recirculation in Canyon Lake
- Ultrasonic algae control
- Algaecide application
- Physical harvesting
- Watershed BMPs in Urban Drainage Areas
- Lake Elsinore Pumped Storage

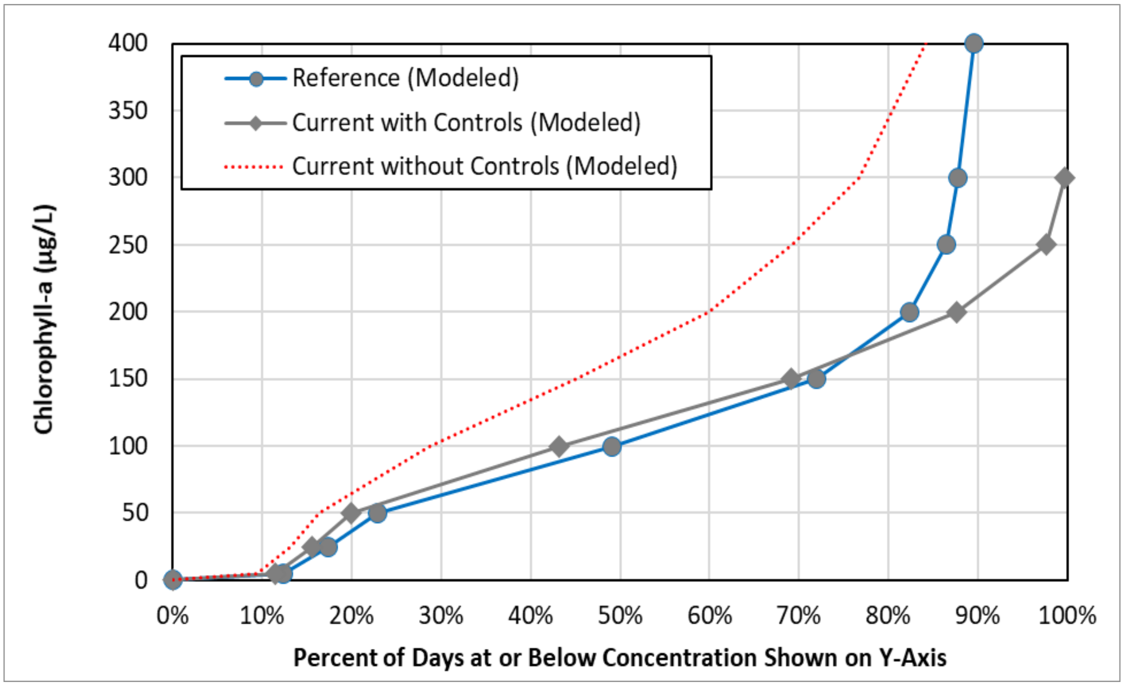

Figure 7-7. CDF Plots of Chlorophyll-a Concentration in Top 1-m of Lake Elsinore for Reference Condition and Current Conditions with and without Existing In-lake Water Quality Controls (Note: (a) Red line represents conditions at the time Lake Elsinore was listed as impaired; (b) difference between red and gray lines shows progress towards attainment)

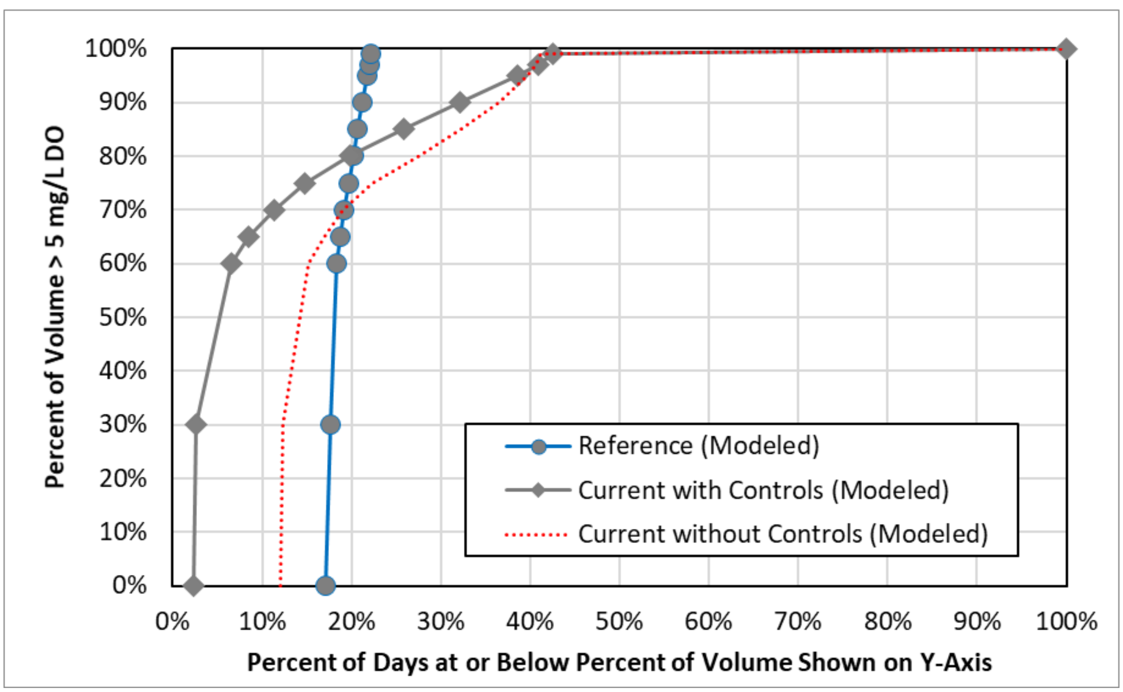

Figure 7-8. CDF Plots of Lake Elsinore Volume with Dissolved Oxygen > 5 mg/L for Reference Condition and Current Conditions with and without Existing In-lake Water Quality Controls (Note: (a) Red line represents conditions when Lake Elsinore was listed as impaired; (b) difference between red and gray lines shows progress towards attainment)

Table 7-9. Estimated Reduction of Internal Loads Attributable to Implementation of In-lake Water Quality Controls

Average Internal Load	TP	TN
Scenario 2: Current without Controls (kg/yr)	23,034	184,772
Scenario 3: Current with Controls (kg/yr)	17,731	123,040
Offset with Current Controls: Scenario 2 – Scenario 3 (kg/yr)	5,303	61,732
Offset with Current Controls (% Reduction)	23%	33%

For each of the above supplemental project concepts, **Table 7-10** provides a summary of the potential water quality benefits that may be obtained, and other considerations associated with implementation. Section 7.4 provides a timeline for consideration of supplemental projects during implementation. The implementation program does not specify which of the listed supplemental projects will be implemented only that these are projects for further consideration. Selection of supplemental projects is an early task in the implementation schedule.

7.4 Program of Implementation

The program of implementation under the revised nutrient TMDLs considers the existing water quality management strategies already being implemented to improve water quality in Lake Elsinore and Canyon Lake, as follows:

- *Lake Elsinore* - For more than 30 years this lake has been managed to stabilize the lake level with a targeted surface elevation of 1,240 ft. This management strategy is contrary to the natural condition, which results in a periodically dry lake. Managing the lake to keep it "wet" changes the water quality dynamics of the lake not only for nutrients but other constituents such as salinity and DO. Regardless, a wet-lake management strategy ensures support of existing recreational beneficial uses; moreover, allowing the lake to go dry is not considered a reasonably foreseeable compliance alternative and thus is not included as a management option. The program of implementation under the revised TMDLs will continue a wet lake management approach.[7]

- *Canyon Lake* – Efforts to improve water quality in this reservoir are focused on managing nutrients within the watershed coupled with the implementation of in-lake TP controls through the application of alum. This approach will continue under the program of implementation, as described below.

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[7] The adoption of the revised TMDLs is intended to facilitate the practice of discharging reclaimed water in Lake Elsinore; not interfere with it. In addition, the TMDL Implementation Program assumes that the discharge of reclaimed water will not only continue but will likely be expanded in the future. This assumption is based on EVMWD's Urban Water Management Plan (UWMP) that states the EVMWD "plans to expand it reclaimed water system to provide reclaimed water for irrigation users and to maintain water levels in Lake Elsinore during normal and dry years" (EVMWD 2016). In addition, EVWMD's permit to discharge reclaimed wastewater designates Lake Elsinore as a receiving waterbody. Per CWC §1211, prior to making any change in the point of discharge, place of use or purpose of use of treated wastewater, the owner of the wastewater treatment facility must obtain Santa Ana Water Board approval for the change. Any such proposal would need to be submitted as part of a Report of Waste Discharge, per the requirements of CWC §13260(c). Thus, any plans to change the point of the discharge in the future will require significant coordination with regulators and stakeholders.

Table 7-10. Potential Supplemental Projects for Consideration During the Phase 2 Program of Implementation (Potential costs for most of these projects are discussed in more detail in Section 11)

Project	Action	Source	Waterbody	Cost	Description	Water Quality Benefits	Potential Constraints & Limitations
Mystic Lake Drawdown	Hydrologic flushing	Internal	Lake Elsinore, Canyon Lake (Main/ East Bay)	$$$	Mystic Lake is a sump that captures all runoff from the upper SJR watershed via a breach in the levee on the north side of the river near Bridge Street. Most runoff that does reach Mystic Lake is retained and subsequently lost via evaporation. The most recent overflow to Canyon Lake occurred in 1998. Few data exist on the flow that reaches Mystic Lake, but the watershed model estimates ~3000 AFY, with many years having zero volume inflow and many years with over 10,000 AFY. While intermittent, this water may have a significant value for EVMWD water supply (at Canyon Lake) and for water quality in both lakes (providing both flushing and dilution). A potential project would involve pumping and conveying the stored runoff out of Mystic Lake (bottom elevation 1,408 ft to the overflow channel leading to the lower San Jacinto River (invert elevation 1,423 ft).	• Flushing of nutrients and phytoplankton out of Canyon Lake • Increasing water levels and dilution of TDS in Lake Elsinore	• Intermittent source of water, further reductions of inflows could occur with increased upstream capture • Impacts to waterfowl and other wildlife • Determination of appropriate increased diversions for EVMWD's treatment plant • Subsidence could impact facilities over time
Alum Addition to Wet Weather Inflows	Phosphorus removal	Internal	Lake Elsinore, Canyon Lake (Main/East Bay)	$	An alternative delivery method for alum additions could involve a small chemical feed storage and delivery system at the two inflows to Canyon Lake. This would treat bioavailable phosphorus immediately as it arrives in the lake and provide a better flocculation with lower pH of wet weather runoff.	Reduction of TP in water column	• Requires on-site chemical storage of low pH material • Outdoor chemical feed system may be susceptible to damage by high flows, wind or vandalism
Increased Reclaimed Water Additions	Hydrologic flushing/ dilution	Internal	Lake Elsinore	$$	EVMWD currently discharges up to 7.5 of its 8 mgd capacity to Lake Elsinore. Phase 1 of the WWTP expansion will allow for discharge of up to 9.0 mgd to Lake Elsinore by 2020, a rate estimated to provide sufficient capacity to maintain at water level of 1,240 ft over the long-term. Increased reclaimed water addition will dilute TDS during periods of drought and increase habitat for submerged vegetation and fish.	Reduction in TDS, aquatic habitat, indirect controls on nutrient cycling and algae	Agreement to ensure up to 9.0 mgd will be discharged to Lake Elsinore in perpetuity

Table 7-10. Potential Supplemental Projects for Consideration During the Phase 2 Program of Implementation (Potential costs for most of these projects are discussed in more detail in Section 11)

Project	Action	Source	Waterbody	Cost	Description	Water Quality Benefits	Potential Constraints & Limitations
Oxygenation	DO control, phosphorus & nitrogen reduction	Internal	Canyon Lake (Main)	$$	Oxygenation involves the direct addition of oxygen to the lake bottom waters in Canyon Lake Main Lake during periods of thermal stratification. The oxygen would reduce anoxic conditions in the lake bottom and thereby limit the internal loading of nutrient to the water column	Reduction of TP and TN in water column	• Low DO in hypolimnion of Canyon Lake occurs in reference condition • Requires large scale on-site oxygen storage
Dredging	Phosphorus & nitrogen reduction	Internal	Canyon Lake (East Bay)	$$$$	Dredging involves the physical removal of lake bottom sediments. This is a very effective way to reduce the pool of mobile nutrients within the lake bottom.	Reduction of TP and TN in water column	• Dredging is very costly • Disposal of sediment may require hauling
Indirect Potable Reuse	Hydrologic flushing	Internal	Canyon Lake (Main/East Bay)	$$$$	EVMWD may consider using Canyon Lake as an environmental buffer to allow for potable reuse of advanced treated reclaimed water. Advanced Wastewater Treatment (AWT) water would be discharged at the upstream end of the lake to maximize residence time prior to reaching the drinking water treatment plant intake. AWT water would serve to dilute ambient water in the lake as well as create additional flushing of water when overflows are not occurring.	Reduction of TP and TN in water column; flushing of nutrients and phytoplankton out of Canyon Lake	• Water quality in the lake may limit the amount of reclaimed water that can be diverted for potable supply. • Operation of the system during the wet season may be less reliable given water quality and capacity limitations.
Enhanced Fishery Management	Algae control	Internal	Lake Elsinore	$$	Carp removal program already active (though currently suspended). LESJWA (2005a) noted that with carp managed, additional fishery management activities could be implemented that would improve water quality and health of the biological community, e.g., zooplankton enhancement; aquatic and emergent vegetation restoration; fish habitat improvement; and fish community structure improvement	Improved aquatic community to enhance zooplankton that graze on algae	• Carp control is fundamental to the successful implementation of these fishery management activities. • Other potential limiting factors for zooplankton such as salinity may require controls

Table 7-10. Potential Supplemental Projects for Consideration During the Phase 2 Program of Implementation (Potential costs for most of these projects are discussed in more detail in Section 11)

Project	Action	Source	Waterbody	Cost	Description	Water Quality Benefits	Potential Constraints & Limitations
Vegetation Management	Algae control	Internal	Lake Elsinore, Canyon Lake (Main/East Bay)	$$	Establishment of submerged aquatic vegetation that will take up nutrients and release oxygen to the water column. Macrophytes can compete for limited nutrients and light with algae thereby providing another control on algae growth.	Reduction of TP and TN in water column, control of algae growth	• Macrophytes may not get established. • Water level fluctuations can kill vegetation by either desiccation or drowning.
Artificial Recirculation in Canyon Lake	Phosphorus & nitrogen reduction	Internal	Canyon Lake (Main/East Bay)	$$$$	Recirculate oxygen depleted, nutrient rich water from the hypolimnion in the Main Lake through East Bay and back to the Main Lake. Transfer of water from the hypolimnion in Main Lake to East Bay is expected to cause a rise in DO at the sediment interface; a reduction of internal loads of TP and TN may also be realized. For East Bay, water delivered from the Main Lake would be reaerated through the process of discharge and flushing through the shallow East Bay. This activity would facilitate flushing of nutrients out of East Bay to reduce the duration of algal blooms. Over time, reduced cycling of nutrients within East Bay would limit sediment nutrient flux; and, thereby, the concentration of bioavailable nutrients flushed to Main Lake.	Net reduction of internal nutrient load and net increase in DO. Algae blooms would be expected to be shortened in duration within East Bay and conditions with DO > 5 mg/L would extend deeper in the water column in the Main Lake.	Net reduction in nutrients is expected, but there may be periods when high concentrations of bioavailable nutrients Main Lake hypolimnion could cause an increase in nutrient concentrations within East Bay
Ultrasonic Algae Control	Algae control	Internal	Canyon Lake (East Bay, North Ski Area)	$	Devices can be deployed that will kill algae within a 50-foot radius by sonication	Control of algae growth	• Sonication is effective over a small area only (e.g., coves in East Bay or the North Ski Area); would require too many devices to impact larger zones. • Impact to other aquatic species could become an important consideration

Table 7-10. Potential Supplemental Projects for Consideration During the Phase 2 Program of Implementation (Potential costs for most of these projects are discussed in more detail in Section 11)

Project	Action	Source	Waterbody	Cost	Description	Water Quality Benefits	Potential Constraints & Limitations
Algaecide	Algae control	Internal	Canyon Lake (Main/East Bay)	$	Algaecides may be effective in controlling algae blooms as they begin to occur	Control of algae growth	• Repeated use of some algaecides can cause elevated levels of toxins in the lake bottom • Nutrients are not addressed and therefore new algae blooms may arise shortly after an algaecide treatment
Physical Harvesting	Algae control	Internal	Lake Elsinore, Canyon Lake (Main/East Bay)	$$	Skimmers and other tools can be used to physically remove algae from the surface of the lake	Control of algae growth	• Labor intensive • Nutrients are not addressed and therefore new algae blooms may arise shortly after physical removal
Watershed BMPs in Urban Drainage Areas	Phosphorus & nitrogen reduction	External	Lake Elsinore, Canyon Lake (Main/East Bay)	$$$	Stormwater BMPs are required to be implemented with new and redevelopment projects that capture and infiltrate or treat runoff and associated nutrients prior to reaching the lakes. Additionally, stormwater BMPs can be retrofitted into existing development areas.	Reduction of TP and TN in water column and in settled sediment	• Load reductions are limited to runoff from small-moderate sized storms only • Extensive upstream runoff retention would reduce flows to Lake Elsinore
LE Advance Pumped Storage (LEAPS)	Hydrologic flushing, DO control	Internal	Lake Elsinore	$$$	Construction of a 200 ft tall dam and new 50 to 100-acre concrete lined reservoir with a spill elevation of ~2,800 ft in the Cleveland National Forest southwest of Lake Elsinore. On average, 5,000 AF of water would be pumped from Lake Elsinore in the evening during periods of low energy demand. Return of the water would generate hydroelectric power in turbines between the new 'upper' reservoir and Lake Elsinore, the 'lower' reservoir.	Control of algae growth, reaeration, potential to reduce P with additional treatment	Potentially numerous regulatory challenges to obtain approval

The above management strategies will be implemented under an overall phased implementation framework. The following sections describe this framework.

7.4.1 Implementation Framework

TMDL implementation in Lake Elsinore and Canyon Lake is being implemented in a phased approach. All work that has been completed since 2005 (effective date of the original TMDLs) up to the effective date of the revised TMDLs is Phase 1. Implementation activities that occur after the effective date of the revised TMDLs is Phase 2. Each of these phases is described in more detail below. The need for any additional revisions to the TMDLs and and/or implementation of additional phases is at the discretion of the Santa Ana Water Board.

7.4.1.1 Phase 1

Since the effective date of the 2004-adopted TMDLs, the entities responsible for compliance with the TMDLs have implemented numerous activities to meet the applicable WLAs and LAs and completed technical studies to better understand the water quality dynamics of each of these lakes. Efforts completed to date include, but may not be limited to:

- Studies as summarized in Table 7-1;
- Lake modeling activities completed by Dr. Anderson and UCR (e.g., see Section 5); and
- Implementation plans established by the MS4 Program (CNRP) and WRCAC (AgNMP).

This approximately 15-year period of study and implementation, which represents Phase 1 of the overall implementation framework (**Table 7-11**), has resulted in a significantly increased understanding of the watershed reference condition, lake dynamics during wet and dry periods and what is attainable with regards to the existing causal and response targets established in the 2004 TMDL. Given the findings from Phase 1 and the analyses completed to support the revision of the original TMDLs, upon the effective date of the revised TMDLs, implementation will occur under Phase 2, as described below.

7.4.1.2 Phase 2

Section 2 (Problem Statement) described the unique hydrologic variability of Lake Elsinore and highlighted the existence of multi-decadal climatic cycles. For example, based on USGS flow gauge data, it would take a period of 40-years after meeting the TMDL to obtain a repeatable (within 20 percent) average runoff inflow to Lake Elsinore from Canyon Lake overflows. Paleolimnology records suggest even longer climate cycles exist (Kirby et al. 2005). Moreover, the impacts of climate change may exacerbate patterns of hydrologic variability in the future by increasing the severity of extended droughts (e.g., see CNRA et al. 2014).

Given the longevity of climatic cycles and the potential impacts from climate change, compliance with the TMDL numeric targets and attainment with water quality objectives may not be demonstrated for multiple decades. However, periodic water quality assessments can be conducted, which not only provide the means to measure progress towards attainment of the water quality objectives, but also provide the opportunity to modify implementation actions over time through the adaptive implementation process.

Table 7-11. Phased Implementation Framework for Lake Elsinore and Canyon Lake TMDLs

Phase	Time Period	Completed or Anticipated Key Activities	Existing or Anticipated Outcomes
Phase 1	Effective date of original TMDLs to effective date of revised TMDLs (2005 - ~2019)	• LECL Task Force Management • Alum applications • LEAMS implementation • Fishery management • Watershed BMPs (CNRP, AgNMP) • Supplemental water additions • Special studies to support TMDL revisions • Monitoring and reporting activities	• Implementation of watershed-based and in-lake BMPs to reduce nutrient loads to the lakes and mitigate nutrient impacts • Development of new data to support revision of nutrient TMDLs
Phase 2	15-20 year period after effective date of revised TMDLs	• Revised permits and management plans (e.g., CNRP and AgNMP) • Continued/enhanced implementation of existing water quality control programs • Supplemental project implementation, as identified through revision of management plans • Additional research/studies, as needed • Annual monitoring and reporting • Periodic assessment to evaluate progress towards compliance with TMDLs and attainment of water quality objectives	• Compliance with TMDL numeric targets and attainment of water quality objectives • Evaluate and revise TMDLs, at discretion of the Santa Ana Water Board

It is anticipated that Phase 2, which begins upon the effective date of the revised nutrient TMDLs, will have a duration of at least 15-20 years (Table 7-11). This multi-year time frame considers the need for a multi-decadal assessment process to evaluate progress towards attainment of water quality objectives through implementation of existing nutrient controls and completion of supplemental projects. The length of this phase allows time to:

- Update existing permits, implementation plans and programs (up to 3 years);
- Enhance existing water quality control activities, where appropriate and design, permit, and construct new, supplemental projects (minimum of 3-7 years); and
- Evaluate the effectiveness of enhanced and supplemental projects (likely to require 10 or more years to cover a full meteorological cycle, i.e., dry and wet cycles).

The time frame for Phase 2 implementation also allows time for the potential impacts from continued changes in the watershed and lakes to occur, resulting from:

- Ongoing conversion of agricultural lands to an urban landscape;
- Expected increase in addition of supplemental reclaimed water to Lake Elsinore; and
- Continued reduction of nutrients in the lake sediments.

7.4.2 Phase 2 Implementation

The revised nutrient TMDLs are subject to approval by the Santa Ana Water Board, State Water Board, California Office of Administrative Law and the federal EPA. The revised TMDLs become effective upon EPA approval. Phase 2 implementation begins upon this effective date. **Table 7-12** provides a summary of the activities and associated milestones expected to be completed during Phase 2 to comply with the WLAs and LAs established by the revised TMDLs (see Table 6-2 for applicable WLAs and LAs). The following subsections provide additional information regarding each of these planned activities.

7.4.2.1 Stakeholder Coordination

The LECL Task Force, administered by LESJWA, has been instrumental in the ongoing implementation of the existing nutrient TMDLs. This group has collaboratively implemented the research and analysis needed to establish the revised TMDLs for Lake Elsinore and Canyon Lake. It is recommended that the LECL Task Force continue to meet at least quarterly and continue its efforts to implement the types of studies and monitoring programs necessary to make continued progress in improving water quality in these lakes and complying with the TMDL numeric targets.

7.4.2.2 Revision to Existing Waste Discharge Requirements and Other Regulatory Actions

The Santa Ana Water Board will revise, where needed, existing regulatory decisions (e.g., Waste Discharge Requirements [WDRs], CWAD, 404 permits, 401 certifications, effluents limits) in the San Jacinto River watershed to support implementation of the revised TMDLs. In addition, the Santa Ana Water Board will use its regulatory authorities to recommend actions by other agencies or entities, where deemed appropriate to support TMDL compliance. Santa Water Board Actions will include:

Revision to Existing Permits

The Santa Ana Water Board will review and revise, as necessary and within a timely manner, the following existing permits to incorporate revised WLAs, LAs and monitoring program requirements:

- NPDES Permit and WDRs for the Riverside County Flood Control and Water Conservation District, the County of Riverside and the Incorporated Cities of Riverside County within the Santa Ana Region, Areawide Urban Runoff, NPDES No. CAS 618033 (Order No. R8-2010-0033) (Santa Ana Water Board 2010).
- NPDES Permit and WDRs for United States Air Force, March Air Reserve Base, Storm Water Runoff, Riverside County (Order No. R8-2010-0005, NPDES No. CA 0111007) (Santa Ana Water Board 2015c).
- Conditional Waiver of WDRs for Discharges from Agricultural Operations in the Watersheds of the San Jacinto River and its Tributaries, and Canyon Lake and Lake Elsinore and their Tributaries, collectively, “The San Jacinto River Watershed” Riverside County (Order No. R8-2016-0003, as amended by Order R8-2017-0023) (Santa Ana Water Board 2017).

Table 7-12. Summary of TMDL Implementation Activities (See Tables 6-2 and 6-3 for identification of responsible entities with WLAs or LAs)

Implementation Element	Activity	Responsible Entity (ies)	Complete by
Stakeholder Coordination	LECL Task Force collaborate at least quarterly on TMDL implementation activities	All entities with a WLA or LA and Santa Ana Water Board	Throughout Phase 2
Revision to Existing Permits and Other Regulatory Actions	Riverside County MS4 Permit	Santa Ana Water Board	In a timely manner; at the discretion of the regulatory agency
	March Air Reserve Base MS4 Permit (industrials stormwater permit)		
	Conditional Waiver for Agricultural Operations		
	EVMWD WDR		
	Dairy General Order		
	Caltrans MS4 Permit	State Water Board	
	Small MS4 General Permit		
	USFS Nutrient Management Plans	Santa Ana Water Board, State Water Board, and EPA	Revised Management Plans within two years of TMDL effective date
Revise Existing Watershed Implementation Plans	Comprehensive Nutrient Reduction Plan: Revise existing CNRP to: (a) identify supplemental projects for implementation, where needed; (b) be consistent with revised TMDLs; (c) develop a tool for tracking detailed data on existing and future watershed BMP deployment by subwatershed zone needed to support compliance demonstrations; and (d) satisfy MS4 permit requirements, as applicable	Phase I MS4 Permittees	Revised CNRP within two years of revised TMDL effective date or as required by reauthorized MS4 permit, whichever is sooner
	Agricultural Nutrient Management Plan: Revise existing AgNMP to: (a) identify supplemental projects for implementation, where needed; (b) be consistent with revised TMDLs; (c) develop a tool for tracking detailed data on watershed BMP deployment by subwatershed zone needed to support compliance demonstrations; and (d) satisfy CWAD requirements, as applicable	Agricultural Operators	Revised AgNMP(s) will be submitted within six months of the submittal to the Santa Ana Water Board of the TMDL Technical Report: Draft for Public Review and Peer Review to support the revised TMDLs
Implementation and/or Revision of Existing Water Quality Controls	Canyon Lake Alum Project	Entities with a WLA or LA applicable to Canyon Lake	As needed application, as determined through revision to the CNRP and AgNMP
	LEAMS	Entities with a WLA or LA applicable to Lake Elsinore	Continued implementation as per LEAMS operational agreements

Table 7-12. Summary of TMDL Implementation Activities (See Tables 6-2 and 6-3 for identification of responsible entities with WLAs or LAs)

Implementation Element	Activity	Responsible Entity (ies)	Complete by
	Fishery Management	Entities with a WLA or LA applicable to Lake Elsinore	As needed carp removal or implementation of additional fishery management activities as determined through revision of CNRP and AgNMP
	Supplemental Reclaimed Water	EVMWD	Maintain minimum discharge of supplemental water
Special Studies	Nutrient Loads from Reference Watershed	All entities with a WLA or LA (see Table 6-2)	Complete study within three years of TMDL effective date
	Other Research Activities	All entities with a WLA or LA (see Table 6-2)	As needed, milestones determined by specific study
Revised Monitoring Program and Quality Assurance Project Plan (QAPP)	Revised Monitoring and Reporting Program	All entities with a WLA or LA (see Table 6-2)	Submitted within 90 days of TMDL effective date; implemented within 90 days of Santa Ana Water Board approval
	Annual Water Quality Reports	All entities with a WLA or LA (see Table 6-2)	By August 15 each year
	TMDL Compliance Evaluation	All entities with a WLA or LA (see Table 6-2)	By August 15 of every fifth year after TMDL effective date TMDL compliance evaluation to be submitted as part of the Report of Waste Discharge prepared to support renewal of an MS4 permit

- Waste Discharge and Water Reclamation Requirements for the EVMWD, RWRF, Riverside County (Order R8-2013-0017; NPDES No. CA8000027) (Santa Ana Water Board 2013b).
- General WDRs for CAFOs (Dairies and Related Facilities) within the Santa Ana Region (Order No. R8-2013-0001; NPDES No. CAG018001) (Santa Ana Water Board 2013c).
- NPDES Statewide Storm Water Permit, WDRs for State of California Department of Transportation, California State Water Board (Order 2012-0011-DWQ, as amended; NPDES No. CAS000003) (State Water Board 2012).
- NPDES General Permit No. CAS000004. WDRs for Storm Water Dischargers from MS4s, California State Water Board (Order 2013-0001-DWQ, as amended (State Water Board 2013a).

Actions Recommended for Implementation by Other Agencies

The Santa Ana Water Board will work with the U.S. Department of Agriculture/USFS on revisions to, or implementation of, the San Bernardino National Forest and the Cleveland National Forest Management Plans to manage the discharge of nutrients from federally-owned lands to reduce nutrient loads. Nutrient loads should be reduced to the maximum extent practicable to the expected nutrient load from the watershed reference condition. In addition, when wildfire occurs, BMPs shall be actively implemented on federally-owned lands to minimize downstream water quality impacts from mobilized nutrients. Required revisions to USFS Management Plans shall be completed within two years of the effective date of the revised TMDLs.

7.4.2.3 Revision of Existing Watershed Implementation Plans

Table 7-12 lists the existing watershed implementation plans that will need to be revised early in the implementation of these revised TMDLs. The minimum requirements to revise these plans are summarized below.

Comprehensive Nutrient Reduction Plan

Riverside County's MS4 permit obligates the MS4 permittees located in the San Jacinto River watershed to comply with the LECL nutrient TMDLs (Santa Ana Water Board 2010). To satisfy this requirement, the permit required development of a CNRP that described how the permittees would achieve compliance with the WLAs established in the existing TMDL. The CNRP was submitted in 2012 and the Santa Ana Water Board approved it in 2013 (RCFC&WCD 2013, Santa Ana Water Board 2013a). The CNRP included a range of implementation activities, including watershed-based BMPs to reduce nutrient concentrations in urban runoff, in-lake remediation projects (LEAMS and alum addition), monitoring and participation in the LECL Task Force and its ongoing projects. The permittees continue to implement the CNRP.

As part of Phase 2, the CNRP will be updated to be consistent with the revised TMDL. This update will (1) evaluate and, where needed, update existing nutrient control BMPs currently being implemented in the watershed under the existing CNRP; (2) incorporate new BMPs that have been implemented since adoption of the existing CNRP to document water quality benefits expected to be achieved, e.g., incorporate the requirements to control trash in the MS4 (State Water Board 2015b); (3) identify supplemental projects that will be implemented to comply with the WLAs in the revised TMDLs; (4) establish the basis for evaluating compliance by each jurisdiction with a WLA (including revisions to the monitoring program, if needed); and (5) establish the process for periodic review and revision of the CNRP, as appropriate.

For any supplemental project included in the revised CNRP, the CNRP will: (1) include a conceptual level design; (2) provide the water quality benefits expected from the project, when implemented; (3) identify the entities that will be responsible for the project's implementation; (4) include a schedule for implementation of the supplemental project with key milestones. The review and revision to the CNRP will be completed either within two years of the effective date of the revised TMDLs or by the date required by a reauthorized MS4 permit, whichever is sooner.[8]

Agriculture Nutrient Management Plan

In 2013, WRCAC submitted a final AgNMP for agricultural operators in the watershed (WRCAC 2013a). This management plan, which has not been formally approved by the Santa Ana Water Board, is scheduled to be updated to support implementation of the CWAD (Santa Ana Water Board 2017). Specifically, the CWAD requires the development of one or more AgNMPs, either by individual agricultural operators or by agricultural operators coordinating as a Coalition Group. The AgNMP(s) are to include proposed plans and schedules for the implementation of nutrient reduction BMPs, including in-lake nutrient reduction measures, and monitoring to assess BMP efficacy and the effects of the proposed BMPs on receiving water quality.

The updated or new AgNMP(s) will (1) evaluate and, where needed, update existing nutrient control agricultural BMPs currently being implemented in the watershed; (2) incorporate any required BMPs consistent with the CWAD (State Water Board 2017); (3) identify supplemental projects, where needed, that will be implemented to comply with the LAs in the revised TMDLs; (4) establish the basis for evaluating compliance with a LA (including revisions to the monitoring program, if needed);and (5) establish the process for periodic review and revision of the AgNMP, as appropriate.

For any supplemental project included in the AgNMP(s), the plan will: (1) include a conceptual level design; (2) provide the water quality benefits expected from the project, when implemented; (3) identify the entities that will be responsible for the project's implementation; (4) include a schedule for implementation of the supplemental project with key milestones.

Per the CWAD, the proposed AgNMP(s) is to be submitted to the Santa Ana Water Board within 6 months of the submittal of the LECL Task Force's draft recommendations for the revisions of the Lake Elsinore and Canyon Lake nutrient TMDLs.

7.4.2.4 Implementation and/or Revision of Existing Water Quality Controls

Since adoption of the original TMDLs the implementation of nutrient management programs through discharge permits, water quality management programs and operation of engineered BMPs have resulted in improved water quality in both Lake Elsinore and Canyon Lake. These projects and programs should continue to be implemented and, where appropriate, updated to incorporate the latest available, relevant information. However, per California Water Code (CWC)

[8] The current MS4 permit was adopted in 2010. When this permit is reauthorized, it is anticipated that it will include a requirement and schedule to update the CNRP.

Section 13360(a), the Santa Ana Water Board cannot specify the method of compliance with a regulatory requirement, including TMDL WLAs or LAs. As such, going forward the entities responsible for TMDL compliance will need to determine the best method, e.g., selection of BMPs or participation in an offset program, to achieve compliance with the requirements of these TMDLs.

Application of Alum

The LECL Task Force selected alum as the most cost effective nutrient control strategy for Canyon Lake, based on the findings of analyses completed using the Canyon Lake model (Anderson 2012a). Application of alum began in September 2013 and has continued semi-annually through 2018. As a result of these treatments, Canyon Lake appears to have shifted to a more phosphorus-limited condition, which was the goal of this water quality management approach. It is recommended that alum addition to Canyon Lake continue as the key in-lake BMP under the Phase 2 TMDL implementation program; however, the current approach for the continued addition of alum to Canyon Lake will be evaluated, and as needed, refined, as part of the update to the CNRP and AgNMP.

Lake Elsinore Aeration and Mixing System (LEAMS)

LEAMS was implemented in Lake Elsinore to improve water quality by improving dissolved oxygen concentrations. It is recommended that LEAMS continue to be operated during Phase 2 as it is expected to continue to remove significant nitrogen from Lake Elsinore. The agreements established to support the operation and use of LEAMS to support TMDL implementation should continue to be revised and/or updated as needed by the signatories to these agreements.

Reclaimed Water for Stabilization of Lake Elsinore Lake Level

Existing agreements to add reclaimed water to Lake Elsinore will continue to be implemented during Phase 2. Currently, EVMWD produces ~6.0 mgd of reclaimed water (5.5 mgd available for discharge to Lake Elsinore; 0.5 mgd to Temescal Wash). In the 2016 RWRF Expansion Master Plan, EVMWD projects 7.5 mgd (~8,400 AFY in dry years) will be available for discharge to Lake Elsinore by 2020 (EVMWD 2015). Beyond 2020, EVMWD plans to continue to make reclaimed water available for lake level stabilization up to 9 mgd (~10,000 AFY in dry years. For the purposes of the Phase 2 implementation program, this increased discharge of reclaimed water to Lake Elsinore is considered a supplemental project (see Table 7-10).

Fishery Management

It is recommended that the LECL Task Force continue to periodically conduct fish surveys to evaluate carp population levels and determine whether additional carp removal is necessary. In addition, as part of the evaluation of supplemental projects, additional fishery management activities, as originally identified by LESJWA (2005a) will be considered for implementation.

7.4.2.5 Special Studies

The revised nutrient TMDLs are based on assumptions developed from numerous technical studies completed during Phase 1 or since adoption of the original TMDL in 2004. During Phase 2, it is recommended that stakeholders consider implementation of the following specific studies or implement other special studies where deemed necessary to support implementation.

Reference Watershed Nutrient Loads

To establish nutrient concentrations representative of a reference watershed, the TMDL relies on water quality data from the San Jacinto River at Cranston Guard Station monitoring site (see Section 3.2.2.3). Other grab samples collected from undeveloped canyon sites in the San Jacinto watershed support the estimated values for total phosphorus and total nitrogen from undeveloped watersheds represented by the Cranston Guard Station. To establish a larger dataset to validate the representation of reference nutrient concentrations in the San Jacinto River watershed, it is recommended that the responsible entities research options for selection of additional watershed reference sites. As part of this research, a special study could be conducted to identify best locations for inclusion in the watershed monitoring program including the original Cranston Guard Station site. Any final selected sites would be incorporated in the San Jacinto River Watershed monitoring program (see Section 7.2.4.6).

Other Research Activities

Stakeholders will implement research studies on an as needed basis to provide supporting data for anticipated technical or regulatory outcomes. These studies may be deemed necessary to verify assumptions in the revised TMDLs (e.g., natural background concentrations, alum binding capacity or sediment flux rates), or refine understandings of watershed or lake dynamics, e.g., with regards to nutrients, or update lake models, or evaluate effectiveness of water quality controls. Another area where further study may be warranted includes the impact of wildfire, which has been identified as a potential source of increased nutrients in the watershed. Studies could be developed to further understand the role of wildfire in establishing background or reference nutrient conditions in the watershed. Where a research project is recommended for implementation, a workplan, budget and schedule will be developed for consideration by the LECL Task Force.

7.4.2.6 Develop and Implement Revised Monitoring and Reporting Program

Section 8 of this TMDL Report provides recommendations for revisions to the existing Lake Elsinore and Canyon Lake monitoring and reporting program (MRP) established to implement the existing TMDLs. After the revised TMDLs become effective, the entities responsible for compliance with WLAs or LAs in each lake shall revise the existing MRP, including the program QAPP, as needed. The revised MRP will be based on the recommendations of Section 8 of this TMDL report and incorporate the following elements:

- *Revised MRP* – Within 90 days of the effective date of the revised TMDLs, a revised state Surface Water Ambient Monitoring Program (SWAMP)-compliant program shall be submitted to the Santa Ana Water Board for approval. The revised MRP shall be implemented within 90 days of Santa Ana Water Board approval.

- *Annual Water Quality Report* – By August 15 of each year, an Annual Water Quality Report shall be submitted to the Santa Ana Water Board. This report shall summarize the findings from in-lake and watershed monitoring activities for the previous one-year period from July 1 through June 30.

- *TMDL Compliance Evaluation* - Every fifth year from the TMDL effective date the Annual Water Quality Report shall be expanded to include an analysis of the effectiveness of the

TMDL Implementation Program and evaluate progress towards achieving compliance with the WLAs and LAs and attainment with applicable water quality objectives. When submitting a Report of Waste Discharge to renew an MS4 permit, the MS4 permittees will incorporate the most recent TMDL compliance evaluation.

7.4.3 Adaptive Management

The Santa Ana Water Board, working through the LECL Task Force, will evaluate the findings from the TMDL compliance evaluation prepared every five years to determine the need for revisions to the TMDL and its implementation program. Where needed, modifications to the implementation program could be made, e.g., in future permits or through future updates to the CNRP and AgNMPs. In addition, at the discretion of the Santa Ana Water Board and in collaboration with the LECL Task Force, the TMDL may be reviewed and again revised in the future, as appropriate.

Section 8

Monitoring Requirements

8.1 Background

In December 2004, the Santa Ana Water Board adopted amendments to the Basin Plan to incorporate TMDLs for nutrients in Lake Elsinore and Canyon Lake. Following adoption of the 2004 nutrient TMDLs, LESJWA developed a monitoring program to support TMDL implementation (LESJWA 2006). The Santa Ana Water Board approved the program's monitoring plan (2006 Monitoring Plan) in March 2006 (Santa Ana Water Board 2006b) and the LECL Task Force implemented the program from April 2006 through June 2012. This initial monitoring program focused on collecting data to better understand in-lake processes, watershed nutrient sources and compliance monitoring.

The 2006 Monitoring Plan utilized the monitoring stations recommended by the 2004 nutrient TMDL: (a) Three stations in Lake Elsinore; (b) four stations in Canyon Lake; and (c) five watershed stations. In-lake sampling was performed monthly October through May and bi-weekly June through September. Watershed sampling was conducted during three storm events per year. For both in-lake and watershed sampling, data were collected for a suite of nutrients, BOD/COD and TSS. Additionally, in-lake samples were analyzed for general water quality properties (pH, specific conductance, DO, and temperature), chlorophyll-*a*, and DOC/TOC. In-lake samples were collected as depth-integrated samples, while watershed stormwater samples were flow-weighted composites.

This initial monitoring approach continued through July 2010. Following a review of available data that indicated consistent and similar nutrient concentrations and physical water quality parameters among the three sampling sites in Lake Elsinore and two sites in the eastern arm of Canyon Lake, the 2006 Monitoring Plan was revised for the 2010-2011 sampling season. Per the approved monitoring program revisions, *in-situ* water quality parameters continued to be recorded at all original stations and the watershed sampling program remained unchanged (Santa Ana Water Board 2011). However, analytical sampling was reduced to one location in Lake Elsinore (LE02; center of lake) and three locations in Canyon Lake (CL07, CL08, and CL10) and selected non-nutrient analytes were no longer analyzed (i.e. BOD, COD, TOC, DOC).

Monitoring continued under the revised program through June 2012. At that time, in agreement with the Santa Ana Water Board, while watershed monitoring would continue, in-lake monitoring would be discontinued temporarily to redirect TMDL program funding towards nutrient reduction actions including lake stabilization, fishery management and alum application in Canyon Lake.

In April 2015, the LECL Task Force prepared a draft revised monitoring work plan to support TMDL implementation. This plan focused on a reassessment of current conditions and established a revised monitoring framework to better assess water quality trends towards meeting the existing TMDL numeric targets. Specific goals of the final work plan included (Haley & Aldrich 2016):

- Evaluate the status and trends toward achieving TMDL response targets in both lakes;
- Determine how to quantify the degree of influence from natural background sources; and
- Distinguish and quantify the external pollutant loading originating from watersheds draining to the lakes.

Watershed monitoring remained unchanged, but based on the above goals, revisions to the previous in-lake monitoring program included:

- Sampling frequency reduced to bi-monthly (every other month) for both lakes.
- Full water column profiles of physical water quality parameters (pH, DO, specific conductance, and temperature) recorded at 1-m intervals in both the morning and afternoon at each in-lake station. These two measurement times were performed to better capture the diurnal cycle of DO and pH as influenced by algal activity. These data have been used to assess both temporal and spatial variability and their comparability to data obtained from the currently installed *in-situ* data sondes operated by EVMWD.
- Acquisition of satellite imagery (30-m resolution) concurrent to in-lake sampling events to assess lake-wide estimates of chlorophyll-*a* and turbidity in both lakes.

The monitoring program was further revised by the LECL Task Force to include the following:

- Two additional annual monitoring events in Lake Elsinore, so that monthly sampling would occur during the summer period (June – September). This enhanced monitoring in Lake Elsinore was initiated given the TMDL criteria for chlorophyll-*a* are based on a summer average, as opposed to an annual average for other constituents.
- Total and dissolved aluminum analyzed at all stations in Canyon Lake to evaluate any influence from alum treatments which have been performed biannually each year beginning in 2013.
- Analysis of the full constituent list at Canyon Lake Station CL09 during each sample event.
- Increased resolution satellite imagery (10-m resolution) has been incorporated into the monitoring program. Finer satellite resolution allows for a more accurate estimation of chlorophyll-*a* and turbidity in the eastern arm of Canyon Lake, as well as providing three times the number of lake-wide data points for data analysis.

In addition to the monitoring activities described above, cyanotoxin monitoring was conducted temporarily on behalf of the LECL Task Force in coordination with TMDL monitoring activities during the 2017-2018 fiscal year. This monitoring was conducted following a cyanobacterial algal bloom in Lake Elsinore and coordinated with other cyanobacteria monitoring occurring by others in the region through a statewide monitoring effort. Since the 2017-2018 fiscal year, cyanotoxin monitoring has been conducted by the City Lake Elsinore, but only on an as needed basis.

8.2 Revised TMDL Monitoring Approach

8.2.1 Overview

Under the numeric targets proposed in this TMDL revision (see Section 3.3), the primary objective is to establish water quality conditions that are equal to or better than what would occur in the lakes if the watershed was returned to a reference condition (i.e., pre-development). The new proposed numeric targets are based on CDFs expected in Lake Elsinore and Canyon Lake (Main Lake and East Bay) based on the reference condition. To support this approach, a revised monitoring design is proposed for implementation under the revised nutrient TMDLs to provide the data types necessary to demonstrate compliance with revised targets.

Other than several small modifications, the overall recommended monitoring design is similar to the monitoring program that currently is being implemented by the LECL Task Force. **Table 8-1** provides a summary of elements to be considered for inclusion in the revised monitoring program to be formalized after the revised TMDLs are adopted (see Table 7-12, TMDL implementation activities). A more detailed description of these elements is provided below.

Table 8-1. Summary of Elements for Inclusion in Revised TMDL Monitoring Program

Waterbody	Elements Recommended for Inclusion in Revised TMDL Monitoring Program
San Jacinto River Watershed	• Re-inclusion of the Cranston Guard Station • Add two new monitoring stations below reference sub-watersheds • Reduce the storm mobilization criteria for the October 1 to December 31 period from a 1.0-inch to a 0.5-inch forecast within 24-hours. The January 1 through April 30 mobilization criteria remains the same.
Lake Elsinore	• Discontinue the afternoon water column profile at each existing monitoring station. Analysis of water column profiles will continue to be performed once in mid to late morning during each monitoring event. • Utilize the two EVMWD multi-depth in-lake water quality sondes in combination with fixed depth DO sondes mounted just under the surface at both EVMWD sondes. These data will supplement the single point-in-time water column profiles recorded during each field monitoring event. • Incorporate Sentinel-2 satellite imagery (10-m resolution) for chlorophyll-*a* and turbidity measurements during months in which it is available (September through May), and LandSat 8 satellite imagery (30-m resolution) during all other months (June through August).
Canyon Lake	• Discontinue the afternoon water column profile at each existing monitoring station. Analysis of water column profiles will continue to be performed once in mid to late morning during each monitoring event. • Utilize a combination of fixed depth in-lake DO and temperature sondes to supplement single point-in-time water column profiles recorded during each field monitoring event. • Add Station CL09 to sites being monitored for full analyte list during each event. • Add total and dissolved aluminum to the analyte list for all sites to assess any influences from alum treatments in Canyon Lake. • Incorporate Sentinel-2 satellite imagery (10-m resolution) for chlorophyll-a and turbidity measurements during months in which it is available (September through May), and LandSat 8 satellite imagery (30-m resolution) during all other months (June through August)

8.2.2 San Jacinto River Watershed Monitoring

The study design for the watershed-wide monitoring program will continue to be focused on quantifying nutrient loading into Lake Elsinore and Canyon Lake from upstream watershed sources, and adding to the historical monitoring data set to assess long-term trends. Additionally, in an effort to better understand loading from natural background sources within the San Jacinto River watershed, one historical reference site (i.e., the Cranston Guard Station) and two new monitoring stations below reference sub-watersheds with little to no anthropogenic development are recommended for addition to the watershed monitoring program.

Stormwater runoff will continue to be sampled during three storm events per year during the wet season at all stations when flow is present. Storm mobilization criteria will be revised to be a 0.5-inch forecast within 24-hours through the entire wet season of October 1 through May 31st.
Samples will not be collected during dry weather; however, total annual flows measured at the collocated USGS stream gauges will be used to calculate total watershed loading.

Sample Locations

Currently, four historical sampling stations are located throughout the San Jacinto River watershed, Lake Elsinore, and Canyon Lake area (**Figure 8-1, Table 8-2**). The sampling locations were selected to reflect various types of land use and have been monitored since 2006. Three of the four sites were selected because they are indicative of inputs to Canyon Lake originating from the mainstem of the San Jacinto River, Salt Creek, and the watershed above Mystic Lake. The fourth site, located below the Canyon Lake Dam, is indicative of loads entering Lake Elsinore from Canyon Lake and the upstream watershed when Canyon Lake overflows. Many of the sampling stations are located in close proximity to stream gauge stations installed by the USGS or the RCFC&WCD. The stream gauges provide a general estimate of the total flow in the channel at a location close to each autosampler.

The San Jacinto River at Ramona Expressway sampling location is downgradient of Mystic Lake, an area of land subsidence. Flow has not been observed at this location since a strong El Niño event in the mid-1990s; however, because of active subsidence in the area, this monitoring station is not expected to flow except under extremely high rainfall conditions.

The Cranston Guard Station (reference location last monitored in the 2014-2015 fiscal year), is recommended for addition back into the monitoring program (Figure 8-1). Table 8-2 provides several candidate reference stations under consideration for estimation of the natural loading to the lakes. As part of the implementation of the revised TMDLs, two of these candidate locations will be selected for inclusion in the watershed monitoring program.

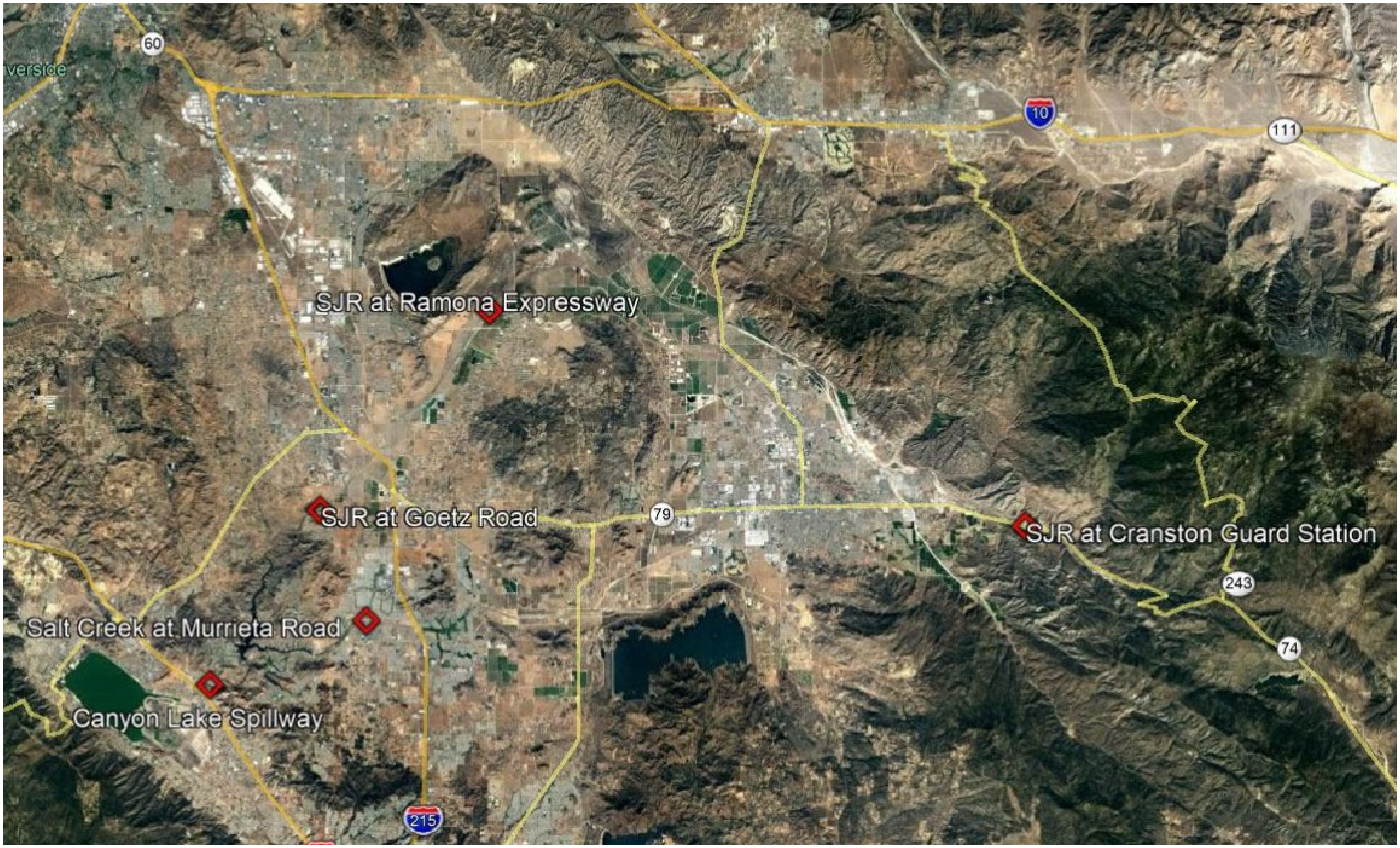

Figure 8-1. San Jacinto River (SJR) Watershed Monitoring Locations (Note: The SJR at Cranston Guard Station is not currently monitored but is recommended for monitoring in the future under the revised TMDLs, see text).

Table 8-2. Watershed-wide Monitoring Stations

Location Number and Description	Historical Database Station Number	Latitude/Longitude
Salt Creek at Murrieta Road	745	33.693842, -117.206041
San Jacinto River at Goetz Road	759	33.751257, -117.223632
San Jacinto River at Ramona Expressway	741	33.840382, -117.135548
Canyon Lake Spillway	841	33.674240, -117.272059
Cranston Guard Station Reference	792	33.736812, -116.826491
Candidate Reference Station 11	--	33.677998, -117.414117
Candidate Reference Station 13	--	33.890439, -117.070250
Candidate Reference Station 15	--	33.761685, -116.882620
Candidate Reference Station 16	--	33.862848, -117.025500

Sample Collection

Flow-weighted composite samples will be collected either manually by compositing discrete grab samples, or by using automatic sampling equipment (e.g., ISCO™ autosamplers equipped with flow meters). Samples will be collected on both the rising limb (increasing flow) and the falling limb (decreasing flow) of the hydrograph. Eight to twelve discrete samples will be collected for compositing if collected manually (consistent with previous direction from the Santa Ana Water Board). Flow will be estimated based on data from USGS stream gauges collocated on the same streams near the sampling stations (if possible). The flow-weighted composite samples for analysis will be created post-storm by combining aliquots of each discrete sample collected across the hydrograph based on flow data from USGS gauges.

Sample Analytes

Table 8-3 summarizes sample analytes and their associated laboratory methods. *In-situ* water quality measurements (pH, temperature and turbidity) will be conducted using handheld portable meters at multiple points throughout each storm event.

8.2.3 Lake Elsinore Monitoring

This section describes the recommended framework for the establishment of an updated Lake Elsinore monitoring program following approval of the revised TMDLs:

- Three historical stations will be monitored during each field event: LE01, LE02, and LE03 (**Table 8-4, Figure 8-2**).
- Lake Elsinore will be monitored monthly during the summer period (June through September) and bi-monthly (every-other month) during the remainder of the annual cycle (October through May) (**Table 8-5**).

Table 8-3. Watershed Analytical Constituents and Methods

Parameter	Analysis (SM = Standard Method)
Turbidity	Field Meter
Water Temperature	Field Meter
pH	Field Meter
Total Organic Nitrogen (Org-N)	Calculated
Nitrite Nitrogen (NO_2-N)	SM4500-NO2 B
Nitrate Nitrogen (NO_3-N)	EPA 300.0
Ammonia Nitrogen (NH_4-N)	SM4500-NH3 H
Total Kjeldahl Nitrogen (TKN)	EPA 351.3
Total Phosphorus (TP)	SM4500-P E
Soluble Reactive Phosphorus (SRP / Ortho-P)	SM4500-P E
Total Suspended Solids (TSS)	SM2540C
Chemical Oxygen Demand (COD)*	SM5220D
Biochemical Oxygen Demand (BOD)*	SM5210B
Total Dissolved Solids (TDS)	EPA 160.1
Total Hardness as Calcium Carbonate ($CaCO_3$)	SM 2340C

*Analyses to be performed on the first discrete sample only.

Table 8-4. Lake Elsinore Monitoring Stations

Location Description	Historical Database Station Number	Latitude/Longitude
North-northeast side of lake	LE01	33.668978, -117.364185
Mid-lake	LE02	33.663344, -117.354213
South-southwest side of lake	LE03	33.654939, -117.341653

Table 8-5. Summary of Lake Elsinore TMDL Monitoring Activities (Y = Yes; N = No)

Sample Period	Location	Analytical Samples[1]	Chlorophyll-*a*[2]	Field Water Quality Measurements[3]
Monthly (June – September); Bimonthly[4] (October – May)	LE01	N	N	Y
	LE02	Y	Y	Y
	LE03	N	N	Y
Continuous	*In-Situ* Sondes	N	N	Y[5]

[1] Includes depth-integrated samples for all constituents listed in Table 8-6.

[2] Chlorophyll-*a*: Two samples: (1) surface-to-bottom depth integrated sample; and (2) a 0 to 2-m depth integrated surface sample.

[3] Includes depth profile field measurements for pH, DO, temperature, and conductivity; water clarity measured using a Secchi disk.

[4] Bi-monthly is sampling every other month from October to May. Monthly sampling to occur over summer months only (June-September).

[5] Two stations located near the center of Lake Elsinore are monitored by EVMWD for DO, conductivity, pH, and temperature at 1-m intervals using permanently installed *in-situ* YSI™ data sondes.

Figure 8-2. Lake Elsinore Monitoring Locations

- Analytical chemistry samples will be collected at one station (Station LE02) for the constituents listed in **Table 8-6**; sampling is coordinated to occur on the same day as the satellite imagery (See Section 8.2.5).
- Depth-integrated samples will be prepared by either combining discrete grab samples collected using a Van Dorn bottle at each 1-m depth interval throughout the water column, including the surface, or using a peristaltic pump and lowering/raising the inlet tube through the water column at a uniform speed.
- Two discrete chlorophyll-*a* samples will be collected at Station LE02: (1) a surface-to-bottom depth integrated sample; and (2) a 0 to 2-m depth integrated surface sample. The 0 to 2-m depth integrated sample provides a better estimation of chlorophyll-*a* for comparison to satellite imagery. Both chlorophyll-*a* sample types will be collected in the same manner as analytical chemistry samples using peristaltic pump.

Table 8-6. In-Lake Analytical Constituents and Methods

Parameter	Analysis Method	Sampling Method
Water Temperature	Field	Point Measure
Specific Conductivity	Field	Portable Meter
pH	Field	Portable Meter
Dissolved Oxygen	Field	Portable Meter
Turbidity	Field	Secchi disk
Total Hardness as CaCO3	SM 2340 C	Depth Integrated[1]
Total Alkalinity as CaCO3	SM 2320 B	Depth Integrated[1]
Nitrite Nitrogen (NO_2-N)	SM4500-NO2 B	Depth Integrated[1]
Nitrate Nitrogen (NO_3-N)	EPA 300.0	Depth Integrated[1]
Total Kjeldahl Nitrogen (TKN)	EPA 351.3	Depth Integrated[1]
Ammonia Nitrogen (NH_4-N)	SM4500-NH_3 H	Depth Integrated[1]
Sulfide	SM 4500S2 D	Depth Integrated[1]
Total Phosphorus (TP)	SM4500-P E & EPA 365.1	Depth Integrated[1]
Soluble Reactive Phosphorus (SRP / Ortho-P)	SM4500-P E	Depth Integrated[1]
Chlorophyll-a	SM 10200H	Surface & Depth Integrated[2]
Total Dissolved Solids (TDS)	SM 2540 C	Depth Integrated[1]
Total Suspended Solids (TSS)	SM 2540D	Depth Integrated[1]
Total Aluminum	EPA 200.7	Depth Integrated[1]
Dissolved Aluminum	EPA 200.7	Depth Integrated[1]

[1] Depth integrated samples are a composite of the entire water column.

[2] Two samples collected for chlorophyll-a: (1) Depth integrated - surface to bottom depth integrated sample; and (2) Surface - 0 to 2 m depth integrated surface sample.

- *In-situ* monitoring using pre-calibrated hand-held YSI™ field meters or equivalent will be performed during each sampling event at all three stations (LE01, LE02, and LE03) for pH, DO, temperature, and specific conductivity measurements. During each field visit, a surface to bottom depth profile at each station will be recorded at 1-m depth intervals.

- Surface and 1-m depth profiles will be assessed immediately adjacent to each of the centrally-located EVMWD multi-depth in-lake sondes ("EVMWD sondes", Lakeshore and Grand Avenue) for comparative purposes. Data from the two EVMWD sondes will be supplemented with DO sondes mounted to the in-lake sonde buoys at a fixed depth just beneath the surface to capture the DO concentration within the surface layer (this data currently lacking from EVMWD sondes). Data from these two sources supplements the manual water column profile measurements taken during each field sampling event. Given the continuous high-resolution dataset provided by the data sondes, these measures will provide a more accurate assessment of water quality conditions over time relative to single point-in-time measures and will thus be used as the primary method to assess TMDL compliance for DO. Data from the hand-held meters recorded immediately adjacent to each sonde during monitoring events will be used to validate the in-lake sonde data.

- To the extent possible, sample collection and field measurements will be conducted prior to noon during each field event to avoid collecting suspended sediments potentially stirred up from the bottom of the lake by frequent afternoon winds.

- Evaluate the need to address cyanotoxins as part of the monitoring program. This evaluation will consider the status of promulgation of EPA 304(a) criteria or State Water Board or Santa Ana Water Board adoption of water quality standards for cyanotoxins.

8.2.4 Canyon Lake Monitoring

This section describes the recommended framework for the establishment of an updated Canyon Lake monitoring program following approval of the revised TMDLs:

- Four historical stations will be monitored during each field event: Sites CL07, CL08, CL09, and CL10 (**Figure 8-3**, **Table 8-7**).

- Canyon Lake sampling will be conducted bi-monthly and coordinated to occur on the same day as satellite imagery as described in Section 8.2.5 below (**Table 8-8**).

- Analytical chemistry samples will be collected at all stations for the constituents listed above in Table 8-6. Sample collection efforts include:

    - Depth-integrated samples are prepared by either combining discrete grab samples collected using a Van Dorn bottle at each 1-m depth interval throughout the water column, including the surface, or using a peristaltic pump and lowering/raising the inlet tube through the water column at a uniform speed.

    - Two discrete chlorophyll-*a* samples will be collected at each station: (1) a surface-to-bottom depth integrated sample; and (2) a 0 to 2-m depth integrated surface sample. The 0 to 2-m depth integrated sample provides a better estimation of chlorophyll-*a* for comparison to satellite imagery. Both chlorophyll-*a* sample types will be collected in the same manner as analytical chemistry samples using a peristaltic pump.

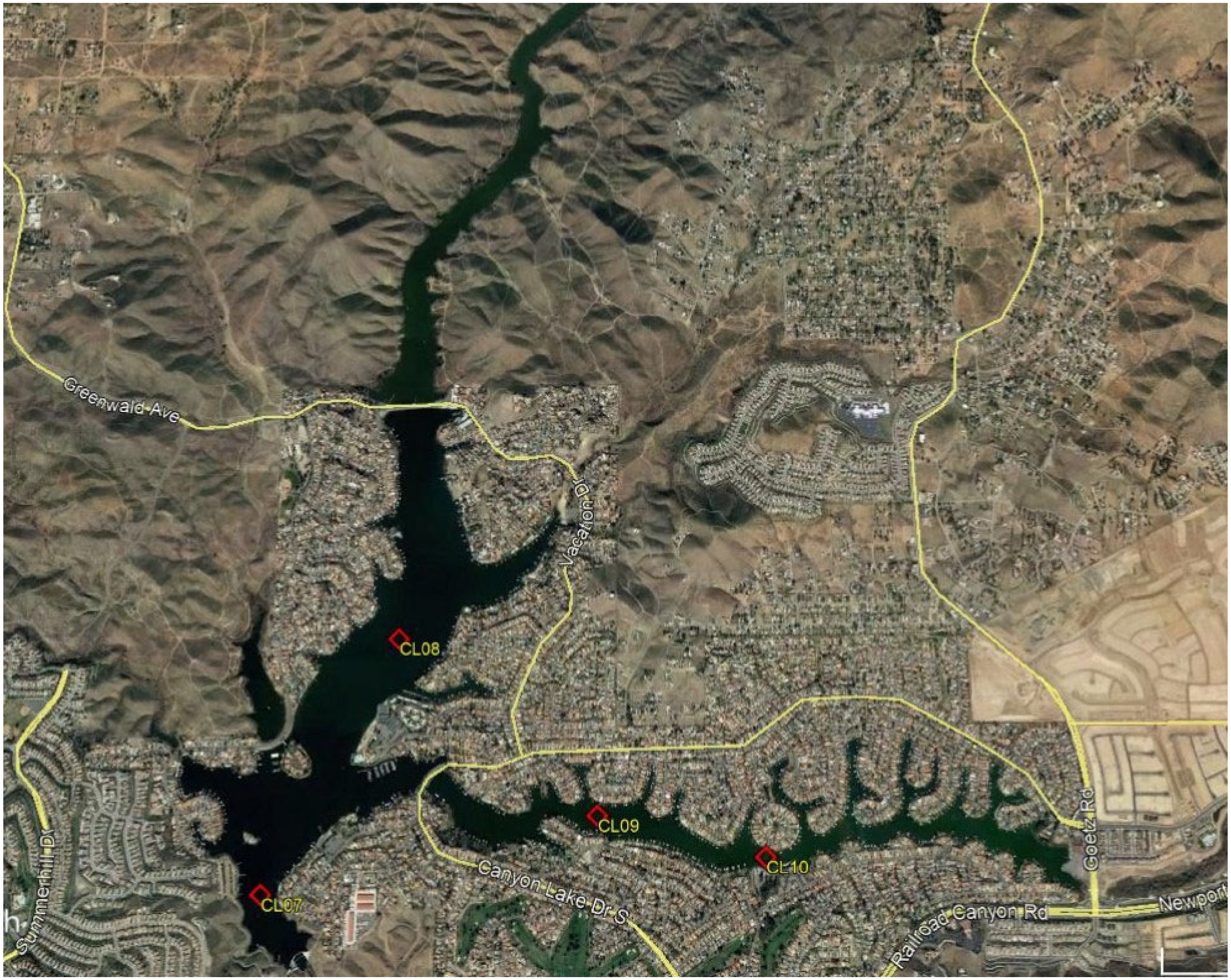

Figure 8-3. Canyon Lake Monitoring Locations

Table 8-7. Canyon Lake Monitoring Stations

Location Description	Historical Database Station Number	Latitude/Longitude
Main Body near Dam	CL07	33.678027, -117.275135
Main Body North Lake	CL08	33.688211, -117.268944
Eastern Arm near Roadrunner Park	CL09	33.681100, -117.258892°
Eastern Arm near Indian Beach Park	CL10	33.679495, -117.250669

- *In-situ* monitoring using pre-calibrated hand-held YSI™ field meters or equivalent will be performed once during each sampling event at all four stations (CL07, CL08, CL09, and CL10) for pH, DO, temperature, and specific conductivity measurements. A complete depth profile at each station will be recorded for each parameter at 1-m intervals.

- Two fixed depth DO sondes will be placed year-round at Sites CL07, CL08, and CL09 at depths corresponding with the upper epilimnion and at the median boundary depth between epilimnion and thermocline.[1] Temperature-only loggers will be deployed at 1-m intervals encompassing the range of depths at which the epilimnion/thermocline boundary is located based on prior monitoring data. All sondes will be programmed to record data at 2-hour intervals. Data from these sondes will supplement the bi-monthly water column profiles, and will provide a higher resolution, continuous data set for DO and temperature. Given the continuous data provided by the DO data sondes, these measures will provide a more accurate assessment of water quality conditions over time relative to single point-in-time measures and will thus be used as the primary method to assess TMDL compliance for DO. Data from the hand-held meters recorded immediately adjacent to each sonde array during bi-monthly monitoring events will be used to validate the in-lake sonde data.

- To the extent possible, water samples will be collected and field measurements made prior to noon during each sampling event.

- Evaluate the need to address cyanotoxins as part of the monitoring program. This evaluation will consider the status of promulgation of EPA 304(a) criteria or State Water Board or Santa Ana Water Board adoption of water quality standards for cyanotoxins.

[1] Epilimnion = upper portion of the water column in which the water temperature is nearly uniform; Thermocline = portion of the water column between the epilimnion and hypolimnion in which there is a marked drop in temperature per unit of depth; Hypolimnion = lower portion of the water column in which the temperature from its upper limit to the bottom is nearly uniform.

Table 8-8. Summary of Canyon Lake TMDL Monitoring Activities (Y = Yes; N = No)

Sample Period	Location	Analytical Samples Collected[1]	Chlorophyll-a[2]	Field Water Quality Measurements[3]
Bi-monthly[4]	CL07	Y	Y	Y
	CL08	Y	Y	Y
	CL09	Y	Y	Y
	CL10	Y	Y	Y
Continuous	*In-Situ* Sondes	N	N	Y[5]

[1] Includes depth-integrated samples for all constituents listed in Table 8-6.

[2] Chlorophyll-*a*: Two samples: (1) surface-to-bottom depth integrated sample; and (2) a 0 to 2-m depth integrated surface sample.

[3] Includes depth profile field measurements for pH, DO, temperature, and conductivity; water clarity measured using a Secchi disk.

[4] Bi-monthly is sampling every other month.

[5] In-lake continuous data sondes at Canyon Lake will only measure DO and temperature.

8.2.5 Satellite Imagery

Satellite imagery was added to the existing TMDL monitoring program to provide a more spatially comprehensive assessment of chlorophyll-*a* concentrations in Lake Elsinore and Canyon Lake on the day of each sampling event. A combination of LandSat 7/8 (30-m pixel resolution) and Sentinel 2 (10-m pixel resolution) satellite imagery will continue to be used under the revised program, dependent upon the time of year. During the summer months (June – September), images from the Sentinel 2A satellite experience an interference referred to as a sunglint. The sunglint results from the geometry angle of the imagery when the satellite faces the sun during recording of the image, causing a direct reflection of sunlight from the water surface to the satellite (i.e., sunglint), thereby causing image quality issues. As a result of this, LandSat 7/8 satellite imagery will be utilized during summer months, and Sentinel 2 imagery during all other months of the year. Maps depicting lake-wide chlorophyll-*a* and turbidity, and potentially also cyanotoxins if included in the monitoring program, will be generated for each monitoring event.

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Section 9

Demonstrating Compliance

This section contains a detailed set of guidelines that describe how data collected by the recommended monitoring program may be used to assess compliance with the numeric targets and allocations included in the revised TMDLs. Multiple approaches are provided by which dischargers may use monitoring data to demonstrate compliance with the TMDL. All the available methods for demonstrating compliance apply to a single reporting period. Demonstrations of progress toward compliance with the TMDL must be submitted every 5 years by all entities with an allocation in Table 6-3 as part of the TMDL Compliance Evaluation (see Revised Monitoring Program and QAPP implementation element in Table 7-12). Even if an area is determined to comply in a reporting period, data collection needed to support compliance demonstrations must continue for future reporting periods. General categories of alternative compliance demonstration approaches are provided in the following sections:

- *Section 9.1, Approach 1 - Numeric Target*: CDFs of in-lake water quality monitoring data are equal to or better than numeric target CDFs for chlorophyll-*a*, DO, and ammonia-N. Section 9.1 provides more guidance and an example with hypothetical data of this compliance demonstration approach.

- *Section 9.2, Approach 2 – Reference Condition Model*: CDFs of in-lake water quality monitoring data are equal to or better than model results for the reference scenario over the same hydrologic period for chlorophyll-*a*, DO, and total ammonia. Section 9.2 provides more guidance and an example with hypothetical data of this compliance demonstration approach.

- *Section 9.3, Approach 3 - External Load Reduction*: Allocations are developed for nutrients in external sources with an allowable concentration of nutrients, TN and TP, representative of a reference watershed. One way to demonstrate compliance involves collection of monitoring data that shows nutrients in external sources have been reduced to allocations, applicable to one or multiple jurisdictions. Section 9.3 provides more guidance and an example with hypothetical data of this compliance demonstration approach.

- *Section 9.4, Approach 4 – In-lake Offsets*: Meet WLA/LAs by offsetting nutrient loads in excess of reference conditions over the same hydrologic period. If only one nutrient is found to meet the LA/WLA, then data needed to demonstrate compliance with in-lake numeric target CDFs must be developed for the following reporting period. Section 9.4 provides more guidance and an example with hypothetical data of this compliance demonstration approach.

- *Section 9.5, Approach 5 – Retention*: Prevent discharge of nutrient loads from a drainage area by retaining all runoff on-site for extreme rainfall events (greater than 10-yr return period). Potential extreme rainfall in excess of on-site retention capacity is estimated and serves as the basis for determining whether the overflows would exceed the WLA/LAs and in-turn require offsets with in-lake BMPs in Lake Elsinore. Section 9.5 provides more guidance and an example with hypothetical data of this compliance demonstration approach.

Any discharger or group of dischargers (e.g., through the CNRP or AgNMP) may propose to the Santa Ana Water Board an alternative approach for demonstrating compliance that is not encompassed in the five approaches summarized above. Any proposed alternative compliance approach is subject to the review and approval of the Santa Ana Water Board Executive Officer.

9.1 Approach 1 - Numeric Target

This compliance demonstration approach compares the preceding 10 years of bimonthly sampling data against the numeric target CDF for chlorophyll-*a*, DO, and ammonia-N. The target CDF curve is developed based on the reference condition CAEDYM model output. Curves for each lake segment and response variable are provided in Section 3 as follow:

Lake Elsinore

- Figure 3-8: Chlorophyll-*a*
- Figure 3-9: Dissolved oxygen
- Figure 3-10: Total ammonia-N

Canyon Lake Main Lake

- Figure 3-11: Chlorophyll-*a*
- Figure 3-12: Dissolved oxygen
- Figure 3-13: Total ammonia-N

Canyon Lake East Bay

- Figure 3-14: Chlorophyll-*a*
- Figure 3-15: Dissolved oxygen
- Figure 3-16: Total ammonia-N

The type of monitoring data plotted as CDFs for comparison to the numeric targets differ depending upon the response variable, as follows:

- *Chlorophyll-a*: Average surface (top 1 meter) concentration from monthly satellite imagery, resulting in 120 estimates over the preceding 10 years. Separate averages are computed for Canyon Lake based on the spatial extent of the Main Lake and East Bay.
- *Dissolved Oxygen*: Bi-monthly depth profiles of DO at 1-m intervals from station LE02 in Lake Elsinore, CL07 in Canyon Lake Main Lake, and CL10 in Canyon Lake East Bay (see Section 2). The DO profile is converted to a fraction of the lake volume with DO > 5 mg/L,

resulting in 60 estimates over the preceding 10 years. Each 1-m DO reading represents a different volume of water for estimating the fraction of the total volume at the time a profile is collected. The volume of water at each depth interval is provided in Figure 5-2 for Lake Elsinore and Figure 5-3 for Canyon Lake Main Lake and East Bay.

- *Total Ammonia-N*: Depth integrated average total ammonia-N concentration from bimonthly samples from station LE02 in Lake Elsinore, CL07 in Canyon Lake Main Lake, and CL10 in Canyon Lake East Bay CDF. The set of 60 depth integrated averages are plotted as a CDF and compared with numeric target CDFs.

CDFs of data must be equal to or better than the numeric target CDF over the full range of frequencies to demonstrate compliance. An example involving the use of this method for a hypothetical (2020-2030) set of DO profiles from site CL07 in Canyon Lake Main Lake is provided below (**Figure 9-1**). To demonstrate compliance with the TMDL, the CDF from field measurements should remain above the reference condition CDF.

9.2 Approach 2 - Reference Condition Model

This compliance demonstration approach evaluates current monitoring data against modeled water quality for a reference condition over the same hydrologic period. This approach is very similar to a comparison with the numeric target CDFs demonstrated above, with the only change involving alignment of hydrology with the preceding 10-yr period. This approach is most appropriate when the preceding 10-yr period is not representative of long-term hydrologic periods used to the develop numeric targets: 1916-2016 for Lake Elsinore and 2001-2016 for Canyon Lake Main Lake and East Bay.

CDFs of data must be equal to or better than a CDF of model results for reference conditions over the full range of frequencies to demonstrate compliance. **Figure 9-2** provides an example demonstrating compliance using this method for chlorophyll-*a* in Lake Elsinore. The example is based on hypothetical (2020-2030) results from extension of the DYRESM-CAEDYM model past the numeric target setting period and a hypothetical set of monthly lake-wide surface chlorophyll-*a* concentrations derived from satellite imagery analysis. To demonstrate compliance with the TMDL, the CDF from satellite imagery analyses should remain below the reference condition CDF.

Step 1. Calculate fraction of Main Lake volume with DO > 5mg/L

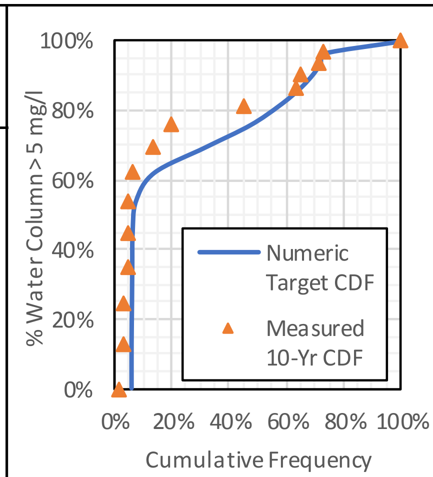
Example for Profile 1 of 60

Water Surface Elevation (ft msl)	Depth of Water (m)	Profile 1 DO Readings (mg/L)	Cumulative Volume (AF)	Incremental Volume (AF)	Volume with DO > 5 mg/L
1382	14.0	9.0	6,537	829	829
1379	13.0	8.5	5,709	766	766
1376	12.0	8.0	4,943	705	705
1373	11.0	8.0	4,238	645	645
1370	10.0	7.0	3,593	587	587
1367	9.0	7.0	3,007	530	530
1364	8.0	6.5	2,477	475	475
1361	7.0	6.0	2,002	421	421
1358	6.0	6.0	1,581	369	369
1355	5.0	5.5	1,212	318	318
1352	4.0	4.5	893	269	0
1349	3.0	4.0	624	221	0
1346	2.0	3.0	403	175	0
1343	1.0	2.5	227	227	0
			Volume (AF)	6,537	5,644
			Fraction above 5 mg/L DO	86.3%	

Step 2. Repeat step 1 for all 60 profiles

Step 3. Plot as CDF

Fraction of Lake Volume with DO > 5 mg/L	Frequency of Occurrence	Measured 10-Yr CDF	Reference CDF (Numeric Target)
0.0%	1	2%	6%
12.7%	1	3%	6%
24.4%	0	3%	7%
35.2%	1	5%	7%
45.0%	0	5%	7%
54.0%	0	5%	8%
62.1%	1	7%	14%
69.4%	4	13%	32%
75.8%	4	20%	48%
81.5%	15	45%	58%
86.3%	11	63%	65%
90.5%	1	65%	69%
93.8%	4	72%	72%
96.5%	1	73%	73%
100.0%	16	100%	100%



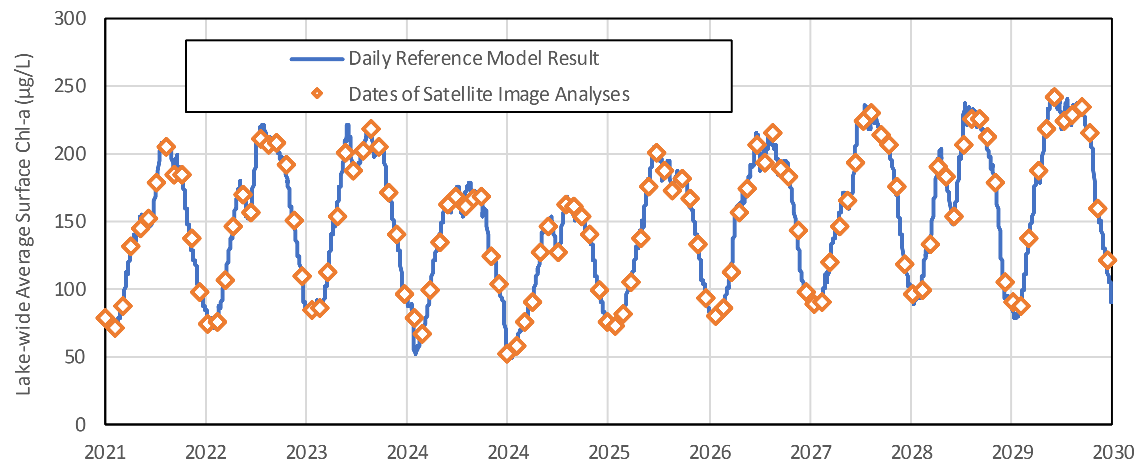
Compliance √

Figure 9-1. Hypothetical Example of Use of Dissolved Oxygen Profile Data to Evaluate Compliance with Numeric Target for Dissolved Oxygen.

Step 1. Run lake water quality model for preceding ten year period, output daily lakewide average surface chlorophyll-a concentration

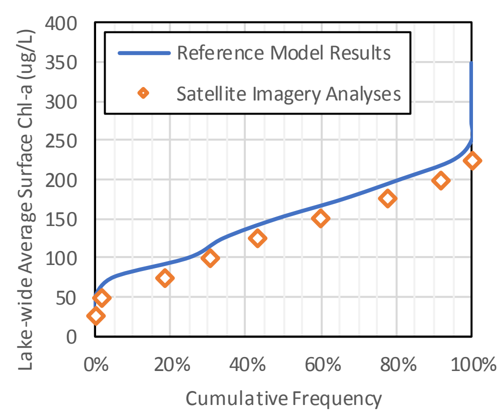
Step 2. Compile satellite imagery analysis data for lakewide average surface chlorophyll-a

Step 3. Extract model results for dates when satellite imagery analysis was conducted



Step 4. Plot 120 paired results of lake-wide average surface chl-a as CDFs

Interval (ug/L chl-a)	Sateliite Image Data		Reference Condition Model	
	Frequency of Occurrence	CDF	Frequency of Occurrence	CDF
25	0	0	0	0
50	2	2%	0	0%
75	20	18%	6	5%
100	15	31%	24	25%
125	15	43%	11	34%
150	20	60%	17	48%
175	21	78%	21	66%
200	17	92%	18	81%
225	10	100%	17	95%
250	0	100%	6	100%
275	0	100%	0	100%
300	0	100%	0	100%
325	0	100%	0	100%
350	0	100%	0	100%



Compliance √

Figure 9-2. Hypothetical Example of Use of Chlorophyll-a Data to Evaluate Compliance Using the Reference Condition Model Approach

9.3 Approach 3: External Load Reduction

Allocations are developed for nutrients from external sources with an allowable concentration of nutrients, TN and TP, representative of a reference watershed. Demonstrating compliance with these allowable concentrations involves collection of monitoring data that shows nutrients in external sources have been reduced to allocations. For example, flow-weighted average TP and/or TN concentration may be used to demonstrate that allocations are being achieved if the 10-yr average of flow weighted composite samples is less than 0.32 mg/L for TP and/or 0.92 mg/L for TN. This approach may be used based on data collected by required watershed monitoring program or from any additional upstream monitoring locations for individual or groups of jurisdictions. However, the following must be considered:

- When using this approach, any samples collected at a downstream monitoring station that is influenced by atypical levels of sediment from burned hillsides (e.g., TSS > 1,000 mg/L) may be excluded from the calculation of average nutrient concentrations.
- If a jurisdiction also includes drainage area in a different tributary to the downstream lakes, any excess nutrient loads from these areas must be accounted for separately (e.g., nutrient reduction credit in Salt Creek watershed cannot be transferred to the San Jacinto watershed). Monitoring at any new jurisdiction-specific locations must collect composite samples and follow requirements described in Section 8. If only one nutrient is found to meet the WLAs/LAs at the first TMDL compliance reporting period following adoption of the TMDL revision, then a demonstration using either Approach 1 or 2 must accompany use of a single nutrient control strategy in all subsequent TMDL compliance reporting periods.

Figure 9-3 provides an example demonstrating compliance using this method for phosphorus in the Salt Creek watershed. The example is based on hypothetical (2020-2030) results from continued implementation of the watershed monitoring program. To demonstrate compliance with the TMDL, the 10-yr average nutrient concentrations must be below the reference watershed nutrient concentration. In the example, only one nutrient is found to meet the WLA/LAs at the first TMDL compliance reporting period following adoption of the TMDL revision, thus a demonstration using either Approach 1 or 2 would be needed in subsequent TMDL compliance reporting periods.

Step 1. Compile 10 years of wet weather compsoite sample concentrations						
Year	**Storm 1 TP (mg/L)**	**Storm 2 TP (mg/L)**	**Storm 3 TP (mg/L)**	**Storm 1 TN (mg/L)**	**Storm 2 TN (mg/L)**	**Storm 3 TN (mg/L)**
Year 1	0.27	0.51	0.21	2.00	1.60	0.93
Year 2	0.20	0.43	0.33	2.40	2.30	1.65
Year 3	0.18	0.32	0.90	4.20	2.10	1.34
Year 4	0.16	0.44	0.32	4.30	2.70	1.84
Year 5	0.10	0.14	0.14	2.10	3.77	3.28
Year 6	0.11	0.21	0.11	1.40	4.12	2.89
Year 7	0.33	0.24	2.88 *	1.20	2.11	6.02 *
Year 8	0.29	0.37	0.20	0.80	2.36	0.68
Year 9	0.42	0.53	0.21	0.96	0.78	0.83
Year 10	0.68	0.32	0.32	3.40	0.91	1.03
Step 2. Compute 10-yr Average		**0.31**			**2.07**	
* Sample removed from average calculation because of influence of burned hillside erosion (TSS = 3163 mg/L)						
Step 3. Determine whether one or both nutrients are reduced to reference concentration				**Compliance √ - TP only**		

Figure 9-3. Hypothetical Example of Use of Nutrient Data to Evaluate Compliance with External Loads from the Reference Watershed

9.4 Approach 4: In-Lake Offsets

Allocations are developed for nutrients in external sources with an allowable concentration of nutrients, TN and TP, representative of a reference watershed. Demonstrating compliance involves first computing the excess nutrients in external sources. This amount is then used for determining the necessary offset credits from implementation of in-lake BMPs. Lastly, a project specific effectiveness analysis must be developed that computes the internal nutrient load reduction achieved with in-lake BMPs. The estimation of excess nutrients should consider the following:

- The load of nutrients in excess of reference conditions is computed from 10-yr average of flow weighted composite samples, collected as described in Section 8, Monitoring Requirements.
- Any samples collected at a downstream monitoring station that is influenced by atypical levels of erosion from burned hillsides (e.g. TSS > 1,000 mg/L) may be excluded from the calculation of average nutrient concentrations.
- Flow gauge data over the same 10-yr period at the same monitoring station is necessary to compute the mass of excess nutrients.
- If only one nutrient is found to meet the WLA/LAs at the first TMDL compliance reporting period following adoption of the TMDL revision, then a demonstration using either Approach 1 or 2 must accompany use of a single nutrient control strategy in all subsequent TMDL compliance reporting periods.

Figure 9-4 provides an example demonstrating compliance using this method for phosphorus in the San Jacinto River watershed to Canyon Lake Main Lake. The example is based on hypothetical (2020-2030) results from continued implementation of the watershed monitoring program.

The LECL Task Force currently uses in-lake offset credits to demonstrate compliance with the 2004 TMDL for Lake Elsinore as described in the CNRP for urban sources and AgNMP for agricultural sources. As of 2018, the methods of estimating demand for offset credits have not involved evaluation of downstream flow and nutrient concentration data relative to a reference condition, as conducted in Steps 1-6 in Approach 4 (Figure 9-4). Instead, loads in excess of a reference condition are computed for jurisdictional areas based on 2014 land use mapping and per acre export coefficients estimated in the LSPC watershed model developed for the 2004 TMDL. Approach 4 will allow in-lake BMPs to be operated on an as needed basis by using actual measured hydrologic and water quality conditions, thereby building in any actual load reductions realized from implementation of watershed BMPs.

Step 1. Compile 10 years of wet weather composite sample concentrations						
Year	**Storm 1 TP (mg/L)**	**Storm 2 TP (mg/L)**	**Storm 3 TP (mg/L)**	**Storm 1 TN (mg/L)**	**Storm 2 TN (mg/L)**	**Storm 3 TN (mg/L)**
Year 1	0.47	0.71	0.41	2.80	2.40	1.73
Year 2	0.40	0.63	0.53	3.20	3.10	2.45
Year 3	0.38	0.52	1.10	5.00	2.90	2.14
Year 4	0.36	0.64	0.52	5.10	3.50	2.64
Year 5	0.30	0.34	0.34	2.90	4.57	4.08
Year 6	0.31	0.41	0.31	2.20	4.92	3.69
Year 7	0.53	0.44	2.88 *	2.00	2.91	6.02 *
Year 8	0.49	0.57	0.40	1.60	3.16	1.48
Year 9	0.62	0.73	0.41	1.76	1.58	1.63
Year 10	0.88	0.52	0.52	4.20	1.71	1.83
Step 2. Compute 10-yr Average Nutrient Concentration in Runoff		TP (mg/L): 0.51			TN (mg/L): 2.87	
* Sample removed from average calculation because of influence of burned hillside erosion (TSS = 3163 mg/L)						
Step 3. Compute 10-yr Average Annual Runoff from Co-located Gauge (AF/yr):					1800	
Step 4. Compute Nutrient Loads in Runoff (Step 2 * Step 3)		TP (kg/yr): 1,132			TN (kg/yr): 6,369	
Step 5. Compute Allowable Nutrient Load (Step 3 * Ref Conc)		TP (kg/yr): 711			TN (kg/yr): 2,043	
Step 6. Compute Nutrient Offset Offset to be demonstrated with in-lake BMPs (Step 4 - Step 5)		TP (kg/yr): 422			TN (kg/yr): 4,326	
Step 7. Independent In-lake BMP Offset Effectiveness Demonstration:		**422 kg/yr TP**			Compliance √ - TP only	

Figure 9-4. Hypothetical Example of Use of Nutrient Data to Evaluate Use of In-Lake Offsets as an Approach to Demonstrating Compliance

The use of in-lake BMPs to offset excess watershed nutrient loads involves multiple upstream entities, except for those able to demonstrate that allowable loads are met within the watershed. The relative contribution of each upstream entity to measured downstream loads is difficult to apportion without extensive upstream monitoring data. The PLOAD model used in the source assessment generalizes nutrient washoff by land use across all jurisdictions and is not equipped to account for disproportionate deployment of watershed BMPs among upstream jurisdictions. Moreover, jurisdictional area is continually evolving in the SJR watershed (i.e., because of agricultural land conversion to urban land use), which would quickly make obsolete a model based on a snapshot in time of land use distribution. Relative contributions to excess downstream nutrient loading, and thereby apportionment of offset demands, must account for jurisdictional and land use changes through routine land use mapping updates. Updates to the CNRP and AgNMPs will include a method for reporting and tracking watershed BMP deployments by subwatershed to support a fair and scientifically defensible distribution of excess nutrient load measured at downstream lake inflows to apportion offset demands to upstream jurisdictions.

9.5 Approach 5: Retention of Extreme Rainfall Events

Another approach for demonstrating compliance with WLA/LAs involves retention of watershed runoff from all storm events up to an extreme rainfall depth (greater than 10-yr return period), on-site or within a downstream control. Runoff that is retained will not contribute to downstream surface waters, which results in a net reduction in nutrient loads relative to a reference watershed. When extreme rainfall events that exceed the retention capacity occur, overflows of runoff and associated nutrient loads may cause exceedances of WLA/LAs. This compliance demonstration approach involves quantification of annualized average nutrients from potential extreme event overflows for comparison to allowable downstream loads based on a reference watershed condition (i.e., WLA/LAs). In the case of an extreme rainfall event that exceeds the retention capacity, all overflow runoff may be assumed to spill from downstream impoundments (e.g., Mystic Lake and/or Canyon Lake) and result in delivery of runoff and associated nutrient load to Lake Elsinore. Thus, any resulting load reductions associated with offsetting nutrient loads in extreme rainfall will involve internal load reduction within Lake Elsinore.

A statistical analysis of annual maximum 24-hr rainfall is used to estimate the frequency of occurrence and incremental depth above the design storm capacity (Appendix C). The depth in excess of the on-site retention capacity is then annualized for comparison with WLA/LAs, which are based on average annual runoff from an undeveloped site with no controls. The concentration of nutrients in the overflows is taken from land use based nutrient concentrations used for the source assessment (see Tables 4-7 and 4-8) to compute annualized overflow load for TP and TN. Depending upon the site land use, annualized nutrient loads from extreme rainfall event overflows may be less than WLA/LAs and thereby demonstrate compliance with on-site retention, or require offsets of internal loads in Lake Elsinore with in-lake BMPs.

If annualized overflow nutrient load exceeds WLA/LAs for the site, the excess amount is then used for determining the necessary offset credits to be obtained from participation in regional in-lake BMPs in Lake Elsinore (e.g., LEAMS). A project specific effectiveness analysis must be developed that computes the internal nutrient load reduction achieved with in-lake BMPs. The use of this compliance demonstration approach should consider the following:

- Statistical rainfall analysis using the spreadsheet tool in Appendix C should be developed with site specific Atlas 14 rainfall frequency information (available at https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html).

- If only one nutrient is found to meet the WLA/LAs, by retention or with in-lake BMP offsets, at the first TMDL compliance reporting period following adoption of the TMDL revision, then a demonstration using either Approach 1 or 2 must accompany use of a single nutrient control strategy in all subsequent TMDL compliance reporting periods.

Figure 9-5 provides an example demonstrating compliance using this method for a typical 70-acre CAFO that is compliant with NPDES permit requirement to retain all runoff from up to a 25-yr, 24-hour return period rainfall event.

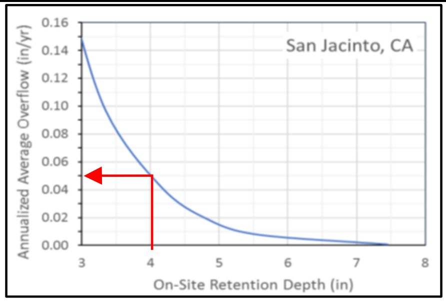
Step 1. Confirm on-site rainfall retention depth:		4.0 inches from site plan	
Step 2. Use statistical analysis tool to approximate annualized overflow runoff depth (in/yr)		 	
Annualized excess runoff (in/yr)	0.05		
Site acres	70.00		
Annualized excess runoff (AF/yr)	0.29		
Step 3. Extract area-weighted land use nutrient concentrations in site runoff (see Table 4-7)			
		TP (mg/L)	TN (mg/L)
Example: 100% dairy		9.10	14.90
Step 4. Compute annualized overflow nutrient load (Step 2 * Step 3)			
		TP (kg/yr)	TN (kg/yr)
Example: 100% dairy		3.27	5.36
Step 5. Compute Allowable Nutrient Load (Average Rainfall * 0.065 * Ref Conc)			
Average Rainfall (in/yr)	12	TP (kg/yr)	TN (kg/yr)
Undeveloped runoff coefficient	0.055	1.48	4.26
Step 6. Compute Nutrient Offset		TP (kg/yr)	TN (kg/yr)
Offset to be demonstrated with in-lake BMPs (Step 4 - Step 5)		1.79	1.10
Step 7. Credits from project specfic in-lake BMP effectiveness demonstration:		**2 kg/yr TP** **3 kg/yr TN**	**Compliance √**

Figure 9-5. Hypothetical Example of Use of Extreme Rainfall Event Compliance Demonstration Approach

CDM Smith

Chapter 10

California Environmental Quality Act Analysis

As a Lead Agency, the Santa Ana Water Board is required to comply with CEQA when considering amendments to the Basin Plan for the Santa Ana River Basin. Accordingly, this Substitute Environmental Document (SED) has been prepared to address the potential environmental effects of an action involving an amendment to the Basin Plan to revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake (Proposed Action). This Section includes the following elements:

- *Section 10.1 – Regulatory Setting*: Summarizes the requirements for completing a CEQA analysis to support a Basin Plan amendment.
- *Section 10.2 – Proposed Action*: Describes the proposed revisions to the Basin Plan that comprise the Proposed Action to be evaluated.
- *Section 10.3 – Environmental Setting*: This section provides a description of the environmental characteristics of the area that may be affected by the Proposed Action.
- *Section 10.4 – Environmental Issues*: This section presents the Environmental Checklist that serves as the basis for a systematic evaluation of the potential for the Proposed Action to result in a significant impact relative to a variety of environmental factors such as biological resources, recreation, and water quality.
- *Section 10.5* – Describes alternatives to the Proposed Action.

10.1 Regulatory Setting

Pursuant to §15251(g) of the State CEQA Guidelines, the Water Quality Control/Section 208 Planning Program of the State and Regional Water Boards is exempt from the requirements of preparing an Environmental Impact Report, Negative Declaration or Initial Study. However, the program is subject to other provisions in CEQA, including the policy of avoiding significant adverse effects on the environment where feasible. This is to be presented in a substitute document which includes, at a minimum, a description of the proposed activities and either: (1) alternatives to the activities and mitigation measure to avoid or reduce any significant or potentially significant effects that the Proposed Action may have on the environment; or (2) a statement that the Proposed Action would not have any significant or potentially significant effects on the environmental as supported by a checklist or other documentation.

Additionally, the Santa Ana Water Board must comply with the State Water Board's regulations on exempt regulatory programs when amending basin plans (California Code of Regulations, Title 23, §3775-3782). These regulations require the completion of an Environmental Checklist and a written report that includes: (1) a brief description of the proposed activity; (2) reasonable alternatives to the proposed activity; and (3) mitigation measures to minimize any significant adverse environmental impacts of the proposed activity.

The analysis must consider a reasonable range of environmental, economic, and technical factors, population and geographic areas, and sites. Where specific data are not available, the Santa Ana Water Board may utilize numerical ranges and averages but is neither required nor encouraged to engage in speculation or conjecture. A project-specific level analysis is not required nor is it feasible.

Pursuant to CWC §13360, the Santa Ana Water Board is prohibited from specifying the design, location, type of construction, or particular manner of compliance with waste discharge requirements or other orders. Instead, those entities subject to the proposed Basin Plan amendment are responsible for identifying compliance strategies and conducting the required CEQA analysis of implementation of the selected strategies at the project-level. Thus, the Santa Ana Water Board cannot conduct project-level CEQA analyses of strategies that would be implemented by others, nor is it required to do so.

Consistent with the State CEQA Guidelines and CWC Sections identified above, the environmental analysis contained herein includes a written analysis that identifies a reasonable range of reasonably foreseeable compliance strategies (Section 10.2.3), presents an Environmental Checklist (Section 10.4) that evaluates reasonably foreseeable environmental effects and mitigation measures if applicable, and discusses alternatives to the Proposed Action (Section 10.5). This analysis takes into consideration a reasonable range of environmental and economic factors, population and geographic areas and sites.

None of this is intended to imply that the original TMDL was deficient or defective. It was not; it was based on the best data available at the time. Today, however, a great deal more is known about how the lakes actually work than was known just a decade ago. In addition, considerably more is known about which nutrient control strategies are most effective at improving water quality, and the many critical factors (especially source loads from changing land use) that are now quite different from what was assumed when the TMDL was first approved.

According to EPA, updating the TMDL to reflect all of this new information will "facilitate better watershed planning and adaptive implementation" (EPA 2012). In fact, the Santa Ana Water Board believed that regular review and revision is so critical to ultimate success that it adopted an Implementation Plan specifying that the TMDL be “re-evaluated at least once every three years to determine the need for modifying the load allocations, numeric targets or implementation schedule” (Santa Ana Water Board 2004a; see Task #14 on page 21 of 22). Doing so provides reasonable assurance of continued progress toward attainment of water quality standards and protection of beneficial uses in Lake Elsinore and Canyon Lake.

10.2 Proposed Action Description

10.2.1 Background

The Santa Ana Water Board (2004a) adopted TMDLs for nutrient discharges to Lake Elsinore and Canyon Lake in 2004. The TMDLs became effective when the EPA gave it final approval on September 30, 2005. The scientific data and analysis used to justify the TMDLs are summarized in a detailed technical support document prepared by the Santa Water Board staff (Santa Ana Water Board 2004b). The 2004 TMDLs specified numeric targets for DO, Chlorophyll-*a*, Ammonia, TP and TN concentrations in each lake (see Table 2-3). It also established LAs and WLAs to govern the discharge of excess nutrients from non-point sources and point sources, respectively. The 2004 TMDLs included a detailed Implementation Plan which described activities that must be undertaken to meet water quality standards in Lake Elsinore and Canyon Lake. In the decade following EPA's approval, stakeholders throughout the watershed, working together through the LECL Task Force, initiated a large number of programs and projects to comply with the requirements set forth in the TMDL Implementation Plan.

Concurrent to the implementation actions, the LECL Task Force also supported a large number of supplemental scientific studies designed to aid the stakeholders in selecting the most effective and efficient management strategies to control nutrient loads in both lakes. These special studies provided additional scientific information that shed light on limitations of the analysis developed to support the 2004 TMDLs, as documented in the petition by the LECL Task Force for the Santa Ana Water Board to reconsider the TMDLs (LESJWA 2015). The petition also referenced changes in the watershed from development and new water quality regulations that should be considered in a revision of the TMDLs. The Santa Ana Water Board reopened the TMDLs to incorporate new scientific information to support water quality targets and allocations that are appropriate and achievable, reflect current land use conditions and account for the large nutrient load reductions that have resulted from BMP implementation, LID requirements, restrictions on dairy discharges, changes in certain water quality standards (e.g., ammonia), and the in-lake remediation projects that have occurred over the last 10 years.

10.2.2 Proposed Action

The proposed action involves adoption of revised TMDLs for Lake Elsinore and Canyon Lake. This action includes revised numeric targets for water quality within the lakes (see Section 3) and WLAs and LAs (see Section 6) to govern the discharge of excess nutrients from non-point sources and point sources, respectively. The scientific basis for these proposed revisions to the TMDL numeric targets and allocations are summarized in other sections above including characterization of water quality and use impairment (see Section 2), estimate of the current loading of nutrients to be reduced from non-point sources and point sources (see Section 4), and description of the water quality models used to translate nutrient loads to the lakes to expected water quality within the lakes (see Section 5).

The 2004 TMDLs and the proposed revision to the TMDLs involve very different approaches in developing allocations (**Figure 10-1**). A stressor-response approach was employed in developing the 2004 TMDLs, which first identified the in-lake water quality numeric targets that would be protective of designated uses. The linkage analysis determined the nutrient load that can be allowed without exceeding these numeric targets. The proposed revisions operate in the reverse order, by first constraining the allowable nutrient loads to the lakes to achieve levels representative of a reference condition. The linkage analysis determines expected in-lake water quality response for a reference condition in the watershed.

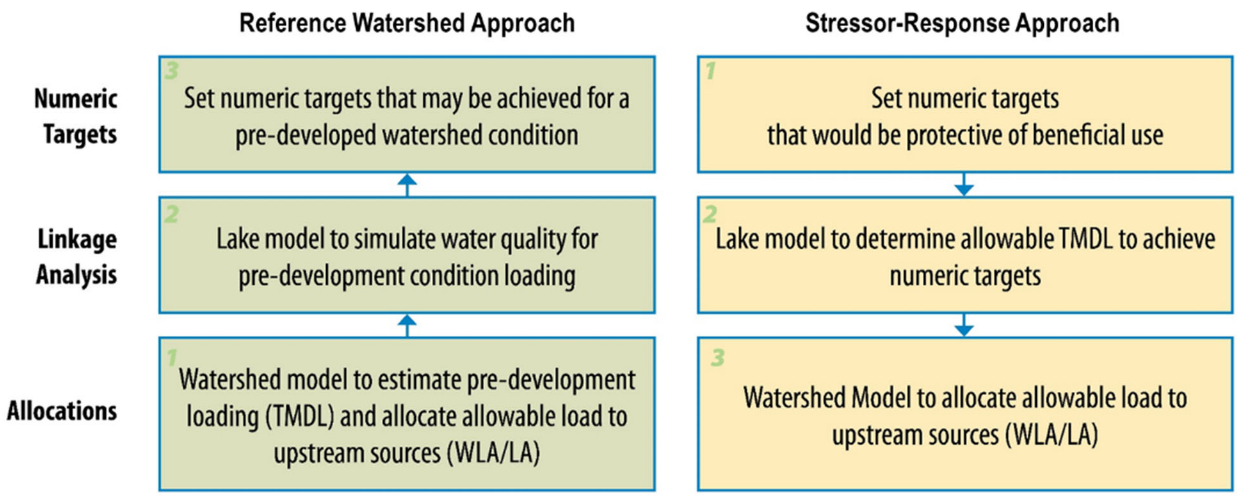


Figure 10-1 Alternative Approaches to TMDL Development

10.2.2.1 Numeric Targets

Lake Elsinore is impaired for the WARM, REC1 and REC2 beneficial uses. Canyon Lake is considered impaired for WARM, REC1, REC2 and MUN uses. A TMDL establishes numeric targets to provide a basis for demonstrating attainment of WQOs and protection of impaired beneficial uses. That is, achievement of the numeric target(s) is expected to result in the waterbody of concern no longer being impaired. Where the WQOs is narrative, the TMDL translates the narrative WQO into appropriate response targets to assure attainment of the objective.

Table 5-9n in the 2004 TMDL presents the numeric targets for Lake Elsinore and Canyon Lake for interim (2015) and final (2020) compliance timelines (Santa Ana Water Board 2004a). The 2004 TMDL Staff Report describes the scientific basis used to determine these targets, including several important areas for further study including: (1) the applicability of DO to the entire water column; (2) the relationship between the TN target and ammonia toxicity; and (3) evaluation of in-lake BMP effectiveness in both lakes (Santa Ana Water Board 2004b). The LECL Task Force implemented numerous studies to address these important research needs specified in the 2004 TMDLs. These study findings provide the level of additional scientific understanding for the Santa Ana Water Board to revise the numeric targets for Lake Elsinore and Canyon Lake (Main Lake and East Bay).

The primary objective in the development of revised numeric TMDL targets is to establish water quality conditions that are equal to or better than what would occur in the lakes if the watershed was returned to a reference condition (i.e., pre-development). To accomplish this objective, long-term hydrologic simulations of external loading for a reference condition (see Section 4 for hydrologic model and Section 6 for the reference condition load estimate) were input to dynamic lake water quality models capable of simulating spatially varying in-lake water quality (see Section 5). Modeling results were expressed as CDFs to develop new TMDL numeric targets accounting for the large range of temporal and spatial variability (see Section 3). The use of a reference watershed approach for developing TMDL numeric targets is consistent with EPA guidance, as demonstrated in Section 3. Differences in the estimation approach and resulting numeric targets between the 2004 TMDLs and the proposed revisions to the TMDLs are summarized below.

Response Target Parameters

The 2004 TMDLs set numeric targets to characterize the narrative WQOs for excess algae using a response target for chlorophyll-*a* and causal targets for TP and TN. The proposed revisions of the TMDLs only provide a response target for chlorophyll-*a*, a direct measure of algae concentration. Both the 2004 TMDLs and proposed revised TMDLs contain numeric targets for DO and ammonia that rely on numeric WQOs in the Basin Plan for protection of the WARM use.

Temporal Resolution

The 2004 TMDLs set numeric targets for response targets based on a static condition in both Lake Elsinore and Canyon Lake present in 2000-2001. This condition was assumed to represent a "reference" state for Lake Elsinore and thereby Canyon Lake. The proposed revision of the TMDLs creates frequency-based numeric targets, expressed as CDFs, that account for the dynamic hydrology of the watershed and impoundment operation in the San Jacinto River watershed. While it is not possible to quantitively compare seasonal or annual average targets with CDF-based targets, the proposed TMDL numeric targets allow for higher concentrations of chlorophyll-*a* most of the time in Lake Elsinore and lower concentrations most of the time in Canyon Lake Main Lake and Canyon Lake East Bay.

Spatial Resolution

The 2004 TMDL set numeric targets for DO that apply to the entire water column, including 1-m from the lake bottom in Lake Elsinore and a hypolimnion average for Canyon Lake, but specifically identified the need for better scientific understanding of seasonal differences that may result in DO variations associated with stratification in the lakes and relationship between nutrient input and DO levels in the lakes. Revision of the TMDLs employed coupled water quality and hydrodynamic models to evaluate the role of naturally occurring thermal stratification on DO concentrations in Lake Elsinore and Canyon Lake for nutrient inputs representative of a reference watershed condition. The proposed TMDL numeric target for DO allows for a portion of the lake volume to have DO concentrations less than 5 mg/L, the numeric WQO in the Basin Plan, as would occur naturally.

10.2.2.2 Allocations

Allocations in the TMDL distribute the allowable nutrient loads to each lake segment that would result in achieving the numeric targets (see Section 6). The proposed revision of the TMDLs involves different methodologies to estimate both current and allowable nutrient loads from the 2004 TMDLs. The fundamental change in the TMDL development process from a stressor-response to a reference watershed approach yields different allowable loads and upstream allocations. In the 2004 TMDLs, allocations were estimated as the external nutrient load that would achieve the in-lake nutrient numeric targets determined to be protective of uses. The full details are provided in the technical staff report for the 2004 TMDLs (Santa Ana Water Board 2004b). Conversely, the proposed revision of the TMDLs begins by computing allowable nutrient loads for a reference watershed, then evaluating downstream water quality response to set numeric targets. Concentration of nutrients in runoff from a reference watershed were estimated from monitoring conducted from the San Jacinto River at Cranston Guard Station, which is a watershed that is primarily undeveloped. These water quality data serve as the basis for all allocations for point and non-point sources in the proposed revision to the TMDLs, and results in a reduction to the total allowable nutrient loading to Lake Elsinore and Canyon Lake. The reduced allocation is a function of an error made in the linkage analysis of the 2004 TMDLs, as described below.

The linkage analysis developed to translate in-lake nutrient targets to allowable watershed loads for the 2004 TMDLs involved a flow-weighted average runoff inflow to the lakes based on representative hydrologic years (1994 as "moderate"; 1998 as "wet"; 2000 as "dry"). A significant error was made in calculating this flow-weighted loading that would be protective of the TMDL numeric targets. The calculation of runoff volume inflow to Lake Elsinore used 133,981 AFY for the "wet" year, but the USGS gauge measured 17,230 AFY in 1998. This error also impacted the calibration of runoff inflows to Canyon Lake for 1998 hydrologic conditions. Allocations to both lakes were significantly greater than intended because of this error. This was later confirmed by Anderson (2012b) in an evaluation of a "TMDL-prescribed external loads reduction" scenario for Canyon Lake using the DYRESM-CAEDYM model. Results show that in-lake nutrient concentrations consistently exceeded the 2004 TMDL numeric targets when external loads are reduced to the allocated allowable mass. The linkage analysis error creates the unusual condition whereby the proposed revision of the TMDLs would reduce allowable nutrient loads, presumably improving downstream water quality with the new allocations, but make some numeric response targets less stringent than the 2004 TMDLs.

10.2.2.3 Required Load Reductions

The difference between allocations and current nutrient loads (see Section 4) amounts to the reduction in nutrients that must be achieved from all sources to comply with the TMDLs. The basis for making changes to the allocations is described above. Key differences for estimation of current loads are discussed below.

Land Use Change

Land use change in the watershed has occurred with development ((WRCAC 2008, 2011, 2012, 2015a, 2018a; San Jacinto River Watershed Council 2015). Many developments also included LID BMPs. The proposed revision to the TMDLs relies on a watershed model that accounts for land use mapping updated in 2014.

Mass Emission Data

The 2004 TMDLs had limited nutrient mass emission data at the inflows to Lake Elsinore and Canyon Lake. USGS operated a flow gauge to record flows in the San Jacinto River coming into Lake Elsinore, which consists of predominantly overflows from Canyon Lake following the construction of Railroad Canyon Dam in 1928. Water quality samples were collected from four storm events in January through March 2001 to support the source assessment for the 2004 TMDLs. Flow gauges at the key inflows to Canyon Lake (San Jacinto River at Goetz Road and Salt Creek at Murrieta Road) were brought online in 2000. These data provided a limited record to support the 2004 TMDLs. In 2007, the watershed monitoring program was developed to collected wet weather water quality data at the inflows to each lake segment. To date, this program in conjunction with ongoing operation of co-located USGS gauges, has amassed water quality mass emission data for 35 storm events between 2007 and 2017. These events represent the majority of wet weather in the San Jacinto River watershed over the past decade. The source assessment in the proposed revision of the TMDLs employs a data driven approach based on a recent (2012-2017) subset of these data (see Table 4-6) to determine current nutrient loads to be reduced to allocations.

Runoff Retention within Upper Watershed

A portion of watershed runoff from drainage areas in the upper watershed is retained within downstream conveyances prior to reaching the lake inflows, including unlined channel bottoms and within storage basins. The major unlined channel segments that infiltrate upstream runoff include Salt Creek, San Jacinto River, and Perris Valley Channel. Runoff is also retained in Menifee Lakes. The proposed revision of the TMDLs accounts for these losses in estimation of current loads by jurisdictional areas.

Mystic Lake

Watershed runoff in the upper San Jacinto River is captured in Mystic Lake, a large shallow depression in the San Jacinto River valley. Mystic Lake has a storage capacity of approximately 17,000 AF, which is sufficient to retain all runoff from the upper watershed in most years. Given the high efficiency for retaining runoff, there are few data to understand how much runoff overflows Mystic Lake in extreme events. The most recent known overflow occurred in 1998, about five years prior to analysis for the 2004 TMDLs. No data on the volume of this overflow was recorded (USGS gauge at Ramona Expressway installed in 2001). The source assessment for the 2004 TMDLs did include a storage element in the watershed model (SAWPA 2003). The lack of any overflow since the 2004 TMDLs were adopted, including following the 2004-2005 wet season, has provided additional understanding of the retention capacity. The proposed revision of the TMDLs includes an updated reservoir water budget analysis to approximate the volume of overflow in a given wet season as a function of key water budget components of runoff inflow (R), available storage capacity (S), and dry season losses (E). The estimate of runoff inflow includes factors to account for upstream retention at Lake Hemet and groundwater recharge by EMWD in spreading grounds. Accordingly, the portion of downstream nutrient load attributable to drainage areas upstream of Mystic Lake is reduced in the proposed revisions of the TMDLs.

Loads from CAFOs

At the time when the 2004 TMDLs were under development, the NPDES permit for CAFOs had been adopted and dairies were beginning efforts to comply with the new requirements. The 2004 TMDL source assessments did not make any assumptions about compliance with the new requirements for CAFOs to retain on-site all runoff from storms up to the 25-year, 24-hour return period. The proposed revision of the TMDLs recognizes the efforts made by CAFOs in the watershed to comply with this on-site retention requirement of the NPDES Permit. As a result, the portion of downstream nutrient loads attributed to runoff leaving CAFO land areas is dramatically reduced in the proposed revised TMDLs.

Loads from Septic Systems

An important source of nutrients quantified in the 2004 TMDLs was failing septic systems, which required rough assumptions about failure rates and how wet weather conditions mobilize incompletely treated sewage. Septic systems were given a separate LA, which was ultimately combined with the WLA for urban sources and included in the 2010 NPDES permit for MS4s in the watershed. The proposed revision of the TMDLs changes the way potentially failing septic systems are evaluated by using water quality monitoring data from a site downstream of a residential area with septic systems (RCFC&WCD Station 834). Results are used to estimate nutrient washoff from a new land use category for residential-septic. Based on this approach, current loads and allocations associated with septic systems are parsed by jurisdictional areas. This change as well as expansion of areas with sewer service since 2004 has dramatically reduced the portion of downstream nutrient loads attributed to potentially failing septic systems in the proposed revision to the TMDLs.

10.2.3 Identification of Reasonably Foreseeable Methods of Compliance

As discussed previously, while the Santa Ana Water Board cannot specify the particular manner of compliance with orders it adopts, the analysis conducted for this SED must address possible environmental impacts of the reasonably foreseeable methods of compliance, taking into account a range of environmental, economic, and other factors.

For more than 30 years Lake Elsinore has been managed to stabilize the lake level with a targeted surface elevation of 1,240 ft. This management strategy is contrary to the natural condition, which results in a periodically dry lake (see Section 2.2.2). Managing the lake to keep it "wet" changes the water quality dynamics of the lake not only for nutrients but other constituents such as salinity and DO. Regardless, a wet-lake management strategy ensures support of existing recreational beneficial uses. The program of implementation under the revised TMDLs proposes to continue this lake management approach.

TMDL implementation in Lake Elsinore and Canyon Lake has been occurring since 2005 after the effective date of the original TMDLs. Two general strategies are being employed: (1) reduction of external nutrient loads to achieve WLAs and LAs and in turn response targets; and (2) implementation of water quality controls that directly affect the response targets in the lakes.

Existing and ongoing implementation activities for each lake and their respective watersheds have spanned both of these strategies, including (1) implementation of external nutrient controls for urban and agricultural sources; and (2) application of direct controls to manage algae, nutrients, DO, and/or hydrology within the lakes. The current strategies being implemented have resulted in water quality improvements; however, the 2004 TMDL response targets continue to be exceeded despite ongoing implementation of water quality controls.

The potential need for supplemental projects will be evaluated within two years of TMDL adoption as part of the update of existing TMDL implementations, e.g., CNRP and AgNMP, and then iteratively thereafter following compliance demonstrations made in five-year increments (see Section 7). Multiple options were conceptualized to provide reasonably foreseeable methods of compliance that could be employed in an adaptive implementation framework (see Section 10.2.3.1 below). The supplemental projects considered are the same, or similar to, projects that could be implemented under the current TMDLs. In fact, many of the possible reasonably foreseeable methods of compliance are already being implemented.

Accordingly, existing water quality controls described in Section 10.2.3.1 below may continue to be implemented and maintained whether or not the proposed TMDLs revisions are adopted. Further, the revised TMDLs are not anticipated to substantially change the manner or types of water quality controls that are implemented in the future, as summarized in Section 10.2.3.2 below and described in greater detail in Section 7.

10.2.3.1 Continued Implementation of Existing Water Quality Controls or Equivalent

Since adoption of the original TMDLs the implementation of nutrient management programs through discharge permits, water quality management programs and operation of engineered BMPs have resulted in improved water quality in both Lake Elsinore and Canyon Lake. These projects and programs should continue to be implemented and, where appropriate, updated or supplemented to incorporate the latest available, relevant information. However, per CWC §13360(a), the Santa Ana Water Board cannot specify the method of compliance with a regulatory requirement, including TMDL WLAs or LAs. As such, going forward the entities responsible for TMDL compliance will need to determine the best method, such as selection of different or enhance BMPs, implementation of supplemental projects, or participation in an offset program, to achieve compliance with the requirements of the revised TMDLs. This approach is the same as would have been expected to occur under the existing TMDLs, and thus, the Proposed Action would not trigger the need for new foreseeable compliance methods.

The variety of methods that are being implemented to achieve compliance with the existing TMDLs include both external nutrient load controls as described below.

External nutrient load controls

Currently, external nutrient loads are addressed through implementation of the following management plans:

- A CNRP for Lake Elsinore and Canyon Lake was developed by Riverside County MS4 permittees per the requirements established in their MS4 permit and approved by the Santa Ana Water Board in 2013 (Santa Ana Water Board 2013a). The CNRP includes implementation of BMPs such as street sweeping and debris removal, septic system management, and new stormwater management requirements for certain development projects. CNRP implementation has also involved implementation of significant in-lake controls described below.
- An AgNMP for agricultural operators in the watershed prepared by WRCAC was submitted to the Santa Ana Water Board in 2013 (WRCAC 2013a). The AgNMP requires agricultural operators to implement BMPs to control, minimize, or eliminate pollutant discharges from their agricultural operations to surface and ground waters. Implemented watershed BMPs include elimination of manure spreading, construction of berms to retain runoff on-site, and implementation of winter crop rotations to provide buffers during wet weather. AgNMP implementation has also involved implementation of significant in-lake controls described below.

In-lake Water Quality BMPs

The LECL Task Force continues to implement in-lake BMPs within Lake Elsinore and Canyon Lake. These are described in detail within Section 7 and summarized as follows:

- *Alum Addition in Canyon Lake* – The LECL Task Force has been implementing a large-scale alum application program in Canyon Lake since 2013. Alum binds with phosphorus thereby preventing excess algae growth in the lake. As of February 2018, approximately 1,500 metric tons of alum have been applied and an estimated 10,000 kg (22,000 lb) of phosphorus have been neutralized. Application of alum currently occurs semi-annually.

- *LEMP* – This project entailed the construction of a levee to reduce the surface area of the lake and thereby evaporative losses to improve water quality as well as provide sustained recreation opportunities.
- *Supplemental Water Addition* -EVMWD continues to discharge tertiary treated effluent to Lake Elsinore to maintain lake levels, amounting to a total volume of ~50,000 AF since 2002. While the addition of reclaimed water stabilizes lake water levels and improves water quality, variations in the lake level and water quality can still be substantial. However, hydrologic models for Lake Elsinore suggest complete lakebed desiccation would likely have occurred in 2015 without EVMWD reclaimed water discharges.
- *LEAMS* – This project relies on a combination of slow turning propellers submerged in the lake and shoreline compressors that disperse air from pipelines anchored to the bottom of the lake to circulate water.
- *Fishery Management* – Program to reduce the carp population.

While the Santa Ana Water Board cannot specify the method of compliance, it is anticipated that the above management strategies, or equivalent, would continue to be implemented under the revised TMDLs.

10.2.3.2 Additional Implementation Actions

The following subsections provide information regarding TMDL implementation actions that are anticipated to occur in addition to the continued implementation of the existing water quality controls or the equivalent discussed in Section 10.2.3.1.

Implementation of Supplemental Water Quality Controls

The existing water quality controls, or equivalent, as described in Section 10.2.3.1, will be evaluated for implementation under the revised TMDLs. The responsible entities with WLAs and LAs will evaluate the preference for alternative controls or need for additional controls as part of the review and revision of the CNRP and AgNMP. As previously described, such supplemental water quality controls could be implemented under both the existing TMDLs and the revised TMDLs. Therefore, the revised TMDLs are not anticipated to substantially change the manner or type of water quality controls that are implemented in the future, and thus, the Proposed Action would not result in the need for additional supplemental water quality controls than would otherwise occur. Therefore, the supplemental water quality controls are not being considered directly in response to the Proposed Action.

Listed below and described in greater detail in **Table 10-1** are the potential supplemental water quality controls that will be considered for implementation in the future (see additional discussion in Sections 7 and 11):

- Mystic Lake drawdown
- Alum additions to wet weather inflows
- Increased reclaimed water additions
- Oxygenation
- Dredging in East Bay of Canyon Lake
- Indirect potable reuse
- Enhanced fishery management
- Vegetation management
- Artificial recirculation in Canyon Lake
- Ultrasonic algae control
- Algaecide application
- Physical harvesting of algae
- Watershed BMPs in urban drainage areas
- LEAPS

The implementation program for the revised TMDLs does not specify which, if any, of the listed supplemental water quality controls will be implemented, only that these are projects for further consideration. Entities subject to the proposed Basin Plan amendment are responsible for conducting the required CEQA compliance documentation for implementation of any of these potential controls at the project-level. Should these, or other supplemental water quality controls be implemented in association with the existing TMDLs or the revised TMDLs, a project specific environmental review pursuant to CEQA would be conducted by the lead agency (i.e., the agency that will carry out the supplemental project). Any potential project specific environmental impacts would be addressed during that process.

Actions Recommended for Implementation by Other Agencies

The Santa Ana Water Board will work with the United States Department of Agriculture/USFS on revisions to, or implementation of, the San Bernardino National Forest and the Cleveland National Forest Management Plans to manage the discharge of nutrients from federally-owned lands to reduce nutrient loads. Nutrient loads should be reduced to the maximum extent practicable to the expected nutrient load from the watershed reference condition. In addition, when wildfire occurs, BMPs shall be actively implemented on federally owned lands to minimize downstream water quality impacts from mobilized nutrients. Required revisions to USFS Management Plans shall be completed within two years of the effective date of the revised TMDLs.

Such actions are the same, or similar to, projects that could be implemented under the current TMDLs to better achieve compliance with the requirements. Thus, the proposed revision of the TMDLs is not anticipated to substantially change the manner or type of water quality controls recommended for implementation by other agencies that may be put into place in the future.

Table 10-1. Potential Supplemental Water Quality Controls

Project	Action	Waterbody	Description	Water Quality Benefits	Potential Constraints & Limitations
Mystic Lake Drawdown	Hydrologic flushing	Lake Elsinore, Canyon Lake (Main/ East Bay)	Mystic Lake is a sump that captures all runoff from the upper SJR watershed via a breach in the levee on the north side of the river near Bridge Street. Most runoff that does reach Mystic Lake is retained and subsequently lost via evaporation. The most recent overflow to Canyon Lake occurred in 1998. Few data exist on the flow that reaches Mystic Lake, but the watershed model estimates ~3000 AFY, with many years having zero volume inflow and many years with over 10,000 AFY. While intermittent, this water may have a significant value for EVMWD water supply (at Canyon Lake) and for water quality in both lakes (providing both flushing and dilution). A potential project would involve pumping and conveying the stored runoff out of Mystic Lake (bottom elevation 1,408 ft to the overflow channel leading to the lower San Jacinto River (invert elevation 1,423 ft).	• Flushing of nutrients and phytoplankton out of Canyon Lake • Increasing water levels and dilution of TDS in Lake Elsinore	• Intermittent source of water, further reductions of inflows could occur with increased upstream capture • Impacts to waterfowl and other wildlife • Determination of appropriate increased diversions for EVMWD's treatment plant • Subsidence could impact facilities over time
Alum Addition to Wet Weather Inflows	Phosphorus removal	Lake Elsinore, Canyon Lake (Main/East Bay)	An alternative delivery method for alum additions could involve a small chemical feed storage and delivery system at the two inflows to Canyon Lake. This would treat bioavailable phosphorus immediately as it arrives in the lake and provide a better flocculation with lower pH of wet weather runoff.	Reduction of TP in water column	• Requires on-site chemical storage of low pH material • Outdoor chemical feed system may be susceptible to damage by high flows, wind or vandalism
Increased Reclaimed Water Additions	Hydrologic flushing/ dilution	Lake Elsinore	EVMWD currently discharges up to 7.5 of its 8 mgd capacity to Lake Elsinore. Phase 1 of the WWTP expansion will allow for discharge of up to 9.0 mgd to Lake Elsinore by 2020, a rate estimated to provide sufficient capacity to maintain at water level of 1,240 ft over the long-term. Increased reclaimed water addition will dilute TDS during periods of drought and increase habitat for submerged vegetation and fish.	Reduction in TDS, aquatic habitat, indirect controls on nutrient cycling and algae	Agreement to ensure up to 9.0 mgd will be discharged to Lake Elsinore in perpetuity

Table 10-1. Potential Supplemental Water Quality Controls

Project	Action	Waterbody	Description	Water Quality Benefits	Potential Constraints & Limitations
Oxygenation	DO control, phosphorus & nitrogen reduction	Canyon Lake (Main)	Oxygenation involves the direct addition of oxygen to the lake bottom waters in Canyon Lake Main Lake during periods of thermal stratification. The oxygen would reduce anoxic conditions in the lake bottom and thereby limit the internal loading of nutrient to the water column	Reduction of TP and TN in water column	• Low DO in hypolimnion of Canyon Lake occurs in reference condition • Requires large scale on-site oxygen storage
Dredging	Phosphorus & nitrogen reduction	Canyon Lake (East Bay)	Dredging involves the physical removal of lake bottom sediments. This is a very effective way to reduce the pool of mobile nutrients within the lake bottom.	Reduction of TP and TN in water column	• Dredging is very costly • Disposal of sediment may require hauling
Indirect Potable Reuse	Hydrologic flushing	Canyon Lake (Main/East Bay)	EVMWD may consider using Canyon Lake as an environmental buffer to allow for potable reuse of advanced treated reclaimed water. Advanced Wastewater Treatment (AWT) water would be discharged at the upstream end of the lake to maximize residence time prior to reaching the drinking water treatment plant intake. AWT water would serve to dilute ambient water in the lake as well as create additional flushing of water when overflows are not occurring.	Reduction of TP and TN in water column; flushing of nutrients and phytoplankton out of Canyon Lake	• Water quality in the lake may limit the amount of reclaimed water that can be diverted for potable supply. • Operation of the system during the wet season may be less reliable given water quality and capacity limitations.
Enhanced Fishery Management	Algae control	Lake Elsinore	Carp removal program already active (though currently suspended). LESJWA (2005a) noted that with carp managed, additional fishery management activities could be implemented that would improve water quality and health of the biological community, e.g., zooplankton enhancement; aquatic and emergent vegetation restoration; fish habitat improvement; and fish community structure improvement	Improved aquatic community to enhance zooplankton that graze on algae	• Carp control is fundamental to the successful implementation of these fishery management activities. • Other potential limiting factors for zooplankton such as salinity may require controls

Table 10-1. Potential Supplemental Water Quality Controls

Project	Action	Waterbody	Description	Water Quality Benefits	Potential Constraints & Limitations
Vegetation Management	Algae control	Lake Elsinore, Canyon Lake (Main/East Bay)	Establishment of submerged aquatic vegetation that will take up nutrients and release oxygen to the water column. Macrophytes can compete for limited nutrients and light with algae thereby providing another control on algae growth.	Reduction of TP and TN in water column, control of algae growth	• Macrophytes may not get established. • Water level fluctuations can kill vegetation by either desiccation or drowning.
Artificial Recirculation in Canyon Lake	Phosphorus & nitrogen reduction	Canyon Lake (Main/East Bay)	Recirculate oxygen depleted, nutrient rich water from the hypolimnion in the Main Lake through East Bay and back to the Main Lake. Transfer of water from the hypolimnion in Main Lake to East Bay is expected to cause a rise in DO at the sediment interface; a reduction of internal loads of TP and TN may also be realized. For East Bay, water delivered from the Main Lake would be reaerated through the process of discharge and flushing through the shallow East Bay. This activity would facilitate flushing of nutrients out of East Bay to reduce the duration of algal blooms. Over time, reduced cycling of nutrients within East Bay would limit sediment nutrient flux; and, thereby, the concentration of bioavailable nutrients flushed to Main Lake.	Net reduction of internal nutrient load and net increase in DO. Algae blooms would be expected to be shortened in duration within East Bay and conditions with DO > 5 mg/L would extend deeper in the water column in the Main Lake.	Net reduction in nutrients is expected, but there may be periods when high concentrations of bioavailable nutrients Main Lake hypolimnion could cause an increase in nutrient concentrations within East Bay
Ultrasonic Algae Control	Algae control	Canyon Lake (East Bay, North Ski Area)	Devices can be deployed that will kill algae within a 50-foot radius by sonication	Control of algae growth	• Sonication is effective over a small area only (e.g., coves in East Bay or the North Ski Area); would require too many devices to impact larger zones. • Impact to other aquatic species could become an important consideration

Table 10-1. Potential Supplemental Water Quality Controls

Project	Action	Waterbody	Description	Water Quality Benefits	Potential Constraints & Limitations
Algaecide	Algae control	Canyon Lake (Main/East Bay)	Algaecides may be effective in controlling algae blooms as they begin to occur	Control of algae growth	• Repeated use of some algaecides can cause elevated levels of toxins in the lake bottom • Nutrients are not addressed and therefore new algae blooms may arise shortly after an algaecide treatment
Physical Harvesting	Algae control	Lake Elsinore, Canyon Lake (Main/East Bay)	Skimmers and other tools can be used to physically remove algae from the surface of the lake	Control of algae growth	• Labor intensive • Nutrients are not addressed and therefore new algae blooms may arise shortly after physical removal
Watershed BMPs in Urban Drainage Areas	Phosphorus & nitrogen reduction	Lake Elsinore, Canyon Lake (Main/East Bay)	Stormwater BMPs are required to be implemented with new and redevelopment projects that capture and infiltrate or treat runoff and associated nutrients prior to reaching the lakes. Additionally, stormwater BMPs can be retrofitted into existing development areas.	Reduction of TP and TN in water column and in settled sediment	• Load reductions are limited to runoff from small-moderate sized storms only • Extensive upstream runoff retention would reduce flows to Lake Elsinore
LE Advance Pumped Storage (LEAPS)	Hydrologic flushing, DO control	Lake Elsinore	Construction of a 200 ft tall dam and new 50 to 100-acre concrete lined reservoir with a spill elevation of ~2,800 ft in the Cleveland National Forest southwest of Lake Elsinore. On average, 5,000 AF of water would be pumped from Lake Elsinore in the evening during periods of low energy demand. Return of the water would generate hydroelectric power in turbines between the new 'upper' reservoir and Lake Elsinore, the 'lower' reservoir.	Control of algae growth, reaeration, potential to reduce P with additional treatment	Potentially numerous regulatory challenges to obtain approval

Special Studies

The revised nutrient TMDLs are based on assumptions developed from numerous technical studies that have been completed during or since adoption of the original TMDLs in 2004. It is recommended that responsible entities consider implementation of the following specific studies or implement other special studies where deemed necessary to support implementation. The implementation of additional studies is not anticipated to trigger new foreseeable methods of compliance that are different from those identified in Section 10.2.3.2 above. However, should any substantially different water quality controls be identified in the studies, such water quality controls are too speculative to be considered in this SED and would be subject to project-specific CEQA review in the future.

- *Reference Watershed Nutrient Loads* - To establish nutrient concentrations representative of a reference watershed, the revised TMDLs rely on water quality data from the San Jacinto River at Cranston Guard Station monitoring site. Other grab samples from undeveloped canyon sites in the San Jacinto River watershed support the estimated values for TP and TN from undeveloped watersheds represented by the Cranston Guard Station. To establish a larger dataset to validate the representation of reference nutrient concentrations in the San Jacinto River watershed, it is recommended that the responsible entities research options for selection of additional watershed reference sites. As part of this research, a special study could be conducted to identify best locations for inclusion in the watershed monitoring program including the original Cranston Guard Station site. Any final selected sites would be incorporated in the San Jacinto River Watershed monitoring program (see Section 8).

- *Other Research Activities* - Stakeholders will implement research studies on an as needed basis to provide supporting data for anticipated technical or regulatory outcomes. These studies may be deemed necessary to verify assumptions in the revised TMDLs or refine understandings of watershed or lake dynamics, such as with regards to nutrients, or update lake models. For example, wildfire has been implicated as a potential source of increased nutrients in the watershed. Studies could be developed to further understand the role of wildfire in establishing background or reference nutrient conditions in the watershed. Where a research project is recommended for implementation, a workplan, budget and schedule will be developed for consideration by the LECL Task Force.

Development and Implementation of Revised Monitoring and Reporting Program

After the revised TMDLs become effective, the entities responsible for compliance with WLAs or LAs in each lake will revise the existing Monitoring and Reporting Program, as needed per the schedule described in Section 7. The modifications may include variations in the frequency or location of monitoring and the water quality parameters analyzed, and increased use of satellite imagery (see Section 8).

10.3 Environmental Setting

10.3.1 Surrounding Land Uses and Setting

Lake Elsinore and Canyon Lake lie within the San Jacinto River Watershed (**Figure 10-2**), an area encompassing approximately 780 square miles in the San Jacinto River Basin. Located approximately 60 miles southeast of Los Angeles and 22 miles south of the City of Riverside, the San Jacinto River Watershed lies primarily in Riverside County with a small portion located within Orange County.

Area climate is characterized as semi-arid with dry warm to hot summers and mild winters. Average annual precipitation in the entire Lake Elsinore/Canyon Lake watershed area is approximately 11 inches occurring primarily as rain during winter and spring seasons. Within just the upper portion of the watershed that drains to these lakes, the precipitation averages 18.7 inches annually. Historically, land use development in the San Jacinto River watershed has been associated with agricultural activities. However, a continual shift from agricultural to urban land use has been occurring for many years.

Following is summary of Lake Elsinore and Canyon Lake, including information on surrounding land uses, water quality, and biological conditions. Section 2 provides additional detail, including a background on the lakes' history, historical and current water quality, and the biological characteristics.

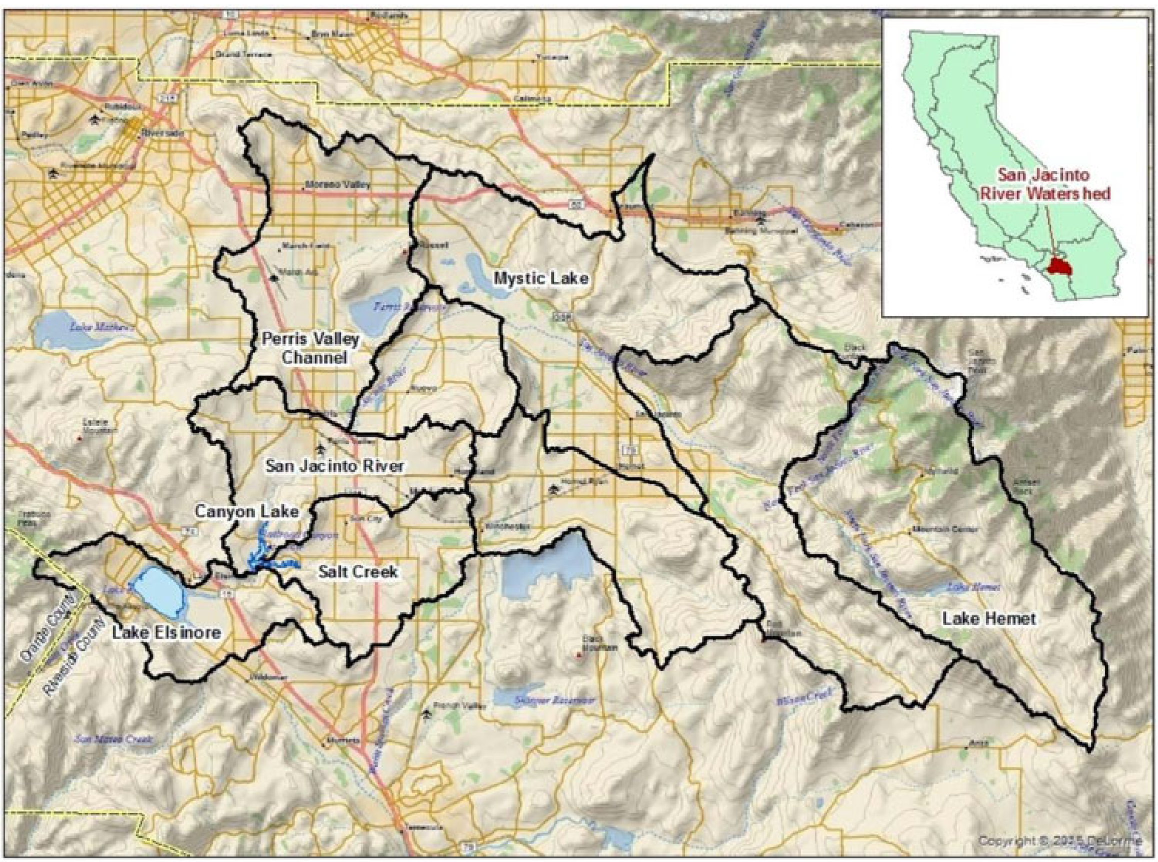


Figure 10-2 San Jacinto River Watershed

10.3.2 Lake Elsinore

Lake Elsinore is the largest natural lake in Southern California. Originally, at a lake elevation of 1,260 ft the surface area of the lake was approximately 5,950 acres with an average depth of 21.5 ft). Under historical natural conditions, Lake Elsinore periodically became a dry lakebed, eliminating aquatic life as well as opportunities for recreation. Under current conditions, the lake continues to experience significant fluctuations in lake levels that effect the attainability of beneficial uses in the lake.

Lake Elsinore is located within the City of Lake Elsinore and also adjacent to the community of Lakeland Village in unincorporated Riverside County along the southwestern shore. Land uses surrounding the lake include recreational uses along the shoreline (such as parks, beaches, boat launch, and camping areas). Other uses in the vicinity primarily consist of residential and commercial development, except for the eastern side of the Lake which is open space. Lake Elsinore is identified in the County of Riverside Elsinore Area Plan as posing a flood hazard. A boundary line has been established around the lake at an elevation of 1,260 ft above mean sea level that limits the construction of any new development (City of Lake Elsinore 2011a).

Formerly a State Recreation Area, the Lake and adjoining recreational area was transferred to City of Lake Elsinore in 1993 under the condition that it be used for a public park and recreational purposes in perpetuity. Recreational uses at the Lake include boating, jet skiing, water skiing, wake boarding, kayaking and fishing (in some areas) (City of Lake Elsinore 2011b).

As a result of modifications to the Lake, particularly the LEMP implemented in the 1980s, Lake Elsinore today now has a current approximate surface area of 3,000 acres (approximately 50 percent of original surface area), average depth of approximately 13 ft, and a maximum depth of approximately 27 ft. Monitoring data indicate that with the exception of periods of stratification Lake Elsinore is typically well-mixed with a limited thermocline.

While one of the key outcomes of LEMP was to stabilize lake water levels, variations in the lake level and water quality can still be substantial in Lake Elsinore due to seasonal fluctuations and alternating periods of drought and heavy rains during El Niño conditions. To mitigate this concern, EVMWD has discharged an average of 3,600 AFY of supplemental water since 2007 to maintain lake levels. Sources of supplemental water include EVMWD reclaimed water (~ 95 percent of total input) and production from non-potable wells on islands in the lake (~ 5 percent of total input).

During the most recent dry period prior to the winter of 2016-2017, modeling analyses indicate that Lake Elsinore would have been completely dry in 2015 to present day. LEMP coupled with inputs of supplemental water have been successful in avoiding lakebed desiccation or extremely low lake levels, despite the recent period of severe drought.

The Santa Ana Water Board first listed Lake Elsinore as impaired in 1994, based on a historical record of periodic fish kills and excessive algae blooms in the lake since the early 20th century. This listing remains in place on the most recently approved impaired waters or 303(d) list for the region and includes toxicity, nutrients, and organic enrichment/low DO (State Water Board 2017a, EPA 2018). Uses impaired include WARM, REC1 and REC2. Based on these impairments the Santa Ana Water Board developed nutrient-based TMDLs. During TMDL development, the first Problem Statement developed in 2000 identified hypereutrophication as the most significant water quality problem affecting Lake Elsinore (Santa Ana Water Board 2000). In 2004, a final Problem Statement was developed that included information from the 2000 Problem Statement and findings from a number of newly completed studies as referenced in the document (Santa Ana Water Board 2004b). These findings provided additional information with regards to the basis for impairment. Specifically, hypereutrophic conditions arise due to nutrient enrichment (phosphorus and nitrogen) resulting in high algal productivity (mostly planktonic algae). Algae respiration and decay depletes available water column oxygen, resulting in adverse effects on aquatic biota, including fish. In 2004, the Problem Statement documented what was known with regards to reported algal blooms and fish kills, which have been documented since early last century. The decay of dead algae and fish also produces offensive odors and an unsightly lakeshore, adversely affecting use of the lake for recreational purposes. In addition, massive populations of algal cells in the water column cause high turbidity in the lake, making the water an uninviting murky green color at times.

Lake Elsinore has a highly variable fishery, with periodic fish kills and intervals of low diversity. The lake has experienced periods of high densities of Common Carp (*Cyprinus carpio*) and a low abundance of sport fish as well as periods of increased fish diversity associated with higher densities of sport fish. Historically, the native Arroyo Chub (*Gila orcuttii*) existed in the lake; however, Lake Elsinore is now a managed fishery with regular stockings of a variety of fish primarily for the purpose of recreational fishing. Stock fish species have included, but are not limited to, Largemouth Bass (*Micropterus salmoides*), Channel Catfish (*Ictalurus punctatus*), Black Crappie (*Pomoxis nigromaculatus*), Bluegill (*Lepomis macrochirus*), and Hybrid Striped Bass (*Morone saxatilis x chrysops*). Other fish known to reside in the lake and considered nuisance species are the Common Carp and Threadfin Shad (*Dorosoma petenense*). The presence of these two nuisance species aggravates the nutrient problem in Lake Elsinore.

Due to the natural cycle of periodic lake drying events, mass extinction events of fish populations have occurred. The in-lake fishery has recovered from these drying events primarily as a result of stocking and secondarily by repopulation from upstream sources (i.e., Canyon Lake) during high flow events.

There are two distinct types of invertebrate populations in Lake Elsinore: a benthic community which resides in or on the lake-bottom sediment, and a pelagic zooplankton community residing in the water column. Previous studies of benthic invertebrate populations have observed low overall taxa richness across all sample locations and during the wet and dry seasons. None of the sample stations contained sensitive, pollutant intolerant taxa., and the taxa present were those typically found at disturbed or stressed sites.

The zooplankton populations generally exhibit large seasonal variations in composition and density. The zooplankton community in Lake Elsinore is composed of three primary types of invertebrates: cladocerans (water fleas), copepods, and rotifers.

The phytoplankton community of Lake Elsinore is a complex assemblage of genera and species that follow a seasonal succession dominated by diatoms in the winter and cyanobacteria during summer months.

10.3.3 Canyon Lake

Canyon Lake, also known as Railroad Canyon Reservoir, was constructed to store water from the San Jacinto River for agricultural irrigation in the area in 1928. Approximately 735 square miles of the San Jacinto River watershed drains into Canyon Lake before reaching Lake Elsinore. In many years, drainage from the San Jacinto River watershed terminates at Canyon Lake without reaching Lake Elsinore. Only during moderate or wet years does Canyon Lake overflow and send water downstream to Lake Elsinore.

Canyon Lake is located approximately five miles upstream of Lake Elsinore. The lake is located within the City of Canyon Lake, which is a private gated city east of the City of Lake Elsinore. Homeowners in Canyon Lake have rights and access to the lake for recreational uses. Guests of homeowners may also use the lake. Allowable watercraft include ski-boats, fishing boats, row boats, paddle boards, sailboats and kayaks. There are also swimming areas, beaches, docks and rental boat slips along the lake. The land uses adjacent to the Canyon Lake are primarily residential, but also include recreation/open space areas, and community facilities.

The surface area of Canyon Lake is approximately 500 acres, with an estimated current storage capacity of 8,760 AF. The lake has three key areas: (1) Main Lake, which is the deepest part of the lake upstream of the dam; (2) East Bay, the relatively shallow arm of the lake upstream of the causeway crossing the lake; and (3) North Ski Area above the causeway crossing upstream of the Main Lake. Canyon Lake receives inflows from two sources: (1) San Jacinto River drains to the Main Lake; and (2) Salt Creek drains to the East Bay. Canyon Lake has a small surface area (500 acres) and steep topography. Water depth varies greatly depending on the location in the Lake. The Main Lake is deepest (over 50 ft near the Dam); the East Bay is shallow (approximately 8 ft near the Salt Creek inflow).

The temperature profile of the Canyon Lake water column routinely demonstrates that the Lake is thermally stratified in the summer. The most pronounced stratification occurs at the Dam where the water is deepest. Thermal stratification within Canyon Lake disappears in the fall and winter when the lake turns over resulting in more uniform water temperatures and DO profiles throughout the water column.

Canyon Lake is a local source of drinking water. The eutrophic conditions in Canyon Lake may impact the MUN beneficial use. Low oxygen levels result in high concentrations of manganese and iron in the hypolimnion. When manganese levels in the water column exceed 0.45 mg/L, EVMWD shuts down the water treatment plant. The high algal productivity also necessitates periodic shutdown of the Canyon Lake Water Treatment Plant because algal cells can clog the water treatment filters.

Concerns regarding water quality were identified in the latter part of the 1990s, involving periodic algal blooms and fish kills, but neither as significant as occur in Lake Elsinore. However, the water quality concerns were sufficient for the Santa Ana Water Board to place Canyon Lake on the impaired waters list in 1998, where it remains listed for nutrients in the most recent 2017 impairment assessment.

Development of the 2004 nutrient TMDL for Canyon Lake was done in coordination with the Lake Elsinore nutrient TMDL. An initial Problem Statement specific to Canyon Lake was drafted in

2001 (Santa Ana Water Board 2001). This Problem Statement documented that the beneficial uses of the lake were impaired because of excess phosphorus and nitrogen. Subsequently, a revised Problem Statement was prepared in 2004 based on completion of a number of studies that provided additional understanding regarding water quality concerns in Canyon Lake (Santa Ana Water Board 2004b).

The lake was originally populated with fish that had migrated (or been washed down) from the San Jacinto River watershed as the lake filled after completion of the dam. The lake was drained in 1949 to perform repairs to the floodgates, and the lake slowly refilled over the next two years. In 1951, the CDFG (now called the California Department of Fish and Wildlife) restocked the lake with largemouth bass, crappie, and bluegill. It is likely that the lake contains catfish and other sunfish (*Lepomis* spp.), as well as small baitfish such a threadfin shad given its prevalence in Lake Elsinore. The lake is stocked with catfish and bass by the Canyon Lake POA. Minimal information is available on fish kills in Canyon Lake. However, a fish kill was documented on October 29, 2010 when about 50 to 100 shad were observed on Sunset Beach.

Limited information is available on the aquatic invertebrate populations in Canyon Lake. A 2004 benthic invertebrate study sampled open water locations and shoreline locations. The study observed a total of 24 taxa and found a significant difference between the offshore benthic community and those along the shoreline. The open water sites exhibited very low taxa diversity and were composed almost exclusively of one dipteran taxa, the phantom midge *Chaoborus* spp., and a relatively small number of annelid oligochaetes (aquatic worms). The shoreline sites contained from 8 to 18 taxa. The midge, *Chironomus* spp., and the amphipod, *Hyalella* spp., were the most abundant taxa in shoreline samples, comprising 28 and 36 percent of the entire community, respectively. The study did not observe the presence of any sensitive taxa.

Information on the phytoplankton community is also limited. The Canyon Lake Nutrient TMDL Problem Statement indicated that the dominant types of algal species in Canyon Lake are flagellate-green and green algae (Santa Ana Water Board 2001). It is likely that diatoms also comprise some proportion of the community during times of the year, given the brownish-green tint of the water during recent 2015-2016 monitoring events.

10.4 Environmental Issues

10.4.1 Overview

This section presents the Environmental Checklist, evaluates the potential impacts of the action relative to 18 environmental issue areas, and presents mandatory findings of significance required under CEQA. The analysis begins with a summary delineation of the environmental factors (issue areas) addressed in the checklist and whether any potentially significant impacts have been identified in the analysis, and is followed by an explanation of the environmental factors potentially affected.

In formulating answers to the checklist questions, the environmental effects of the Proposed Action were evaluated in the context of the existing regulatory and environmental setting (see Sections 10.1 and 10.3 respectively). Social or economic changes related to a physical change in the environment were also considered in determining whether there would be a significant effect on the environment; however, adverse social and economic impacts alone are not considered significant effects on the environment. §15382 of the State CEQA Guidelines defines a significant effect on the environment as "a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project, including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic or aesthetic significance. A social or economic change by itself would be limited in size and scope and all not be considered a significant effect on the environment. A social or economic change related to a physical change may be considered in determining whether the physical change is significant."

This section provides an evaluation of, and presents significance findings for, both the proposed revisions to the TMDLs (Proposed Action) and reasonably foreseeable methods of compliance associated with the Proposed Action. As described in Section 10.2.3, the existing water quality controls and potential supplemental water quality controls are actions that may be implemented (and continue to be implemented) regardless of whether the Proposed Action is adopted. Similarly, the proposed revision of the TMDLs is not anticipated to substantially change the manner or type of water quality controls recommended for implementation by other agencies that may be put into place in the future. Therefore, continuation of existing water quality controls and possible implementation of new water quality controls identified and actions recommended for implementation by other agencies would not be triggered with implementation of the Proposed Action. Additionally, there are no foreseeable methods of compliance associated with implementation of additional studies. Therefore, the analysis of foreseeable methods of compliance addresses only updates to the monitoring plans, which could include a change in the locations and frequency of monitoring activities (see Section 10.2.3.2 and Section 8).

The following environmental factors were considered as part of this analysis:

- Aesthetics
- Agriculture and Forestry Resources
- Air Quality
- Biological Resources
- Cultural Resources
- Geology and Soils
- Greenhouse Gas Emissions
- Hazards and Hazardous Materials
- Hydrology and Water Quality
- Land Use and Planning
- Mineral Resources
- Noise
- Population/Housing
- Public Services
- Recreation and Parks
- Transportation and Traffic
- Utilities and Service Systems
- Tribal Culture Resources
- Mandatory Findings of Significance

10.4.2 Determination Based on Initial Evaluation

This review concluded that the revision of the TMDLs and the reasonably foreseeable methods of compliance do not have the potential to result in significant adverse impacts on any of the 18 resource areas. However, pursuant to CWC §13360, a Regional Board cannot define the specific actions that entities would take to comply with requirements derived from the amendments. While no substantial physical changes resulting from implementation of the Proposed Action are foreseeable at this time, specific compliance actions will be subject to CEQA review and/or approval by the Santa Ana Water Board or other responsible agencies once they have been developed. As a result, the Santa Ana Water Board (or other lead/responsible agencies under CEQA) could either disapprove actions with significant and unacceptable environmental impacts, or require implementation of mitigation measures (e.g., best construction management practices) to ensure that potential environmental impacts associated with such actions are reduced to less than significant levels.

Based on the evaluation contained in this Section, the finding was made that the Proposed Action could not have a significant effect on the environment. The following sections provides the basis for that finding.

10.4.3 Environmental Factors Analysis (Checklist)

This section provides the findings from the analysis of each of the factors included in the Environmental Checklist. For each element included in the evaluation of an environmental factor a discussion is provided regarding the potential impacts that may occur as a result of the Proposed Action, reasonably foreseeable methods of compliance and findings of significance.

10.4.3.1 Aesthetics

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
I. AESTHETICS - Would the action:				
a) Have a substantial adverse effect on a scenic vista?				X
b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?				X
c) Substantially degrade the existing visual character or quality of the site and its surroundings?				X
d) Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?				X

Discussion

a) Would the action have a substantial adverse effect on a scenic vista?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. This revision would not result in any physical changes that would affect a scenic vista or other aesthetic resources.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel and does not result in any permanent alteration of visual conditions at monitoring locations. A potential change in the frequency or location of monitoring would not affect scenic vistas or other aesthetic resources.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

b) Would the action substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?

See I. Aesthetics a) above.

c) Would the action substantially degrade the existing visual character or quality of the site and its surroundings?

See I. Aesthetics a) above.

d) Would the action create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not create a new source of light or glare.

Reasonably Foreseeable Methods of Compliance

Development and Implementation of Revised Monitoring and Reporting Program - Monitoring is a temporary activity that occurs on an infrequent basis. A potential change in the frequency or location of monitoring would not create a new source of light or glare.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

10.4.3.2 Agriculture and Forest Resources

In determining whether impacts to forest resources, including timberland, are significant environmental effects, lead agencies may refer to information compiled by the California Department of Forestry and Fire Protection regarding the state's inventory of forest land, including the Forest and Range Assessment Project and the Forest Legacy Assessment project; and forest carbon measurement methodology provided in Forest Protocols adopted by the California Air Resources Board.

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
II. AGRICULTURE AND FOREST RESOURCES - Would the action:				
a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?				X
b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?				X
c) Conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code §12220(g)), timberland (as defined by Public Resources Code §4526), or timberland zoned Timberland Production (as defined by Government Code §51104(g))?				X
d) Result in the loss of forest land or conversion of forest land to non-forest use?				X
e) Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use or conversion of forest land to non-forest use?				X

Discussion

a) Would the action convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. This revision would not result in any physical changes that would result in conversion of agricultural land to non-agricultural use or otherwise affect agricultural operations.

Reasonably Foreseeable Methods of Compliance

A potential change in the frequency or location of monitoring would not affect agricultural land or operations.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

b) Would the action conflict with existing zoning for agricultural use or a Williamson Act contract?

See II. Agriculture and Forest Resources a) above.

c) Would the action conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code §12220(g)), timberland (as defined by Public Resources Code §4526), or timberland zoned Timberland Production (as defined by Government Code §51104(g))?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not affect zoning for forest land or timberland, or otherwise result in the conversion of forest land or timberland to non-forest land/timberland use.

Reasonably Foreseeable Methods of Compliance

A potential change in the frequency or location of monitoring would not affect zoning for forest land or timberland or otherwise result in the conversion of forest land or timberland to non-forest land/timberland use.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

d) Would the action result in the loss of forest land or conversion of forest land to non-forest use?

See II. Agriculture and Forest Resources c) above.

e) Would the action involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use or conversion of forest land to non-forest use?

See II. Agriculture and Forest Resources a) and c) above.

10.4.3.3 Air Quality

Where available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations.

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
III. AIR QUALITY - Would the action:				
a) Conflict with or obstruct implementation of the applicable air quality plan?				X
b) Violate any air quality standard or contribute substantially to an existing or projected air quality violation?				X
c) Result in a cumulatively considerable net increase of any criteria pollutant for which the action region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)?				X
d) Expose sensitive receptors to substantial pollutant concentrations?				X
e) Create objectionable odors affecting a substantial number of people?				X

Discussion

a) Would the action conflict with or obstruct implementation of the applicable air quality plans?

The Santa Ana region is within the South Coast Air Basin (SCAB), a 6,600-square mile basin encompassing all of Orange County, most of Los Angeles and Riverside Counties, and the western portion of San Bernardino County, which is under the jurisdiction of the South Coast Air Quality Management District (SCAQMD). SCAB is currently designated as a nonattainment area is for both national and state 1-hour ozone and particulate matter standards. SCAQMD is responsible for administering the Air Quality Management Plan (AQMP), which is a comprehensive air pollution control program for attaining federal and state ambient air quality standards. Conformity with adopted plans, forecasts and programs relative to population, housing, employment is a primary determinant of a project's consistency with the AQMP.

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. Projects such as the Proposed Action do not directly relate to the AQMP in that there are no specific air quality programs or regulations governing water quality management activities. The revision of the TMDLs would not conflict with adopted plans, forecasts and programs relative to population, housing, and employment. As such, the revision of the TMDLs would not conflict with or obstruct implementation of the AQMP or any other air quality plans.

Reasonably Foreseeable Methods of Compliance

A potential change in the frequency or location of monitoring would not conflict with or obstruct implementation of the AQMP or any other air quality plans.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

b) Would the action violate any air quality standard or contribute substantially to an existing or projected air quality violation?

Under the SCAQMD, the SCAB is designed as a nonattainment area for ozone and particulate matter. In addition, the SCAB is designated as a maintenance area for carbon monoxide and nitrogen dioxide and is in attainment for sulfur dioxide. In determining attainment and maintenance of air quality standards, the SCAQMD has established thresholds of significance for these and other criteria pollutants. A significant impact would occur if project operation results in substantial emissions which would exceed the established thresholds.

Proposed TMDLs Revision

The revision of the TMDLs would not involve new construction activities, increased traffic generation, or other activities that could generate new emissions. Thus, the revisions to the TMDLs would not result in exceedances of established thresholds for criteria pollutants or otherwise result in a violation of air quality standards or substantially contribute to existing or projected air quality violations.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not involve sufficient traffic or other activities that could generate emissions that result in a violation of air quality standards or substantially contribute to existing or projected air quality violations.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

c) Would the action result in a cumulatively considerable net increase of any criteria pollutant for which the region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emission which exceeds quantitative thresholds for ozone precursors)?

See III. Air Quality b) above.

d) Would the action expose sensitive receptors to substantial pollutant concentrations?

See III. Air Quality b) above.

e) Would the action create objectionable odors affecting a substantial number of people?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not involve construction activities, increased traffic generation, or other activities that could generate objectionable odors affecting a substantial number of people.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not involve sufficient traffic or other activities that could generate objectionable odors affecting a substantial number of people.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

10.4.3.4 Biological Resources

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
IV. BIOLOGICAL RESOURCES - Would the action:				
a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the CDFG or U.S. Fish and Wildlife Service?				X
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the California Department of Fish and Game or US Fish and Wildlife Service?				X
c) Have a substantial adverse effect on federally protected wetlands as defined by §404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?				X
d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?				X
e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?				X

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
IV. BIOLOGICAL RESOURCES - Would the action:				
f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?				X

Discussion

a) Would the action have a substantial adverse impact, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFG or the U.S. Fish and Wildlife Service?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would meet statutory and regulatory water quality standards and requirements. The Proposed Action would not lower surface water quality or otherwise adversely impact sensitive wildlife and/or wildlife habitat, including riparian habitat and wetlands; additionally, it would not interfere with the movement of any wildlife species or wildlife corridors, or impede the use of wildlife nursery sites, or conflict with any local policies or ordinances protecting biological resources or conflict with an adopted habitat conservation plan.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel and would not involve modifications to habitat or other adverse impacts to sensitive species. A potential change in the frequency or location of monitoring would not result in a substantial adverse impact, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

b) Would the action have a substantial adverse impact on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, or regulations, or by the CDFG or the U.S. Fish and Wildlife Service?

See IV. Biological Resources a) above.

c) Would the action have a substantial adverse effect on federally protected wetlands as defined by §404 of the Clean Water Act (including, but not limited to, marshes, vernal pools, coastal wetlands, etc.) through direct removal, filling, hydrological interruption, or other means?

See IV. Biological Resources a) above.

d) Would the action interfere substantially with the movement of any native resident or migratory fish or wildlife species, or with established native resident or migratory wildlife corridors, or impede the use of wildlife nursery sites?

See IV. Biological Resources a) above.

e) Would the action conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?

See IV. Biological Resources a) above.

f) Would the action conflict with the provisions of adopted habitat conservation plan, natural communities' conservation plan, or any other approved local, regional, or state habitat conservation plan?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would meet statutory and regulatory water quality standards and requirements. The revision would not establish any new uses, adversely impact sensitive habitats or species, nor would it otherwise conflict with the provisions of adopted habitat conservation plan, natural communities' conservation plan, or any other approved local, regional, or state habitat conservation plan. Further, the revision would contribute to improved water quality which would serve to improve biological resources.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not establish any new uses, adversely impact sensitive habitats or species, nor would it otherwise conflict with the provisions of adopted habitat conservation plan, natural communities' conservation plan, or any other approved local, regional, or state habitat conservation plan.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

10.4.3.5 Cultural Resources

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
V. CULTURAL RESOURCES - Would the action:				
a) Cause a substantial adverse change in the significance of a historical resource as defined in §15064.5?				X
b) Cause a substantial adverse change in the significance of an archaeological resource pursuant to §15064.5?				X
c) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?				X
d) Disturb any human remains, including those interred outside of formal cemeteries?				X

Discussion

a) Would the action cause a substantial adverse change in significance of a historical resource as defined in State CEQA §15064.5?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not involve construction, earth movement, or other disturbance which could impact any structures or buried cultural resources. As such, the revised TMDLs would not cause a substantial adverse change in significance of a historical resource.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not involve earth movement or other disturbance which could impact any structures or buried cultural resources.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

b) Would the action cause a substantial adverse change in significance of an archaeological resource pursuant to State CEQA §15064.5?

See V. Cultural Resources a) above.

c) Would the action directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?

See V. Cultural Resources a) above.

d) Would the action disturb any human remains, including those interred outside of formal cemeteries?

See V. Cultural Resources a) above.

10.4.3.6 Geology and Soils

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
VI. GEOLOGY AND SOILS - Would the action:				
a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:				X
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.				X
ii) Strong seismic ground shaking?				X
iii) Seismic-related ground failure, including liquefaction?				X
iv) Landslides?				X
b) Result in substantial soil erosion or the loss of topsoil?				X
c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the action, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?				X
d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?				X
e) Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?				X
f) Is the action located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?				X

Discussion

a) Would the action expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the state geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.

Several major earthquake faults are located in the Santa Ana region, including the San Andreas Fault, the San Jacinto Fault, the Elsinore-Whittier Fault, and the Newport-Inglewood Fault. In the vicinity of Lake Elsinore and Canyon Lake, the State of California Earthquake Hazard Maps designated Alquist-Priolo Earthquake Fault Zones are located southeast and northwest of Lake Elsinore.

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not involve the construction of habitable structures or otherwise result in any human safety risks related to fault rupture, seismic ground-shaking, ground failure, or landslides.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not involve the construction of habitable structures or otherwise result in any human safety risks related to fault rupture, seismic ground-shaking, ground failure, or landslides.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

ii) Strong seismic ground shaking?

See VI. Geology and Soils a), i) above.

iii) Seismic-related ground failure, including liquefaction?

See VI. Geology and Soils a), i) above.

iv) Landslides?

See VI. Geology and Soils a), i) above.

b) Would the action result in substantial soil erosion or the loss of topsoil?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. This revision would not involve construction or other earthmoving activities that could result in substantial soil erosion or the loss of topsoil.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not involve construction or other earthmoving activities that could result in substantial soil erosion or the loss of topsoil.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

c) Is the action located on a geologic unit or soil that is unstable, or that would become unstable as a result of the action, and potentially result in onsite or offsite landslides, lateral spreading, subsidence, liquefaction, or collapse?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not involve construction or other earthmoving activities on a geologic unit or soil that is unstable or would be unstable, potentially resulting in landslides, lateral spreading, subsidence, liquefaction, or collapse.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not involve construction or other earthmoving activities on a geologic unit or soil that is unstable or would be unstable, potentially resulting in landslides, lateral spreading, subsidence, liquefaction, or collapse.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

d) Is the action located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?

See VI. Geology and Soils a), b), and c) above.

e) Would the action have soils that are incapable of supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not entail the construction of septic tanks or alternative wastewater disposal systems.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not entail the construction of septic tanks or alternative wastewater disposal systems.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

f) Is the action located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?

See VI. Geology and Soils a), b), and c) above.

10.4.3.7 Greenhouse Gas Emissions

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
VII. GREENHOUSE GAS EMISSIONS - Would the action:				
a) Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?				X
b) Conflict with an applicable plan, policy or regulation adopted for the purpose of reducing the emissions of greenhouse gases?				X

Discussion

a) Would the action generate greenhouse gas emissions (GHG), either directly or indirectly, that may have a significant impact on the environment?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not involve new construction, generation of large numbers of vehicle trips, or other activities that could generate GHG emissions directly or indirectly in quantities that could have a significant impact on the environment.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not result in new construction, generation of large numbers of vehicle trips, or other activities that could generate GHG emissions directly or indirectly in quantities that could have a significant impact on the environment.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

b) Would the action conflict with an applicable plan, policy or regulation adopted for the purpose of reducing the emissions of greenhouse gases?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. As discussed in VII. Greenhouse Gas Emissions a) above, the revisions would not result in the generation of GHG emissions in quantities that could have a significant impact on the environment, nor would it otherwise conflict with an applicable plan, policy or regulation adopted for the purpose of reducing GHG emissions.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. As discussed in VII. Greenhouse Gas Emissions a) above, a potential change in the frequency or location of monitoring would not result in the generation of GHG emissions in quantities that could have a significant impact on the environment. Additionally, the amendments would not otherwise conflict with an applicable plan, policy or regulation adopted for the purpose of reducing GHG emissions.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

10.4.3.8 Hazards and Hazardous Materials

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
VIII. HAZARDS AND HAZARDOUS MATERIALS - Would the action:				
a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?				X
b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?				X

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
VIII. HAZARDS AND HAZARDOUS MATERIALS - Would the action:				
c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?				X
d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code §65962.5 and, as a result, would it create a significant hazard to the public or the environment?				X
e) For an action located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the action result in a safety hazard for people residing or working in the action area?				X
f) For an action within the vicinity of a private airstrip, would the action result in a safety hazard for people residing or working in the action area?				X
g) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?				X
h) Expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?				X

Discussion

a) Would the action create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. This revision would not involve the transport, use, disposal, release, or transmission of hazardous materials.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

b) Would the action create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the likely release of hazardous materials into the environment?

See VIII. Hazards and Hazardous Materials a) above.

c) Would the action emit hazardous emissions or handle hazardous materials or acutely hazardous materials, substances, or waste within 0.25 mile of an existing or proposed school?

See VIII. Hazards and Hazardous Materials a) above.

d) Is the action located on a site that is included on a list of hazardous material sites compiled pursuant to Government Code §65962.5 and, as a result, would it create a significant hazard to the public or the environment?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not involve construction or other disturbance at a hazardous site such that a significant hazard to the public or the environment would be created.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not involve construction or other disturbance at a hazardous site such that a significant hazard to the public or the environment would be created.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

e) For an action located within an airport land use plan or, where such a plan has not been adopted, within 2 miles of a public airport or public use airport, would the action result in a safety hazard for people residing or working in the action area?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not result in exposing people to a safety hazard associated with a public or private airport.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not result in exposing people to a safety hazard associated with a public or private airport.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

f) For an action located within the vicinity of a private airstrip, would the action result in a safety hazard for people residing or working in the action area?

See VIII. Hazards and Hazardous Materials e) above.

g) Would the action impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not involve construction or other activities that could impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not involve construction or other activities that could impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

h) Would the action expose people or structures to the risk of loss, injury, or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not expose people or structures to wildland fires.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not expose people or structures to wildland fires.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

10.4.3.9 Hydrology and Water Quality

	Potentially Significant Impact	**Less Than Significant with Mitigation Incorporation**	**Less Than Significant Impact**	**No Impact**
IX. HYDROLOGY AND WATER QUALITY - Would the action:				
a) Violate any water quality standards or waste discharge requirements?				X
b) Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?				X
c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site?				X
d) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?				X
e) Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?				X
f) Otherwise substantially degrade water quality?				X
g) Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?				X
h) Place within a 100-year flood hazard area structures which would impede or redirect flood flows?				X

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
IX. HYDROLOGY AND WATER QUALITY - Would the action:				
i) Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam?				X
j) Inundation by seiche, tsunami, or mudflow?				X

Discussion

a) Would the action violate any water quality standards or waste discharge requirements?

Proposed TMDLs Revision

As discussed in Section 2, the current Basin Plan for the Santa Ana Region establishes water quality standards for the surface and ground waters of the Santa Ana Region and provides the basis for the Santa Ana Water Board's TMDL and other regulatory programs. The Basin Plan designates the beneficial uses of specific waterbodies within the Santa Ana Region and establishes WQOs for the protection of these uses. In addition, the CWC (Porter-Cologne Water Quality Act) requires that any entity discharging waste, or proposing to discharge waste that could affect the quality of the waters of the state must submit a report of waste discharge to the Santa Ana Water Board. The Santa Ana Water Board regulates such discharges by issuing general and individual WDRs which, for discharges to surface waters, are jointly issued as NPDES permits in accordance with the federal Clean Water Act, and, where applicable, conditional waivers of WDRs. These WDRS/permits and waivers of WDRs include detailed and prescriptive requirement to ensure that discharges do not cause a violation of WQOs in surface and groundwaters. The revisions to the TMDLs do not involve construction or other activities that would result in a waste discharge or otherwise violate water quality standards, nor would the proposed revisions result in a lowering of the existing water quality of waters affected by the proposed revisions. Further, the revisions would occur in compliance with the Santa Ana Water Board’s regulatory programs, and therefore, would not violate any water quality standards or waste discharge requirements.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not violate any water quality standards or waste discharge requirements.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

b) Would the action substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (i.e., the production rate of pre-existing nearby wells would drop to a level that would not support existing land uses or planned uses for which permits have been granted)?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not deplete groundwater supplies or interfere with groundwater recharge.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not deplete groundwater supplies or interfere with groundwater recharge.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

c) Would the action substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner that would result in substantial erosion or siltation on site or off site?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not involve construction or other activities that could substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner that would result in substantial erosion or siltation on site or off site. The impact is less than significant.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner that would result in substantial erosion or siltation on site or off site.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

d) Would the action substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner that would result in flooding on site or off site?

See IX. Hydrology and Water Quality c) above.

e) Would the action create or contribute runoff water that would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not involve construction or other activities that could create or contribute runoff water that would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not create or contribute runoff water that would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

f) Would the action otherwise substantially degrade water quality?

See IX. Hydrology and Water Quality a) above

g) Would the action place housing within a 100-year floodplain, as mapped on a federal Flood Hazard Boundary, Flood Insurance Rate Map or other flood hazard delineation map?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not involve the construction of housing and, thus, would not place housing within a 100-year floodplain.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not involve the construction of housing and, thus, would not place housing within a 100-year floodplain.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

h) Would the action place within a 100-year floodplain structures that would impede or redirect flood flows?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake and would not involve any construction. The revised TMDLs would not place structures within a 100-year floodplain that would impede or redirect flows.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not place structures within a 100-year floodplain that would impede or redirect flows.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

i) Would the action expose people or structures to a significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake and would not involve any construction. The revision of the TMDLs would not expose people or structures to a significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not expose people or structures to a significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

j) Would the action expose people or structures to a significant risk of loss, injury or death involving inundation by seiche, tsunami, or mudflow?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake and would not involve construction. The revision of the TMDLs would not expose people or structures to a significant risk of loss, injury or death involving inundation by seiche, tsunami, or mudflow.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not expose people or structures to a significant risk of loss, injury or death involving inundation by seiche, tsunami, or mudflow.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

10.4.3.10 Land Use and Planning

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
X. LAND USE AND PLANNING - Would the action:				
a) Physically divide an established community?				X
b) Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the action (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?				X
c) Conflict with any applicable habitat conservation plan or natural community conservation plan?				X

Discussion

a) Would the action physically divide an established community?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not involve construction or otherwise result in a physical division that could divide an established community.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would involve temporary activities and would not result in a physical division that could divide an established community.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

b) Would the action conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the action (including, but not limited to, the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would meet statutory and regulatory water quality standards and requirements. The revision would not establish any new uses, nor would it otherwise conflict with any land use plan, policy, or regulation; or any habitat conservation plan or natural community conservation plan.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not establish any new uses nor otherwise conflict with any land use plan, policy, or regulation; or any habitat conservation plan or natural community conservation plan.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

c) Would the action conflict with any applicable habitat conservation plan or natural communities' conservation plan?

See X. Land Use and Planning b) above.

10.4.3.11 Mineral Resources

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XI. MINERAL RESOURCES - Would the action:				
a) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?				X
b) Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?				X

Discussion

a) Would the action result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not involve construction or other activities that could result in the loss of availability of a known mineral resource.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not involve construction or other activities that could result in the loss of availability of a known mineral resource.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

b) Would the action result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan?

See XI. Mineral Resources a) above.

10.4.3.12 Noise

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XII. NOISE - Would the action result in:				
a) Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?				X
b) Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?				X
c) A substantial permanent increase in ambient noise levels in the action vicinity above levels existing without the action?				X
d) A substantial temporary or periodic increase in ambient noise levels in the action vicinity above levels existing without the action?				X
e) For an action located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the action expose people residing or working in the action area to excessive noise levels?				X
f) For an action within the vicinity of a private airstrip, would the action expose people residing or working in the action area to excessive noise levels?				X

Discussion

a) Would the action result in exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance or applicable standards of other agencies?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not involve construction or other noise generating activities that would result in temporary or permanent increase in noise levels.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not require construction or other noise generating activities that would result in temporary or permanent increase in noise levels.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

b) Would the action expose persons to or generate excessive groundborne vibration or groundborne noise?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not require construction or other groundborne vibration or groundborne noise generating activities that would result in temporary or permanent increase in noise levels.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not involve groundborne vibration or groundborne noise generating construction or other activities that would result in temporary or permanent increase in noise levels.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

c) Would the action result in a substantial permanent increase in ambient noise levels in the action vicinity above levels existing without the action?

See XII. Noise a) above.

d) Would the action result in a substantial temporary or periodic increase in ambient noise levels in the action vicinity above levels existing without the action?

See XII. Noise a) above.

e) For an action located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the action expose people residing or working in the action area to excessive noise levels?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not involve exposing people to excessive noise levels associated with a public or private airport.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not involve exposing people to excessive noise levels associated with a public or private airport.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

f) For an action located within the vicinity of a private airstrip, would the action expose people residing or working in the action area to excessive noise levels?

See XII. Noise e) above.

10.4.3.13 Population and Housing

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XIII. POPULATION AND HOUSING - Would the action:				
a) Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?				X
b) Displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?				X
c) Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?				X

Discussion

a) Would the action induce substantial population growth in an area, either directly (e.g., by proposing new homes and business) or indirectly (e.g., through extension of roads or other infrastructure)?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not involve new construction or other activities that could induce population growth to the region, either directly or indirectly; nor would they involve displacing housing or people.

Reasonably Foreseeable Methods of Compliance

A potential change in the frequency or location of monitoring would not involve new construction or other activities that could induce population growth to the region, either directly or indirectly; nor would they involve displacing housing or people.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

b) Would the action displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?

See XIII. Population and Housing a) above.

c) Would the action displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?

See XIII. Population and Housing a) above.

10.4.3.14 Public Services

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XIV. PUBLIC SERVICES				
a) Would the action result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services:				
Fire protection?				X
Police protection?				X
Schools?				X
Parks				X
Other public facilities?*				X

*See XV. Recreation and Parks below for an evaluation of impacts on parks and other recreational facilities.

Discussion

a) Would the action result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities or a need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times, or other performance objectives for any of the public services:

i) Fire Protection

ii) Police Protection

iii) Schools

iv) Parks

v) Other Public Facilities

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not involve new construction or establishing new land uses that could affect service ratios, response times, or other performance objectives for any public services, including fire protection, police protection, schools, or parks, nor would it induce new population growth to the region, either directly or indirectly, which would could generate a need for expanded public services.

Reasonably Foreseeable Methods of Compliance

A potential change in the frequency or location of monitoring would not affect service ratios, response times, or other performance objectives for any public services, including fire protection, police protection, schools, or parks, nor would it induce new population growth to the region, either directly or indirectly, which would could generate a need for expanded public services.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

10.4.3.15 Recreation and Parks

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XV. RECREATION AND PARKS				
a) Would the action increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?				X
b) Does the action include recreational facilities or require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment?				X

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Discussion

a) Would the action increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake and would not induce new growth to the region that could increase the demand for parks or other recreational facilities in the area.

Reasonably Foreseeable Methods of Compliance

A potential change in the frequency or location of monitoring would not induce new growth to the region that could increase the demand for parks or other recreational facilities in the area.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

b) Does the action include recreational facilities or require the construction or expansion of recreational facilities that might have an adverse physical effect on the environment?

See XV. Recreation and Parks a) above.

10.4.3.16 Transportation and Traffic

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XVI. TRANSPORTATION AND TRAFFIC - Would the action:				
a) Conflict with an applicable plan, ordinance or policy establishing measures of effectiveness for the performance of the circulation system, taking into account all modes of transportation including mass transit and non-motorized travel and relevant components of the circulation system, including but not limited to intersections, streets, highways and freeways, pedestrian and bicycle paths, and mass transit?				X
b) Conflict with an applicable congestion management program, including, but not limited to level of service standards and travel demand measures, or other standards established by the county congestion management agency for designated roads or highways?				X

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
c) Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?				X
d) Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?				X
e) Result in inadequate emergency access?				X
f) Conflict with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities?				X

Discussion

a) Would the action conflict with an applicable plan, ordinance or policy establishing measures of effectiveness for the performance of the circulation system, taking into account all modes of transportation including mass transit and non-motorized travel and relevant components of the circulation system, including but not limited to intersections, streets, highways and freeways, pedestrian and bicycle paths, and mass transit?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not involve new construction or new uses that could result in the generation of new traffic that could conflict with an applicable plan, ordinance, or policy establishing measures of effectiveness for the performance of the circulation system.

Reasonably Foreseeable Methods of Compliance

A potential change in the frequency or location of monitoring could involve a small number of infrequent vehicle trips, but would not involve the generation of new traffic that could conflict with an applicable plan, ordinance, or policy establishing measures of effectiveness for the performance of the circulation system.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

b) Would the action conflict with an applicable congestion management program, including, but not limited to level of service standards and travel demand measures, or other standards established by the county congestion management agency for designated roads or highways?

See XVI. Transportation and Traffic a) above.

c) Would the action result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not result in any construction or other physical changes that would affect air traffic patterns.

Reasonably Foreseeable Methods of Compliance

A potential change in the frequency or location of monitoring would not affect air traffic patterns.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

d) Would the action substantially increase hazards because of a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. revision of the TMDLs would not involve new construction or activities that could substantially increase hazards because of a design feature or incompatible uses.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not substantially increase hazards because of a design feature or incompatible uses.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

e) Would the action result in inadequate emergency access?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not involve new construction or other activities that could result in inadequate emergency access.

Reasonably Foreseeable Methods of Compliance

A potential change in the frequency or location of monitoring would not involve new construction or other activities that could result in inadequate emergency access.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

f) Would the action conflict with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not involve any construction or land uses changes that create a conflict with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities. No impact would occur.

Reasonably Foreseeable Methods of Compliance

A potential change in the frequency or location of monitoring would not conflict with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

10.4.3.17 Tribal Cultural Resources

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XVII. TRIBAL CULTURAL RESOURCES - Would the action:				
a) Would the action cause a substantial adverse change in the significance of a tribal cultural resource, defined in Public Resources Code §21074 as either a site, feature, place, cultural landscape that is geographically defined in terms of the size and scope of the landscape, sacred place, or object with cultural value to a California Native American Tribe, and that is:				
(1) Listed or eligible for listing in the California Register of Historical Resources, or in a local register of historical resources as defined in Public Resources Code §5020.1(k)				X
(2) A resource determined by the lead agency, in its discretion and supported by substantial evidence, to be significant pursuant to criteria set forth in subdivision (c) of Public Resources Code §5024.1. In applying the criteria set forth in subdivision (c) of Public Resource Code §5024.1, the lead agency shall consider the significance of the resource to a California Native American tribe?				X

Discussion of a)

(1) Would the action cause a substantial adverse change in the significance of a tribal cultural resource, defined in Public Resources Code §21074 as either a site, feature, place, cultural landscape that is geographically defined in terms of the size and scope of the landscape, sacred place, or object with cultural value to a California Native American Tribe, and that is listed or eligible for listing in the California Register of Historical Resources, or in a local register of historical resources as defined in Public Resources Code §5020.1(k).

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not involve construction, earth movement, or other disturbance which could impact any a site, feature, place, cultural landscape, sacred place, or object with cultural value to a California Native American Tribe.

Reasonably Foreseeable Methods of Compliance

Monitoring is a temporary activity that occurs on an infrequent basis involving a minimal number of vehicles and personnel. A potential change in the frequency or location of monitoring would not involve construction, earth movement, or other disturbance which could impact any a site, feature, place, cultural landscape, sacred place, or object with cultural value to a California Native American Tribe.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

(2) Would the action cause a substantial adverse change in the significance of a tribal cultural resource, defined in Public Resources Code §21074 as either a site, feature, place, cultural landscape that is geographically defined in terms of the size and scope of the landscape, sacred place, or object with cultural value to a California Native American Tribe, and that is a resource determined by the lead agency, in its discretion and supported by substantial evidence, to be significant pursuant to criteria set forth in subdivision (c) of Public Resources Code §5024.1. In applying the criteria set forth in subdivision (c) of Public Resource Code §5024.1, the lead agency shall consider the significance of the resource to a California Native American tribe?

See XVII. Tribal Cultural Resources a), (1) above

10.4.3.18 Utilities and Service Systems

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XVIII. UTILITIES AND SERVICE SYSTEMS - Would the action:				
a) Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?				X

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XVIII. UTILITIES AND SERVICE SYSTEMS - Would the action:				
b) Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?				X
c) Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?				X
d) Have sufficient water supplies available to serve the action from existing entitlements and resources, or are new or expanded entitlements needed?				X
e) Result in a determination by the wastewater treatment provider which serves or may serve the action that it has adequate capacity to serve the action's projected demand in addition to the provider's existing commitments?				X
f) Be served by a landfill with sufficient permitted capacity to accommodate the action's solid waste disposal needs?				X
g) Comply with federal, state, and local statutes and regulations related to solid waste?				X

Discussion

a) Would the action exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not increase water demand or generate wastewater which could exceed the Santa Ana Water Board's wastewater treatment requirements. See also IX. Hydrology and Water Quality a).

Reasonably Foreseeable Methods of Compliance

A potential change in the frequency or location of monitoring would not increase water demand or generate wastewater which could exceed the Santa Ana Water Board's wastewater treatment requirements.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

b) Would the action require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?

See XVIII. Utilities and Service Systems a) above.

c) Would the action require or result in the construction of new stormwater drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not alter the amount or rate and stormwater runoff and would not require construction of new stormwater drainage facilities or expansion of existing facilities.

Reasonably Foreseeable Methods of Compliance

A potential change in the frequency or location of monitoring would not involve construction of new stormwater drainage facilities or expansion of existing facilities.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

d) Would the action have sufficient water supplies available to serve the action from existing entitlements and resources, or are new or expanded entitlements needed?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not require new or expanded water supply entitlements. No impacts would occur.

Reasonably Foreseeable Methods of Compliance

A potential change in the frequency or location of monitoring would not require new or expanded water supply entitlements.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

e) Has the wastewater treatment provider that serves or may serve the action determined that it has adequate capacity to serve the action's projected demand in addition to the provider's existing commitments?

See XVIII. Utilities and Service Systems a) above.

f) Is the action served by a landfill with sufficient permitted capacity to accommodate the action's solid waste disposal needs?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not involve construction or other activities that could result the generation of solid waste generation or otherwise affect landfill capacities.

Reasonably Foreseeable Methods of Compliance

A potential change in the frequency or location of monitoring would not result in solid waste generation or affect landfill capacities.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

g) Would the action comply with federal, state, and local statutes and regulations related to solid waste?

See XVIII. Utilities and Service Systems f) above.

10.4.3.19 Mandatory Findings of Significance

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XIX. MANDATORY FINDINGS OF SIGNIFICANCE - Would the action:				
a) Does the action have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?				X
b) Does the action have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of an action are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future actions)?				X

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XIX. MANDATORY FINDINGS OF SIGNIFICANCE - Would the action:				
c) Does the action have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?				X

Discussion

a) Does the action have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal, or eliminate important examples of the major periods of California history or prehistory?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. As discussed in IV. Biological Resources, this revision would not degrade the quality of the environment (including water quality) or adversely affect biological resources directly or indirectly. As discussed in V. Cultural Resources, no construction, earthwork, or removal of existing structures would occur, and thus, examples of the major periods of California history or prehistory would not be eliminated.

Reasonably Foreseeable Methods of Compliance

A potential change in the frequency or location of monitoring would not degrade the quality of the environment (including water quality) or adversely affect biological resources directly or indirectly as discussed in IV. Biological Resources, and would not result in construction, earthwork, or removal of existing structures, and thus, would not eliminate examples of the major periods of California history or prehistory as discussed in V. Cultural Resources.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

b) Does the action have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of an action are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future actions.)

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. As discussed throughout this section, this revision would not have significant adverse effects on the environment, and thus, would not cause or add to a cumulative impact.

Reasonably Foreseeable Methods of Compliance

As discussed throughout this section, a potential change in the frequency or location of monitoring would not have significant adverse effects on the environment, and thus, would not cause or add to a cumulative impact.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary.

c) Does the action have environmental effects that would cause substantial adverse effects on human beings, either directly or indirectly?

Proposed TMDLs Revision

The Proposed Action would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. As discussed throughout this section, the Proposed Action would not have significant adverse effects on the environment, and thus, would not cause substantial adverse effects on human beings, either directly or indirectly.

Reasonably Foreseeable Methods of Compliance

Development and Implementation of Revised Monitoring and Reporting Program - A potential change in the frequency or location of monitoring would not have significant adverse effects on the environment, and thus, would not cause substantial adverse effects on human beings, either directly or indirectly.

Finding of Significance

No impacts are anticipated, and no mitigation is necessary

10.5 Alternatives

Pursuant to the State Water Board's regulations for implementing CEQA (CWC Title 23, §3777[b]), this environmental review must include an analysis of reasonable alternatives to the Proposed Action. The intent is to consider whether there are reasonable alternatives that would fulfill the underlying purpose of the Proposed Action which involves revising the original TMDLs, to also achieve and protect water quality standards, but that would minimize or eliminate the potential adverse environmental effects of the Proposed Action. Further pursuant to CEQA §15187, this environmental review must also include an analysis of reasonable foreseeable alternative means of compliance with the rule or regulation which would avoid or eliminate the identified impacts.

As described in the discussion of potential Environmental Issues (Section 10.4), there are no potential adverse environmental impacts associated with the Proposed Action or reasonably foreseeable methods of compliance. As there are no potential environmental impacts which could be reduced by an alternative to the Proposed Project or alternative means of compliance with the Proposed Project, the only alternative addressed herein is the No Project Action Alternative, which entails leaving the current TMDL in place.

Under the "No Action" Alternative, the Santa Ana Water Board would not adopt the proposed revisions to the existing TMDLs. The existing TMDLs would remain in force and the existing implementation actions would continue. Several of the 2004 TMDL response targets continue to be exceeded despite ongoing implementation of water quality controls. Thus, as described in Section 10.2.3, existing water quality controls would continue to be implemented and additional supplemental water quality controls may also be implemented. The water quality controls implemented under the No Action Alternative and the associated water quality improvements would occur at a functionally equivalent level to the Proposed Action.

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Section 11

Economic Considerations

The adoption of revised nutrient TMDLs requires an amendment to the Basin Plan. As such, the Santa Ana Water Board is required to conduct an economic analysis of the proposed Basin Plan revisions to address the following legal requirements:

- CWC §13141 requires that prior to implementation of any agricultural water quality control program, the Santa Ana Water Board must include an estimated cost of such a program, together with an identification of potential sources of funding.
- California Public Resources Code §21159 requires the Santa Ana Water Board, when adopting an amendment that will require the installation of pollution control equipment or is a performance standard or treatment requirement, to include an environmental analysis of the reasonably foreseeable methods of compliance. As part of this analysis is necessary to demonstrate that there are reasonable, economically feasible means to comply with the provisions of the Basin Plan amendment.

The proposed revisions to the nutrient TMDLs update response targets and allocations are based on the findings of studies completed since the 2004 adoption of the original TMDLs. Revision of the 2004-adopted TMDLs was a required implementation task under the existing TMDL and was to be conducted after the completion of necessary modeling analyses and special studies (see Task 14, Santa Ana Water Board 2004a).

Compliance with the proposed revised TMDLs will likely require continued implementation of current, or equivalent, level of controls. In addition, studies conducted by the LECL Task Force since 2004 have shown that supplemental projects, e.g., as described in Section 7.3, may be needed to assure compliance with the TMDLs – regardless of whether the TMDLs are revised. Accordingly, adoption of the revised TMDLs will require that jurisdictions with an allocation either update existing TMDL implementation plans (i.e., CNRP for MS4 permittees; AgNMP for agricultural lands >20 acres) or develop new TMDL implementation plans (e.g., Caltrans, March JPA) to meet revised external nutrient load allocations and/or in-lake response targets. Through this process potential supplemental projects will be identified for implementation to comply with the TMDLs.

To fulfill the economic analysis requirements associated with the proposed Basin Plan amendment to incorporate revised nutrient TMDLS for Lake Elsinore and Canyon Lake, this section provides the following information:

- *Section 11.1 – Economic Costs*: This section provides a summary of the costs of the types of projects that may be employed to meet the allocations and in-lake response targets in the revised TMDLs. Projects may include a combination of implementation of existing controls and consideration of potential supplemental projects.

- *Section 11.2 – Economic Value*: The expected economic and environmental benefits associated with implementation of the revised TMDLs are summarized in this section.
- *Section 11.3 – Agricultural Costs*: A brief discussion of potential costs applicable to agriculture is provided along with potential funding sources.
- *Section 11.4 – Antidegradation Review*: This section addresses compliance with state and federal antidegradation review requirements, as applicable to the revised TMDLs.
- *Section 11.5 – Summary of Key Findings*: This section summarizes the key findings from this economic analysis.

11.1 Economic Costs

To evaluate the economic cost of the implementation of the revised TMDLs to meet the allocations and in-lake response targets in the revised TMDLs, it is assumed that costs will include continued implementation of existing controls and implementation of new supplemental projects. Each of these cost areas is evaluated below.

11.1.1 Existing Projects

Since 2004, numerous projects have been implemented to reduce nutrient loads from the San Jacinto River watershed and to improve water quality within Lake Elsinore and Canyon Lake. Since the 2004 adoption of the TMDLs these projects include activities implemented by MS4 and agricultural dischargers, reclaimed water addition to Lake Elsinore, and multi-agency projects implemented through the LECL Task Force, such as alum addition and carp management.[1] **Table 11-1** summarizes the average annual cost to implement some of these existing water quality controls. It is assumed that going forward the cost of continued implementation of these controls would be approximately equal to recent expenditures.

The greatest cost of currently implemented projects involves the addition of reclaimed water to Lake Elsinore for lake level stabilization, approximately $1.4 million annually. At present, this cost is shared between the City of Lake Elsinore and the EVMWD. During wet hydrologic periods, reclaimed water discharges to Lake Elsinore would be ceased temporarily to prevent use of minimum flood storage requirements. Since regular reclaimed water additions began in 2007, it has not been necessary to suspend discharges to Lake Elsinore due to low lake levels associated with an extended drought. However, if a prolonged period of wet weather returns to the region, EVMWD may be required to temporarily suspend reclaimed water discharges to Lake Elsinore in order to minimize the risk of shoreline flooding.

Many of the watershed BMPs deployed in the San Jacinto River watershed are associated with meeting core requirements in the MS4 permit (Santa Ana Water Board 2010), CWAD (Santa Ana Water Board 2017), and programs designed to meet groundwater basin objectives. "Core requirements" are general obligations imposed on all stormwater permittees to minimize pollutants to the Maximum Extent Practicable (MEP) by implementing BMPs. The expense

[1] The implementation costs since 2004 do not include capital expenditures associated with other key projects completed in Lake Elsinore prior to TMDL adoption, including the construction of the levee, back-bay wetlands, and LEAMS.

incurred to implement these core requirements would occur regardless of whether the TMDL was adopted or is updated. Nevertheless, these core requirements do contribute to achieving compliance with the TMDL by helping reduce dry nutrient loads in urban runoff (e.g., street sweeping, restaurant inspections, etc.). Some of these costs are incurred by private entities. For example, the cost to implement post-construction BMPs to capture and infiltrate or treat runoff from new urban development to meet MS4 permit requirements is often incurred by private developers. Costs incurred by developers to implement WQMPs in the San Jacinto River watershed since 2004 may be in excess of $100 million when applying Los Angeles regional planning level cost functions for typical LID BMPs (Los Angeles County 2011).

Table 11-1. Summary of Current Annual Average Public Expenditures for Water Quality Control Type

Project	Core Programs[1] ($/yr)	TMDL Project ($/yr)[2]	Total Cost ($/yr)
MS4 Program BMP Control Measures	$400,000	--	$400,000
Reclaimed Water Addition (~4,000 AFY)	$1,400,000	--	$1,400,000
Monitoring Program, Task Force Administration	--	$400,000	$400,000
LEAMS[3]	--	$400,000	$400,000
Canyon Lake Alum Addition	--	$300,000	$300,000
Carp Removal	--	$100,000	$100,000
Total	**$1,800,000**	**$1,200,000**	**$3,000,000**

[1] Core programs include minimum control measures implemented by MS4 permittees and reclaimed water addition by EVMWD. Costs incurred by developers to construct LID BMPs in project WQMPs and specific BMPs implemented by agricultural land owners subject to the CWAD are not shown.

[2] TMDL Projects are implemented collaboratively through the LECL Task Force and funded through funds collected per the Task Force Agreement and grants.

[3] LEAMS costs include annual operation and maintenance (O&M) plus $90,000/yr dedicated to a capital reserve fund to update/replace systems in future for operation of the system.

Agricultural dischargers responsible for TMDL implementation have been participating in the Task Force through WRCAC and contribute funds to implement TMDL projects. In addition, specific BMPs are being implemented by agricultural land owners subject to the CWAD. It is estimated that since adoption of the original TMDLs in 2004, an estimated $10 million has been spent on the implementation of agricultural-related BMP projects in the San Jacinto River watershed (personal communication, Pat Boldt on behalf of WRCAC, April 9, 2018). Implementation of agricultural BMPs as required by the CWAD and participation in the Task Force will continue under the revised TMDLs.

The LECL Task Force has developed multiple plans for managing water quality in Lake Elsinore and Canyon Lake. Special studies have been conducted to provide the necessary data to guide the selection and design of in-lake water quality controls and to support development of plans for project implementation. In total, studies and plans conducted by the LECL Task Force have amounted to approximately $100,000 per year (personal communication with Rick Whetsel, Santa Ana Watershed Project Authority, April 27, 2018). The TMDL revision includes several requirements for future updates to pollution control plans as well as new special studies (See Section 7.4).

11.1.2 Potential Supplemental Projects

Section 7.3 identifies additional BMPs that could potentially be implemented to modify or supplement the current portfolio of water quality controls to meet the revised TMDL targets. With the exception of enhanced fishery management (projects other than carp removal) and LEAPs, planning level costs were developed for these potential supplemental projects. The following sections below provide project concept descriptions, anticipated water quality benefits, implementation assumptions, and a basis for the cost estimate. Enhanced fishery management is not included because of the varied options associated with this BMP and its dependence on other factors such as carp removal (see Tables 7-1 and 7-10 for discussion of fishery management and/or LESJWA 2005a). LEAPS is not included because the ability to estimate planning level costs is limited at this time given the highly conceptual nature of the existing project description.

When conducting an economic analysis over a future time period, such as from 2018 to 2040, it is necessary to consider the 'time value of money' through a process called 'discounting'. Discounting converts the dollar values in future time periods into today's value, called the 'present value'. By doing so, economic values from diverse time periods can be compared on an equal basis. The concept of discounting assumes that a dollar today is more valuable than a dollar in the future. For example, one million dollars 25 years from now does not have the same economic value as one million dollars today. In fact, the farther out in time the future value occurs, the less it is worth today. For example, one million dollars invested today earning 3 percent per year would be worth about $1,343,900 in 10 years, and about $2,100,000 in 25 years. Conversely, at a discount rate of 3 percent, one million dollars in 10 years is equivalent to about $744,000 today, and one million dollars in 25 years is equivalent to about $478,000 today.

In this section, the costs of implementing supplemental projects in the future were discounted back to a present worth to allow for cost comparisons to be made on an equal basis. For this cost discounting analysis, it was assumed that supplemental project implementation would begin in 2025, after approval of revised TMDL implementation plans (e.g., CNRP and AgNMP, see Section 7) and completion of engineering design and environmental permitting requirements. A discount rate of 3 percent was used to discount future dollars (25-year period from 2020-2045) into present worth dollars. This is the current minimum rate that municipalities pay for money, i.e., the interest paid out on municipal bonds.

Figure 11-1 presents a summary of costs for ongoing O&M for existing controls and potential implementation of supplemental controls. Additional information regarding the basis for the estimated costs for each project is provided in the sections below. For each project, costs are presented as present value including both capital and O&M over a 25-year period. These are planning level estimates developed solely to approximate the order of magnitude cost of different projects to provide context for evaluating whether a significant societal economic impact may be incurred as a result of implementation of the revised TMDLs. A few important caveats to these cost estimates include:

- Cost estimates are planning level and intended to understand the general magnitude for evaluating societal economic impacts.
- The level of implementation that may be sufficient to yield water quality benefits (e.g., volume of dredging, acres of macrophyte planting, drainage acres for stormwater BMP retrofits, etc.) was estimated based on past experience, published literature and best professional judgment.
- No quantitative analysis of the water quality effectiveness or progress toward TMDL compliance by any one option or combination of options is made in this analysis. The effectiveness of individual project(s) will be evaluated through the development of revised TMDL implementation plans.
- Estimated costs are expressed as collective amounts with no discussion or assumptions as to how such costs might be distributed among individual stakeholders.
- The identification of potential compliance projects and preparation of associated cost estimates imposes no obligation whatsoever on stakeholders to select one or more of these alternatives for implementation.

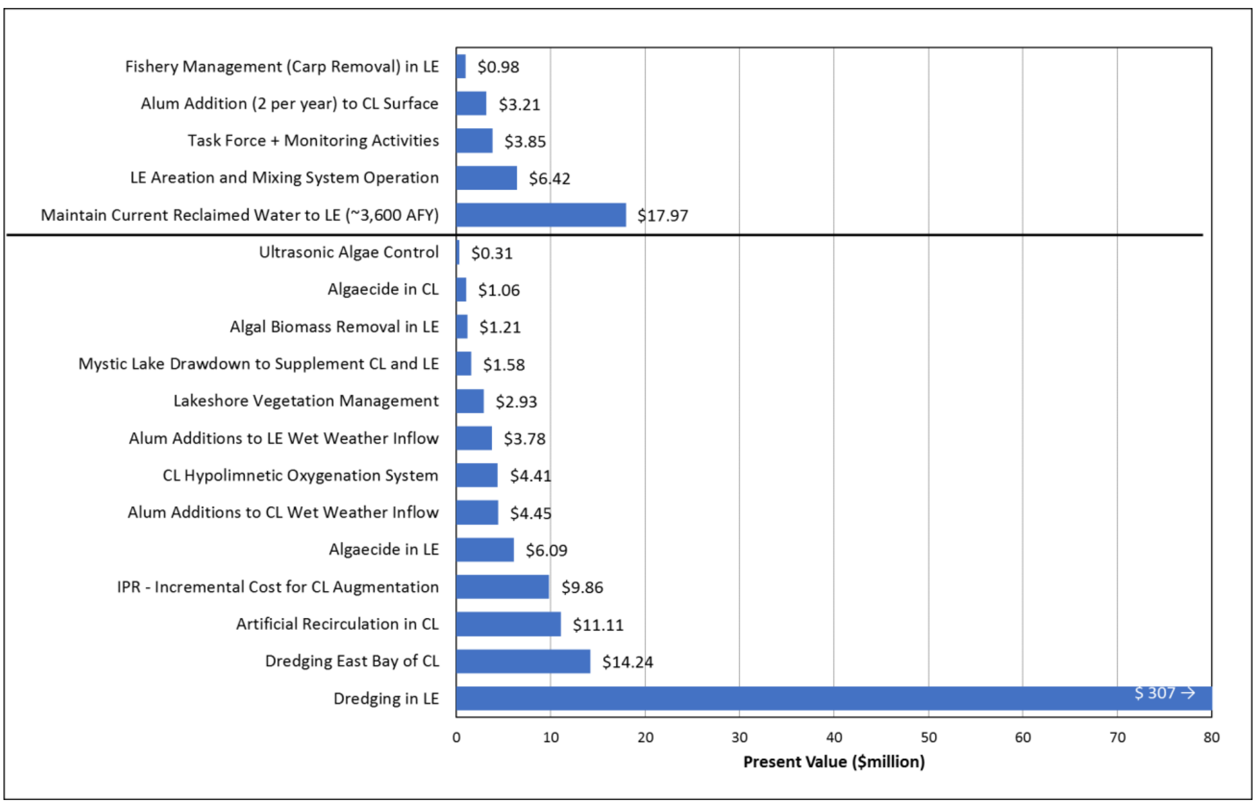

Figure 11-1. Approximate Present Value over Next 25 years for Existing and Potential Supplemental Projects (CL – Canyon Lake; LE – Lake Elsinore)

11.1.2.1 Mystic Lake Drawdown

Description

Mystic Lake is a depression in the upper San Jacinto River watershed that captures all runoff from the upper watershed via a breach in the levee on the north side of the river near Bridge Street. Most runoff that reaches Mystic Lake is retained and subsequently lost via evaporation. A potential project would involve pumping stored runoff out of Mystic Lake to the lower San Jacinto River (**Figure 11-2**). These flows to Canyon Lake would result in increased overflows of lower TDS water from Canyon Lake to Lake Elsinore.

Few data exist on the flow that reaches Mystic Lake. The USGS operates a gauge on the San Jacinto River at State Street, about 4 miles upstream of the levee breach. The average annual volume at that location is ~13,000 AFY. Much of this runoff is lost to channel bottom recharge, e.g., in the 2004-2005 wet season, the flow volume at State Street was ~34,000 AFY, yet field observations documented no overflows of Mystic Lake, which only has ~17,000 AF of storage.

The watershed model conservatively estimates an annual average inflow to Mystic Lake of ~4,000 AFY, with many years having zero and many years over 10,000 AF. While intermittent, the water that gets trapped within Mystic Lake may have a significant value for EVMWD water supply (at Canyon Lake) and for improving water quality in both lakes (providing both flushing and dilution with low TDS water).

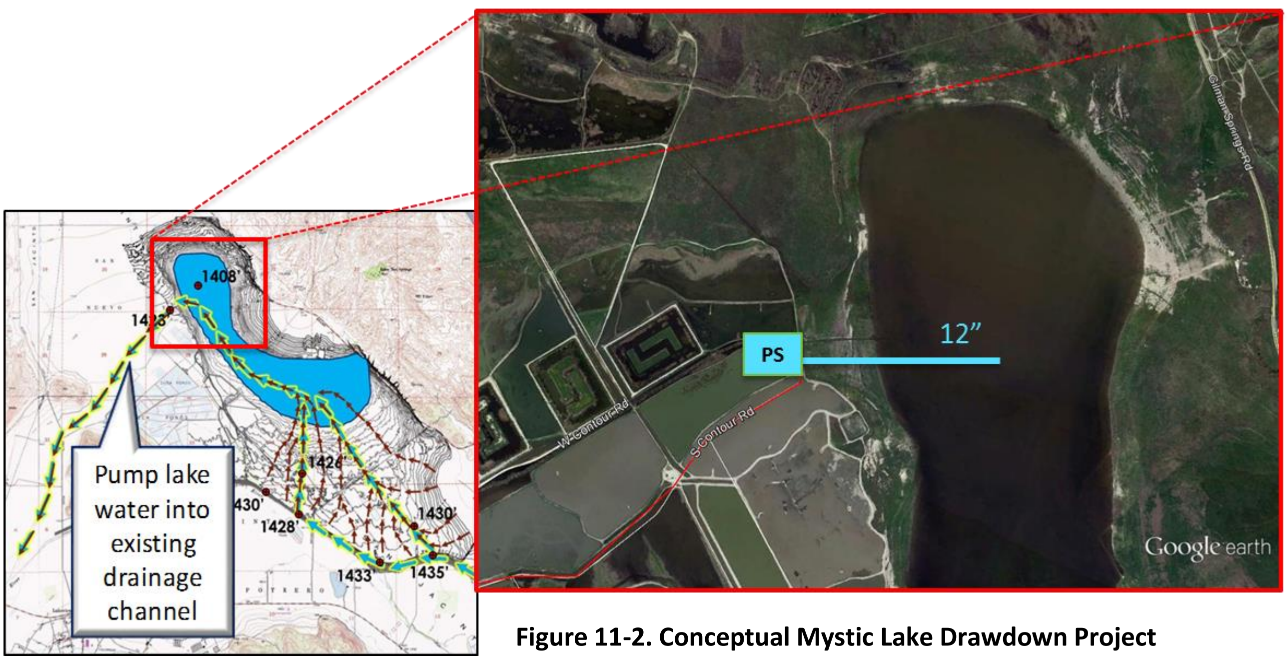

Figure 11-2. Conceptual Mystic Lake Drawdown Project

Potential Water Quality/Other Benefits

Water quality benefits may include increased flushing of nutrients and algae out of Canyon Lake, dilution of TDS in overflows from Canyon Lake to Lake Elsinore, and increased runoff volume to stabilize lake levels in Lake Elsinore. The potential project would improve raw water quality of water treated for water supply by EVMWD and limit the potential for flooding impacts to farms and other properties near Mystic Lake.

Potential Implementation Issues

Water from Mystic Lake would be available in wetter hydrologic years, when Lake Elsinore may need it least. However, Mystic Lake would detain runoff, allowing for drawdown to extend for months or years following large rain events. Also, the use of the existing overflow ditch for more consistent flow must be evaluated. Lastly, movement of the water downstream may impact local water rights.

Sizing Assumptions and Estimated Costs

To evaluate the economics of the Mystic Lake drawdown project, several cost options were evaluated involving different pump horsepower and required conveyance facilities. **Table 11-2** provides findings from the lowest cost option evaluated. By limiting the drawdown rate to 5 cfs (~4,000 AFY), it may be feasible to use the existing overflow ditch to route the water to the San Jacinto River mainstem. Higher drawdown rates would involve construction of pipelines, which could increase the capital cost to $16 million.

Table 11-2. Estimated Implementation and O&M Costs for Potential Mystic Lake Drawdown Project

Facilities	Cost ($)
Intake pipeline (2500', 12" diameter)[1]	$1,200,000
Pump Station (25 HP)[2]	$125,000
Discharge pipeline (500', 12" diameter)[3]	$120,000
Capital Cost (2018)	$1,445,000
O&M[4] ($/yr)	$28,900
Present Value for 25 years ($)[5]	**$1,580,000**

[1] Pipeline cost assumes $480 per linear foot for trenchless construction – 2X open trench cost basis
[2] Pump station cost assumes $5,000 per Horsepower (HP) (Carollo 2017)
[3] Pipeline cost assumes $240 per linear foot for open trench construction (Carollo 2017)
[4] Assumes 2% of capital for annual O&M including power to run pumps and facility maintenance
[5] Assumes 3% discount rate with capital expenditure in 2025 and O&M in 2025-2045

11.1.2.2 Alum Addition to Wet Weather Flows

Description

Current alum additions to Canyon Lake involve the spreading of a slurry onto the lake surface twice per year, typically in September and in February or March. The timing of wet weather events that bring new external nutrient loads to Canyon Lake can limit the effectiveness of preceding alum additions, especially during the wet season in February and March. Wet weather may also extend into April in some years. An alternative to the current approach to applying alum is to apply the alum directly at the lake inflows during runoff events with installation of emitters, feed pumps, and on-site materials storage. Alum floc would form within the inflow channel, work to binds TP in the runoff as it enters the lake, and then settle to the lake bottom. Applications of alum at lake inflows using this alternative approach have been successful (Churchill et al. 2009; Cooke and Carlson 1986).

Potential Water Quality/Other Benefits

The addition of alum to wet weather inflows allows for the reduction of bioavailable phosphorus as it enters the lake. The shift to a dynamic application approach eliminates the potential for a large storm event to recharge nutrients to the lake shortly after a singular large surface application.

Alum floc that has the capacity to bind with orthophosphate requires the formation of aluminum hydroxide, which is most effective when the pH of the water is less than 8.0. Unlike the ambient pH in Canyon Lake and Lake Elsinore, the pH of wet weather runoff is typically between 7.5 and 8.0, thus more effective floc formation could be expected from additions at the lake inflows.

Potential Implementation Issues

A key consideration for this project is the need to house equipment and provide for on-site chemical storage alongside the creek inflows near developed areas. The rate of alum addition will be dependent upon real-time flow measurements to provide a consistent dose to the inflows. There is the potential for alum additions to be delivered at unplanned dose levels as a result of instrument malfunction or failure. Less turbulent conditions could result in settling of floc in the channel bottom to levels that would require removal and off-site disposal.

Estimated Costs

The costs of this project include constructing on-site chemical storage and feed systems, purchase of alum material, and labor to manage the site. **Table 11-3** provides estimated costs for a typical in-line system, including the variable amounts of alum material required at three key inflow stations; Salt Creek inflow to East Bay, San Jacinto River inflow to Canyon Lake Main Lake, and San Jacinto River inflow to Lake Elsinore. This cost estimate suggests that a system of this type for Canyon Lake would be similar in cost to the current alum addition program. Moreover, this potential program would be used in-lieu of, and not in addition to, current surface alum applications. Elsewhere, similar projects have required larger capital investments including construction of an off-line mixing system and forebay for settling floc prior to lake discharge as well as routine sludge removal. If needed for Canyon Lake and Lake Elsinore, these components could result in a significant increase in cost for a project involving alum additions with wet weather inflows.

11.1.2.3 Increased Reclaimed Water Addition

Description

EVMWD, City of Lake Elsinore and the Lake Elsinore Redevelopment Agency entered into an agreement in 2003 (replacing prior agreements). This agreement requires EVMWD to maintain water levels in Lake Elsinore at 1,240 ft before it can divert water from Canyon Lake for water treatment (Lake Elsinore Comprehensive Water Management Agreement 2003). EVWMD, to meet their obligation under this agreement, provides reclaimed water to Lake Elsinore (see discussion in Sections 2.2.2.3 and 7.2.3.3.).

Table 11-3. Estimated Implementation and O&M Costs for Alum Addition to Wet Weather Flows

Wet Weather Inflow Alum Addition	San Jacinto River at Goetz (Main Lake)	Salt Creek at Murrieta (East Bay)	San Jacinto River near Elsinore (Lake Elsinore)
Average Annual Runoff (AFY)	6,120	2,400	6,850
Average TP in Runoff (mg/L)	0.73	0.39	0.46
Average TP in Watershed Runoff w/Additional Alum (mg/L)	0.48	0.2	0.2
TP Reduction (kg/yr)	1,887	563	2,197
Additional Alum Material (kg/yr)	283,116	84,380	329,561
Alum Dose (mg/L as alum)	37.5	28.5	39
Capital Cost (2018)	$165,000	$165,000	$165,000
O&M Cost ($/yr) including Alum Material	$244,986	$80,035	$283,536
Present Value for 25 years ($)[1]	$3,280,000	$1,170,000	$3,780,000

[1] Assumes 3% discount rate with capital expenditure in 2025 and O&M in 2025-2045

Approximately, 50,000 AF of supplemental water has been added to Lake Elsinore since 2007, which is estimated to have prevented the lake from a desiccation event sometime in 2014 (**Figure 11-3**). However, these reclaimed water additions were not able to offset evaporative losses during the most recent extended drought, and lake levels have fallen to as low as 1,232 ft.

The TMDL linkage analysis (see Section 5) shows that an increase in the inflow rate to 7.5 MGD would be sufficient to maintain lake levels above 1240 ft based on 1916-2016 hydrology (see green line in Figure 11-3). Currently, EVMWD produces ~6.0 MGD of reclaimed water (5.5 MGD available for discharge to Lake Elsinore; 0.5 MGD for discharge to Temescal Wash. EVMWD projects 7.5 MGD (~8,400 AFY in dry years) will be available for discharge to Lake Elsinore by 2020 (EVMWD 2017). Beyond 2020, EVMWD plans to continue to make reclaimed water available for lake level stabilization with the potential to increase the discharge to 9 MGD (~10,000 AFY in dry years). It may also be possible to allow for reclaimed water additions during periods when lake levels are between 1,240 and 1,247 ft, a recommendation in the 2003 agreement. This additional increment would allow for maintenance of lake levels above 1,241.5 ft at all times and keep levels closer to 1,245 ft in most years (see reddish-brown line Figure 11-3).

Potential Water Quality/Other Benefits

Reclaimed water represents an additional external source of nutrient loads in excess of reference conditions, despite the relatively low effluent nutrient concentration from EVMWD's RWRF (TP ~0.4 mg/L; TN~3.0 mg/L). Thus, the addition of reclaimed water has the potential to increase eutrophication relative to the reference watershed condition. The linkage analysis was used to evaluate the balance of increased nutrient loads against the benefits of increased water volume in Lake Elsinore, including reducing wind driven sediment resuspension, facilitating aquatic vegetation on shorelines, and diluting TDS under most conditions. The findings from this analysis shows that the implementation of other existing controls (watershed BMPs, levee, LEAMS, and fishery management) along with projected increases of reclaimed water addition to 7.5 MGD is expected to reduce eutrophication to levels better than reference condition in all but ~3 percent of the time (see Figure 7-7).

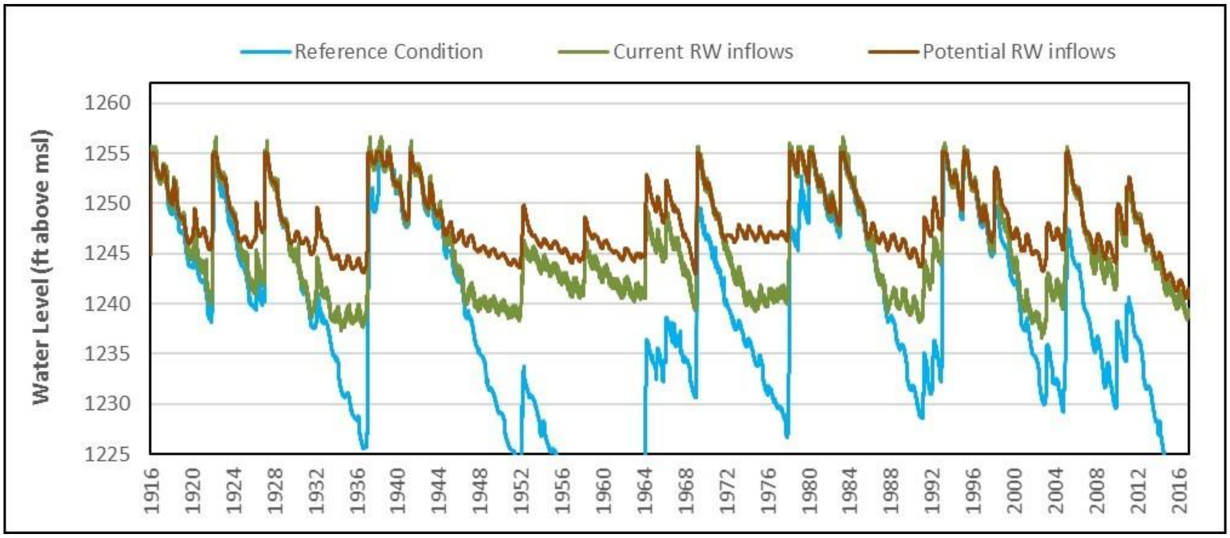

Figure 11-3. Modeled Lake Levels for Lake Elsinore Using a 100-year Simulation with and without Reclaimed Water (RW) Addition (Note: The blue line below 1,225 feet indicates the lake would have been dry).

Reclaimed water additions to Lake Elsinore have unquestionably prevented a lakebed desiccation event, which is estimated would have occurred in 2015 (e.g., see Section 2.2.2.3). Clearly, then, reclaimed water additions provide better protection of recreational uses than would be realized in a reference condition. Moreover, other public health issues associated with periods of lakebed desiccation, such as severe gnat infestations and dust are prevented with reclaimed water addition (see description of the impact of previous desiccation events in Section 2.2.2.2). As noted in Section 7, the greatest potential impact of climate change to Lake Elsinore would involve increased evaporative losses and more severe extended droughts. Enhanced reclaimed water additions make Lake Elsinore more resilient to potential climate change impacts.

Water agencies have developed ways to increase capture of surface runoff for groundwater basin recharge in the upper watershed, which has resulted in a decline in Canyon Lake overflows. Thus, increasing EVMWD reclaimed water additions to Lake Elsinore will play a greater role in maintaining water levels above 1,240 ft, indirectly allowing for increased potable water supplies from Canyon Lake and groundwater recharge for the region.

Potential Implementation Issues

Reclaimed water addition to the lake when levels are between 1,240 and 1,247 ft may limit the available flood storage capacity to prevent flooding lake levels during wet hydrologic years.

Estimated Costs

The current cost to add reclaimed water to Lake Elsinore is ~$1.4 million/year based on a cost to produce tertiary treated effluent at EVMWD's RWRF for discharge to Lake Elsinore of approximately $350 per AF. As a result of the current extended drought, EVMWD has been able to discharge its full capacity (minus 0.5 mgd for Temescal Wash) to Lake Elsinore since the start of supplemental water addition in 2007. Despite effluent rates at less than 7.5 mgd in the first decade of reclaimed water addition, the continuous discharge has amounted to an average annual volume of ~4,000 AFY, which exceeds what the DYRESM-CAEDYM model predicts would be necessary, on average, over a 100-yr period. Therefore, current average annual costs incurred are not reflective of a long-term hydrologic condition including wet periods when discharges would not be allowed. **Table 11-4** shows the estimated incremental increases in reclaimed water addition costs, which is only realized in future dry years when effluent rates are increased and can support increased volumes delivered in a single year. The two scenarios provided in Table 11-4 bookend the amount of reclaimed water that could be added in future, with 7.5 mgd when the lake level is below 1,240 ft representing the expected inflow in the near-term and 9.0 mgd up to 1,247 ft as a potential future amount if discharges were to be allowed when the lake is between 1,240 ft and 1,247 ft. Present value is not calculated for increased reclaimed water addition because purchases over the next 25 years will be dependent upon hydrologic conditions. Moreover, if the next 25 years is representative of an average hydrologic condition, then the incremental cost above current expenditures would be zero.

Table 11-4. Estimated Costs to Increase Reclaimed Water Additions to Lake Elsinore

Cost Basis	Reclaimed Water Addition 7.5 mgd up to 1,240 ft	Reclaimed Water Addition 9.0 mgd up to 1,247 ft
Maximum RW addition (AF/yr)	8,400	10,000
Maximum Annual Incremental[1] Cost ($million)	$1,500,000	$2,100,000
Long-Term Average Reclaimed Water incremental[2] addition (AF/yr)	0	0
Long-Term Average Annual Incremental[2] Cost ($million)	$0	$0

[1] The incremental cost is in addition to the current $1.4 million spent per year on ~4,000 AFY of reclaimed water addition.

[2] With current drought conditions, supplemental water inputs have been maximized in most years since 2007, thus current annual volume (even at lower inflow rates) are greater than the simulated 100-year average at 7.5 and 9.0 mgd, which would include wet years with no supplemental water addition.

11.1.2.4 Oxygenation – Canyon Lake Hypolimnetic Oxygenation System

Description

HOS is used to inject liquid oxygen into lake water within a pressurized chamber. This pumped lake water becomes oxygen enriched in the chamber and is then piped to the anoxic water layer overlying the sediment, which can rapidly increase DO concentrations throughout the hypolimnion. The increase in DO greatly reduces the diffusive flux rates of phosphorus and nitrogen from the sediment into the water column. A Canyon Lake HOS would deliver a greater amount of oxygen to the lake bottom than could be achieved with an aeration system and is thereby a more effective method for suppressing sediment nutrient flux. In the case of the Main Lake of Canyon Lake, thermal stratification is a naturally occurring process that serves to limit the pool of bioavailable nutrients in the photic zone over much of the year. HOS would maintain thermal stratification while delivering oxygen rich water into the hypolimnion. PACE (2011) developed a preliminary design for a HOS system in Canyon Lake (**Figure 11-4**). This system was considered for inclusion in the CNRP and AgNMP, but ultimately the LECL Task Force decided to pursue alum addition as the primary in-lake nutrient control strategy. A key decision factor was the fact that HOS would not provide water quality benefits within East Bay. If alum additions in the Main Lake do not provide sufficient water quality improvement to meet the revised TMDL response target CDFs for DO, chlorophyll-*a* and ammonia, then HOS may be a supplemental project to consider.

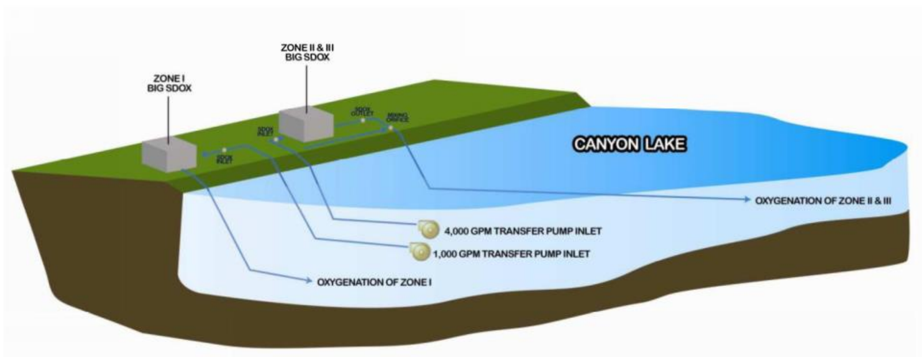

Figure 11-4. Conceptual Drawing of Canyon Lake Dual On-Shore Oxygenation System (adapted from Figure ES-4, PACE 2011)

Potential Water Quality/Other Benefits

HOS would directly increase DO in the lake bottom and would be able to create a condition that is significantly more oxygen rich than estimated for a reference condition. Reduction in sediment nutrient flux would reduce nutrients in the water column potentially available to support excess algae growth. Increased DO in the lake bottom would also support increased rates of nitrification of ammonia released from the lake bottom to the less toxic nitrate form.

Potential Implementation Issues

HOS would require shoreline disturbance and underwater construction activities. Also, the regular delivery of liquid oxygen may be disruptive and require additional safety precautions.

Sizing Assumptions and Estimated Costs

To estimate the economic cost of this potential supplemental project, the recommended alternative (10b) in the preliminary design report was evaluated (PACE 2011). This alternative included two shoreline oxygen generation locations, ~10,000 feet of underwater oxygen delivery pipe along the lake bottom, pumps, and other equipment. **Table 11-5** provides the estimated implementation and operational cost; costs were updated to reflect 2018 dollars using the standard Engineering News-Record (ENR) index.

Table 11-5. Estimated Costs to Implement HOS in Canyon Lake (adapted from PACE 2011)

Cost Item	Cost ($)[1]
Total Capital Cost[1]	$3,382,000
Annual O&M[2]	$123,000
Present Value[3]	$4,410,000

[1] Cost from PACE 2011 escalated to 2018 dollars using ENR index 11936 (December 2017)
[2] O&M cost escalated assuming 3% inflation over seven years since original estimate in 2011.
[3] Assumes 3% discount rate with capital expenditure in 2025 and O&M in 2025-2045

11.1.2.5 Dredging of Canyon Lake East Bay

Project Description

A project to remove bottom material from Canyon Lake East Bay would reduce the pool of potentially mobile nutrients and thereby reduce internal loads. Incubation chamber studies from Canyon Lake in 2001, 2006 and 2014 showed that sites in the East Bay had some of the greatest rates of diffusive flux from the lake bottom sediments (Anderson 2016a; see Section 4.3.1.2).

In 2006/2007, a dredging project implemented in Canyon Lake removed approximately 21,000 cubic yards (CY) of sediment but was ceased (for non-technical reasons) before reaching the sediment removal goal of 225,000 CY. A potential future dredging project that targets the most downstream end of East Bay near the causeway to the Main Lake could provide significant water quality improvement (**Figure 11-5**).

Potential Water Quality/Other Benefits

Dredging, which will reduce the internal diffusive sediment nutrient flux for both TP and TN, will improve water quality in East Bay. Other benefits include addition of flood storage capacity and extension of the lifespan of Canyon Lake Reservoir.

Potential Implementation Issues

The long-term benefits remain limited, since the bioavailable P loading would resume after dredging. Without a local disposal area, project implementation costs would be significant.

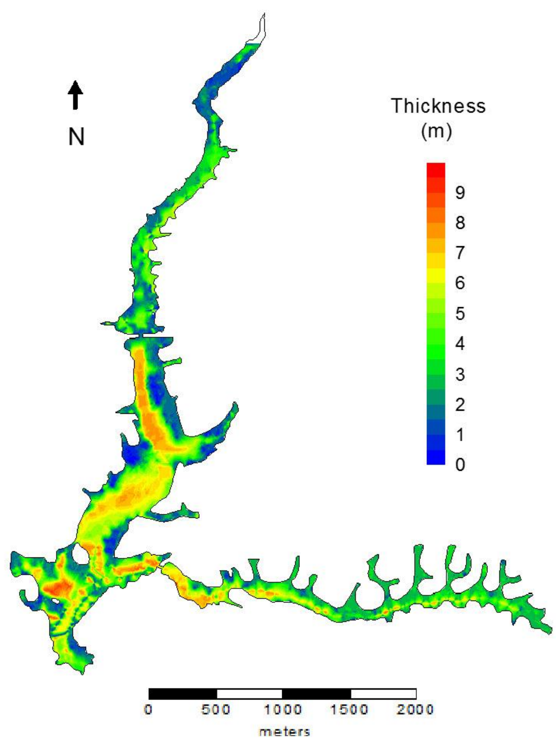

Figure 11-5. Sediment Thickness (Meters) in Canyon Lake (Anderson 2016a)

Estimated Cost

For this cost estimate, it was assumed that dredging would focus on the top two feet of the lake bottom sediment (consistent with the earlier dredging project) and extend over ~50 acres in areas with the greatest thickness of bottom sediments, based on the recent hydroacoustic survey analysis (see Figure 11-5; Anderson 2016a). Dredging this area to this depth would require removal of approximately 200,000 CY of sediment. To develop a cost estimate, the following factors were considered:

- The 2005 cost estimate for dredging at East Bay was ~$11/CY removed. Using the Army Corps of Engineers (ACOE) Civil Works Construction Cost Index System (CWCCIS) for Navigation, Ports, and Harbors (ACOE 2017), this cost escalated to 2018 dollars is ~$14/CY. Originally, the Canyon Lake POA intended to manage the dredging operations, which would help manage cost. However, if all costs were fully contracted, these costs are likely to increase; accordingly, it is estimated at $20 per CY removed. This estimate is consistent with the dredging cost estimate developed for the Machado Lake Nutrient TMDL (Los Angeles Water Board 2008).
- The 2005 cost estimate states that sediment disposal to a landfill would cost $9 million, or $13 million in 2018 dollars. Thus, disposal cost is estimated at $65 per CY. Disposal cost would be drastically reduced if a local disposal area was identified.
- Dredging is assumed to occur once, with no annual O&M.

Based on the above considerations, **Table 11-6** provides a summary of the estimated cost to dredge and dispose of sediments from East Bay.

Table 11-6. Summary of Estimated Costs to Dredge East Bay of Canyon Lake

Cost Item	Cost ($)
Excavation Cost (200,000 CY)	$4,000,000
Landfill Disposal Cost	$13,000,000
Present Value[1] (capital cost only; no annual O&M)	$14,240,000

[1] Assumes 3% discount rate with capital expenditure in 2025

11.1.2.6 Indirect Potable Reuse

Project Description

This project would rely on the use of Canyon Lake as an environmental buffer to support indirect potable reuse (IPR) by EVMWD (EVMWD 2017). Advanced treated reclaimed water would be discharged at the upstream end of the lake to maximize residence time prior to water being withdrawn for treatment at the Canyon Lake Water Treatment Plant at the lower end of Canyon Lake (**Figure 11-6**). This IPR approach, involving reservoir augmentation, was evaluated against other methods such as groundwater recharge and recovery (EVMWD 2017).

While the primary objective of this project is not to improve lake-wide water quality, the addition of advanced treated reclaimed water would result in the dilution of nutrients in the lake. Continuous inflows would also reduce water level fluctuations that occur under current operations during the dry season. By maintaining water levels in advance of the wet season, storm event overflows from Canyon Lake to Lake Elsinore would be expected to occur more frequently, resulting in an increase in the downstream transport of water and associated nutrients.

Potential Water Quality/Other Benefits

The most significant benefit is the development of a new source of local potable water supply. IPR flows to Canyon Lake would dilute ambient TP and TN concentrations in the water column. Also, IPR additions would support higher lake levels in Canyon Lake at the beginning of the wet season, thereby increasing the frequency of overflows to Lake Elsinore. More frequent overflows would increase downstream transport of nutrients out of Canyon Lake.

Potential Implementation Issues

Even with the expected improvements to water quality from the discharge of advanced treated wastewater, there may be times when conditions are sufficient to influence the treatability of water that could require temporary shutdowns of EVMWD's RWRF. Water quality in the lake may limit the amount of reclaimed water than can be diverted for potable supply. Operation of the system during the wet season may be less reliable given water quality and capacity limitations.

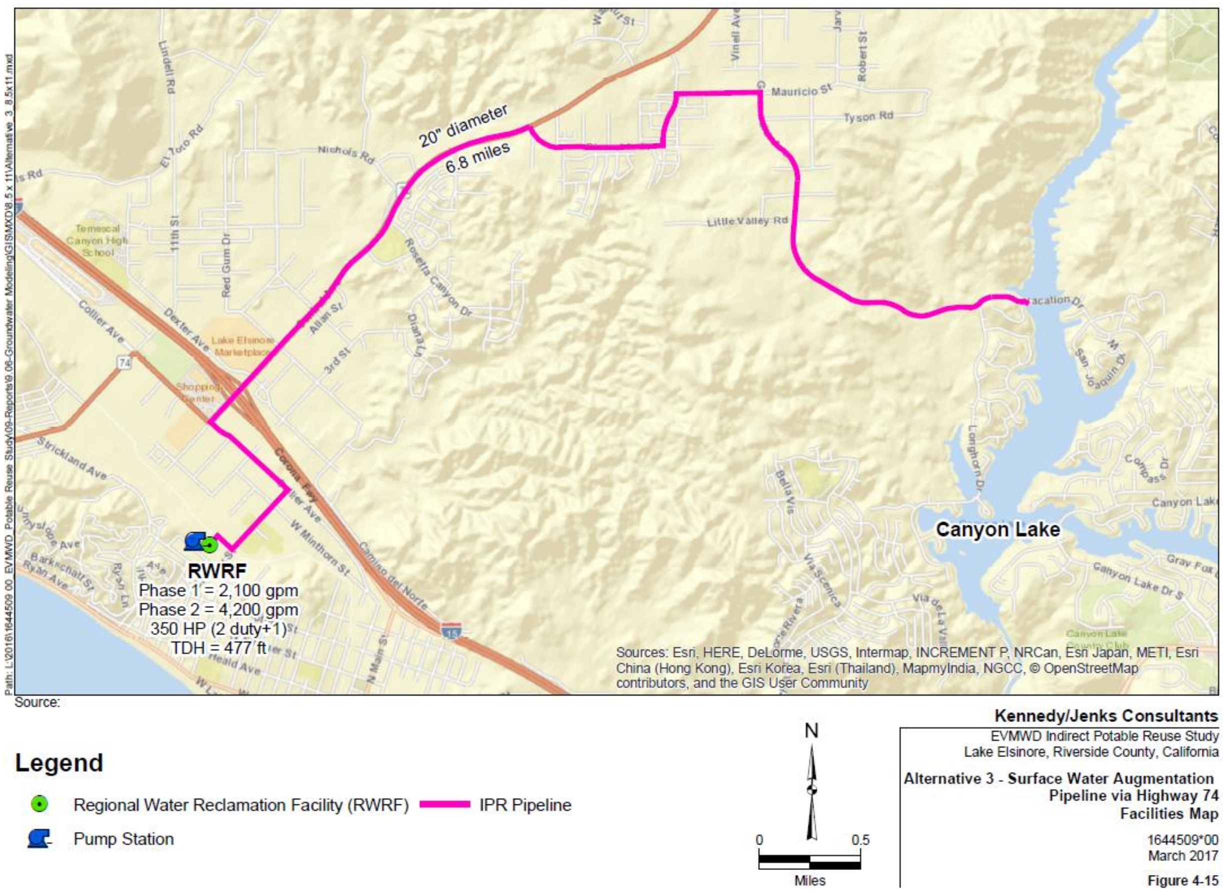

Figure 11.6 Surface Water Augmentation Concept for Canyon Lake (from EVMWD 2017).

Estimated Cost

EVMWD has several options for implementing an IPR project that comprise either groundwater recharge or surface reservoir augmentation in Canyon Lake (EVMWD 2017). Sizing assumptions and estimated costs for IPR project options involving groundwater recharge via injection wells (Alternative 1) and Canyon Lake augmentation (Alternative 3) are presented in **Table 11-7**. All of the evaluated options would involve construction of an Advanced Water Treatment Facility (AWTF) to produce water from RWRF treated tertiary effluent and disposal of brine. No water quality benefits would be realized for Canyon Lake if EVMWD selected to implement a groundwater recharge IPR project, thus the incremental cost associated with Canyon Lake augmentation over groundwater recharge was assumed to represent the cost to stakeholders with the objective of meeting the revised TMDL. The most significant cost distinct to reservoir augmentation involves pumping and conveyance of the product water to the discharge location in Canyon Lake.

The AWTF capacity is 3.0 mgd in Phase 1 and expanded to 6.0 mgd in Phase 2. The planned water pipeline from the RWRF to the AWTF to be constructed in Phase 1 is 6.8 miles in length. Costs presented Table 11-7 represent the incremental difference between Alternative 3 (surface water augmentation) and Alternative 1 (injection wells) or $10 million for life cycle cost.

Table 11-7. Summary of Estimated Incremental Costs to Implement Indirect Potable Reuse Project by Canyon Lake Reservoir Augmentation Relative to Injections Wells

Cost Item	Alternative 3 (Canyon Lake Augmentation)	Alternative 1 (Injection Wells)	Incremental Cost for Canyon Lake Augmentation (Alternative 3 minus Alternative 1)
Present Value for Capital Cost[1]	$68,950,000	$71,090,000	($2,140,000)
Present Value for O&M (25 years)[1]	$111,000,000	$99,000,000	$12,000,000
Total Present Value [1]	$179,950,000	$170,090,000	$9,860,000

[1] Estimates of present value as reported in EVMWD 2017, including discount rate of 4% over 25-year period of analysis

11.1.2.7 Lakeshore Vegetation Management

Description

This project would establish a community of emergent and submerged aquatic vegetation in the Lake Elsinore littoral zone that can take up nutrients and release oxygen to the water column (**Figure 11-7**). These plants can compete with algae for limited nutrients and light thereby providing a potential control on the growth of nuisance algae.

Potential Water Quality/Other Benefits

Established lakeshore vegetative cover would reduce bank erosion and physical resuspension of sediments. Submerged plants take up phosphorus and nitrogen, thereby reducing the pool of bioavailable nutrients to fuel algae growth. Some lakeshore vegetation can provide shade and some reduction in localized water temperatures. Other benefits include the creation of habitat areas for fish and wildlife.

Potential Implementation Issues

Efforts to establish submerged aquatic vegetation may be challenging given that fluctuations in water levels can kill vegetation by either desiccation or drowning. In the case of Lake Elsinore, fluctuations in salinity may also stress plants; therefore, the selection of salt tolerant species will be important.

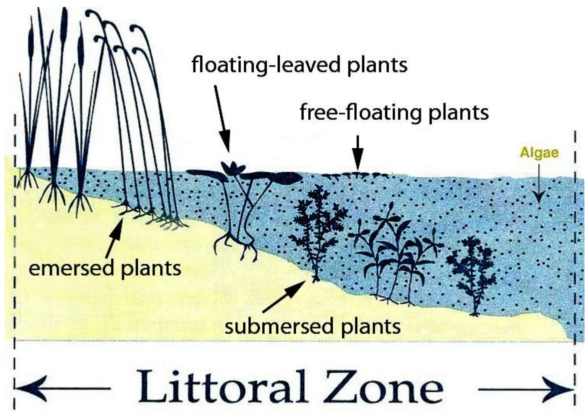

Figure 11-7. Conceptual View of the Littoral Zone of a Typical Lake (Source: https://plants.ifas.ufl.edu/manage/why-manage-plants/aquatic-and-wetland-plants-in-florida/)

Sizing Assumptions and Estimated Costs

The cost estimate for this potential project includes the following assumptions:

- Up to 100 acres of shoreline in Lake Elsinore are candidate areas for establishment of macrophytes.
- Vegetation establishment, including labor, installation, and plant cost, is approximately ~$35,000 per converted acre based on an analysis performed for the San Francisco Bay Joint Venture (Steere 2004).
- No extensive O&M is necessary once plants are established.

Given these assumptions, the estimated project cost in 2025 to establish 100 acres of shoreline discounted to present value at 3 percent is $2,930,000.

11.1.2.8 Artificial Recirculation in Canyon Lake

Project Description

This potential Canyon Lake project would recirculate oxygen depleted, nutrient rich water from the hypolimnion in Canyon Lake Main Lake through East Bay and back to the Main Lake (**Figure 11-8**). The transfer of water from the hypolimnion in Main Lake to East Bay would be expected to cause a rise in DO at the sediment interface; a reduction of internal loads of TP and TN may also be realized. For East Bay, water delivered from the Main Lake would be reaerated through the process of discharge and flushing through the shallow East Bay. This activity would facilitate flushing of nutrients out of East Bay to reduce the duration of algal blooms. Over time, the reduced cycling of nutrient within East Bay would limit sediment nutrient flux and thereby the concentration of bioavailable nutrients flushed to Main Lake. A conceptual facility plan for this option includes:

- 16,000-ft of 30-inch diameter pipeline
- 400 HP pump station
- Riser intake with mechanical sluice gates

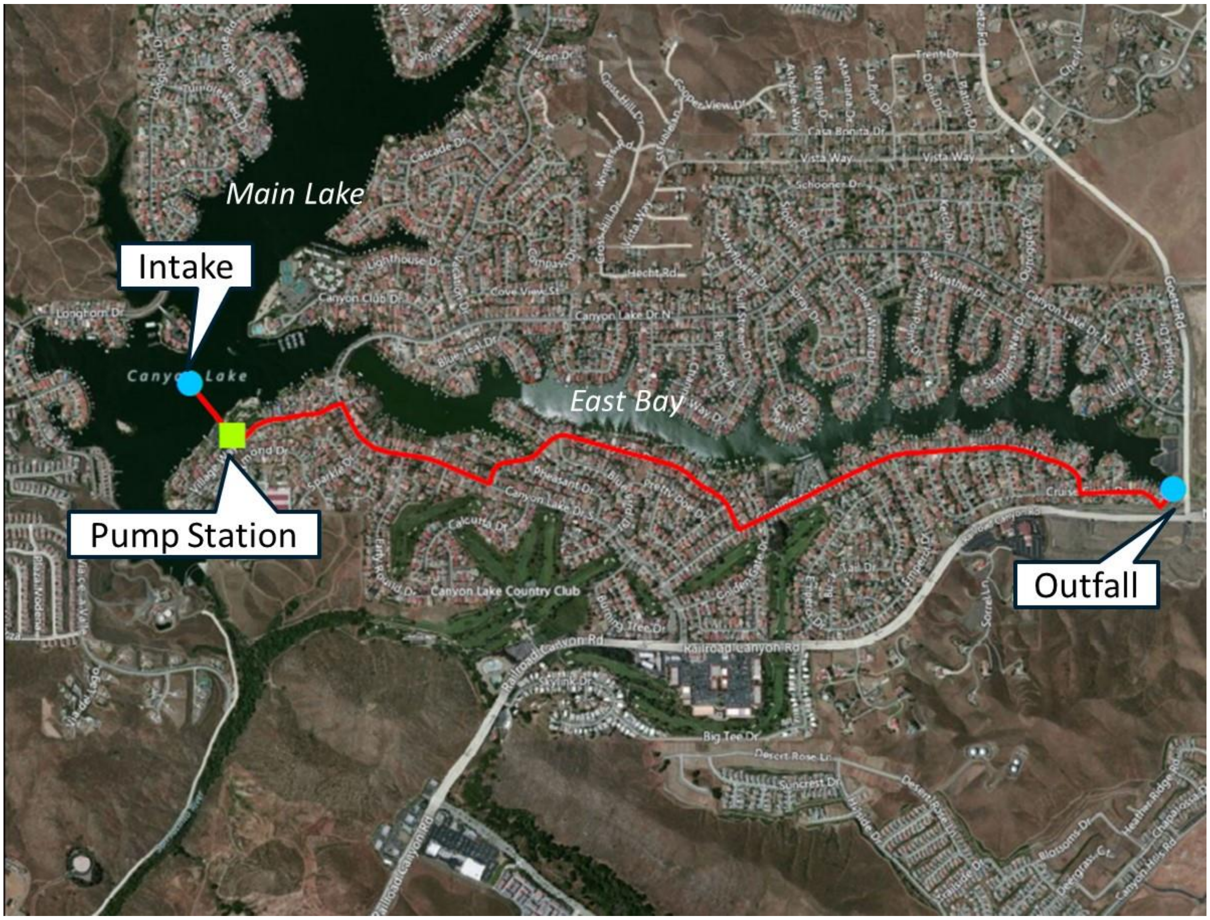

Figure 11-8. Canyon Lake Recirculation Project Concept

Potential Water Quality / Other Benefits

The recirculation process would result in a net reduction of internal nutrient load and net increase in DO. Algae blooms would be expected to be shortened in duration within East Bay and conditions with DO > 5 mg/L would extend deeper in the water column in the Main Lake. Also, the project would improve raw water quality at the EVMWD water treatment plant.

Potential Implementation Issues

Although a net reduction in nutrients is expected, there may be periods when high concentrations of bioavailable nutrients in the hypolimnion of Canyon Lake Main Lake could cause an increase in nutrient concentrations within East Bay. One alternative would involve incorporation of a process to treat the recirculated water. Also, designs would need to consider the potential for resuspension or lake bottom sediments with increased turbulence around the intake and outfall.

Sizing Assumptions and Estimated Costs

A simulation of the effects of a recirculation project was completed using the Simplified Lake Analysis Model (SLAM). SLAM is a single dimensional model (CDM Smith 2017). Estimates of water quality benefits from increased flushing are determined by adjusting terms in an empirical phytoplankton growth estimation. Using the model, it was determined that a recirculation rate of

~10 mgd of Main Lake water, or roughly one month to completely flush East Bay water into the Main Lake, would yield significant water quality improvements. Sizing criteria for preliminary designs would need to be developed based on results of a more spatially rigorous three-dimensional model of Canyon Lake, such as ELCOM-CAEDYM. **Table 11-8** summarizes the estimated costs for construction operation of a recirculation facility in Canyon Lake based on constructing the pipeline in the street right of way adjacent to the lake. One alternative design would involve constructing the pipeline along the lake bottom, instead. This alternative could potentially reduce costs by as much as 50 percent. Further study is needed to assess the feasibility of an underwater pipeline system in East Bay.

Table 11-8. Planning-Level Cost Estimate for a Recirculation Facility in Canyon Lake

Facilities	Cost ($)
Intake pipeline (16,000 ft, 30-inch diameter)[1]	$8,450,000
Intake, outfall with rock protection	$500,000
Pump Station (400 HP)[2]	$1,200,000
Capital Cost (2018)	$10,150,000
O&M ($/yr)[3]	$203,000
Present Value for 25 years ($)[4]	**$11,110,000**

[1] Pipeline (30-inch diameter) cost assumed $528 per linear foot (Carollo 2017)
[2] Pump station cost assumes $3,000 per HP (Carollo 2017)
[3] Assumes 2% of capital for annual O&M including power to run pumps and facility maintenance
[4] Assumes 3% discount rate with capital expenditure in 2025 and O&M in 2025-2045

11.1.2.9 Ultrasonic Algae Control

Project Description

Many species of cyanobacteria contain gas vacuoles that provide a competitive advantage by allowing algae cells to regulate their position in the water column. However, gas vacuoles make cyanobacteria more susceptible to cavitation, and research has been conducted to evaluate the potential to control them by sonication. Deployment of devices that emit directional ultrasonic waves are effective in killing cyanobacteria by causing cavitation. Multiple studies have shown sonication to significantly reduce growth of cyanobacteria (Rajasekhar et al. 2012).

Sound waves produced by sonication have a limited area of influence (~8 acres); therefore, this potential project is generally envisioned only for Canyon Lake East Bay. However, this option could be incorporated as an element of other in-lake controls where isolated locations (e.g., near intakes, beaches, boat ramps) would benefit from reduced concentrations of cyanobacteria.

Potential Water Quality/Other Benefits

The primary benefit of this type of project is control of algae growth and preferential reduction of cyanobacteria species. Reduction in cyanobacteria would in turn reduce levels of cyanotoxins, thereby reducing the risk of exposure for swimmers.

Potential Implementation Issues

Sonication has been proven effective over a small area but may require many devices to impact larger zones. Impacts to other non-target aquatic species is an important consideration.

Sizing Assumptions:

Each ultrasonic unit provides sufficient wave signals to kill algae over roughly 8 acres. Twelve units are assumed for East Bay at a cost of $4,795 each (Quote provided by Sonic Solutions, June 2016, www.sonicsolutionsllc.com). The units can be powered in different ways, but for this estimate it was assumed that three floating solar units would be necessary at a cost of $7,510 each. Shipping and installation costs are estimated. Per the unit owner's manuals, ultrasonic units require monthly maintenance, estimated at 1-hour each per month. The units have a useful equipment life of 10 years; thus, reinvestment is assumed at year 11. **Table 11-9** provides a summary of the estimated cost for a project in East Bay Canyon Lake.

Table 11-9. Estimated Cost to Deploy Ultrasonic Units in East Bay Canyon Lake

Cost Item	Cost ($)
Total Equipment plus Installation Cost[1]	$93,230
Annual O&M	$10,080
Present Value[2]	$310,000

[1] Includes cost of replacement at year 11

[2] Assumes 3% inflation rate and a 25-year period with annual O&M in years 2025 - 2045

11.1.2.10 Algaecide

Project Description

The application of an algaecide directly to the surface of either Lake Elsinore or Canyon Lake would kill algae and prevents algal blooms from forming (**Figure 11-9**). PAK® 27 is an algaecide that works through an oxidation process, releasing hydrogen peroxide into the water supply. This algaecide allows for selective treatment for cyanobacteria and is non-toxic to other forms of aquatic life. Other algaecides could also be considered that may be more effective for all types of algae, but potentially more toxic to other aquatic species after repeated usage over multiple years (e.g., copper sulfate). Algaecides may be used on an as-needed basis or as part of a treatment train with alum or other treatment methods. California has a statewide general NPDES permit for use of algaecides or aquatic herbicides registered for use in California (State Water Board 2013). Costs were estimated for a single application, but multiple applications per year, timed around historical algal blooms, would provide the greatest benefit.

Figure 11-9. Example of Application of Algaecide to a Surface Waterbody (Source: http://www.peroxygensolutions.com/pak-27/how-to-apply)

CDM Smith

Water Quality Benefits

Algaecides may be used to control algae growth and impairments caused by eutrophication.

Constraints and Limitations

Repeated use of some algaecides can cause elevated levels of toxins in the lake bottom. Also, given that nutrients are not addressed, new algae blooms may arise shortly after an algaecide treatment. The frequency of application required to achieve effective results is unknown and will require additional study.

Costs & Assumptions

Table 11-10 summarizes the estimated planning level costs for this BMP project. The analysis assumes the top four feet of both Lake Elsinore and Canyon Lake are treated annually with PAK27 at an application rate of 30 lbs/AF. The cost per pound is assumed at $1.30, based on discussions with a leading algaecide provider in spring 2018. Additional costs are assumed for shipping and application by lake staff.

Table 11-10. Planning-Level Costs for Application of Algaecide to Lake Elsinore or Canyon Lake

Per Application Cost Items	Canyon Lake	Lake Elsinore
Surface Acres	500	3,000
Volume of Treatment (AF)[1]	2,000	12,000
Algaecide Application (lbs/Event)	60,000	360,000
Total Annual Algaecide Product Cost ($/Event)	$78,000	$468,000
Shipping and Application Labor ($/Event)	$4,000	$7,000
Present Value ($) [2]	$1,060,000	$6,090,000

[1] Treated volume is top 4 feet of water column

[2] Assumes 3% inflation rate and a 25-year period with annual applications in years 2025 - 2045

11.1.2.11 Physical Harvesting of Algal Biomass

Description

Several technologies exist to remove algal biomass from lakes using screens, filters, or flotation/separation processes. In the 66,000-acre Upper Klamath Lake, physical harvesting of algae in conducted commercially to produce a dietary supplement from nitrogen-fixing cyanobacterium *Aphanizomenon flos-aquae* (AFA) (**Figure 11-10**) (Klamath Valley Botanicals 2018). AFA production from Upper Klamath Lake is currently conducted using two methods, a lakeshore filtration system and a floating barge equipped with algal screens.

A floating barge system could be used to removal algal biomass from Lake Elsinore and/or Canyon Lake. Instead of producing species specific AFA dietary supplements, other potential uses of the harvested algae from the lakes could include production of biofuels or soil amendments. Alternatively, harvested algae could be disposed of in a composting facility.

Figure 11-10. Floating Algal Harvesting Barge on Upper Klamath Lake in Oregon (Source: http://www.spiritofleadership.info/health/earths-first-foods/algae-information/

Potential Water Quality/Other Benefits

Physical removal of algae will reduce concentrations of chlorophyll-*a* in lake water, reduce potential for release of cyanotoxins, and remove nitrogen and phosphorus mass from the system. The harvested algae may be useful to other entities in the region to reduce operational costs by providing a sustainable source for production of biofuels or in composting operations.

Potential Implementation Issues

Due to the limited lake surface area and narrow configuration, it may be difficult to conduct algal biomass removal in Canyon Lake East Bay by floating barge. In addition, if algal toxins are present at high levels in collected biomass, these conditions may constitute a hazardous waste and involve additional disposal requirements. Lastly, the regular operation of a floating barge may disturb recreational use within the lakes.

Sizing Assumptions and Estimated Costs

Cost estimates were developed based on the assumption used in estimating potential costs to expand commercial AFA harvesting in Klamath Lake to target all algal species and operate on a more regular 100-day per year schedule (**Table 11-11**) (Stillwater Sciences et al. 2012). Costs were updated to reflect 2018 dollars using the standard ENR index. There were no comparable projects implemented on a smaller lake, so capital and O&M is downscaled by 80% given that the surface area of Lake Elsinore (~3,000 acres) is 20% the surface area of Upper Klamath Lake (~60,000 acres). Consistent with the

Table 11-11. Estimated Costs for Algal Biomass Harvesting

Cost Item	Cost ($)
Total Capital Cost[1]	$144,000
Annual O&M[2]	$84,000
Present Value[3]	$1,210,000

[1] Cost of filtration barge and off-load tender estimated for Klamath Lake, escalated to 2018 dollars, and downscaled by 20 percent for Lake Elsinore surface area, includes cost of replacement at year 11.

[2] O&M cost includes fuel, labor, and maintenance involved in 100 days of operation per year, downscaled by 20 percent for Lake Elsinore surface area.

[3] Assumes 3% inflation rate and a 25-year period with annual applications in years 2025 -2045.

Upper Klamath Lake estimate, useful equipment life is assumed to be 10 years; thus, reinvestment is assumed at year 11. A detailed take-off estimate should be developed if this technology is to be further considered in subsequent implementation plans. Potential disposal costs are not included in this estimate.

11.1.2.12 Watershed BMPs in Urban Drainage Areas

Description

Watershed runoff and associated excess nutrient loads could be captured and infiltrated or treated prior to reaching Canyon Lake and Lake Elsinore with watershed-wide deployment of low LID BMPs. Examples of LID BMPs include bioretention facilities, porous pavement, detention basins, media filtration, and regional infiltration basins. Under the areas MS4 permit, such projects are required in new urban development and significant re-development projects within the San Jacinto River watershed (Santa Ana Water Board 2010) (**Figure 11-11**).

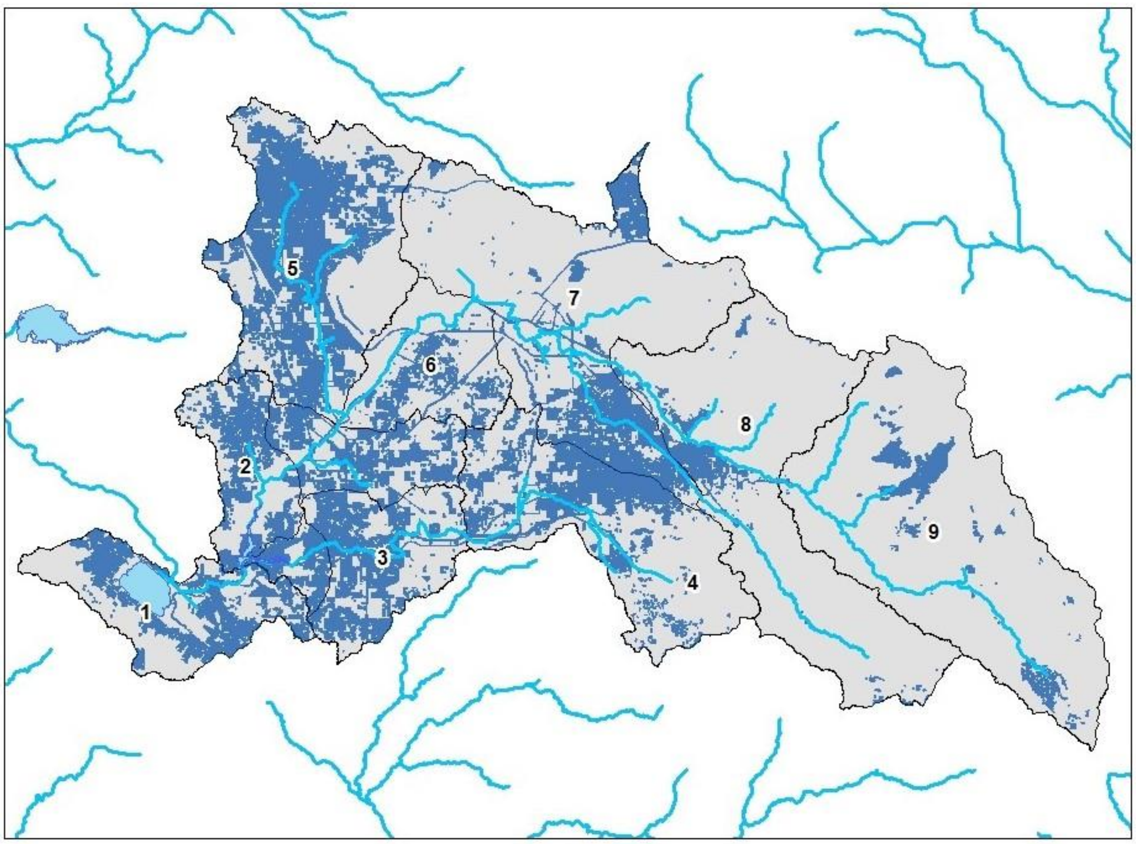

Figure 11-11. Urbanized Area of the San Jacinto River Watershed

Collectively, MS4 permittees have overseen the construction of numerous LID BMPs within ~7,000 acres of new development in the San Jacinto River watershed. These LID BMPs are designed to capture at a minimum, all runoff from storms events up to the 85th percentile depth. To minimize nutrients loads to Canyon Lake and Lake Elsinore from the watershed, it is larger storm events (> 5-year return period) that must be controlled to protect downstream waters. These events occur infrequently but are responsible for the majority of total watershed nutrient loading. The nutrients ultimately settle to the bottom of Canyon Lake and Lake Elsinore, where data analysis suggests cycling between the sediment, water column, and phytoplankton pools proceed over multiple decades (Anderson 2011).

In the future, jurisdictions could retrofit other urbanized areas in the San Jacinto River watershed (up to ~90,000 acres, see Figure 11-12) with similar water quality controls; however, costs to deploy LID BMPs in existing urban land use areas are much greater than in new development. For some jurisdictions with limited drainage area and potential sites for establishing downstream BMPs to capture urban runoff, watershed BMPs to capture excess nutrient loads from large storms may be a viable alternative path to compliance.

Potential Water Quality/Other Benefits

Reduction of nutrient loads from urban areas within the areas that drain to the MS4 in the Lake Elsinore and Canyon Lake watersheds.

Potential Implementation Issues

Implementation of BMPs to capture runoff would need to consider a number of potential constraints, including, for example, land availability, technical feasibility, environmental impacts from construction activities, and reduction in runoff volume delivered to lakes that support beneficial uses dependent on adequate water, e.g., municipal water supply in Canyon Lake and recreation in Lake Elsinore.

While LID BMPs can be very effective in managing stormwater quality within localized areas, reliance on these BMPs only to comply with WLAs applicable to watershed runoff would be costly. For example, for Riverside County jurisdictions in the Santa Ana Region, it was estimated previously that the cost to achieve bacteria water quality objectives in urban runoff under dry weather conditions only was $780 million (Santa Ana Water Board 2012b). Based on this information the Santa Ana Water Board made the following finding related to compliance with bacteria water quality objectives under wet weather conditions (Santa Ana Water Board 2012b):

> *Given the large challenges and costs that would be associated with reducing bacterial indicators and the associated potential pathogens under large storm event flows, it may be economically infeasible for local agencies to implement actions to try and attain these standards under all flow conditions. Expending resources to address standards compliance under all flow conditions could delay expenditures to address compliance when and where most needed, i.e., when and where recreational use occurs. This would be contrary to the public interest.*

While these findings were applicable to compliance with bacteria water quality objectives, it is expected that the cost to deploy BMPs to control nutrients to meet the WLAs applicable to watershed runoff (e.g., see Table 6-3) would also likely be very high. Therefore, while LID-based BMPs can be a useful water quality management tool in local areas, it is expected that compliance with the revised TMDL will require implementation of other watershed or in-lake projects.

Sizing Assumptions and Estimated Costs

The watershed model developed to complete the source assessment in the revised TMDLs (Section 4) was used to estimate minimum runoff capture requirements. The model estimates that the capture of ~16 AF would be sufficient to capture and infiltrate or treat excess nutrients from a typical 500-acre urban drainage area from a five-year return period rainfall event (~3.2 inches). To development a cost estimate, three types of watershed BMPs were evaluated, including regional BMPs on public land, bioretention, and permeable pavement. Assumptions include:

- Maximum depth of ponded water for each BMP: (a) Regional BMP = 6.0 ft; (b) bioretention = 1.5 ft; and (c) permeable pavement = zero depth.
- Depth of gravel sublayer: 2-foot for all three BMP types (regional BMP, bioretention, and permeable pavement).

Costs can vary significantly depending upon the types of BMPs that may be feasible for a given watershed, with regional BMPs on public lands being the most cost effective, i.e., ~$3 million capital and $200,000 per year O&M (**Table 11-12**). In some cases, regional BMPs costs could be further reduced if there are existing facilities that could be repurposed to capture runoff. Permeable pavement is the most cost prohibitive and would not be reasonable to implement at a subwatershed scale. Regardless of BMP type, individual opportunities for deployment of these or other types of BMPs may be implemented at lower costs when incorporated as features within other public infrastructure projects. Costs could also be reduced if it can be shown that smaller design storm criteria can be shown to meet allowable watershed runoff loads.

Table 11-12. Estimated Costs to Deploy Selected BMPs in the San Jacinto River Watershed

Costs to Control 5-yr, 24-hr Storm from 500-acre Urban Drainage Area	Regional BMP on Public Land ($)	Bioretention (million $)	Permeable Pavement (million $)
Capital[1]	$3,410,000	$8,350,000	$17,660,000
O&M ($/year)[1]	$220,000	$1,180,000	$1,210,000
Total Net Present Value[2]	$5,720,000	$22,140,000	$30,360,000

[1] Capital and O&M cost based on functions developed for Los Angeles County (Upper Los Angeles River Watershed Management Group 2016)

[2] Assumes 3% inflation rate and a 25-year period with annual applications in years 2025 - 2045

11.2 Economic Value

Costs of existing TMDL implementation activities that are likely to continue, as well as planning level cost estimates for potential supplemental projects, are provided above. The specific environmental and economic benefits that may be realized from protection of water quality are more difficult to measure given that economic benefits are subject to large sources of uncertainty, are highly subjective, and can be rather time consuming and expensive (Keplinger 2003). For this TMDL revision, a detailed quantitative analysis in economic terms was not developed to quantify anticipated benefits of improved water quality in Lake Elsinore and Canyon Lake. Instead, this section provides qualitative information on the economic and environmental benefits associated with implementation of revised TMDLs.

Water quality improvement in both lakes will positively benefit the biological diversity in the area by increasing the extent and health of aquatic and terrestrial habitats. Lake Elsinore is the largest natural lake in southern California but provides unreliable support for aquatic habitat in the reference (naturally occurring) condition, mostly caused by dramatic fluctuations in water level and water quality, especially with regards to salinity. As discussed in Section 9, Lake Elsinore is being managed in a manner that targets a stable lake level with a surface elevation of 1,240 ft. This management strategy is contrary to the natural condition, which results in a periodically dry lake (see Section 2). Implementation of this wet-lake management strategy ensures support of existing recreational and aquatic life beneficial uses. Under the revised TMDLs this preferred management approach is presumed to continue.

By managing Lake Elsinore to have a more consistent water level, the following benefits are expected to be realized:

- Lakeshore vegetation will have an opportunity to become established, and in turn provide habitat for many species as well as facilitate the uptake of nutrients otherwise used by algae.
- Visitors to Lake Elsinore and Canyon Lake enjoy fishing, boating, swimming, and other outdoor recreation activities. Numerous studies in other areas have found that water quality impacts recreational lake usage, resulting in a significant loss of tourism revenue for local areas as water quality declines (Abidoye and Herriges 2012; Hjerppe et al. 2017). The decrease in lake usage impacts tourism spending in the local area surrounding the lakes, especially when water clarity is decreased during summer months (Voigt et al. 2015).
- Water quality also impacts fishing and the purchase of fishing licenses and lake passes, a condition experienced in recent years by the City of Lake Elsinore, as shown in a downward trend in day use passes purchased (**Figure 11-12**).
- Improved water quality can positively impact nonuser benefits, such as aesthetics and the overall ecological health of the watershed (Keplinger 2003). These are benefits that are difficult to quantify but still highly valued by residents and visitors to the area.
- Lastly, the water quality in recreation lakes has been proven to impact surrounding parcel scale property values. Voigt et al. (2015) found that a one-meter increase in water clarity is equated with a nearly 3 percent average increase in single family home value and a 37 percent increase in seasonal home values.
- Reduced algae growth in Canyon Lake Main Lake will improve the treatability of water drawn from the lake by EVMWD for municipal water supply. Taste and order issues would be reduced with improved water quality in the source water.
- Implementation of the TMDLs will improve the health and water quality of upstream Canyon Lake. As part of a shared watershed the health and quality of Canyon Lake is vital to the health of species in and around the lake and the entire watershed.

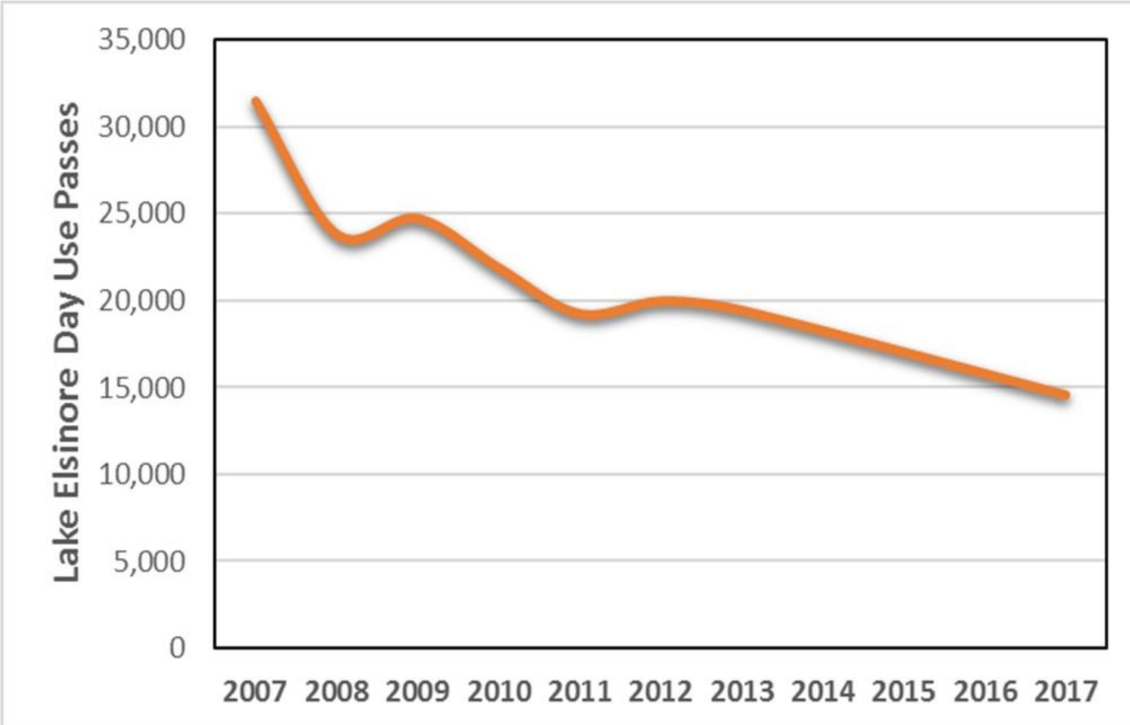

Figure 11-12. Declining Trend in Purchases of Lake Elsinore Day Use Passes (Data provided by Nicole Dailey, City of Lake Elsinore)

11.3 Agricultural Costs

California Water Code §13141 requires that prior to implementation of any agricultural water quality control program, the Santa Ana Water Board must include an estimated cost of such a program and identify potential sources of funding. With the adoption of the revised TMDLs, agricultural costs are expected to be similar with continued implementation of existing control programs, e.g., as required by the CWAD, and continued support of the LECL Task Force and TMDL Monitoring Program. Where supplemental projects are identified for implementation, the portion of the costs allocated to agriculture will be determined as part of the development and implementation of the project. With the ongoing urban development in the San Jacinto River watershed, regional BMP cost shares for agricultural operators are likely to be reduced from historical levels. When it becomes necessary to secure funds for selected projects, the following are potential sources for obtaining funding:

1. Private financing by individual and/or group sources;
2. Bonded indebtedness or loans from governmental institutions;
3. Federal grants or low-interest loan programs;
4. Single-purpose appropriations from federal or State legislative bodies;

5. Grant and loan programs administered by the State Water Board and California Department of Water Resources (CDWR), which are targeted for agricultural water quality improvement. These programs currently include:

   (a) Clean Water Act funds (State Water Board);

   (b) Agricultural Water Quality Grant Program (State Water Board);

   (c) Clean Water State Revolving Fund (State Water Board); and

   (d) Integrated Regional Water Management grants (State Water Board, CDWR)

11.4 Antidegradation Analysis

The proposed Basin Plan amendment to revise the nutrient TMDLs complies with both the federal and state antidegradation policies. The proposed amendment will ensure the protection of existing uses in Lake Elsinore and Canyon Lake by establishing allocations necessary to meet water quality objectives in the waterbodies designed to provide protection for those uses. Overall, the proposed revisions to the TMDLs are expected to result in better water quality than current conditions in Lake Elsinore and Canyon Lake. Ultimately, water quality conditions achieved with the proposed TMDL revision will represent conditions that are equal to or better than a reference watershed condition. Therefore, the allocations and response targets set forth in the TMDL revision consist of an advancement of the scientific basis and not a reduction in expected lake water quality, so long as data continues to support the expected outcome involving equal or better water quality than the reference watershed condition.

Neither Lake Elsinore or Canyon Lake are part of an Outstanding National Resource Waters area. The proposed revisions to the TMDLs do not relate potential impairments that could be caused by a thermal discharge.

Discharges in the watersheds associated with Lake Elsinore and Canyon Lake are regulated under various Santa Ana Water Board-issued orders, including the discharge of recycled water, municipal stormwater and discharges from agriculture subject to the CWAD. Where necessary, as noted in Section 7.4.2.2, the Santa Ana Water Board will revise WDRs to incorporate the requirements of the revised TMDLs. Any substantial change in discharge quantity or quality for any type of discharger will trigger further environmental evaluation at that time.

11.5 Summary of Key Findings

Several of the potential supplemental in-lake water quality controls identified in the TMDL revision may be less costly than current expenditures on existing projects. Thus, supplemental project options do exist that could be implemented without causing an unmanageable increase in the total cost for water quality controls in the San Jacinto River watershed. Updates to TMDL implementation plans, e.g., CNRP and AgNMP, should consider these low-cost options and their potential water quality benefit toward compliance with the revised TMDL allocations and response targets.

Section 12

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Appendix A

Supporting Biological Data

List of Figures

List of Tables

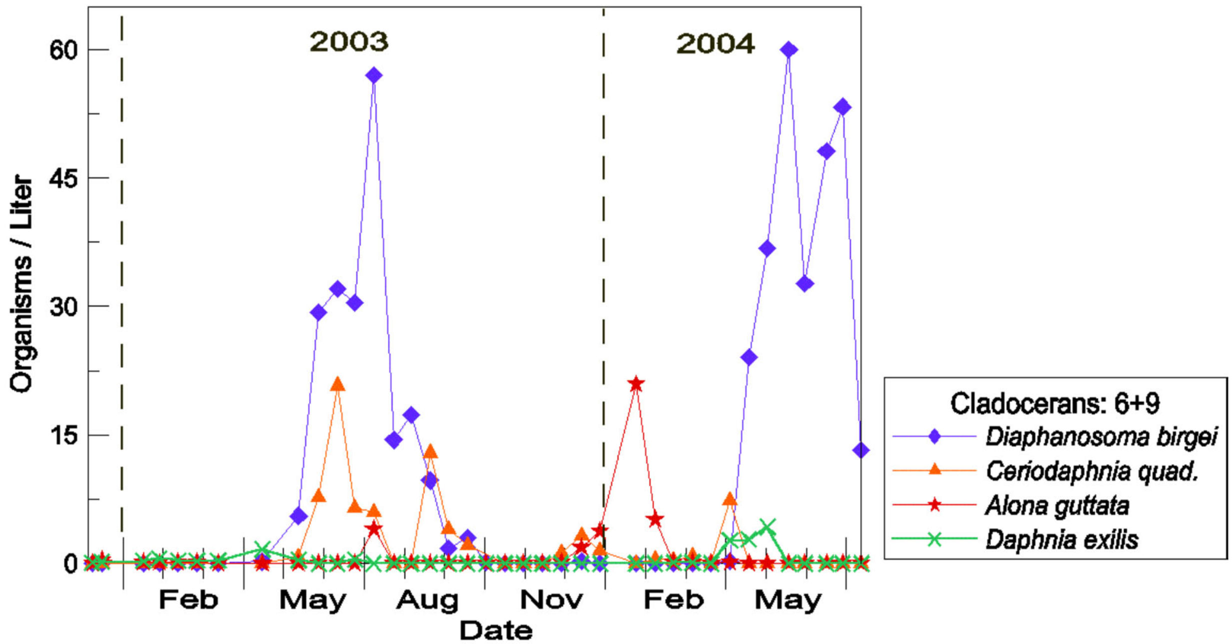


Figure A-1. Cladoceran Population Density at Deep Sites in Lake Elsinore (Sites 6+9) (Veiga Nascimento 2004)

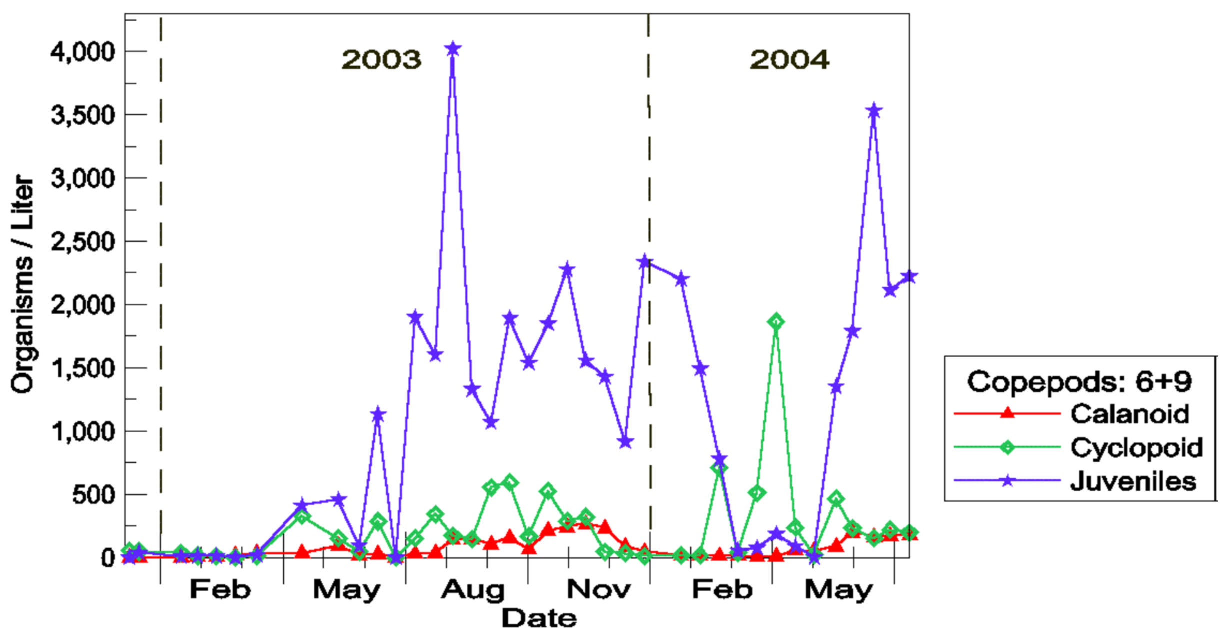


Figure A-2. Copepod Population Density at Deep Sites in Lake Elsinore (Sites 6+9) (Veiga Nascimento 2004)

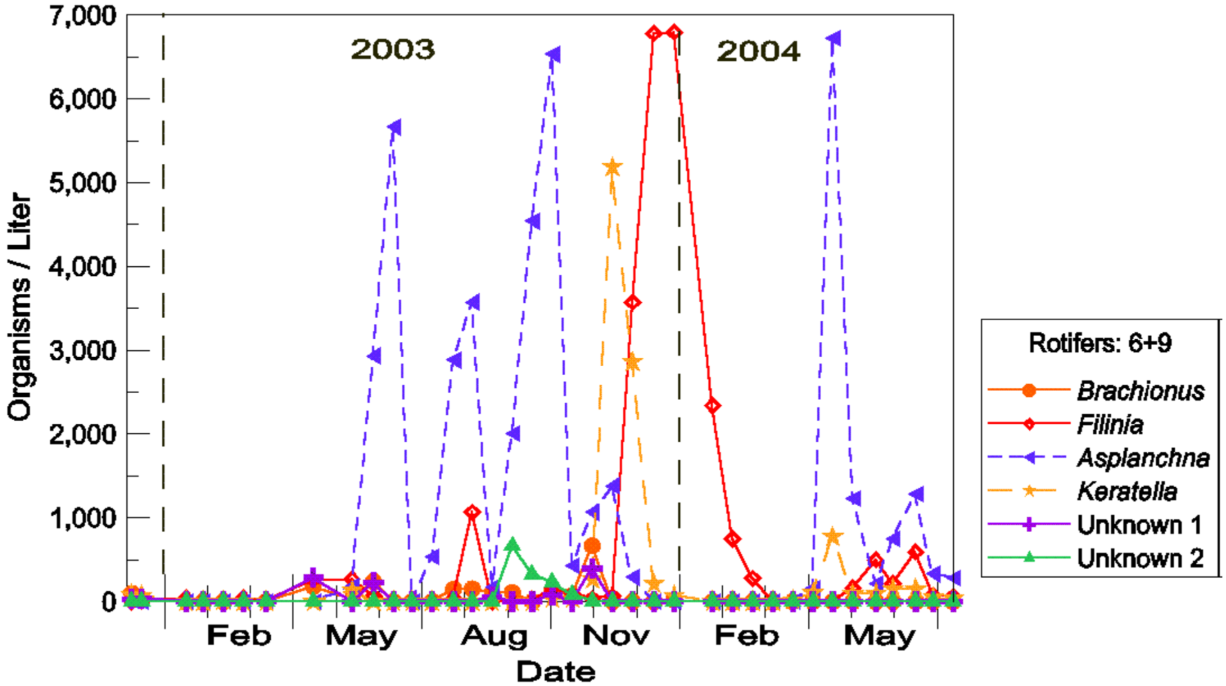


Figure A-3. Rotifer Population Density at Deep Sites in Lake Elsinore (Sites 6+9) (Veiga Nascimento 2004)

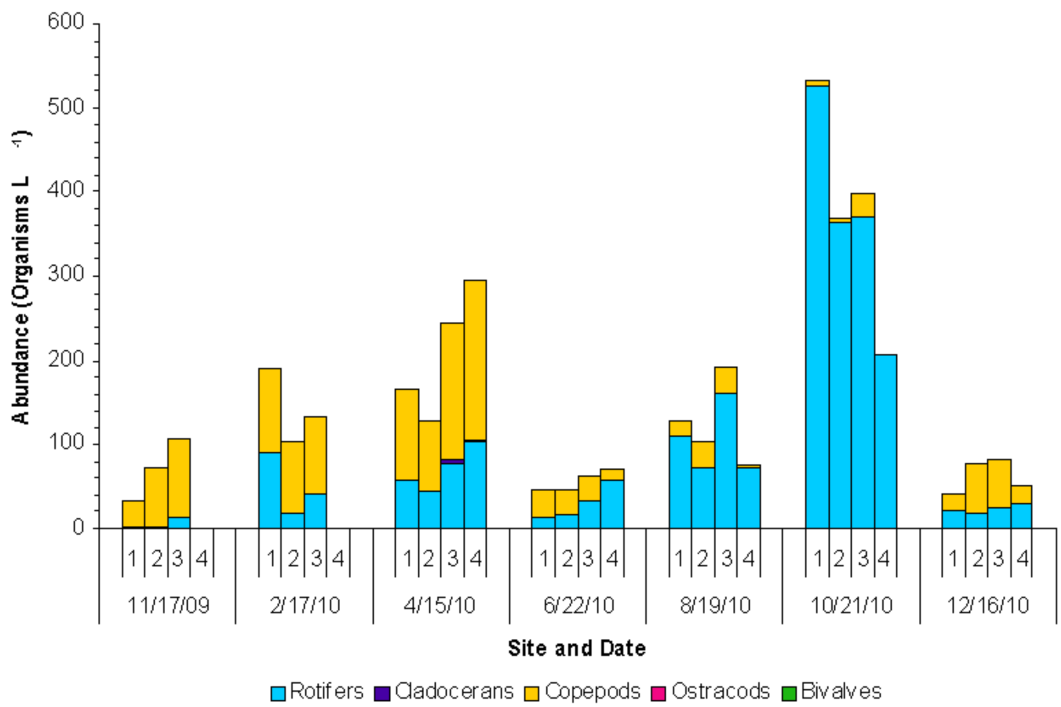


Figure A-4. Zooplankton Abundance by Major Groups at the Four Sampling Sites in Lake Elsinore from November 2009 through December 2010 (Tobin 2011)

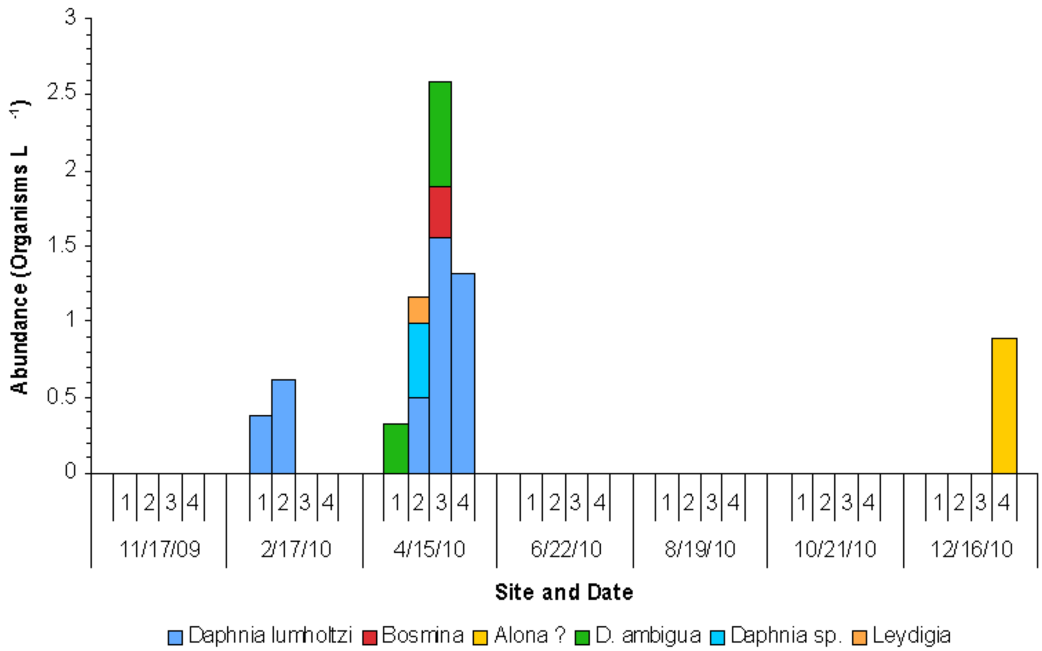


Figure A-5. Cladoceran Abundances by Species at the Four Sampling Sites in Lake Elsinore from November 17, 2009 through December 16, 2010 (Tobin 2011)

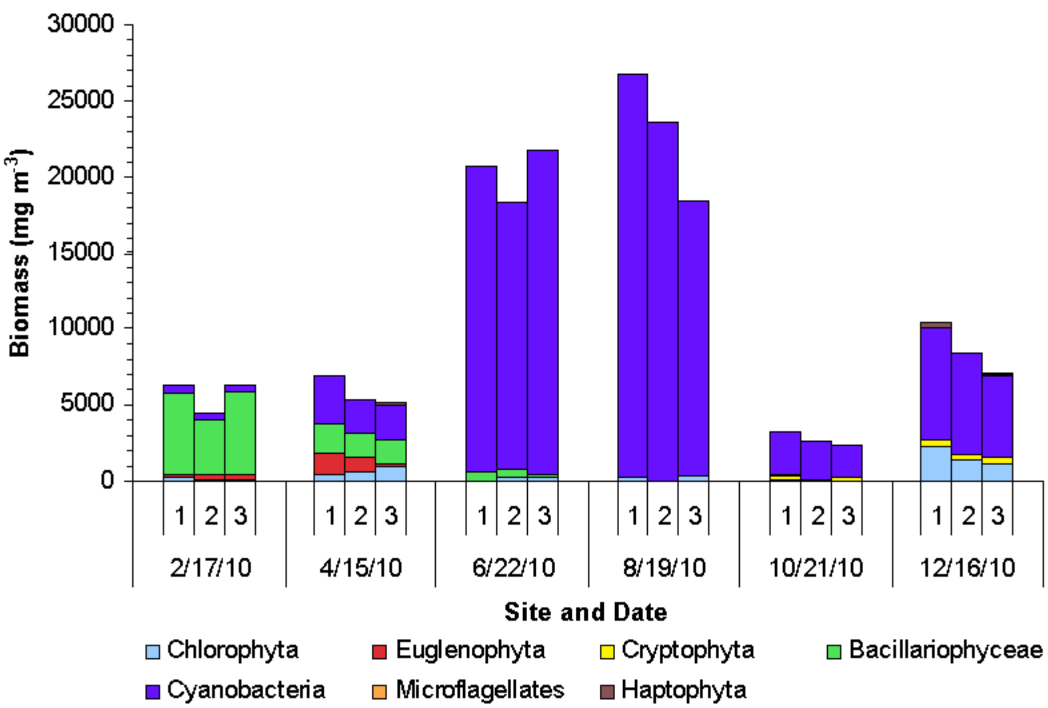


Figure A-6. Phytoplankton Biomass by Major Algal Groups at the Three Sampling Sites in Lake Elsinore during 2010 (Tobin 2011)

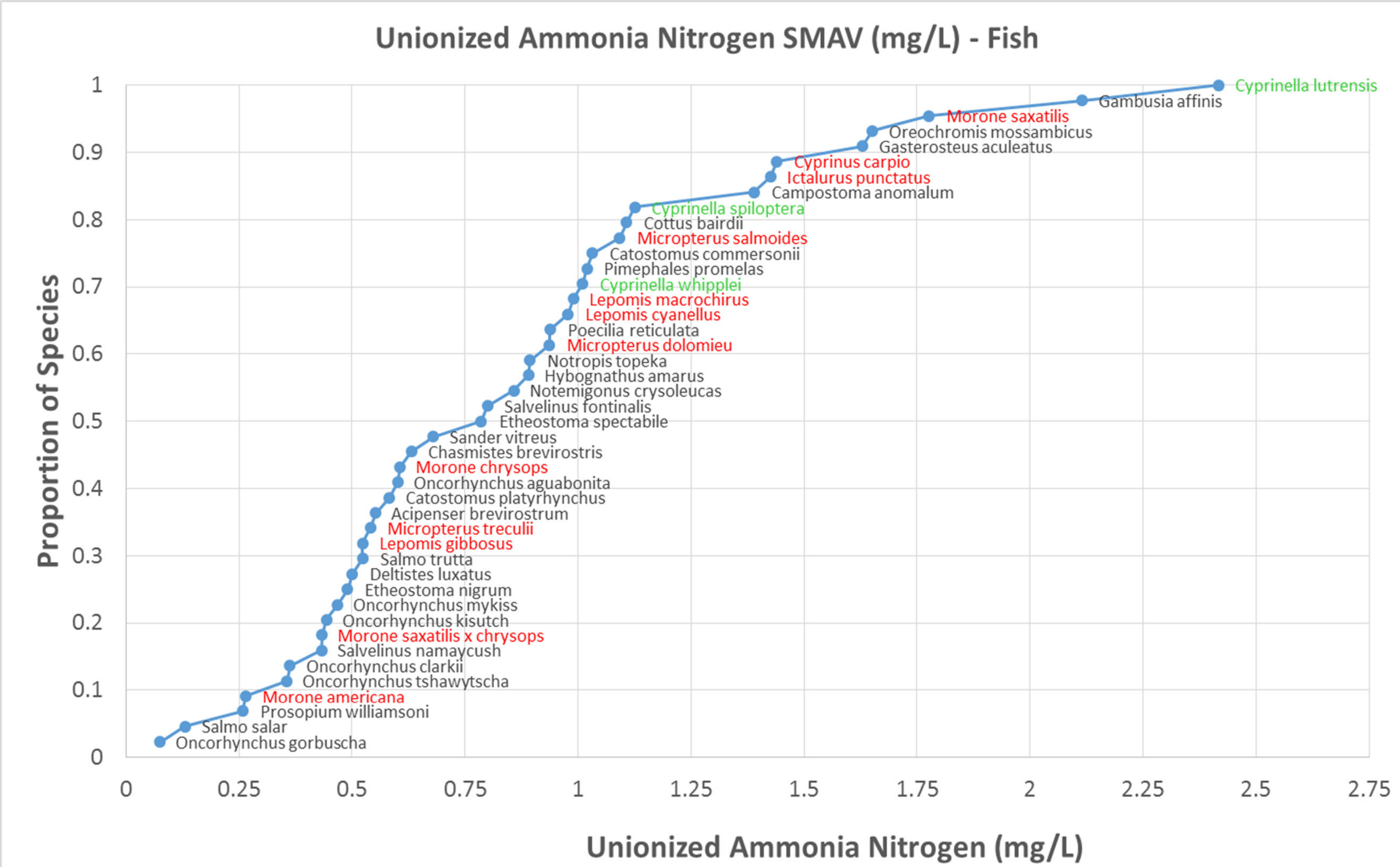


Figure A-7. Species Sensitivity Distribution of Fish Species, Plotting the Species Mean Acute Value (SMAV) Relative to Un-ionized Ammonia (those highlighted in red and green are species found in the lakes [red], or closely related species [green])

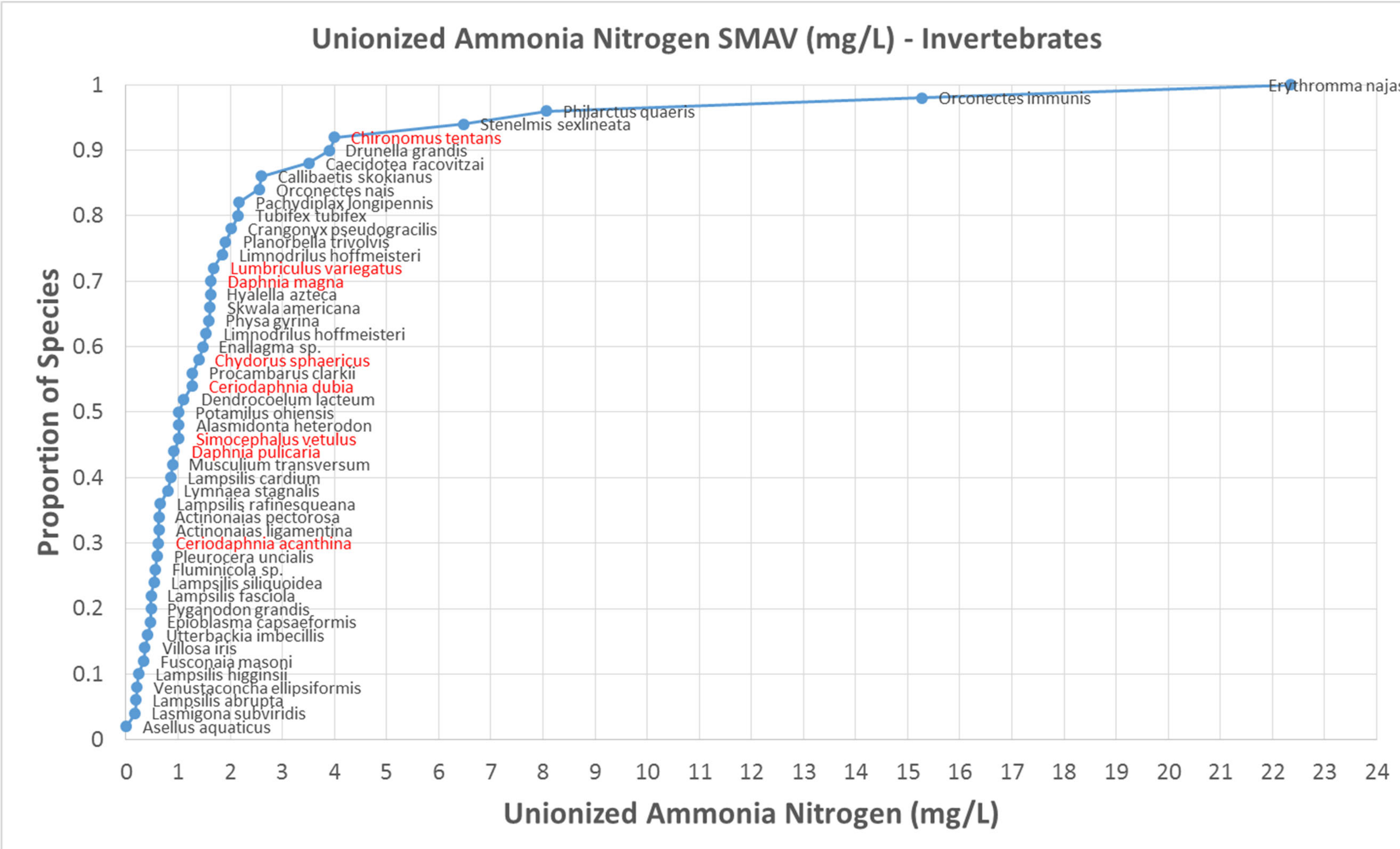


Figure A-8. Species Sensitivity Distribution of Various Aquatic Invertebrate Species, Plotting the Species Mean Acute Value (SMAV) Relative to Un-ionized Ammonia (those highlighted in red are species either found in the lakes or closely related species [i.e., same genus]).

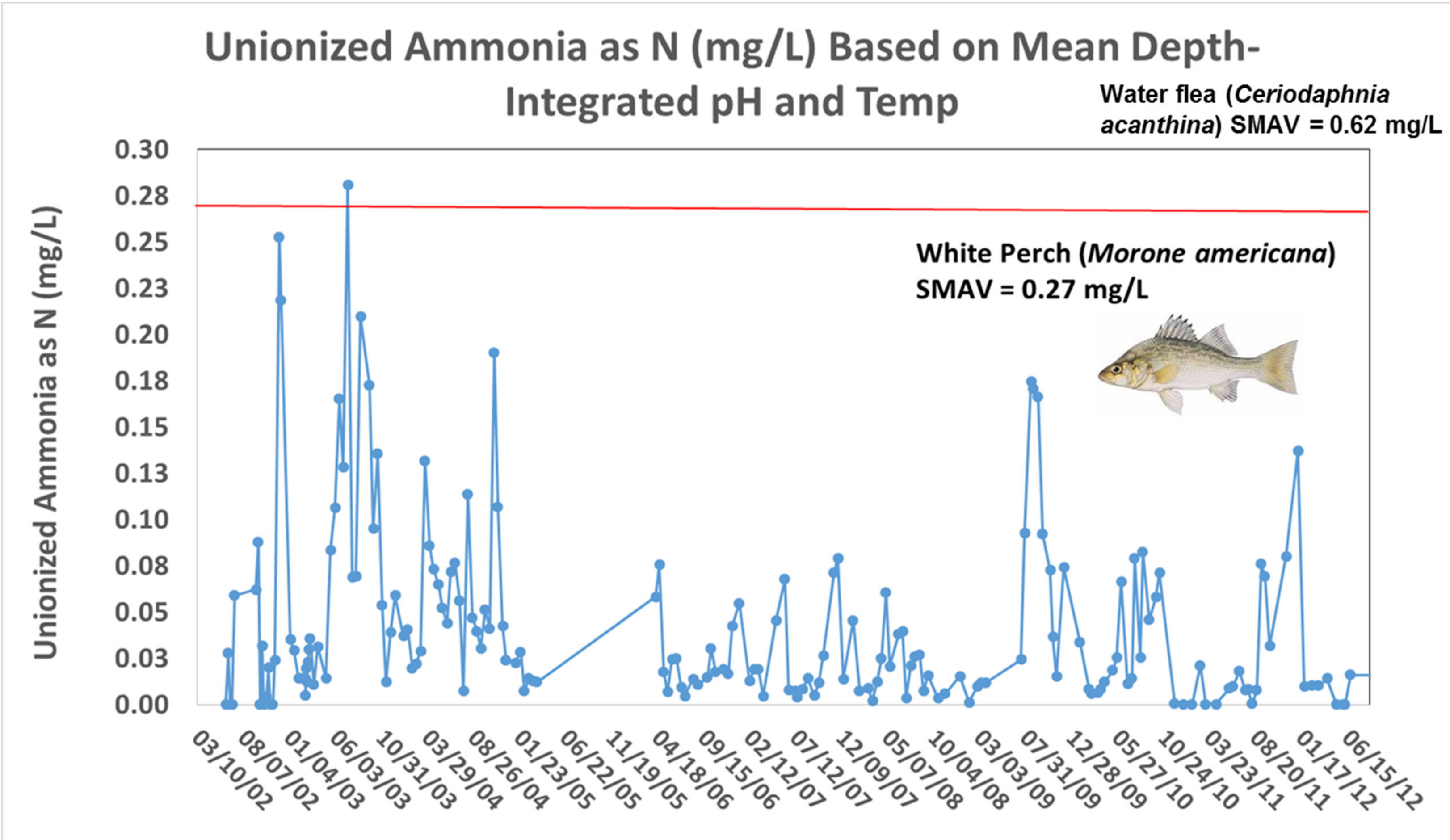


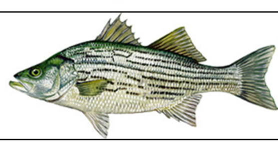
Figure A-9. Historical Un-ionized Ammonia Concentrations for Lake Elsinore (Site LEE2) Calculated from Depth Integrated Total Ammonia, pH, Temperature, and Salinity

Table A-1. Hydroacoustic Fish Survey Results from Lake Elsinore Comparing Most Current Survey (April 2015) with Surveys Conducted in 2008 and 2010 (Anderson 2016b)

Date	Population (fish/acre)	Mean Size[a] (cm)	Size Range[a] (cm)	Fish >20 cm[a] (fish/acre)
April 24, 2008	18,090	4.7	0.5 - 100	1,050 (5.8%)
March 15, 2010[b]	2,867	4.0	0.5 – 29	6 (0.2%)
December 1, 2010	27,720	4.3	0.5 – 61	273 (1.0%)
April 2, 2015	56,600	1.8	0.5 - 30	12 (0.02%)

[a] Based on Loves' equation (Love 1970).
[b] March 2010 survey was conducted after fish kill in summer of 2009.

Table A-2. Conductivity Thresholds of Common Fish Taxa in Lake Elsinore and Canyon Lake

Common Name	Example Photograph	Species	Endpoint	Salinity Threshold (ppt)	Conductivity Threshold (µS/cm)
Black Crappie		*Pomoxis nigromaculatus*	Presence	Up to 4.7	Up to 8,457
Channel Catfish		*Ictalurus punctatus*	No effect	Up to 8	13,855
Common Carp		*Cyprinus carpio*	Lethality	7.2	12,568
			LD_{50}	12.8	21,356
Gizzard shad		*Dorosoma cepedianum**	No effect	2.0 – 34	4,130 – 51,714
Striped Bass		*Morone saxatilis*	LC_{50}	> 22	> 34,981
Largemouth Bass		*Micropterus salmoides*	Decline in abundance	> 4.0	> 7,276

*****Same genus as the Threadfin Shad, *Dorosoma petenense*

CDM Smith

Table A-3. Conductivity Thresholds of Common Invertebrate Taxa in Lake Elsinore and Canyon Lake

Common Name	Species	Survival Conductivity Threshold (LC_{50} µS/cm)	Reproduction Conductivity Threshold (EC_{50} µS/cm)	Comment
Water flea	*Daphnia pulex*	1,820	< 1,070 < 2,680	10-day LC_{50}, tiered reproduction response
Water flea	*Diaphanosoma brachyurum*	< 1,968		48-hr LC_{50}
Water flea	*Daphnia pulex*	2,480 < 3,280	2,480 < 3,280	17-day LC_{50}/EC_{50}
Water flea	*Daphnia middendorffiana*	2,856		96-hr LC_{50}, field collected organisms
Water flea	*Moinodaphnia macleayi*	2,893		48-hr LC_{50}
Water flea	*Ceriodaphnia rigaudii*	3,075		48-hr LC_{50}
Water flea	*Daphnia magna*	3,120		No *Daphnia* in lakes > 3,120 µS/cm
Water flea	*Daphnia pulex*	3,318		96-hr LC_{50}, field collected organisms
Water flea	*Ceriodaphnia dubia*	3,350	2,890	7-day chronic LC_{50}, EC_{50} not reported for reproduction
Water flea	*Daphnia magna*	4,284		96-hr LC_{50}, field collected organisms
Water flea	*Ceriodaphnia dubia*	4,620	3,830	7-day chronic
Water flea	*Simocephalus sp.*	4,900		48-hr LC_{50}
Water flea	*Daphnia longispina*	5,384	4,153	48-hr LC_{50}; 21-day EC_{50} reproduction
Water flea	*Chydoridae*	6,000		24-hr LC_{50}
Rotifer	*Epiphanes macrourus*	6,100	2,000 < 4,000	96-hr LC_{50}, EC_{50} 120-hrs population growth
Calanoid Copepod	*Leptodiaptomus tyrelli*	8,591		96-hr LC_{50}, field collected organisms
Water flea	*Daphnia magna*	9,125		
Water flea	*Daphnia magna*	10,449	8,959	48-hr LC_{50}; 21-day EC_{50} reproduction
Cyclopoid Copepod	*Eucyclops sp.*	12,000		72-hr LC_{50}
Calanoid Copepod	*Hesperodiaptomus arcticus*	12,332		96-hr LC_{50}, field collected organisms
Cyclopoid Copepod	*Acanthocyclops sp.*	> 15,000		72-hr LC_{50}

Table A-4. Dissolved Oxygen Thresholds of Common Fish Taxa in Lake Elsinore and Canyon Lake

Common Name	Species	Endpoint	DO Threshold (mg/L)	Comment
Largemouth Bass	*Micropterus salmoides*	distress	5.0	adults
Black Crappie	*Pomoxis nigromaculatus*	lethality	4.3	caged at 26 degrees
Common Carp	*Cyprinus carpio*	increased respiration	4.2	at 10 degrees
Common Carp	*Cyprinus carpio*	reduced metabolic rate	3.4	at 10 degrees
Channel Catfish	*Ictalurus punctatus*	retarded growth	3.0	
Striped Bass	*Morone saxatilis*	lethality	3.0	juvenile
Striped Bass	*Morone saxatilis*	lethality	3.0	at 16 degrees, juvenile
Largemouth Bass	*Micropterus salmoides*	lethality	2.5	larval
Largemouth Bass	*Micropterus salmoides*	reduced metabolic rate	2.3	adults at 20 degrees
Gizzard Shad	*Dorosoma cepedianum*	lethality	2.0	
White Bass	*Morone chrysops*	distress	2.0	at 24 degrees
White Bass	*Morone chrysops*	reduced survival	1.8	larvae at 16 degrees
American Shad	*Alosa sapidissima*	lethality	1.6	juvenile at 23 degrees
Striped Bass	*Morone saxatilis*	LC_{50}	1.6	juvenile & adult
Bluegill	*Lepomis macrochirus*	avoidance	1.5	adults
Largemouth Bass	*Micropterus salmoides*	avoidance	1.5	adult
Black Crappie	*Pomoxis nigromaculatus*	lethality	1.4	
Largemouth Bass	*Micropterus salmoides*	lethality	1.2	at 25 degrees
Gizzard Shad	*Dorosoma cepedianum*	lethality	1.0	at 16 degrees
White Bass	*Morone chrysops*	lethality	1.0	at 24 degrees
Bluegill	*Lepomis macrochirus*	LC_{50}	0.9	at 30 degrees
Channel Catfish	*Ictalurus punctatus*	lethality	0.9	juvenile at 25-35 degrees
Common Carp	*Cyprinus carpio*	lethality	0.7	juveniles at 18 degrees
Common Carp	*Cyprinus carpio*	gulping air at surface	0.5	

Table A-5. Un-ionized Ammonia Thresholds of Common Fish Taxa Observed in Lake Elsinore and Canyon Lake

Common Name	Species	Endpoint	Un-ionized Ammonia as N Threshold (mg/L)
White Perch	*Morone americana*	Species Mean Acute Value (LC_{50})	0.27
Hybrid Striped Bass	*Morone saxatilis x chrysops*		0.43
Pumpkinseed	*Lepomis gibbosus*		0.52
Guadalupe bass	*Micropterus treculii*		0.54
White Bass	*Morone chrysops*		0.61
Smallmouth bass	*Micropterus dolomieu*		0.94
Green sunfish	*Lepomis cyanellus*		0.98
Bluegill	*Lepomis macrochirus*		0.99
Steelcolor shiner	*Cyprinella whipplei*		1.01
Largemouth Bass	*Micropterus salmoides*		1.09
Spotfin shiner	*Cyprinella spiloptera*		1.13
Channel Catfish	*Ictalurus punctatus*		1.43
Common Carp	*Cyprinus carpio*		1.44
Striped Bass	*Morone saxatilis*		1.78
Rainbow dace	*Cyprinella lutrensis*		2.42

Table A-6. Un-ionized Ammonia Thresholds of Common Invertebrate Taxa Observed in Lake Elsinore and Canyon Lake (or those closely related)

Common Name	Species	Endpoint	Unionized Ammonia as N Threshold (mg/L)
Water flea	*Ceriodaphnia acanthina*	Species Mean Acute Value (LC_{50})	0.6
Water flea	*Daphnia pulicaria*		0.9
Water flea	*Simocephalus vetulus*		1.0
Water flea	*Ceriodaphnia dubia*		1.3
Water flea	*Chydorus sphaericus*		1.4
Water flea	*Daphnia magna*		1.6
Oligochaete Worm	*Lumbriculus variegatus*		1.7
Midge	*Chironomus tentans*		4.0

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Appenidix B: Total Acres

Owner	Land Use	Zone 1 (Acres)	Zone 2 (Acres)	Zone 3 (Acres)	Zone 4 (Acres)	Zone 5 (Acres)	Zone 6 (Acres)	Zone 7 (Acres)	Zone 8 (Acres)	Zone 9 (Acres)
Ag-CWAD Non-irrigated	Commercial / Industrial	1.56	0.00	12.41	30.91	3.42	87.04	129.79	25.79	
Ag-CWAD Non-irrigated	Forested		0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Ag-CWAD Irrigated	Irrigated Cropland		1673.51	1905.48	1615.97	953.89	5674.33	6726.33	305.54	
Ag-CWAD Non-irrigated	Non-Irrigated Cropland	15.80	1896.16	2194.35	2135.77	2034.35	626.73	2351.06		
Ag-CWAD Non-irrigated	Open Space					7.68				
Ag-CWAD Irrigated	Orchards / Vineyards		0.92	2.40	114.40	9.68	11.75	505.10	2241.17	65.54
Ag-CWAD Non-irrigated	Other Livestock		130.35	124.24	301.12	1.05	280.89	512.14		189.10
Ag-CWAD Non-irrigated	Pasture / Hay			10.40				2.57		7.16
Ag-CWAD Non-irrigated	Roadway						0.00	0.00	0.00	
Ag-CWAD Non-irrigated	Sewered Residential		0.00		0.00		0.00	0.00	0.00	0.00
Ag-Small	Commercial / Industrial	6.73	6.08	12.98	55.13	40.24	21.54	16.72	22.29	
Ag-Small	Irrigated Cropland		241.03	128.96	149.18	221.77	424.57	209.92	12.90	
Ag-Small	Non-Irrigated Cropland	5.91	300.23	572.54	403.08	523.32	158.07	166.64	1.64	
Ag-Small	Orchards / Vineyards	42.62	33.76	31.93	52.59	24.24	12.49	140.25	220.80	15.93
Ag-Small	Other Livestock				24.76		11.29	0.07		
Ag-Small	Pasture / Hay		11.65	8.89	12.16	1.11	11.30	4.16		
BANNING	Commercial / Industrial							48.16		
BANNING	Forested							70.45		
BANNING	Open Space							45.45		
BANNING	Roadway							1.42		
BANNING	Sewered Residential							142.19		
BANNING	Water							1.07		
BEAUMONT	Commercial / Industrial							672.50		
BEAUMONT	Forested							2031.18		
BEAUMONT	Open Space							87.46		
BEAUMONT	Roadway							10.11		
BEAUMONT	Sewered Residential							1328.41		
CAFO	Dairy	4.03					195.27	616.75		
CAFO	Pasture / Hay	2.52		123.81	14.55		181.83	1090.56		
California Department of Fish and Wildlife	Commercial / Industrial					1.84		2.10		
California Department of Fish and Wildlife	Forested					513.02	3013.13	14267.15	122.44	
California Department of Fish and Wildlife	Non-Irrigated Cropland							33.33		
California Department of Fish and Wildlife	Other Livestock							0.00		
California Department of Fish and Wildlife	Roadway					0.00		0.00		
Caltrans	Commercial / Industrial	17.63	47.53	2.19	53.91	17.78		74.18	14.89	24.82
Caltrans	Forested	82.43	84.10	16.74	72.44	20.46		166.14	87.42	460.34
Caltrans	Non-Irrigated Cropland				0.94				1.15	1.81
Caltrans	Open Space	7.96	0.30		3.83	1.61		16.82	7.67	6.10
Caltrans	Orchards / Vineyards		0.10							
Caltrans	Other Livestock					0.01				1.09
Caltrans	Pasture / Hay				0.12					0.00
Caltrans	Roadway	118.01	155.35	204.82	0.49	455.61		170.39	0.15	
Caltrans	Sewered Residential	11.01	40.32	0.01	20.39	12.80		9.36	19.34	62.54
Caltrans	Unsewered Residential		1.02		0.53			0.11	0.00	1.29
Caltrans	Water								0.41	

Owner	Land Use	Zone 1 (Acres)	Zone 2 (Acres)	Zone 3 (Acres)	Zone 4 (Acres)	Zone 5 (Acres)	Zone 6 (Acres)	Zone 7 (Acres)	Zone 8 (Acres)	Zone 9 (Acres)
CANYON LAKE	Commercial / Industrial	24.24	9.16	19.79						
CANYON LAKE	Forested	104.58	72.79	53.67						
CANYON LAKE	Non-Irrigated Cropland			0.00						
CANYON LAKE	Open Space	77.43	32.73	43.86						
CANYON LAKE	Other Livestock		8.00							
CANYON LAKE	Roadway	8.37	4.12	12.91						
CANYON LAKE	Sewered Residential	101.92	442.87	731.89						
CANYON LAKE	Water		287.37	127.97						
CR&R	Open Space							200.00		
Federal - DOD	Commercial / Industrial					524.69				
Federal - DOD	Forested					3.13				
Federal - DOD	Irrigated Cropland					2.04				
Federal - DOD	Open Space					1120.84				
Federal - DOD	Roadway					495.40				
Federal - DOD	Sewered Residential					0.22				
Federal - National Forest	Commercial / Industrial								11.54	59.82
Federal - National Forest	Forested	5125.56			385.14				27891.88	57401.18
Federal - National Forest	Non-Irrigated Cropland								0.05	43.22
Federal - National Forest	Open Space								12.42	102.50
Federal - National Forest	Other Livestock									1.88
Federal - National Forest	Pasture / Hay	3.72								1.68
Federal - National Forest	Sewered Residential	12.77							1.91	111.72
Federal - National Forest	Unsewered Residential	0.32							0.15	4.95
Federal - National Forest	Water								3.94	113.76
Federal - Other	Commercial / Industrial		0.13				8.32	1.56	0.83	
Federal - Other	Forested		1969.52	118.94	1130.44	61.15	198.36	6820.29	7700.05	
Federal - Other	Non-Irrigated Cropland			0.01	55.43				0.00	
Federal - Other	Open Space		0.07						2.02	
Federal - Other	Orchards / Vineyards								0.77	
Federal - Other	Pasture / Hay				0.22				2.04	
Federal - Other	Roadway		0.00							
Federal - Other	Sewered Residential		4.83	0.62	1.22		0.15		9.77	
Federal - Other	Unsewered Residential		0.56							
Federal - Other	Water		75.84							
Federal - Wilderness	Forested								12538.08	7994.02
Federal - Wilderness	Pasture / Hay									0.31
HEMET	Commercial / Industrial				1681.01			685.32	17.95	
HEMET	Forested				3141.65			580.27	18.66	
HEMET	Non-Irrigated Cropland				1020.79			129.40	2.60	
HEMET	Open Space				938.53			98.41	24.02	
HEMET	Orchards / Vineyards							0.66		
HEMET	Other Livestock				3.45			32.20		
HEMET	Pasture / Hay				5.21			39.02	0.01	
HEMET	Roadway				177.54			2.47	0.05	
HEMET	Sewered Residential				3961.68			1986.04	255.29	
HEMET	Unsewered Residential				9.70			20.68		
HEMET	Water				21.06					

Owner	Land Use	Zone 1 (Acres)	Zone 2 (Acres)	Zone 3 (Acres)	Zone 4 (Acres)	Zone 5 (Acres)	Zone 6 (Acres)	Zone 7 (Acres)	Zone 8 (Acres)	Zone 9 (Acres)
LAKE ELSINORE	Commercial / Industrial	1402.29	12.77	143.68						
LAKE ELSINORE	Forested	5657.66	706.84	215.70						
LAKE ELSINORE	Open Space	423.94	24.86							
LAKE ELSINORE	Other Livestock		0.00							
LAKE ELSINORE	Pasture / Hay	1.57								
LAKE ELSINORE	Roadway	56.24								
LAKE ELSINORE	Sewered Residential	2845.05	301.26	71.46						
LAKE ELSINORE	Unsewered Residential	6.05		0.12						
LAKE ELSINORE	Water	3073.53								
March Joint Powers Authority	Commercial / Industrial					542.91				
March Joint Powers Authority	Forested					1496.74				
March Joint Powers Authority	Open Space					185.49				
March Joint Powers Authority	Roadway					9.49				
March Joint Powers Authority	Sewered Residential					116.21				
MENIFEE	Commercial / Industrial		844.40	1853.74						
MENIFEE	Forested	273.38	1806.57	5352.43						
MENIFEE	Non-Irrigated Cropland	7.03	95.31	712.33						
MENIFEE	Open Space		227.88	1891.65						
MENIFEE	Orchards / Vineyards		15.16	59.94						
MENIFEE	Other Livestock	2.68	78.00	108.96						
MENIFEE	Pasture / Hay	4.56	94.11	204.65						
MENIFEE	Roadway		54.76	209.60						
MENIFEE	Sewered Residential	99.56	1985.50	8247.63						
MENIFEE	Unsewered Residential	23.64	136.14	398.38						
MENIFEE	Water		1.47	148.94						
MORENO VALLEY	Commercial / Industrial					3718.05		40.41		
MORENO VALLEY	Forested					6112.74		448.11		
MORENO VALLEY	Irrigated Cropland					0.02				
MORENO VALLEY	Open Space					814.83				
MORENO VALLEY	Orchards / Vineyards					64.15		8.74		
MORENO VALLEY	Other Livestock					14.53		4.32		
MORENO VALLEY	Pasture / Hay					78.44		3.56		
MORENO VALLEY	Roadway					318.37		2.76		
MORENO VALLEY	Sewered Residential					11821.07		5.64		
MORENO VALLEY	Unsewered Residential					93.82		0.00		
MORENO VALLEY	Water					72.35				
MURRIETA	Commercial / Industrial			76.90						
MURRIETA	Forested			83.31						
MURRIETA	Open Space			8.38						
MURRIETA	Pasture / Hay			0.12						
MURRIETA	Roadway			5.79						
MURRIETA	Sewered Residential			184.69						

Appenidix B: Total Acres

Owner	Land Use	Zone 1 (Acres)	Zone 2 (Acres)	Zone 3 (Acres)	Zone 4 (Acres)	Zone 5 (Acres)	Zone 6 (Acres)	Zone 7 (Acres)	Zone 8 (Acres)	Zone 9 (Acres)
PERRIS	Commercial / Industrial		1455.68			2329.47	8.20			
PERRIS	Forested		3730.21	52.28		2234.12	0.46			
PERRIS	Non-Irrigated Cropland					0.00				
PERRIS	Open Space		731.24	0.06		390.44	0.81			
PERRIS	Orchards / Vineyards		23.89			14.60				
PERRIS	Pasture / Hay		1.03			12.04				
PERRIS	Roadway		106.65			191.97				
PERRIS	Sewered Residential		1240.78			2846.79				
PERRIS	Unsewered Residential		10.45			0.26				
PERRIS	Water		24.36							
RIVERSIDE	Commercial / Industrial					30.40				
RIVERSIDE	Forested					2.71				
RIVERSIDE	Open Space					15.01				
RIVERSIDE	Sewered Residential					428.72				
Riverside County	Commercial / Industrial	159.29	447.56	383.28	847.15	586.22	773.48	1507.57	607.89	612.42
Riverside County	Forested	3748.56	10396.13	3331.47	19282.38	7833.55	8592.17	20295.98	11267.72	11352.16
Riverside County	Non-Irrigated Cropland		0.00	316.23	5428.78	860.92	438.11	1026.88	713.71	1693.62
Riverside County	Open Space	13.13	105.90	1009.31	391.29	924.89	37.63	1609.44	415.68	384.05
Riverside County	Orchards / Vineyards	0.99	179.41	19.74	40.60	116.53	121.34	15.12	79.78	
Riverside County	Other Livestock	27.25	68.80	50.84	535.75	56.43	215.13	16.95	26.45	330.80
Riverside County	Pasture / Hay	24.52	320.66	14.98	270.21	142.67	299.58	33.26	38.75	30.62
Riverside County	Roadway	2.74	10.34	64.34	110.50	117.17	126.07	133.70	29.13	
Riverside County	Sewered Residential	1725.30	4983.34	308.77	3941.40	1159.38	2453.61	1021.14	1816.72	3224.59
Riverside County	Unsewered Residential	110.94	1033.43	44.83	566.28	325.71	540.62	58.51	33.02	308.60
Riverside County	Water	108.54	17.32	123.52	5.29	14.16		31.76	158.37	342.92
SAN JACINTO	Commercial / Industrial				42.06			1691.38	30.27	
SAN JACINTO	Forested				100.44		51.42	3720.66	883.00	
SAN JACINTO	Non-Irrigated Cropland								0.03	
SAN JACINTO	Open Space				16.14			577.22	199.49	
SAN JACINTO	Orchards / Vineyards							26.02	4.41	
SAN JACINTO	Other Livestock							170.61		
SAN JACINTO	Pasture / Hay							42.59		
SAN JACINTO	Roadway							87.64	24.30	
SAN JACINTO	Sewered Residential				7.34			3248.25	194.23	
SAN JACINTO	Unsewered Residential							16.13		
SAN JACINTO	Water				14.74			0.74	233.74	
State Land	Commercial / Industrial		0.46			22.02			17.70	2.30
State Land	Forested		386.23			1948.89	150.56	639.71	230.96	5148.87
State Land	Non-Irrigated Cropland					58.94				
State Land	Open Space					469.81				29.45
State Land	Orchards / Vineyards		0.21							
State Land	Roadway					1.27				
State Land	Sewered Residential		1.59			21.73			2.45	6.46
State Land	Unsewered Residential		3.43							0.04
State Land	Water					0.19				

Appenidix B: Total Acres

Owner	Land Use	Zone 1 (Acres)	Zone 2 (Acres)	Zone 3 (Acres)	Zone 4 (Acres)	Zone 5 (Acres)	Zone 6 (Acres)	Zone 7 (Acres)	Zone 8 (Acres)	Zone 9 (Acres)
Tribal Reservations	Commercial / Industrial								71.53	
Tribal Reservations	Forested							718.55	6623.40	219.71
Tribal Reservations	Non-Irrigated Cropland							1.49		
Tribal Reservations	Open Space								53.45	
Tribal Reservations	Pasture / Hay								3.42	
Tribal Reservations	Sewered Residential								284.14	
Tribal Reservations	Water								98.83	
Western Riverside County Regional Conservation Aut	Commercial / Industrial							7.69		
Western Riverside County Regional Conservation Aut	Forested				979.81	508.62	131.85	1081.31		
Western Riverside County Regional Conservation Aut	Non-Irrigated Cropland							235.26		
Western Riverside County Regional Conservation Aut	Open Space							33.63		
Western Riverside County Regional Conservation Aut	Sewered Residential				4.73	0.27				
Western Riverside County Regional Conservation Aut	Unsewered Residential				0.00					
WILDOMAR	Commercial / Industrial	242.34								
WILDOMAR	Forested	2473.22		6.51						
WILDOMAR	Open Space	21.67								
WILDOMAR	Orchards / Vineyards	12.43								
WILDOMAR	Pasture / Hay	16.38								
WILDOMAR	Roadway	54.46								
WILDOMAR	Sewered Residential	1856.50								
WILDOMAR	Unsewered Residential	112.89								
WILDOMAR	Water	1.05								

Owner	Land Use	Zone 1 Imperv (Acres)	Zone 2 Imperv (Acres)	Zone 3 Imperv (Acres)	Zone 4 Imperv (Acres)	Zone 5 Imperv (Acres)	Zone 6 Imperv (Acres)	Zone 7 Imperv (Acres)	Zone 8 Imperv (Acres)	Zone 9 Imperv (Acres)
Ag-CWAD Non-irrigated	Commercial / Industrial	0.09	0.00	0.42	0.72	0.03	3.14	5.24	1.80	
Ag-CWAD Non-irrigated	Forested		0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Ag-CWAD Irrigated	Irrigated Cropland		17.89	16.80	18.63	11.97	46.78	31.21	2.55	
Ag-CWAD Non-irrigated	Non-Irrigated Cropland	0.13	11.35	25.39	11.01	18.83	4.54	17.30		
Ag-CWAD Non-irrigated	Open Space					0.00				
Ag-CWAD Irrigated	Orchards / Vineyards		0.00	0.14	0.09	0.09	0.43	7.52	31.02	0.02
Ag-CWAD Non-irrigated	Other Livestock		1.74	3.35	1.42	0.00	26.16	9.83		2.56
Ag-CWAD Non-irrigated	Pasture / Hay			0.42				0.07		0.08
Ag-CWAD Non-irrigated	Roadway						0.00	0.00	0.00	
Ag-CWAD Non-irrigated	Sewered Residential		0.00		0.00		0.00	0.00	0.00	0.00
Ag-Small	Commercial / Industrial	0.37	0.12	0.84	1.83	1.15	0.86	1.32	1.21	
Ag-Small	Irrigated Cropland		3.10	4.50	1.47	3.70	4.77	4.48	0.11	
Ag-Small	Non-Irrigated Cropland	0.06	3.57	7.87	2.58	5.57	2.76	1.89	0.00	
Ag-Small	Orchards / Vineyards	3.52	0.57	0.80	1.80	1.02	0.23	7.83	4.85	0.00
Ag-Small	Other Livestock				0.60		2.16	0.01		
Ag-Small	Pasture / Hay		0.10	0.15	0.37	0.04	0.14	0.31		
BANNING	Commercial / Industrial							23.32		
BANNING	Forested							4.96		
BANNING	Open Space							3.34		
BANNING	Roadway							0.54		
BANNING	Sewered Residential							62.68		
BANNING	Water							0.03		
BEAUMONT	Commercial / Industrial							82.53		
BEAUMONT	Forested							21.08		
BEAUMONT	Open Space							4.79		
BEAUMONT	Roadway							3.44		
BEAUMONT	Sewered Residential							230.32		
CAFO	Dairy	0.08					4.07	8.50		
CAFO	Pasture / Hay	0.00		6.20	0.29		16.82	35.26		
California Department of Fish and Wildlife	Commercial / Industrial					0.07		0.02		
California Department of Fish and Wildlife	Forested					10.26	30.32	47.95	0.00	
California Department of Fish and Wildlife	Non-Irrigated Cropland							0.46		
California Department of Fish and Wildlife	Other Livestock							0.00		
California Department of Fish and Wildlife	Roadway					0.00		0.00		
Caltrans	Commercial / Industrial	8.93	19.26	0.75	26.58	6.86		40.05	6.73	3.47
Caltrans	Forested	8.21	14.82	3.71	11.43	3.79		23.49	7.90	25.95
Caltrans	Non-Irrigated Cropland				0.14				0.13	0.12
Caltrans	Open Space	2.66	0.02		0.55	0.31		2.26	0.71	0.56
Caltrans	Orchards / Vineyards		0.02							
Caltrans	Other Livestock					0.00				0.08
Caltrans	Pasture / Hay				0.00					0.00
Caltrans	Roadway	49.59	50.15	64.50	0.18	176.43		47.79	0.08	
Caltrans	Sewered Residential	3.31	10.44	0.00	5.66	4.62		4.07	6.98	4.66
Caltrans	Unsewered Residential		0.21		0.04			0.01	0.00	0.12
Caltrans	Water								0.00	

Appenidix B: Impervious Acres

Owner	Land Use	Zone 1 Imperv (Acres)	Zone 2 Imperv (Acres)	Zone 3 Imperv (Acres)	Zone 4 Imperv (Acres)	Zone 5 Imperv (Acres)	Zone 6 Imperv (Acres)	Zone 7 Imperv (Acres)	Zone 8 Imperv (Acres)	Zone 9 Imperv (Acres)
CANYON LAKE	Commercial / Industrial	12.90	4.78	10.69						
CANYON LAKE	Forested	13.81	21.61	6.69						
CANYON LAKE	Non-Irrigated Cropland			0.00						
CANYON LAKE	Open Space	5.03	10.82	7.05						
CANYON LAKE	Other Livestock		2.40							
CANYON LAKE	Roadway	3.77	1.70	6.38						
CANYON LAKE	Sewered Residential	41.20	192.53	302.71						
CANYON LAKE	Water		19.74	25.59						
CR&R	Open Space							0.00		
Federal - DOD	Commercial / Industrial					166.57				
Federal - DOD	Forested					0.19				
Federal - DOD	Irrigated Cropland					0.00				
Federal - DOD	Open Space					51.51				
Federal - DOD	Roadway					199.33				
Federal - DOD	Sewered Residential					0.06				
Federal - National Forest	Commercial / Industrial								0.64	2.31
Federal - National Forest	Forested	0.68			0.00				0.94	0.00
Federal - National Forest	Non-Irrigated Cropland								0.00	0.03
Federal - National Forest	Open Space								0.25	1.07
Federal - National Forest	Other Livestock									0.00
Federal - National Forest	Pasture / Hay	0.00								0.00
Federal - National Forest	Sewered Residential	0.16							0.02	0.55
Federal - National Forest	Unsewered Residential	0.00							0.00	0.08
Federal - National Forest	Water								0.01	0.49
Federal - Other	Commercial / Industrial		0.00				0.00	0.00	0.05	
Federal - Other	Forested		16.60	0.00	0.00	0.22	0.85	0.02	0.52	
Federal - Other	Non-Irrigated Cropland			0.00	0.00				0.00	
Federal - Other	Open Space		0.02						0.00	
Federal - Other	Orchards / Vineyards								0.01	
Federal - Other	Pasture / Hay				0.00				0.00	
Federal - Other	Roadway		0.00							
Federal - Other	Sewered Residential		0.13	0.00	0.00		0.00		0.09	
Federal - Other	Unsewered Residential		0.00							
Federal - Other	Water		2.63							
Federal - Wilderness	Forested								0.00	0.00
Federal - Wilderness	Pasture / Hay									0.00
HEMET	Commercial / Industrial				557.89			297.41	7.07	
HEMET	Forested				108.84			47.99	1.96	
HEMET	Non-Irrigated Cropland				11.32			4.63	0.18	
HEMET	Open Space				139.81			16.17	1.97	
HEMET	Orchards / Vineyards							0.02		
HEMET	Other Livestock				0.03			1.09		
HEMET	Pasture / Hay				0.10			1.79	0.00	
HEMET	Roadway				30.55			0.28	0.03	
HEMET	Sewered Residential				1863.59			781.29	107.71	
HEMET	Unsewered Residential				0.08			2.99		
HEMET	Water				6.21					

Owner	Land Use	Zone 1 Imperv (Acres)	Zone 2 Imperv (Acres)	Zone 3 Imperv (Acres)	Zone 4 Imperv (Acres)	Zone 5 Imperv (Acres)	Zone 6 Imperv (Acres)	Zone 7 Imperv (Acres)	Zone 8 Imperv (Acres)	Zone 9 Imperv (Acres)
LAKE ELSINORE	Commercial / Industrial	316.60	7.20	0.91						
LAKE ELSINORE	Forested	341.60	69.06	1.92						
LAKE ELSINORE	Open Space	47.21	4.71							
LAKE ELSINORE	Other Livestock		0.00							
LAKE ELSINORE	Pasture / Hay	0.38								
LAKE ELSINORE	Roadway	21.41								
LAKE ELSINORE	Sewered Residential	1065.40	163.43	3.10						
LAKE ELSINORE	Unsewered Residential	1.72		0.01						
LAKE ELSINORE	Water	92.02								
March Joint Powers Authority	Commercial / Industrial					76.76				
March Joint Powers Authority	Forested					72.12				
March Joint Powers Authority	Open Space					15.20				
March Joint Powers Authority	Roadway					0.38				
March Joint Powers Authority	Sewered Residential					20.44				
MENIFEE	Commercial / Industrial		152.19	366.51						
MENIFEE	Forested	1.41	116.22	189.31						
MENIFEE	Non-Irrigated Cropland	0.00	1.19	28.96						
MENIFEE	Open Space		6.38	172.61						
MENIFEE	Orchards / Vineyards		0.39	3.01						
MENIFEE	Other Livestock	0.00	1.10	7.15						
MENIFEE	Pasture / Hay	0.01	4.86	7.51						
MENIFEE	Roadway		7.89	58.98						
MENIFEE	Sewered Residential	2.96	346.82	2804.80						
MENIFEE	Unsewered Residential	0.39	13.71	25.10						
MENIFEE	Water		0.03	12.60						
MORENO VALLEY	Commercial / Industrial					1075.81		6.46		
MORENO VALLEY	Forested					203.65		16.78		
MORENO VALLEY	Irrigated Cropland					0.00				
MORENO VALLEY	Open Space					81.65				
MORENO VALLEY	Orchards / Vineyards					2.61		0.75		
MORENO VALLEY	Other Livestock					0.41		0.00		
MORENO VALLEY	Pasture / Hay					2.26		0.03		
MORENO VALLEY	Roadway					135.45		0.52		
MORENO VALLEY	Sewered Residential					4511.43		0.34		
MORENO VALLEY	Unsewered Residential					11.81		0.00		
MORENO VALLEY	Water					11.18				
MURRIETA	Commercial / Industrial			19.52						
MURRIETA	Forested			3.95						
MURRIETA	Open Space			1.01						
MURRIETA	Pasture / Hay			0.00						
MURRIETA	Roadway			0.52						
MURRIETA	Sewered Residential			95.08						

Owner	Land Use	Zone 1 Imperv (Acres)	Zone 2 Imperv (Acres)	Zone 3 Imperv (Acres)	Zone 4 Imperv (Acres)	Zone 5 Imperv (Acres)	Zone 6 Imperv (Acres)	Zone 7 Imperv (Acres)	Zone 8 Imperv (Acres)	Zone 9 Imperv (Acres)
PERRIS	Commercial / Industrial		263.32			522.96	0.08			
PERRIS	Forested		98.10	0.15		94.26	0.02			
PERRIS	Non-Irrigated Cropland					0.00				
PERRIS	Open Space		10.81	0.00		29.29	0.13			
PERRIS	Orchards / Vineyards		2.51			2.30				
PERRIS	Pasture / Hay		0.02			0.39				
PERRIS	Roadway		15.98			41.85				
PERRIS	Sewered Residential		377.21			1042.06				
PERRIS	Unsewered Residential		0.33			0.10				
PERRIS	Water		2.19							
RIVERSIDE	Commercial / Industrial					6.59				
RIVERSIDE	Forested					0.58				
RIVERSIDE	Open Space					1.80				
RIVERSIDE	Sewered Residential					218.65				
Riverside County	Commercial / Industrial	43.66	40.13	8.67	93.88	111.78	57.87	88.75	57.17	25.72
Riverside County	Forested	51.28	118.51	32.48	30.90	72.75	91.91	69.80	26.75	1.61
Riverside County	Non-Irrigated Cropland		0.00	5.05	14.12	5.91	3.19	19.78	14.17	2.91
Riverside County	Open Space	2.73	5.06	8.23	9.48	26.16	0.63	12.85	19.91	11.68
Riverside County	Orchards / Vineyards	0.18	15.14	0.97	1.62	24.71	3.47	2.85	23.03	
Riverside County	Other Livestock	0.53	1.71	0.73	7.85	0.65	5.25	0.25	0.00	1.89
Riverside County	Pasture / Hay	0.35	5.98	0.43	3.21	2.68	6.85	0.85	0.93	0.26
Riverside County	Roadway	0.25	0.31	1.34	2.50	17.35	14.40	19.38	6.96	
Riverside County	Sewered Residential	401.09	434.14	31.08	612.79	88.15	257.55	283.88	623.75	34.97
Riverside County	Unsewered Residential	14.65	54.04	1.84	20.81	18.84	36.08	6.36	3.59	3.48
Riverside County	Water	18.51	2.77	11.12	0.56	1.14		1.94	0.56	0.01
SAN JACINTO	Commercial / Industrial				3.32			356.56	2.13	
SAN JACINTO	Forested				1.22		0.00	113.60	14.10	
SAN JACINTO	Non-Irrigated Cropland								0.00	
SAN JACINTO	Open Space				3.71			42.67	10.97	
SAN JACINTO	Orchards / Vineyards							4.45	0.90	
SAN JACINTO	Other Livestock							2.79		
SAN JACINTO	Pasture / Hay							1.52		
SAN JACINTO	Roadway							14.14	1.70	
SAN JACINTO	Sewered Residential				0.73			1100.23	86.16	
SAN JACINTO	Unsewered Residential							1.65		
SAN JACINTO	Water				1.77			0.09	5.04	
State Land	Commercial / Industrial		0.11			1.46			2.12	0.04
State Land	Forested		0.78			11.60	0.19	0.00	2.31	0.04
State Land	Non-Irrigated Cropland					0.59				
State Land	Open Space					9.86				0.35
State Land	Orchards / Vineyards		0.00							
State Land	Roadway					0.12				
State Land	Sewered Residential		0.03			5.58			0.15	0.01
State Land	Unsewered Residential		0.00							0.00
State Land	Water					0.06				

Appendix B: Impervious Acres

Owner	Land Use	Zone 1 Imperv (Acres)	Zone 2 Imperv (Acres)	Zone 3 Imperv (Acres)	Zone 4 Imperv (Acres)	Zone 5 Imperv (Acres)	Zone 6 Imperv (Acres)	Zone 7 Imperv (Acres)	Zone 8 Imperv (Acres)	Zone 9 Imperv (Acres)
Tribal Reservations	Commercial / Industrial								23.71	
Tribal Reservations	Forested							0.00	0.00	0.00
Tribal Reservations	Non-Irrigated Cropland							0.00		
Tribal Reservations	Open Space								2.63	
Tribal Reservations	Pasture / Hay								0.00	
Tribal Reservations	Sewered Residential								11.54	
Tribal Reservations	Water								2.34	
Western Riverside County Regional Conservation Aut	Commercial / Industrial							1.83		
Western Riverside County Regional Conservation Aut	Forested				0.00	0.71	0.58	0.33		
Western Riverside County Regional Conservation Aut	Non-Irrigated Cropland							0.35		
Western Riverside County Regional Conservation Aut	Open Space							5.38		
Western Riverside County Regional Conservation Aut	Sewered Residential				0.01	0.00				
Western Riverside County Regional Conservation Aut	Unsewered Residential				0.00					
WILDOMAR	Commercial / Industrial	74.37								
WILDOMAR	Forested	41.85		0.00						
WILDOMAR	Open Space	2.88								
WILDOMAR	Orchards / Vineyards	2.67								
WILDOMAR	Pasture / Hay	0.88								
WILDOMAR	Roadway	19.51								
WILDOMAR	Sewered Residential	406.47								
WILDOMAR	Unsewered Residential	13.05								
WILDOMAR	Water	0.19								

Owner	Land Use	Zone 1 RC	Zone 2 RC	Zone 3 RC	Zone 4 RC	Zone 5 RC	Zone 6 RC	Zone 7 RC	Zone 8 RC	Zone 9 RC
Ag-CWAD Non-irrigated	Commercial / Industrial	0.062	0.055	0.059	0.058	0.056	0.059	0.060	0.063	-
Ag-CWAD Non-irrigated	Forested	-	0.056	0.057	0.059	0.057	0.058	0.061	0.060	-
Ag-CWAD Irrigated	Irrigated Cropland	-	0.056	0.056	0.056	0.056	0.056	0.056	0.056	-
Ag-CWAD Non-irrigated	Non-Irrigated Cropland	0.056	0.056	0.056	0.056	0.056	0.056	0.056	-	-
Ag-CWAD Non-irrigated	Open Space	-	-	-	-	0.055	-	-	-	-
Ag-CWAD Irrigated	Orchards / Vineyards	-	0.055	0.062	0.055	0.056	0.059	0.057	0.057	0.055
Ag-CWAD Non-irrigated	Other Livestock	-	0.056	0.058	0.056	0.055	0.066	0.057	-	0.057
Ag-CWAD Non-irrigated	Pasture / Hay	-	-	0.060	-	-	-	0.058	-	0.056
Ag-CWAD Non-irrigated	Roadway	-	-	-	-	-	0.068	0.074	0.056	-
Ag-CWAD Non-irrigated	Sewered Residential	-	0.055	-	0.055	-	0.061	0.060	0.055	0.055
Ag-Small	Commercial / Industrial	0.061	0.057	0.063	0.059	0.058	0.060	0.064	0.061	-
Ag-Small	Irrigated Cropland	-	0.056	0.059	0.056	0.057	0.056	0.057	0.056	-
Ag-Small	Non-Irrigated Cropland	0.056	0.056	0.057	0.056	0.056	0.057	0.056	0.055	-
Ag-Small	Orchards / Vineyards	0.065	0.057	0.058	0.059	0.060	0.057	0.061	0.057	0.055
Ag-Small	Other Livestock	-	-	-	0.058	-	0.081	0.070	-	-
Ag-Small	Pasture / Hay	-	0.056	0.057	0.058	0.059	0.056	0.064	-	-
BANNING	Commercial / Industrial	-	-	-	-	-	-	0.145	-	-
BANNING	Forested	-	-	-	-	-	-	0.063	-	-
BANNING	Open Space	-	-	-	-	-	-	0.064	-	-
BANNING	Roadway	-	-	-	-	-	-	0.118	-	-
BANNING	Sewered Residential	-	-	-	-	-	-	0.133	-	-
BANNING	Water	-	-	-	-	-	-	0.058	-	-
BEAUMONT	Commercial / Industrial	-	-	-	-	-	-	0.070	-	-
BEAUMONT	Forested	-	-	-	-	-	-	0.056	-	-
BEAUMONT	Open Space	-	-	-	-	-	-	0.061	-	-
BEAUMONT	Roadway	-	-	-	-	-	-	0.109	-	-
BEAUMONT	Sewered Residential	-	-	-	-	-	-	0.078	-	-
CAFO	Dairy	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034
CAFO	Pasture / Hay	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034
California Department of Fish and Wildlife	Commercial / Industrial	-	-	-	-	0.060	-	0.056	-	-
California Department of Fish and Wildlife	Forested	-	-	-	-	0.057	0.056	0.055	0.055	-
California Department of Fish and Wildlife	Non-Irrigated Cropland	-	-	-	-	-	-	0.057	-	-
California Department of Fish and Wildlife	Other Livestock	-	-	-	-	-	-	0.055	-	-
California Department of Fish and Wildlife	Roadway	-	-	-	-	0.066	-	0.055	-	-
Caltrans	Commercial / Industrial	0.151	0.124	0.110	0.147	0.119	-	0.162	0.136	0.073
Caltrans	Forested	0.067	0.078	0.086	0.075	0.080	-	0.073	0.066	0.062
Caltrans	Non-Irrigated Cropland	-	-	-	0.074	-	-	-	0.069	0.063
Caltrans	Open Space	0.107	0.065	-	0.073	0.081	-	0.072	0.066	0.066
Caltrans	Orchards / Vineyards	-	0.085	-	-	-	-	-	-	-
Caltrans	Other Livestock	-	-	-	-	0.061	-	-	-	0.063
Caltrans	Pasture / Hay	-	-	-	0.055	-	-	-	-	0.057
Caltrans	Roadway	0.127	0.105	0.103	0.113	0.119	-	0.096	0.147	-
Caltrans	Sewered Residential	0.100	0.092	0.077	0.096	0.113	-	0.131	0.113	0.064
Caltrans	Unsewered Residential	-	0.084	-	0.064	-	-	0.069	0.120	0.066
Caltrans	Water	-	-	-	-	-	-	-	0.055	-
CANYON LAKE	Commercial / Industrial	0.159	0.156	0.162	-	-	-	-	-	-
CANYON LAKE	Forested	0.072	0.100	0.071	-	-	-	-	-	-
CANYON LAKE	Non-Irrigated Cropland	-	-	0.070	-	-	-	-	-	-
CANYON LAKE	Open Space	0.063	0.107	0.076	-	-	-	-	-	-
CANYON LAKE	Other Livestock	-	0.100	-	-	-	-	-	-	-
CANYON LAKE	Roadway	0.135	0.126	0.148	-	-	-	-	-	-
CANYON LAKE	Sewered Residential	0.123	0.131	0.126	-	-	-	-	-	-
CANYON LAKE	Water	-	0.063	0.082	-	-	-	-	-	-
CR&R	Open Space	-	-	-	-	-	-	0.055	-	-

Owner	Land Use	Zone 1 RC	Zone 2 RC	Zone 3 RC	Zone 4 RC	Zone 5 RC	Zone 6 RC	Zone 7 RC	Zone 8 RC	Zone 9 RC
Federal - DOD	Commercial / Industrial	-	-	-	-	0.104	-	-	-	-
Federal - DOD	Forested	-	-	-	-	0.062	-	-	-	-
Federal - DOD	Irrigated Cropland	-	-	-	-	0.055	-	-	-	-
Federal - DOD	Open Space	-	-	-	-	0.060	-	-	-	-
Federal - DOD	Roadway	-	-	-	-	0.123	-	-	-	-
Federal - DOD	Sewered Residential	-	-	-	-	0.090	-	-	-	-
Federal - National Forest	Commercial / Industrial	-	-	-	-	-	-	-	0.061	0.059
Federal - National Forest	Forested	0.055	-	-	0.055	-	-	-	0.055	0.055
Federal - National Forest	Non-Irrigated Cropland	-	-	-	-	-	-	-	0.055	0.055
Federal - National Forest	Open Space	-	-	-	-	-	-	-	0.057	0.056
Federal - National Forest	Other Livestock	-	-	-	-	-	-	-	-	0.055
Federal - National Forest	Pasture / Hay	0.055	-	-	-	-	-	-	-	0.055
Federal - National Forest	Sewered Residential	0.056	-	-	-	-	-	-	0.056	0.056
Federal - National Forest	Unsewered Residential	0.055	-	-	-	-	-	-	0.058	0.057
Federal - National Forest	Water	-	-	-	-	-	-	-	0.055	0.055
Federal - Other	Commercial / Industrial	-	0.055	-	-	-	0.055	0.055	0.062	-
Federal - Other	Forested	-	0.056	0.055	0.055	0.055	0.055	0.055	0.055	-
Federal - Other	Non-Irrigated Cropland	-	-	0.055	0.055	-	-	-	0.055	-
Federal - Other	Open Space	-	0.104	-	-	-	-	-	0.055	-
Federal - Other	Orchards / Vineyards	-	-	-	-	-	-	-	0.056	-
Federal - Other	Pasture / Hay	-	-	-	0.055	-	-	-	0.055	-
Federal - Other	Roadway	-	0.055	-	-	-	-	-	-	-
Federal - Other	Sewered Residential	-	0.058	0.055	0.055	-	0.055	-	0.056	-
Federal - Other	Unsewered Residential	-	0.055	-	-	-	-	-	-	-
Federal - Other	Water	-	0.059	-	-	-	-	-	-	-
Federal - Wilderness	Forested	-	-	-	-	-	-	-	0.055	0.055
Federal - Wilderness	Pasture / Hay	-	-	-	-	-	-	-	-	0.055
HEMET	Commercial / Industrial	-	-	-	0.107	-	-	0.131	0.121	-
HEMET	Forested	-	-	-	0.059	-	-	0.065	0.068	-
HEMET	Non-Irrigated Cropland	-	-	-	0.056	-	-	0.059	0.063	-
HEMET	Open Space	-	-	-	0.074	-	-	0.076	0.065	-
HEMET	Orchards / Vineyards	-	-	-	-	-	-	0.058	-	-
HEMET	Other Livestock	-	-	-	0.056	-	-	0.059	-	-
HEMET	Pasture / Hay	-	-	-	0.057	-	-	0.060	0.061	-
HEMET	Roadway	-	-	-	0.078	-	-	0.069	0.169	-
HEMET	Sewered Residential	-	-	-	0.141	-	-	0.121	0.128	-
HEMET	Unsewered Residential	-	-	-	0.056	-	-	0.073	-	-
HEMET	Water	-	-	-	0.099	-	-	-	-	-
LAKE ELSINORE	Commercial / Industrial	0.086	0.170	0.056	-	-	-	-	-	-
LAKE ELSINORE	Forested	0.062	0.067	0.056	-	-	-	-	-	-
LAKE ELSINORE	Open Space	0.069	0.080	-	-	-	-	-	-	-
LAKE ELSINORE	Other Livestock	-	0.115	-	-	-	-	-	-	-
LAKE ELSINORE	Pasture / Hay	0.089	-	-	-	-	-	-	-	-
LAKE ELSINORE	Roadway	0.118	-	-	-	-	-	-	-	-
LAKE ELSINORE	Sewered Residential	0.116	0.163	0.060	-	-	-	-	-	-
LAKE ELSINORE	Unsewered Residential	0.097	-	0.065	-	-	-	-	-	-
LAKE ELSINORE	Water	0.058	-	-	-	-	-	-	-	-
March Joint Powers Authority	Commercial / Industrial	-	-	-	-	0.073	-	-	-	-
March Joint Powers Authority	Forested	-	-	-	-	0.061	-	-	-	-
March Joint Powers Authority	Open Space	-	-	-	-	0.065	-	-	-	-
March Joint Powers Authority	Roadway	-	-	-	-	0.060	-	-	-	-
March Joint Powers Authority	Sewered Residential	-	-	-	-	0.078	-	-	-	-

Owner	Land Use	Zone 1 RC	Zone 2 RC	Zone 3 RC	Zone 4 RC	Zone 5 RC	Zone 6 RC	Zone 7 RC	Zone 8 RC	Zone 9 RC
MENIFEE	Commercial / Industrial	-	0.079	0.082	-	-	-	-	-	-
MENIFEE	Forested	0.056	0.063	0.059	-	-	-	-	-	-
MENIFEE	Non-Irrigated Cropland	0.055	0.056	0.060	-	-	-	-	-	-
MENIFEE	Open Space	-	0.058	0.066	-	-	-	-	-	-
MENIFEE	Orchards / Vineyards	-	0.058	0.061	-	-	-	-	-	-
MENIFEE	Other Livestock	0.055	0.057	0.063	-	-	-	-	-	-
MENIFEE	Pasture / Hay	0.055	0.061	0.059	-	-	-	-	-	-
MENIFEE	Roadway	-	0.073	0.097	-	-	-	-	-	-
MENIFEE	Sewered Residential	0.058	0.078	0.109	-	-	-	-	-	-
MENIFEE	Unsewered Residential	0.057	0.067	0.062	-	-	-	-	-	-
MENIFEE	Water	-	0.057	0.065	-	-	-	-	-	-
MORENO VALLEY	Commercial / Industrial	-	-	-	-	0.098	-	0.076	-	-
MORENO VALLEY	Forested	-	-	-	-	0.059	-	0.059	-	-
MORENO VALLEY	Irrigated Cropland	-	-	-	-	0.055	-	-	-	-
MORENO VALLEY	Open Space	-	-	-	-	0.067	-	-	-	-
MORENO VALLEY	Orchards / Vineyards	-	-	-	-	0.060	-	0.065	-	-
MORENO VALLEY	Other Livestock	-	-	-	-	0.058	-	0.055	-	-
MORENO VALLEY	Pasture / Hay	-	-	-	-	0.058	-	0.056	-	-
MORENO VALLEY	Roadway	-	-	-	-	0.129	-	0.080	-	-
MORENO VALLEY	Sewered Residential	-	-	-	-	0.118	-	0.062	-	-
MORENO VALLEY	Unsewered Residential	-	-	-	-	0.071	-	0.079	-	-
MORENO VALLEY	Water	-	-	-	-	0.075	-	-	-	-
MURRIETA	Commercial / Industrial	-	-	0.091	-	-	-	-	-	-
MURRIETA	Forested	-	-	0.060	-	-	-	-	-	-
MURRIETA	Open Space	-	-	0.070	-	-	-	-	-	-
MURRIETA	Pasture / Hay	-	-	0.055	-	-	-	-	-	-
MURRIETA	Roadway	-	-	0.066	-	-	-	-	-	-
MURRIETA	Sewered Residential	-	-	0.154	-	-	-	-	-	-
PERRIS	Commercial / Industrial	-	0.079	-	-	0.086	0.056	-	-	-
PERRIS	Forested	-	0.058	0.055	-	0.060	0.060	-	-	-
PERRIS	Non-Irrigated Cropland	-	-	-	-	0.062	-	-	-	-
PERRIS	Open Space	-	0.057	0.055	-	0.064	0.076	-	-	-
PERRIS	Orchards / Vineyards	-	0.068	-	-	0.075	-	-	-	-
PERRIS	Pasture / Hay	-	0.057	-	-	0.059	-	-	-	-
PERRIS	Roadway	-	0.074	-	-	0.085	-	-	-	-
PERRIS	Sewered Residential	-	0.101	-	-	0.114	-	-	-	-
PERRIS	Unsewered Residential	-	0.059	-	-	0.117	-	-	-	-
PERRIS	Water	-	0.066	-	-	-	-	-	-	-
RIVERSIDE	Commercial / Industrial	-	-	-	-	0.085	-	-	-	-
RIVERSIDE	Forested	-	-	-	-	0.084	-	-	-	-
RIVERSIDE	Open Space	-	-	-	-	0.070	-	-	-	-
RIVERSIDE	Sewered Residential	-	-	-	-	0.153	-	-	-	-
Riverside County	Commercial / Industrial	0.095	0.066	0.058	0.069	0.081	0.064	0.062	0.066	0.060
Riverside County	Forested	0.057	0.056	0.056	0.055	0.056	0.056	0.055	0.055	0.055
Riverside County	Non-Irrigated Cropland	-	0.055	0.057	0.055	0.056	0.056	0.057	0.057	0.055
Riverside County	Open Space	0.083	0.061	0.056	0.058	0.058	0.057	0.056	0.061	0.058
Riverside County	Orchards / Vineyards	0.079	0.065	0.061	0.060	0.084	0.058	0.080	0.098	-
Riverside County	Other Livestock	0.057	0.058	0.057	0.057	0.056	0.058	0.057	0.055	0.056
Riverside County	Pasture / Hay	0.057	0.057	0.058	0.056	0.057	0.058	0.058	0.058	0.056
Riverside County	Roadway	0.066	0.058	0.057	0.058	0.074	0.069	0.073	0.089	-
Riverside County	Sewered Residential	0.088	0.065	0.067	0.075	0.064	0.068	0.096	0.109	0.056
Riverside County	Unsewered Residential	0.072	0.061	0.060	0.059	0.062	0.063	0.068	0.068	0.056
Riverside County	Water	0.077	0.076	0.066	0.068	0.065	-	0.062	0.055	0.055

Owner	Land Use	Zone 1 RC	Zone 2 RC	Zone 3 RC	Zone 4 RC	Zone 5 RC	Zone 6 RC	Zone 7 RC	Zone 8 RC	Zone 9 RC
SAN JACINTO	Commercial / Industrial	-	-	-	0.064	-	-	0.084	0.063	-
SAN JACINTO	Forested	-	-	-	0.056	-	0.055	0.058	0.057	-
SAN JACINTO	Non-Irrigated Cropland	-	-	-	-	-	-	-	0.057	-
SAN JACINTO	Open Space	-	-	-	0.087	-	-	0.064	0.061	-
SAN JACINTO	Orchards / Vineyards	-	-	-	-	-	-	0.077	0.083	-
SAN JACINTO	Other Livestock	-	-	-	-	-	-	0.057	-	-
SAN JACINTO	Pasture / Hay	-	-	-	-	-	-	0.059	-	-
SAN JACINTO	Roadway	-	-	-	-	-	-	0.076	0.063	-
SAN JACINTO	Sewered Residential	-	-	-	0.067	-	-	0.108	0.134	-
SAN JACINTO	Unsewered Residential	-	-	-	-	-	-	0.067	-	-
SAN JACINTO	Water	-	-	-	0.070	-	-	0.070	0.057	-
State Land	Commercial / Industrial	-	0.089	-	-	0.063	-	-	0.070	0.057
State Land	Forested	-	0.055	-	-	0.056	0.055	0.055	0.056	0.055
State Land	Non-Irrigated Cropland	-	-	-	-	0.056	-	-	-	-
State Land	Open Space	-	-	-	-	0.057	-	-	-	0.056
State Land	Orchards / Vineyards	-	0.055	-	-	-	-	-	-	-
State Land	Roadway	-	-	-	-	0.066	-	-	-	-
State Land	Sewered Residential	-	0.057	-	-	0.092	-	-	0.062	0.055
State Land	Unsewered Residential	-	0.055	-	-	-	-	-	-	0.055
State Land	Water	-	-	-	-	0.106	-	-	-	-
Tribal Reservations	Commercial / Industrial	-	-	-	-	-	-	-	0.107	-
Tribal Reservations	Forested	-	-	-	-	-	-	0.055	0.055	0.055
Tribal Reservations	Non-Irrigated Cropland	-	-	-	-	-	-	0.055	-	-
Tribal Reservations	Open Space	-	-	-	-	-	-	-	0.061	-
Tribal Reservations	Pasture / Hay	-	-	-	-	-	-	-	0.055	-
Tribal Reservations	Sewered Residential	-	-	-	-	-	-	-	0.060	-
Tribal Reservations	Water	-	-	-	-	-	-	-	0.058	-
Western Riverside County Regional Conservation Aut	Commercial / Industrial	-	-	-	-	-	-	0.089	-	-
Western Riverside County Regional Conservation Aut	Forested	-	-	-	0.055	0.055	0.055	0.055	-	-
Western Riverside County Regional Conservation Aut	Non-Irrigated Cropland	-	-	-	-	-	-	0.055	-	-
Western Riverside County Regional Conservation Aut	Open Space	-	-	-	-	-	-	0.076	-	-
Western Riverside County Regional Conservation Aut	Sewered Residential	-	-	-	0.055	0.056	-	-	-	-
Western Riverside County Regional Conservation Aut	Unsewered Residential	-	-	-	0.058	-	-	-	-	-
WILDOMAR	Commercial / Industrial	0.102	-	-	-	-	-	-	-	-
WILDOMAR	Forested	0.057	-	0.055	-	-	-	-	-	-
WILDOMAR	Open Space	0.072	-	-	-	-	-	-	-	-
WILDOMAR	Orchards / Vineyards	0.085	-	-	-	-	-	-	-	-
WILDOMAR	Pasture / Hay	0.061	-	-	-	-	-	-	-	-
WILDOMAR	Roadway	0.113	-	-	-	-	-	-	-	-
WILDOMAR	Sewered Residential	0.085	-	-	-	-	-	-	-	-
WILDOMAR	Unsewered Residential	0.069	-	-	-	-	-	-	-	-
WILDOMAR	Water	0.079	-	-	-	-	-	-	-	-

Owner	Land Use	Zone 1 Q (AFY)	Zone 2 Q (AFY)	Zone 3 Q (AFY)	Zone 4 Qshed (AFY)	Zone 4 Q (AFY)	Zone 5 Qshed (AFY)	Zone 5 Q (AFY)	Zone 6 Qshed (AFY)	Zone 6 Q (AFY)	Zone 7 Qshed (AFY)	Zone 7 Q (AFY)	Zone 8 Qshed (AFY)	Zone 8 Q (AFY)	Zone 9 Qshed (AFY)	Zone 9 Q (AFY)
Ag-CWAD Non-irrigated	Commercial / Industrial	0.09	0.00	0.69	1.60	0.68	0.16	0.15	5.15	4.63	7.75	0.77	1.63	0.16	-	-
Ag-CWAD Non-irrigated	Forested	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
Ag-CWAD Irrigated	Irrigated Cropland	-	89.02	100.98	81.78	34.46	46.22	42.78	317.81	285.40	374.02	37.03	17.12	1.69	-	-
Ag-CWAD Non-irrigated	Non-Irrigated Cropland	0.84	99.92	116.93	106.72	44.97	97.93	90.64	35.03	31.46	131.44	13.01	-	-	-	-
Ag-CWAD Non-irrigated	Open Space	-	-	-	-	-	0.36	0.34	-	-	-	-	-	-	-	-
Ag-CWAD Irrigated	Orchards / Vineyards	-	0.05	0.14	5.67	2.39	0.47	0.43	0.70	0.63	28.67	2.84	126.94	12.57	7.72	0.76
Ag-CWAD Non-irrigated	Other Livestock	-	6.97	6.83	15.03	6.33	0.05	0.05	18.64	16.74	29.32	2.90	-	-	22.88	2.26
Ag-CWAD Non-irrigated	Pasture / Hay	-	-	0.59	-	-	-	-	-	-	0.15	0.01	-	-	0.86	0.09
Ag-CWAD Non-irrigated	Roadway	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	-	-
Ag-CWAD Non-irrigated	Sewered Residential	-	0.00	-	0.00	0.00	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ag-Small	Commercial / Industrial	0.39	0.33	0.77	2.91	1.23	2.01	1.86	1.29	1.15	1.08	0.11	1.37	0.14	-	-
Ag-Small	Irrigated Cropland	-	12.88	7.20	7.52	3.17	10.84	10.03	23.92	21.48	12.07	1.19	0.72	0.07	-	-
Ag-Small	Non-Irrigated Cropland	0.31	16.01	30.64	20.19	8.51	25.26	23.38	9.02	8.10	9.39	0.93	0.09	0.01	-	-
Ag-Small	Orchards / Vineyards	2.62	1.82	1.75	2.79	1.17	1.25	1.15	0.71	0.64	8.64	0.86	12.71	1.26	1.88	0.19
Ag-Small	Other Livestock	-	-	-	1.29	0.54	-	-	0.91	0.82	0.00	0.00	-	-	-	-
Ag-Small	Pasture / Hay	-	0.62	0.48	0.64	0.27	0.06	0.05	0.64	0.57	0.27	0.03	-	-	-	-
BANNING	Commercial / Industrial	-	-	-	-	-	-	-	-	-	6.99	0.69	-	-	-	-
BANNING	Forested	-	-	-	-	-	-	-	-	-	4.47	0.44	-	-	-	-
BANNING	Open Space	-	-	-	-	-	-	-	-	-	2.90	0.29	-	-	-	-
BANNING	Roadway	-	-	-	-	-	-	-	-	-	0.17	0.02	-	-	-	-
BANNING	Sewered Residential	-	-	-	-	-	-	-	-	-	18.92	1.87	-	-	-	-
BANNING	Water	-	-	-	-	-	-	-	-	-	0.06	0.01	-	-	-	-
BEAUMONT	Commercial / Industrial	-	-	-	-	-	-	-	-	-	47.36	4.69	-	-	-	-
BEAUMONT	Forested	-	-	-	-	-	-	-	-	-	114.25	11.31	-	-	-	-
BEAUMONT	Open Space	-	-	-	-	-	-	-	-	-	5.38	0.53	-	-	-	-
BEAUMONT	Roadway	-	-	-	-	-	-	-	-	-	1.10	0.11	-	-	-	-
BEAUMONT	Sewered Residential	-	-	-	-	-	-	-	-	-	103.52	10.25	-	-	-	-
CAFO	Dairy	0.01	-	-	-	-	-	-	0.67	0.60	2.10	2.10	-	-	-	-
CAFO	Pasture / Hay	0.01	-	0.40	0.04	0.02	-	-	0.62	0.56	3.71	3.71	-	-	-	-
California Department of Fish and Wildlife	Commercial / Industrial	-	-	-	-	-	0.09	0.09	-	-	0.12	0.01	-	-	-	-
California Department of Fish and Wildlife	Forested	-	-	-	-	-	25.23	23.35	169.37	152.10	791.30	78.34	6.75	0.67	-	-
California Department of Fish and Wildlife	Non-Irrigated Cropland	-	-	-	-	-	-	-	-	-	1.89	0.19	-	-	-	-
California Department of Fish and Wildlife	Other Livestock	-	-	-	-	-	-	-	-	-	0.00	0.00	-	-	-	-
California Department of Fish and Wildlife	Roadway	-	-	-	-	-	0.00	0.00	-	-	0.00	0.00	-	-	-	-
Caltrans	Commercial / Industrial	2.53	5.57	0.23	7.15	3.01	1.82	1.68	-	-	12.03	1.19	2.03	0.20	3.86	0.38
Caltrans	Forested	5.24	6.23	1.36	4.91	2.07	1.40	1.30	-	-	12.14	1.20	5.77	0.57	60.67	6.01
Caltrans	Non-Irrigated Cropland	-	-	-	0.06	0.03	-	-	-	-	-	-	0.08	0.01	0.24	0.02
Caltrans	Open Space	0.81	0.02	-	0.25	0.11	0.11	0.10	-	-	1.21	0.12	0.51	0.05	0.86	0.09
Caltrans	Orchards / Vineyards	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-
Caltrans	Other Livestock	-	-	-	-	-	0.00	0.00	-	-	-	-	-	-	0.15	0.01
Caltrans	Pasture / Hay	-	-	-	0.01	0.00	-	-	-	-	-	-	-	-	0.00	0.00
Caltrans	Roadway	14.24	15.43	20.02	0.05	0.02	46.71	43.23	-	-	16.45	1.63	0.02	0.00	-	-
Caltrans	Sewered Residential	1.05	3.52	0.00	1.76	0.74	1.25	1.15	-	-	1.23	0.12	2.19	0.22	8.55	0.85
Caltrans	Unsewered Residential	-	0.08	-	0.03	0.01	-	-	-	-	0.01	0.00	0.00	0.00	0.18	0.02
Caltrans	Water	-	-	-	-	-	-	-	-	-	-	-	0.02	0.00	-	-
CANYON LAKE	Commercial / Industrial	3.66	1.35	3.04	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Forested	7.09	6.86	3.59	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Non-Irrigated Cropland	-	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Open Space	4.59	3.30	3.15	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Other Livestock	-	0.76	-	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Roadway	1.07	0.49	1.81	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Sewered Residential	11.91	55.01	87.15	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Water	-	17.17	9.94	-	-	-	-	-	-	-	-	-	-	-	-
CR&R	Open Space	-	-	-	-	-	-	-	-	-	11.02	1.09	-	-	-	-
Federal - DOD	Commercial / Industrial	-	-	-	-	-	46.78	43.30	-	-	-	-	-	-	-	-
Federal - DOD	Forested	-	-	-	-	-	0.17	0.15	-	-	-	-	-	-	-	-
Federal - DOD	Irrigated Cropland	-	-	-	-	-	0.10	0.09	-	-	-	-	-	-	-	-
Federal - DOD	Open Space	-	-	-	-	-	58.06	53.74	-	-	-	-	-	-	-	-
Federal - DOD	Roadway	-	-	-	-	-	52.35	48.45	-	-	-	-	-	-	-	-
Federal - DOD	Sewered Residential	-	-	-	-	-	0.02	0.02	-	-	-	-	-	-	-	-

Owner	Land Use	Zone 1 Q (AFY)	Zone 2 Q (AFY)	Zone 3 Q (AFY)	Zone 4 Qshed (AFY)	Zone 4 Q (AFY)	Zone 5 Qshed (AFY)	Zone 5 Q (AFY)	Zone 6 Qshed (AFY)	Zone 6 Q (AFY)	Zone 7 Qshed (AFY)	Zone 7 Q (AFY)	Zone 8 Qshed (AFY)	Zone 8 Q (AFY)	Zone 9 Qshed (AFY)	Zone 9 Q (AFY)
Federal - National Forest	Commercial / Industrial	-	-	-	-	-	-	-	-	-	-	-	0.71	0.07	7.61	0.75
Federal - National Forest	Forested	266.94	-	-	19.05	8.03	-	-	-	-	-	-	1,536.71	152.13	6,758.75	669.12
Federal - National Forest	Non-Irrigated Cropland	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	5.10	0.50
Federal - National Forest	Open Space	-	-	-	-	-	-	-	-	-	-	-	0.71	0.07	12.32	1.22
Federal - National Forest	Other Livestock	-	-	-	-	-	-	-	-	-	-	-	-	-	0.22	0.02
Federal - National Forest	Pasture / Hay	0.19	-	-	-	-	-	-	-	-	-	-	-	-	0.20	0.02
Federal - National Forest	Sewered Residential	0.68	-	-	-	-	-	-	-	-	-	-	0.11	0.01	13.29	1.32
Federal - National Forest	Unsewered Residential	0.02	-	-	-	-	-	-	-	-	-	-	0.01	0.00	0.60	0.06
Federal - National Forest	Water	-	-	-	-	-	-	-	-	-	-	-	0.22	0.02	13.51	1.34
Federal - Other	Commercial / Industrial	-	0.01	-	-	-	-	-	0.46	0.41	0.09	0.01	0.05	0.01	-	-
Federal - Other	Forested	-	104.29	6.19	55.91	23.56	2.91	2.69	11.02	9.90	375.74	37.20	424.27	42.00	-	-
Federal - Other	Non-Irrigated Cropland	-	-	0.00	2.74	1.16	-	-	-	-	-	-	0.00	0.00	-	-
Federal - Other	Open Space	-	0.01	-	-	-	-	-	-	-	-	-	0.11	0.01	-	-
Federal - Other	Orchards / Vineyards	-	-	-	-	-	-	-	-	-	-	-	0.04	0.00	-	-
Federal - Other	Pasture / Hay	-	-	-	0.01	0.00	-	-	-	-	-	-	0.11	0.01	-	-
Federal - Other	Roadway	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal - Other	Sewered Residential	-	0.27	0.03	0.06	0.03	-	-	0.01	0.01	-	-	0.55	0.05	-	-
Federal - Other	Unsewered Residential	-	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal - Other	Water	-	4.23	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal - Wilderness	Forested	-	-	-	-	-	-	-	-	-	-	-	690.74	68.38	941.26	93.19
Federal - Wilderness	Pasture / Hay	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	0.00
HEMET	Commercial / Industrial	-	-	-	161.45	68.04	-	-	-	-	89.93	8.90	2.17	0.22	-	-
HEMET	Forested	-	-	-	166.51	70.17	-	-	-	-	37.72	3.73	1.27	0.13	-	-
HEMET	Non-Irrigated Cropland	-	-	-	51.62	21.75	-	-	-	-	7.66	0.76	0.16	0.02	-	-
HEMET	Open Space	-	-	-	62.52	26.35	-	-	-	-	7.53	0.75	1.56	0.15	-	-
HEMET	Orchards / Vineyards	-	-	-	-	-	-	-	-	-	0.04	0.00	-	-	-	-
HEMET	Other Livestock	-	-	-	0.17	0.07	-	-	-	-	1.90	0.19	-	-	-	-
HEMET	Pasture / Hay	-	-	-	0.27	0.11	-	-	-	-	2.36	0.23	0.00	0.00	-	-
HEMET	Roadway	-	-	-	12.39	5.22	-	-	-	-	0.17	0.02	0.01	0.00	-	-
HEMET	Sewered Residential	-	-	-	501.96	211.53	-	-	-	-	240.31	23.79	32.70	3.24	-	-
HEMET	Unsewered Residential	-	-	-	0.49	0.21	-	-	-	-	1.52	0.15	-	-	-	-
HEMET	Water	-	-	-	1.88	0.79	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Commercial / Industrial	114.68	2.05	7.58	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Forested	332.38	44.75	11.43	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Open Space	27.58	1.89	-	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Other Livestock	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Pasture / Hay	0.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Roadway	6.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Sewered Residential	313.27	46.42	4.06	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Unsewered Residential	0.56	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Water	169.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-
March Joint Powers Authority	Commercial / Industrial	-	-	-	-	-	34.04	31.51	-	-	-	-	-	-	-	-
March Joint Powers Authority	Forested	-	-	-	-	-	77.88	72.09	-	-	-	-	-	-	-	-
March Joint Powers Authority	Open Space	-	-	-	-	-	10.33	9.56	-	-	-	-	-	-	-	-
March Joint Powers Authority	Roadway	-	-	-	-	-	0.49	0.45	-	-	-	-	-	-	-	-
March Joint Powers Authority	Sewered Residential	-	-	-	-	-	7.81	7.23	-	-	-	-	-	-	-	-
MENIFEE	Commercial / Industrial	-	63.05	143.33	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Forested	14.38	106.98	299.11	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Non-Irrigated Cropland	0.37	5.09	40.23	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Open Space	-	12.55	118.21	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Orchards / Vineyards	-	0.83	3.45	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Other Livestock	0.14	4.18	6.47	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Pasture / Hay	0.24	5.43	11.47	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Roadway	-	3.80	19.16	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Sewered Residential	5.50	146.61	847.76	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Unsewered Residential	1.27	8.67	23.53	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Water	-	0.08	9.18	-	-	-	-	-	-	-	-	-	-	-	-

Owner	Land Use	Zone 1 Q (AFY)	Zone 2 Q (AFY)	Zone 3 Q (AFY)	Zone 4 Qshed (AFY)	Zone 4 Q (AFY)	Zone 5 Qshed (AFY)	Zone 5 Q (AFY)	Zone 6 Qshed (AFY)	Zone 6 Q (AFY)	Zone 7 Qshed (AFY)	Zone 7 Q (AFY)	Zone 8 Qshed (AFY)	Zone 8 Q (AFY)	Zone 9 Qshed (AFY)	Zone 9 Q (AFY)
MORENO VALLEY	Commercial / Industrial	-	-	-	-	-	313.39	290.07	-	-	3.06	0.30	-	-	-	-
MORENO VALLEY	Forested	-	-	-	-	-	308.76	285.78	-	-	26.61	2.63	-	-	-	-
MORENO VALLEY	Irrigated Cropland	-	-	-	-	-	0.00	0.00	-	-	-	-	-	-	-	-
MORENO VALLEY	Open Space	-	-	-	-	-	47.05	43.55	-	-	-	-	-	-	-	-
MORENO VALLEY	Orchards / Vineyards	-	-	-	-	-	3.29	3.04	-	-	0.57	0.06	-	-	-	-
MORENO VALLEY	Other Livestock	-	-	-	-	-	0.73	0.67	-	-	0.24	0.02	-	-	-	-
MORENO VALLEY	Pasture / Hay	-	-	-	-	-	3.93	3.63	-	-	0.20	0.02	-	-	-	-
MORENO VALLEY	Roadway	-	-	-	-	-	35.23	32.61	-	-	0.22	0.02	-	-	-	-
MORENO VALLEY	Sewered Residential	-	-	-	-	-	1,198.36	1,109.20	-	-	0.35	0.03	-	-	-	-
MORENO VALLEY	Unsewered Residential	-	-	-	-	-	5.70	5.28	-	-	0.00	0.00	-	-	-	-
MORENO VALLEY	Water	-	-	-	-	-	4.66	4.31	-	-	-	-	-	-	-	-
MURRIETA	Commercial / Industrial	-	-	6.65	-	-	-	-	-	-	-	-	-	-	-	-
MURRIETA	Forested	-	-	4.77	-	-	-	-	-	-	-	-	-	-	-	-
MURRIETA	Open Space	-	-	0.55	-	-	-	-	-	-	-	-	-	-	-	-
MURRIETA	Pasture / Hay	-	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-
MURRIETA	Roadway	-	-	0.36	-	-	-	-	-	-	-	-	-	-	-	-
MURRIETA	Sewered Residential	-	-	26.92	-	-	-	-	-	-	-	-	-	-	-	-
PERRIS	Commercial / Industrial	-	108.83	-	-	-	172.46	159.63	0.46	0.41	-	-	-	-	-	-
PERRIS	Forested	-	204.71	2.74	-	-	114.87	106.32	0.03	0.02	-	-	-	-	-	-
PERRIS	Non-Irrigated Cropland	-	-	-	-	-	0.00	0.00	-	-	-	-	-	-	-	-
PERRIS	Open Space	-	39.22	0.00	-	-	21.44	19.84	0.06	0.05	-	-	-	-	-	-
PERRIS	Orchards / Vineyards	-	1.53	-	-	-	0.95	0.87	-	-	-	-	-	-	-	-
PERRIS	Pasture / Hay	-	0.06	-	-	-	0.61	0.56	-	-	-	-	-	-	-	-
PERRIS	Roadway	-	7.49	-	-	-	14.03	12.99	-	-	-	-	-	-	-	-
PERRIS	Sewered Residential	-	118.66	-	-	-	279.73	258.92	-	-	-	-	-	-	-	-
PERRIS	Unsewered Residential	-	0.58	-	-	-	0.03	0.02	-	-	-	-	-	-	-	-
PERRIS	Water	-	1.52	-	-	-	-	-	-	-	-	-	-	-	-	-
RIVERSIDE	Commercial / Industrial	-	-	-	-	-	2.22	2.05	-	-	-	-	-	-	-	-
RIVERSIDE	Forested	-	-	-	-	-	0.20	0.18	-	-	-	-	-	-	-	-
RIVERSIDE	Open Space	-	-	-	-	-	0.90	0.83	-	-	-	-	-	-	-	-
RIVERSIDE	Sewered Residential	-	-	-	-	-	56.18	52.00	-	-	-	-	-	-	-	-
Riverside County	Commercial / Industrial	14.35	27.88	20.88	52.29	22.04	40.56	37.54	49.49	44.44	93.43	9.25	40.42	4.00	78.43	7.76
Riverside County	Forested	200.59	553.77	176.87	956.66	403.14	377.11	349.05	483.59	434.28	1,125.86	111.46	623.71	61.75	1,337.05	132.37
Riverside County	Non-Irrigated Cropland	-	0.00	17.00	269.88	113.73	41.24	38.18	24.49	21.99	58.79	5.82	40.91	4.05	200.10	19.81
Riverside County	Open Space	1.04	6.07	53.42	20.31	8.56	46.25	42.81	2.14	1.92	90.09	8.92	25.20	2.50	48.05	4.76
Riverside County	Orchards / Vineyards	0.07	11.06	1.13	2.17	0.92	8.41	7.79	7.08	6.36	1.22	0.12	7.83	0.78	-	-
Riverside County	Other Livestock	1.48	3.77	2.72	27.28	11.50	2.73	2.53	12.44	11.18	0.96	0.10	1.46	0.14	39.40	3.90
Riverside County	Pasture / Hay	1.31	17.33	0.83	13.68	5.77	7.00	6.48	17.28	15.51	1.93	0.19	2.24	0.22	3.67	0.36
Riverside County	Roadway	0.17	0.57	3.49	5.72	2.41	7.45	6.89	8.73	7.84	9.84	0.97	2.59	0.26	-	-
Riverside County	Sewered Residential	143.00	308.85	19.66	266.01	112.10	63.78	59.04	166.75	149.74	98.09	9.71	198.88	19.69	388.01	38.41
Riverside County	Unsewered Residential	7.52	59.74	2.53	30.14	12.70	17.28	15.99	34.04	30.57	4.01	0.40	2.26	0.22	37.16	3.68
Riverside County	Water	7.95	1.24	7.70	0.32	0.14	0.79	0.73	-	-	1.98	0.20	8.79	0.87	40.38	4.00
SAN JACINTO	Commercial / Industrial	-	-	-	2.44	1.03	-	-	-	-	142.05	14.06	1.92	0.19	-	-
SAN JACINTO	Forested	-	-	-	5.09	2.14	-	-	2.83	2.54	217.88	21.57	50.22	4.97	-	-
SAN JACINTO	Non-Irrigated Cropland	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	-	-
SAN JACINTO	Open Space	-	-	-	1.26	0.53	-	-	-	-	36.87	3.65	12.27	1.21	-	-
SAN JACINTO	Orchards / Vineyards	-	-	-	-	-	-	-	-	-	2.02	0.20	0.37	0.04	-	-
SAN JACINTO	Other Livestock	-	-	-	-	-	-	-	-	-	9.71	0.96	-	-	-	-
SAN JACINTO	Pasture / Hay	-	-	-	-	-	-	-	-	-	2.52	0.25	-	-	-	-
SAN JACINTO	Roadway	-	-	-	-	-	-	-	-	-	6.67	0.66	1.54	0.15	-	-
SAN JACINTO	Sewered Residential	-	-	-	0.44	0.19	-	-	-	-	352.32	34.88	25.98	2.57	-	-
SAN JACINTO	Unsewered Residential	-	-	-	-	-	-	-	-	-	1.09	0.11	-	-	-	-
SAN JACINTO	Water	-	-	-	0.93	0.39	-	-	-	-	0.05	0.01	13.44	1.33	-	-
State Land	Commercial / Industrial	-	0.04	-	-	-	1.19	1.10	-	-	-	-	1.24	0.12	0.28	0.03
State Land	Forested	-	20.19	-	-	-	93.20	86.26	8.32	7.47	35.24	3.49	12.98	1.29	606.27	60.02
State Land	Non-Irrigated Cropland	-	-	-	-	-	2.84	2.63	-	-	-	-	-	-	-	-
State Land	Open Space	-	-	-	-	-	23.15	21.43	-	-	-	-	-	-	3.55	0.35
State Land	Orchards / Vineyards	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-
State Land	Roadway	-	-	-	-	-	0.07	0.07	-	-	-	-	-	-	-	-
State Land	Sewered Residential	-	0.09	-	-	-	1.72	1.59	-	-	-	-	0.15	0.02	0.76	0.08
State Land	Unsewered Residential	-	0.18	-	-	-	-	-	-	-	-	-	-	-	0.01	0.00
State Land	Water	-	-	-	-	-	0.02	0.02	-	-	-	-	-	-	-	-

Owner	Land Use	Zone 1 Q (AFY)	Zone 2 Q (AFY)	Zone 3 Q (AFY)	Zone 4 Qshed (AFY)	Zone 4 Q (AFY)	Zone 5 Qshed (AFY)	Zone 5 Q (AFY)	Zone 6 Qshed (AFY)	Zone 6 Q (AFY)	Zone 7 Qshed (AFY)	Zone 7 Q (AFY)	Zone 8 Qshed (AFY)	Zone 8 Q (AFY)	Zone 9 Qshed (AFY)	Zone 9 Q (AFY)
Tribal Reservations	Commercial / Industrial	-	-	-	-	-	-	-	-	-	-	-	7.65	0.76	-	-
Tribal Reservations	Forested	-	-	-	-	-	-	-	-	-	39.59	3.92	364.89	36.12	25.87	2.56
Tribal Reservations	Non-Irrigated Cropland	-	-	-	-	-	-	-	-	-	0.08	0.01	-	-	-	-
Tribal Reservations	Open Space	-	-	-	-	-	-	-	-	-	-	-	3.25	0.32	-	-
Tribal Reservations	Pasture / Hay	-	-	-	-	-	-	-	-	-	-	-	0.19	0.02	-	-
Tribal Reservations	Sewered Residential	-	-	-	-	-	-	-	-	-	-	-	16.98	1.68	-	-
Tribal Reservations	Water	-	-	-	-	-	-	-	-	-	-	-	5.71	0.57	-	-
Western Riverside County Regional Conservation Aut	Commercial / Industrial	-	-	-	-	-	-	-	-	-	0.68	0.07	-	-	-	-
Western Riverside County Regional Conservation Aut	Forested	-	-	-	48.46	20.42	24.10	22.31	7.33	6.58	59.61	5.90	-	-	-	-
Western Riverside County Regional Conservation Aut	Non-Irrigated Cropland	-	-	-	-	-	-	-	-	-	13.00	1.29	-	-	-	-
Western Riverside County Regional Conservation Aut	Open Space	-	-	-	-	-	-	-	-	-	2.55	0.25	-	-	-	-
Western Riverside County Regional Conservation Aut	Sewered Residential	-	-	-	0.23	0.10	0.01	0.01	-	-	-	-	-	-	-	-
Western Riverside County Regional Conservation Aut	Unsewered Residential	-	-	-	0.00	0.00	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Commercial / Industrial	23.31	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Forested	133.20	-	0.34	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Open Space	1.47	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Orchards / Vineyards	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Pasture / Hay	0.95	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Roadway	5.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Sewered Residential	149.77	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Unsewered Residential	7.41	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Water	0.08	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Owner	Land Use	Zone 1 TP (kg/yr)	Zone 2 TP (kg/yr)	Zone 3 TP (kg/yr)	Zone 4 TPshed (kg/yr)	Zone 4 TP (kg/yr)	Zone 5 TPshed (kg/yr)	Zone 5 TP (kg/yr)	Zone 6 TPshed (kg/yr)	Zone 6 TP (kg/yr)	Zone 7 TPshed (kg/yr)	Zone 7 TP (kg/yr)	Zone 8 TPshed (kg/yr)	Zone 8 TP (kg/yr)	Zone 9 TPshed (kg/yr)	Zone 9 TP (kg/yr)
Ag-CWAD Non-irrigated	Commercial / Industrial	0.06	0.00	0.46	1.07	0.45	0.11	0.10	3.43	3.08	5.16	0.51	1.09	0.11	-	-
Ag-CWAD Non-irrigated	Forested	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
Ag-CWAD Irrigated	Irrigated Cropland	-	51.29	58.19	47.12	19.86	26.63	24.65	183.13	164.45	215.52	21.34	9.86	0.98	-	-
Ag-CWAD Non-irrigated	Non-Irrigated Cropland	1.59	189.99	222.34	202.93	85.52	186.21	172.36	66.61	59.82	249.94	24.74	-	-	-	-
Ag-CWAD Non-irrigated	Open Space	-	-	-	-	-	0.14	0.13	-	-	-	-	-	-	-	-
Ag-CWAD Irrigated	Orchards / Vineyards	-	0.02	0.05	1.87	0.79	0.15	0.14	0.23	0.21	9.44	0.93	41.80	4.14	2.54	0.25
Ag-CWAD Non-irrigated	Other Livestock	-	78.25	76.64	168.75	71.11	0.56	0.52	209.29	187.95	329.13	32.58	-	-	256.81	25.42
Ag-CWAD Non-irrigated	Pasture / Hay	-	-	1.42	-	-	-	-	-	-	0.36	0.04	-	-	2.09	0.21
Ag-CWAD Non-irrigated	Roadway	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	-	-
Ag-CWAD Non-irrigated	Sewered Residential	-	0.00	-	0.00	0.00	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ag-Small	Commercial / Industrial	0.26	0.22	0.51	1.94	0.82	1.34	1.24	0.86	0.77	0.72	0.07	0.91	0.09	-	-
Ag-Small	Irrigated Cropland	-	7.42	4.15	4.34	1.83	6.24	5.78	13.78	12.38	6.95	0.69	0.42	0.04	-	-
Ag-Small	Non-Irrigated Cropland	0.60	30.44	58.27	38.39	16.18	48.03	44.46	17.15	15.40	17.86	1.77	0.17	0.02	-	-
Ag-Small	Orchards / Vineyards	0.86	0.60	0.58	0.92	0.39	0.41	0.38	0.24	0.21	2.84	0.28	4.19	0.41	0.62	0.06
Ag-Small	Other Livestock	-	-	-	14.44	6.08	-	-	10.24	9.20	0.06	0.01	-	-	-	-
Ag-Small	Pasture / Hay	-	1.49	1.16	1.55	0.65	0.14	0.13	1.55	1.39	0.64	0.06	-	-	-	-
BANNING	Commercial / Industrial	-	-	-	-	-	-	-	-	-	4.65	0.46	-	-	-	-
BANNING	Forested	-	-	-	-	-	-	-	-	-	1.76	0.17	-	-	-	-
BANNING	Open Space	-	-	-	-	-	-	-	-	-	1.15	0.11	-	-	-	-
BANNING	Roadway	-	-	-	-	-	-	-	-	-	0.06	0.01	-	-	-	-
BANNING	Sewered Residential	-	-	-	-	-	-	-	-	-	11.20	1.11	-	-	-	-
BANNING	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BEAUMONT	Commercial / Industrial	-	-	-	-	-	-	-	-	-	31.55	3.12	-	-	-	-
BEAUMONT	Forested	-	-	-	-	-	-	-	-	-	45.10	4.46	-	-	-	-
BEAUMONT	Open Space	-	-	-	-	-	-	-	-	-	2.12	0.21	-	-	-	-
BEAUMONT	Roadway	-	-	-	-	-	-	-	-	-	0.42	0.04	-	-	-	-
BEAUMONT	Sewered Residential	-	-	-	-	-	-	-	-	-	61.30	6.07	-	-	-	-
CAFO	Dairy	0.15	-	-	-	-	-	-	7.47	6.70	23.58	23.58	-	-	-	-
CAFO	Pasture / Hay	0.02	-	0.96	0.11	0.05	-	-	1.50	1.35	8.99	8.99	-	-	-	-
California Department of Fish and Wildlife	Commercial / Industrial	-	-	-	-	-	0.06	0.06	-	-	0.08	0.01	-	-	-	-
California Department of Fish and Wildlife	Forested	-	-	-	-	-	9.96	9.22	66.86	60.04	312.37	30.92	2.66	0.26	-	-
California Department of Fish and Wildlife	Non-Irrigated Cropland	-	-	-	-	-	-	-	-	-	3.59	0.36	-	-	-	-
California Department of Fish and Wildlife	Other Livestock	-	-	-	-	-	-	-	-	-	0.00	0.00	-	-	-	-
California Department of Fish and Wildlife	Roadway	-	-	-	-	-	0.00	0.00	-	-	0.00	0.00	-	-	-	-
Caltrans	Commercial / Industrial	1.68	3.71	0.15	4.76	2.01	1.21	1.12	-	-	8.01	0.79	1.35	0.13	2.57	0.25
Caltrans	Forested	2.07	2.46	0.54	1.94	0.82	0.55	0.51	-	-	4.79	0.47	2.28	0.23	23.95	2.37
Caltrans	Non-Irrigated Cropland	-	-	-	0.12	0.05	-	-	-	-	-	-	0.15	0.02	0.46	0.05
Caltrans	Open Space	0.32	0.01	-	0.10	0.04	0.04	0.04	-	-	0.48	0.05	0.20	0.02	0.34	0.03
Caltrans	Orchards / Vineyards	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Caltrans	Other Livestock	-	-	-	-	-	0.01	0.01	-	-	-	-	-	-	1.65	0.16
Caltrans	Pasture / Hay	-	-	-	0.01	0.01	-	-	-	-	-	-	-	-	0.00	0.00
Caltrans	Roadway	5.45	5.90	7.66	0.02	0.01	17.86	16.53	-	-	6.29	0.62	0.01	0.00	-	-
Caltrans	Sewered Residential	0.62	2.09	0.00	1.04	0.44	0.74	0.68	-	-	0.73	0.07	1.30	0.13	5.06	0.50
Caltrans	Unsewered Residential	-	0.06	-	0.02	0.01	-	-	-	-	0.01	0.00	0.00	0.00	0.13	0.01
Caltrans	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Commercial / Industrial	2.44	0.90	2.02	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Forested	2.80	2.71	1.42	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Non-Irrigated Cropland	-	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Open Space	1.81	1.30	1.24	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Other Livestock	-	8.52	-	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Roadway	0.41	0.19	0.69	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Sewered Residential	7.05	32.57	51.60	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CR&R	Open Space	-	-	-	-	-	-	-	-	-	4.35	0.43	-	-	-	-
Federal - DOD	Commercial / Industrial	-	-	-	-	-	31.16	28.85	-	-	-	-	-	-	-	-
Federal - DOD	Forested	-	-	-	-	-	0.07	0.06	-	-	-	-	-	-	-	-
Federal - DOD	Irrigated Cropland	-	-	-	-	-	0.06	0.05	-	-	-	-	-	-	-	-
Federal - DOD	Open Space	-	-	-	-	-	22.92	21.22	-	-	-	-	-	-	-	-
Federal - DOD	Roadway	-	-	-	-	-	20.02	18.53	-	-	-	-	-	-	-	-
Federal - DOD	Sewered Residential	-	-	-	-	-	0.01	0.01	-	-	-	-	-	-	-	-

Owner	Land Use	Zone 1 TP (kg/yr)	Zone 2 TP (kg/yr)	Zone 3 TP (kg/yr)	Zone 4 TPshed (kg/yr)	Zone 4 TP (kg/yr)	Zone 5 TPshed (kg/yr)	Zone 5 TP (kg/yr)	Zone 6 TPshed (kg/yr)	Zone 6 TP (kg/yr)	Zone 7 TPshed (kg/yr)	Zone 7 TP (kg/yr)	Zone 8 TPshed (kg/yr)	Zone 8 TP (kg/yr)	Zone 9 TPshed (kg/yr)	Zone 9 TP (kg/yr)
Federal - National Forest	Commercial / Industrial	-	-	-	-	-	-	-	-	-	-	-	0.47	0.05	5.07	0.50
Federal - National Forest	Forested	105.38	-	-	7.52	3.17	-	-	-	-	-	-	606.63	60.06	2,668.07	264.14
Federal - National Forest	Non-Irrigated Cropland	-	-	-	-	-	-	-	-	-	-	-	0.01	0.00	9.69	0.96
Federal - National Forest	Open Space	-	-	-	-	-	-	-	-	-	-	-	0.28	0.03	4.87	0.48
Federal - National Forest	Other Livestock	-	-	-	-	-	-	-	-	-	-	-	-	-	2.48	0.25
Federal - National Forest	Pasture / Hay	0.47	-	-	-	-	-	-	-	-	-	-	-	-	0.48	0.05
Federal - National Forest	Sewered Residential	0.40	-	-	-	-	-	-	-	-	-	-	0.06	0.01	7.87	0.78
Federal - National Forest	Unsewered Residential	0.01	-	-	-	-	-	-	-	-	-	-	0.01	0.00	0.44	0.04
Federal - National Forest	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal - Other	Commercial / Industrial	-	0.00	-	-	-	-	-	0.31	0.27	0.06	0.01	0.03	0.00	-	-
Federal - Other	Forested	-	41.17	2.44	22.07	9.30	1.15	1.06	4.35	3.91	148.33	14.68	167.48	16.58	-	-
Federal - Other	Non-Irrigated Cropland	-	-	0.00	5.21	2.20	-	-	-	-	-	-	0.00	0.00	-	-
Federal - Other	Open Space	-	0.00	-	-	-	-	-	-	-	-	-	0.04	0.00	-	-
Federal - Other	Orchards / Vineyards	-	-	-	-	-	-	-	-	-	-	-	0.01	0.00	-	-
Federal - Other	Pasture / Hay	-	-	-	0.03	0.01	-	-	-	-	-	-	0.27	0.03	-	-
Federal - Other	Roadway	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal - Other	Sewered Residential	-	0.16	0.02	0.04	0.02	-	-	0.00	0.00	-	-	0.32	0.03	-	-
Federal - Other	Unsewered Residential	-	0.02	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal - Other	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal - Wilderness	Forested	-	-	-	-	-	-	-	-	-	-	-	272.68	27.00	371.57	36.79
Federal - Wilderness	Pasture / Hay	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09	0.01
HEMET	Commercial / Industrial	-	-	-	107.55	45.32	-	-	-	-	59.91	5.93	1.45	0.14	-	-
HEMET	Forested	-	-	-	65.73	27.70	-	-	-	-	14.89	1.47	0.50	0.05	-	-
HEMET	Non-Irrigated Cropland	-	-	-	98.15	41.36	-	-	-	-	14.56	1.44	0.31	0.03	-	-
HEMET	Open Space	-	-	-	24.68	10.40	-	-	-	-	2.97	0.29	0.62	0.06	-	-
HEMET	Orchards / Vineyards	-	-	-	-	-	-	-	-	-	0.01	0.00	-	-	-	-
HEMET	Other Livestock	-	-	-	1.95	0.82	-	-	-	-	21.30	2.11	-	-	-	-
HEMET	Pasture / Hay	-	-	-	0.65	0.27	-	-	-	-	5.70	0.56	0.00	0.00	-	-
HEMET	Roadway	-	-	-	4.74	2.00	-	-	-	-	0.06	0.01	0.00	0.00	-	-
HEMET	Sewered Residential	-	-	-	297.23	125.26	-	-	-	-	142.30	14.09	19.37	1.92	-	-
HEMET	Unsewered Residential	-	-	-	0.36	0.15	-	-	-	-	1.11	0.11	-	-	-	-
HEMET	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Commercial / Industrial	76.40	1.37	5.05	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Forested	131.21	17.66	4.51	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Open Space	10.89	0.75	-	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Other Livestock	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Pasture / Hay	0.32	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Roadway	2.40	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Sewered Residential	185.50	27.49	2.40	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Unsewered Residential	0.41	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
March Joint Powers Authority	Commercial / Industrial	-	-	-	-	-	22.68	20.99	-	-	-	-	-	-	-	-
March Joint Powers Authority	Forested	-	-	-	-	-	30.74	28.46	-	-	-	-	-	-	-	-
March Joint Powers Authority	Open Space	-	-	-	-	-	4.08	3.77	-	-	-	-	-	-	-	-
March Joint Powers Authority	Roadway	-	-	-	-	-	0.19	0.17	-	-	-	-	-	-	-	-
March Joint Powers Authority	Sewered Residential	-	-	-	-	-	4.62	4.28	-	-	-	-	-	-	-	-
MENIFEE	Commercial / Industrial	-	42.00	95.48	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Forested	5.68	42.23	118.08	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Non-Irrigated Cropland	0.70	9.67	76.50	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Open Space	-	4.95	46.66	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Orchards / Vineyards	-	0.27	1.14	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Other Livestock	1.57	46.89	72.62	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Pasture / Hay	0.58	13.15	27.75	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Roadway	-	1.45	7.33	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Sewered Residential	3.26	86.81	501.99	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Unsewered Residential	0.93	6.31	17.12	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Owner	Land Use	Zone 1 TP (kg/yr)	Zone 2 TP (kg/yr)	Zone 3 TP (kg/yr)	Zone 4 TPshed (kg/yr)	Zone 4 TP (kg/yr)	Zone 5 TPshed (kg/yr)	Zone 5 TP (kg/yr)	Zone 6 TPshed (kg/yr)	Zone 6 TP (kg/yr)	Zone 7 TPshed (kg/yr)	Zone 7 TP (kg/yr)	Zone 8 TPshed (kg/yr)	Zone 8 TP (kg/yr)	Zone 9 TPshed (kg/yr)	Zone 9 TP (kg/yr)
MORENO VALLEY	Commercial / Industrial	-	-	-	-	-	208.76	193.23	-	-	2.04	0.20	-	-	-	-
MORENO VALLEY	Forested	-	-	-	-	-	121.88	112.82	-	-	10.50	1.04	-	-	-	-
MORENO VALLEY	Irrigated Cropland	-	-	-	-	-	0.00	0.00	-	-	-	-	-	-	-	-
MORENO VALLEY	Open Space	-	-	-	-	-	18.57	17.19	-	-	-	-	-	-	-	-
MORENO VALLEY	Orchards / Vineyards	-	-	-	-	-	1.08	1.00	-	-	0.19	0.02	-	-	-	-
MORENO VALLEY	Other Livestock	-	-	-	-	-	8.15	7.55	-	-	2.67	0.26	-	-	-	-
MORENO VALLEY	Pasture / Hay	-	-	-	-	-	9.50	8.79	-	-	0.48	0.05	-	-	-	-
MORENO VALLEY	Roadway	-	-	-	-	-	13.47	12.47	-	-	0.09	0.01	-	-	-	-
MORENO VALLEY	Sewered Residential	-	-	-	-	-	709.59	656.80	-	-	0.21	0.02	-	-	-	-
MORENO VALLEY	Unsewered Residential	-	-	-	-	-	4.15	3.84	-	-	0.00	0.00	-	-	-	-
MORENO VALLEY	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MURRIETA	Commercial / Industrial	-	-	4.43	-	-	-	-	-	-	-	-	-	-	-	-
MURRIETA	Forested	-	-	1.88	-	-	-	-	-	-	-	-	-	-	-	-
MURRIETA	Open Space	-	-	0.22	-	-	-	-	-	-	-	-	-	-	-	-
MURRIETA	Pasture / Hay	-	-	0.02	-	-	-	-	-	-	-	-	-	-	-	-
MURRIETA	Roadway	-	-	0.14	-	-	-	-	-	-	-	-	-	-	-	-
MURRIETA	Sewered Residential	-	-	15.94	-	-	-	-	-	-	-	-	-	-	-	-
PERRIS	Commercial / Industrial	-	72.50	-	-	-	114.89	106.34	0.31	0.28	-	-	-	-	-	-
PERRIS	Forested	-	80.81	1.08	-	-	45.34	41.97	0.01	0.01	-	-	-	-	-	-
PERRIS	Non-Irrigated Cropland	-	-	-	-	-	0.00	0.00	-	-	-	-	-	-	-	-
PERRIS	Open Space	-	15.48	0.00	-	-	8.46	7.83	0.02	0.02	-	-	-	-	-	-
PERRIS	Orchards / Vineyards	-	0.51	-	-	-	0.31	0.29	-	-	-	-	-	-	-	-
PERRIS	Pasture / Hay	-	0.13	-	-	-	1.47	1.36	-	-	-	-	-	-	-	-
PERRIS	Roadway	-	2.87	-	-	-	5.36	4.97	-	-	-	-	-	-	-	-
PERRIS	Sewered Residential	-	70.27	-	-	-	165.64	153.32	-	-	-	-	-	-	-	-
PERRIS	Unsewered Residential	-	0.42	-	-	-	0.02	0.02	-	-	-	-	-	-	-	-
PERRIS	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RIVERSIDE	Commercial / Industrial	-	-	-	-	-	1.48	1.37	-	-	-	-	-	-	-	-
RIVERSIDE	Forested	-	-	-	-	-	0.08	0.07	-	-	-	-	-	-	-	-
RIVERSIDE	Open Space	-	-	-	-	-	0.36	0.33	-	-	-	-	-	-	-	-
RIVERSIDE	Sewered Residential	-	-	-	-	-	33.27	30.79	-	-	-	-	-	-	-	-
Riverside County	Commercial / Industrial	9.56	18.57	13.91	34.83	14.68	27.02	25.01	32.97	29.61	62.24	6.16	26.93	2.67	52.25	5.17
Riverside County	Forested	79.18	218.61	69.82	377.65	159.14	148.87	137.79	190.90	171.43	444.44	44.00	246.22	24.38	527.81	52.25
Riverside County	Non-Irrigated Cropland	-	0.00	32.33	513.18	216.26	78.43	72.59	46.57	41.82	111.80	11.07	77.80	7.70	380.50	37.67
Riverside County	Open Space	0.41	2.39	21.09	8.02	3.38	18.26	16.90	0.85	0.76	35.57	3.52	9.95	0.98	18.97	1.88
Riverside County	Orchards / Vineyards	0.02	3.64	0.37	0.72	0.30	2.77	2.56	2.33	2.09	0.40	0.04	2.58	0.26	-	-
Riverside County	Other Livestock	16.56	42.27	30.58	306.28	129.07	30.63	28.35	139.70	125.45	10.80	1.07	16.36	1.62	442.28	43.79
Riverside County	Pasture / Hay	3.18	41.94	2.00	33.12	13.96	16.94	15.68	41.81	37.55	4.67	0.46	5.42	0.54	8.88	0.88
Riverside County	Roadway	0.07	0.22	1.34	2.19	0.92	2.85	2.64	3.34	3.00	3.76	0.37	0.99	0.10	-	-
Riverside County	Sewered Residential	84.68	182.88	11.64	157.51	66.38	37.77	34.96	98.74	88.67	58.08	5.75	117.76	11.66	229.75	22.75
Riverside County	Unsewered Residential	5.48	43.48	1.84	21.94	9.24	12.58	11.64	24.77	22.25	2.92	0.29	1.65	0.16	27.05	2.68
Riverside County	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SAN JACINTO	Commercial / Industrial	-	-	-	1.62	0.68	-	-	-	-	94.63	9.37	1.28	0.13	-	-
SAN JACINTO	Forested	-	-	-	2.01	0.85	-	-	1.12	1.00	86.01	8.52	19.83	1.96	-	-
SAN JACINTO	Non-Irrigated Cropland	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	-	-
SAN JACINTO	Open Space	-	-	-	0.50	0.21	-	-	-	-	14.55	1.44	4.84	0.48	-	-
SAN JACINTO	Orchards / Vineyards	-	-	-	-	-	-	-	-	-	0.66	0.07	0.12	0.01	-	-
SAN JACINTO	Other Livestock	-	-	-	-	-	-	-	-	-	109.02	10.79	-	-	-	-
SAN JACINTO	Pasture / Hay	-	-	-	-	-	-	-	-	-	6.10	0.60	-	-	-	-
SAN JACINTO	Roadway	-	-	-	-	-	-	-	-	-	2.55	0.25	0.59	0.06	-	-
SAN JACINTO	Sewered Residential	-	-	-	0.26	0.11	-	-	-	-	208.62	20.65	15.39	1.52	-	-
SAN JACINTO	Unsewered Residential	-	-	-	-	-	-	-	-	-	0.79	0.08	-	-	-	-
SAN JACINTO	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
State Land	Commercial / Industrial	-	0.03	-	-	-	0.79	0.73	-	-	-	-	0.83	0.08	0.19	0.02
State Land	Forested	-	7.97	-	-	-	36.79	34.05	3.28	2.95	13.91	1.38	5.12	0.51	239.33	23.69
State Land	Non-Irrigated Cropland	-	-	-	-	-	5.40	5.00	-	-	-	-	-	-	-	-
State Land	Open Space	-	-	-	-	-	9.14	8.46	-	-	-	-	-	-	1.40	0.14
State Land	Orchards / Vineyards	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
State Land	Roadway	-	-	-	-	-	0.03	0.03	-	-	-	-	-	-	-	-
State Land	Sewered Residential	-	0.05	-	-	-	1.02	0.94	-	-	-	-	0.09	0.01	0.45	0.04
State Land	Unsewered Residential	-	0.13	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00
State Land	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Owner	Land Use	Zone 1 TP (kg/yr)	Zone 2 TP (kg/yr)	Zone 3 TP (kg/yr)	Zone 4 TPshed (kg/yr)	Zone 4 TP (kg/yr)	Zone 5 TPshed (kg/yr)	Zone 5 TP (kg/yr)	Zone 6 TPshed (kg/yr)	Zone 6 TP (kg/yr)	Zone 7 TPshed (kg/yr)	Zone 7 TP (kg/yr)	Zone 8 TPshed (kg/yr)	Zone 8 TP (kg/yr)	Zone 9 TPshed (kg/yr)	Zone 9 TP (kg/yr)
Tribal Reservations	Commercial / Industrial	-	-	-	-	-	-	-	-	-	-	-	5.09	0.50	-	-
Tribal Reservations	Forested	-	-	-	-	-	-	-	-	-	15.63	1.55	144.05	14.26	10.21	1.01
Tribal Reservations	Non-Irrigated Cropland	-	-	-	-	-	-	-	-	-	0.16	0.02	-	-	-	-
Tribal Reservations	Open Space	-	-	-	-	-	-	-	-	-	-	-	1.28	0.13	-	-
Tribal Reservations	Pasture / Hay	-	-	-	-	-	-	-	-	-	-	-	0.46	0.05	-	-
Tribal Reservations	Sewered Residential	-	-	-	-	-	-	-	-	-	-	-	10.05	1.00	-	-
Tribal Reservations	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Western Riverside County Regional Conservation Aut	Commercial / Industrial	-	-	-	-	-	-	-	-	-	0.45	0.04	-	-	-	-
Western Riverside County Regional Conservation Aut	Forested	-	-	-	19.13	8.06	9.51	8.81	2.89	2.60	23.53	2.33	-	-	-	-
Western Riverside County Regional Conservation Aut	Non-Irrigated Cropland	-	-	-	-	-	-	-	-	-	24.72	2.45	-	-	-	-
Western Riverside County Regional Conservation Aut	Open Space	-	-	-	-	-	-	-	-	-	1.01	0.10	-	-	-	-
Western Riverside County Regional Conservation Aut	Sewered Residential	-	-	-	0.14	0.06	0.01	0.01	-	-	-	-	-	-	-	-
Western Riverside County Regional Conservation Aut	Unsewered Residential	-	-	-	0.00	0.00	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Commercial / Industrial	15.53	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Forested	52.58	-	0.13	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Open Space	0.58	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Orchards / Vineyards	0.33	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Pasture / Hay	2.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Roadway	2.22	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Sewered Residential	88.69	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Unsewered Residential	5.39	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Owner	Land Use	Zone 1 TN (kg/yr)	Zone 2 TN (kg/yr)	Zone 3 TN (kg/yr)	Zone 4 TNshed (kg/yr)	Zone 4 TN (kg/yr)	Zone 5 TNshed (kg/yr)	Zone 5 TN (kg/yr)	Zone 6 TNshed (kg/yr)	Zone 6 TN (kg/yr)	Zone 7 TNshed (kg/yr)	Zone 7 TN (kg/yr)	Zone 8 TNshed (kg/yr)	Zone 8 TN (kg/yr)	Zone 9 TNshed (kg/yr)	Zone 9 TN (kg/yr)
Ag-CWAD Non-irrigated	Commercial / Industrial	0.44	0.00	3.32	7.69	3.24	0.79	0.73	24.73	22.21	37.20	3.68	7.84	0.78	-	-
Ag-CWAD Non-irrigated	Forested	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
Ag-CWAD Irrigated	Irrigated Cropland	-	47.63	54.03	43.76	18.44	24.73	22.89	170.05	152.70	200.12	19.81	9.16	0.91	-	-
Ag-CWAD Non-irrigated	Non-Irrigated Cropland	2.02	241.81	282.98	258.27	108.84	237.00	219.36	84.78	76.14	318.11	31.49	-	-	-	-
Ag-CWAD Non-irrigated	Open Space	-	-	-	-	-	0.41	0.38	-	-	-	-	-	-	-	-
Ag-CWAD Irrigated	Orchards / Vineyards	-	0.01	0.03	1.28	0.54	0.11	0.10	0.16	0.14	6.49	0.64	28.73	2.84	1.75	0.17
Ag-CWAD Non-irrigated	Other Livestock	-	128.13	125.48	276.31	116.44	0.91	0.85	342.68	307.73	538.90	53.35	-	-	420.50	41.63
Ag-CWAD Non-irrigated	Pasture / Hay	-	-	1.32	-	-	-	-	-	-	0.34	0.03	-	-	1.94	0.19
Ag-CWAD Non-irrigated	Roadway	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	-	-
Ag-CWAD Non-irrigated	Sewered Residential	-	0.00	-	0.00	0.00	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ag-Small	Commercial / Industrial	1.88	1.58	3.69	13.98	5.89	9.66	8.94	6.17	5.54	5.18	0.51	6.57	0.65	-	-
Ag-Small	Irrigated Cropland	-	6.89	3.85	4.03	1.70	5.80	5.37	12.80	11.49	6.46	0.64	0.39	0.04	-	-
Ag-Small	Non-Irrigated Cropland	0.76	38.74	74.16	48.86	20.59	61.13	56.59	21.82	19.60	22.73	2.25	0.22	0.02	-	-
Ag-Small	Orchards / Vineyards	0.59	0.41	0.40	0.63	0.27	0.28	0.26	0.16	0.15	1.96	0.19	2.88	0.28	0.42	0.04
Ag-Small	Other Livestock	-	-	-	23.64	9.96	-	-	16.77	15.06	0.09	0.01	-	-	-	-
Ag-Small	Pasture / Hay	-	1.39	1.08	1.44	0.61	0.13	0.12	1.44	1.29	0.60	0.06	-	-	-	-
BANNING	Commercial / Industrial	-	-	-	-	-	-	-	-	-	33.53	3.32	-	-	-	-
BANNING	Forested	-	-	-	-	-	-	-	-	-	5.07	0.50	-	-	-	-
BANNING	Open Space	-	-	-	-	-	-	-	-	-	3.29	0.33	-	-	-	-
BANNING	Roadway	-	-	-	-	-	-	-	-	-	1.00	0.10	-	-	-	-
BANNING	Sewered Residential	-	-	-	-	-	-	-	-	-	68.37	6.77	-	-	-	-
BANNING	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BEAUMONT	Commercial / Industrial	-	-	-	-	-	-	-	-	-	227.25	22.50	-	-	-	-
BEAUMONT	Forested	-	-	-	-	-	-	-	-	-	129.66	12.84	-	-	-	-
BEAUMONT	Open Space	-	-	-	-	-	-	-	-	-	6.10	0.60	-	-	-	-
BEAUMONT	Roadway	-	-	-	-	-	-	-	-	-	6.62	0.66	-	-	-	-
BEAUMONT	Sewered Residential	-	-	-	-	-	-	-	-	-	374.17	37.04	-	-	-	-
CAFO	Dairy	0.24	-	-	-	-	-	-	12.22	10.98	38.61	38.61	-	-	-	-
CAFO	Pasture / Hay	0.02	-	0.90	0.10	0.04	-	-	1.39	1.25	8.35	8.35	-	-	-	-
California Department of Fish and Wildlife	Commercial / Industrial	-	-	-	-	-	0.45	0.42	-	-	0.57	0.06	-	-	-	-
California Department of Fish and Wildlife	Forested	-	-	-	-	-	28.64	26.51	192.23	172.62	898.07	88.91	7.66	0.76	-	-
California Department of Fish and Wildlife	Non-Irrigated Cropland	-	-	-	-	-	-	-	-	-	4.57	0.45	-	-	-	-
California Department of Fish and Wildlife	Other Livestock	-	-	-	-	-	-	-	-	-	0.00	0.00	-	-	-	-
California Department of Fish and Wildlife	Roadway	-	-	-	-	-	0.00	0.00	-	-	0.00	0.00	-	-	-	-
Caltrans	Commercial / Industrial	12.14	26.71	1.09	34.30	14.45	8.72	8.07	-	-	57.74	5.72	9.72	0.96	18.54	1.84
Caltrans	Forested	5.94	7.07	1.54	5.58	2.35	1.59	1.47	-	-	13.78	1.36	6.55	0.65	68.86	6.82
Caltrans	Non-Irrigated Cropland	-	-	-	0.15	0.06	-	-	-	-	-	-	0.19	0.02	0.59	0.06
Caltrans	Open Space	0.92	0.02	-	0.29	0.12	0.13	0.12	-	-	1.38	0.14	0.58	0.06	0.98	0.10
Caltrans	Orchards / Vineyards	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Caltrans	Other Livestock	-	-	-	-	-	0.01	0.01	-	-	-	-	-	-	2.71	0.27
Caltrans	Pasture / Hay	-	-	-	0.01	0.01	-	-	-	-	-	-	-	-	0.00	0.00
Caltrans	Roadway	85.72	92.87	120.52	0.30	0.13	281.18	260.26	-	-	99.03	9.80	0.14	0.01	-	-
Caltrans	Sewered Residential	3.78	12.73	0.00	6.35	2.68	4.50	4.17	-	-	4.44	0.44	7.93	0.78	30.90	3.06
Caltrans	Unsewered Residential	-	0.53	-	0.20	0.08	-	-	-	-	0.05	0.00	0.00	0.00	1.20	0.12
Caltrans	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Commercial / Industrial	17.55	6.49	14.57	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Forested	8.05	7.79	4.07	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Non-Irrigated Cropland	-	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Open Space	5.21	3.75	3.57	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Other Livestock	-	13.95	-	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Roadway	6.46	2.94	10.87	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Sewered Residential	43.05	198.84	314.99	-	-	-	-	-	-	-	-	-	-	-	-
CANYON LAKE	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CR&R	Open Space	-	-	-	-	-	-	-	-	-	12.51	1.24	-	-	-	-
Federal - DOD	Commercial / Industrial	-	-	-	-	-	224.50	207.80	-	-	-	-	-	-	-	-
Federal - DOD	Forested	-	-	-	-	-	0.19	0.18	-	-	-	-	-	-	-	-
Federal - DOD	Irrigated Cropland	-	-	-	-	-	0.05	0.05	-	-	-	-	-	-	-	-
Federal - DOD	Open Space	-	-	-	-	-	65.90	60.99	-	-	-	-	-	-	-	-
Federal - DOD	Roadway	-	-	-	-	-	315.13	291.68	-	-	-	-	-	-	-	-
Federal - DOD	Sewered Residential	-	-	-	-	-	0.06	0.06	-	-	-	-	-	-	-	-
Federal - National Forest	Commercial / Industrial	-	-	-	-	-	-	-	-	-	-	-	3.41	0.34	36.51	3.61
Federal - National Forest	Forested	302.96	-	-	21.62	9.11	-	-	-	-	-	-	1,744.06	172.66	7,670.71	759.40
Federal - National Forest	Non-Irrigated Cropland	-	-	-	-	-	-	-	-	-	-	-	0.01	0.00	12.33	1.22
Federal - National Forest	Open Space	-	-	-	-	-	-	-	-	-	-	-	0.81	0.08	13.99	1.38
Federal - National Forest	Other Livestock	-	-	-	-	-	-	-	-	-	-	-	-	-	4.07	0.40
Federal - National Forest	Pasture / Hay	0.44	-	-	-	-	-	-	-	-	-	-	-	-	0.44	0.04
Federal - National Forest	Sewered Residential	2.46	-	-	-	-	-	-	-	-	-	-	0.39	0.04	48.02	4.75
Federal - National Forest	Unsewered Residential	0.11	-	-	-	-	-	-	-	-	-	-	0.06	0.01	3.93	0.39
Federal - National Forest	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Owner	Land Use	Zone 1 TN (kg/yr)	Zone 2 TN (kg/yr)	Zone 3 TN (kg/yr)	Zone 4 TNshed (kg/yr)	Zone 4 TN (kg/yr)	Zone 5 TNshed (kg/yr)	Zone 5 TN (kg/yr)	Zone 6 TNshed (kg/yr)	Zone 6 TN (kg/yr)	Zone 7 TNshed (kg/yr)	Zone 7 TN (kg/yr)	Zone 8 TNshed (kg/yr)	Zone 8 TN (kg/yr)	Zone 9 TNshed (kg/yr)	Zone 9 TN (kg/yr)
Federal - Other	Commercial / Industrial	-	0.03	-	-	-	-	-	2.20	1.98	0.41	0.04	0.25	0.02	-	-
Federal - Other	Forested	-	118.36	7.03	63.45	26.74	3.30	3.06	12.51	11.23	426.44	42.22	481.51	47.67	-	-
Federal - Other	Non-Irrigated Cropland	-	-	0.00	6.63	2.80	-	-	-	-	-	-	0.00	0.00	-	-
Federal - Other	Open Space	-	0.01	-	-	-	-	-	-	-	-	-	0.13	0.01	-	-
Federal - Other	Orchards / Vineyards	-	-	-	-	-	-	-	-	-	-	-	0.01	0.00	-	-
Federal - Other	Pasture / Hay	-	-	-	0.02	0.01	-	-	-	-	-	-	0.25	0.02	-	-
Federal - Other	Roadway	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal - Other	Sewered Residential	-	0.96	0.12	0.22	0.09	-	-	0.03	0.03	-	-	1.98	0.20	-	-
Federal - Other	Unsewered Residential	-	0.19	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal - Other	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal - Wilderness	Forested	-	-	-	-	-	-	-	-	-	-	-	783.95	77.61	1,068.27	105.76
Federal - Wilderness	Pasture / Hay	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08	0.01
HEMET	Commercial / Industrial	-	-	-	774.77	326.49	-	-	-	-	431.57	42.73	10.43	1.03	-	-
HEMET	Forested	-	-	-	188.98	79.64	-	-	-	-	42.81	4.24	1.44	0.14	-	-
HEMET	Non-Irrigated Cropland	-	-	-	124.92	52.64	-	-	-	-	18.53	1.83	0.40	0.04	-	-
HEMET	Open Space	-	-	-	70.96	29.90	-	-	-	-	8.55	0.85	1.77	0.18	-	-
HEMET	Orchards / Vineyards	-	-	-	-	-	-	-	-	-	0.01	0.00	-	-	-	-
HEMET	Other Livestock	-	-	-	3.20	1.35	-	-	-	-	34.88	3.45	-	-	-	-
HEMET	Pasture / Hay	-	-	-	0.60	0.25	-	-	-	-	5.30	0.52	0.00	0.00	-	-
HEMET	Roadway	-	-	-	74.57	31.43	-	-	-	-	1.02	0.10	0.05	0.00	-	-
HEMET	Sewered Residential	-	-	-	1,814.34	764.58	-	-	-	-	868.59	85.99	118.21	11.70	-	-
HEMET	Unsewered Residential	-	-	-	3.19	1.35	-	-	-	-	9.95	0.98	-	-	-	-
HEMET	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Commercial / Industrial	550.34	9.86	36.36	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Forested	377.23	50.78	12.98	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Open Space	31.30	2.15	-	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Other Livestock	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Pasture / Hay	0.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Roadway	37.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Sewered Residential	1,132.31	167.79	14.67	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Unsewered Residential	3.64	-	0.05	-	-	-	-	-	-	-	-	-	-	-	-
LAKE ELSINORE	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
March Joint Powers Authority	Commercial / Industrial	-	-	-	-	-	163.34	151.19	-	-	-	-	-	-	-	-
March Joint Powers Authority	Forested	-	-	-	-	-	88.39	81.82	-	-	-	-	-	-	-	-
March Joint Powers Authority	Open Space	-	-	-	-	-	11.72	10.85	-	-	-	-	-	-	-	-
March Joint Powers Authority	Roadway	-	-	-	-	-	2.92	2.71	-	-	-	-	-	-	-	-
March Joint Powers Authority	Sewered Residential	-	-	-	-	-	28.22	26.12	-	-	-	-	-	-	-	-
MENIFEE	Commercial / Industrial	-	302.54	687.82	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Forested	16.32	121.41	339.47	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Non-Irrigated Cropland	0.89	12.31	97.36	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Open Space	-	14.24	134.16	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Orchards / Vineyards	-	0.19	0.78	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Other Livestock	2.57	76.78	118.91	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Pasture / Hay	0.54	12.21	25.77	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Roadway	-	22.89	115.33	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Sewered Residential	19.89	529.91	3,064.23	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Unsewered Residential	8.32	56.68	153.83	-	-	-	-	-	-	-	-	-	-	-	-
MENIFEE	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MORENO VALLEY	Commercial / Industrial	-	-	-	-	-	1,503.87	1,391.98	-	-	14.71	1.46	-	-	-	-
MORENO VALLEY	Forested	-	-	-	-	-	350.42	324.34	-	-	30.20	2.99	-	-	-	-
MORENO VALLEY	Irrigated Cropland	-	-	-	-	-	0.00	0.00	-	-	-	-	-	-	-	-
MORENO VALLEY	Open Space	-	-	-	-	-	53.40	49.42	-	-	-	-	-	-	-	-
MORENO VALLEY	Orchards / Vineyards	-	-	-	-	-	0.74	0.69	-	-	0.13	0.01	-	-	-	-
MORENO VALLEY	Other Livestock	-	-	-	-	-	13.35	12.35	-	-	4.38	0.43	-	-	-	-
MORENO VALLEY	Pasture / Hay	-	-	-	-	-	8.82	8.17	-	-	0.45	0.04	-	-	-	-
MORENO VALLEY	Roadway	-	-	-	-	-	212.09	196.31	-	-	1.34	0.13	-	-	-	-
MORENO VALLEY	Sewered Residential	-	-	-	-	-	4,331.48	4,009.22	-	-	1.27	0.13	-	-	-	-
MORENO VALLEY	Unsewered Residential	-	-	-	-	-	37.28	34.51	-	-	0.00	0.00	-	-	-	-
MORENO VALLEY	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MURRIETA	Commercial / Industrial	-	-	31.92	-	-	-	-	-	-	-	-	-	-	-	-
MURRIETA	Forested	-	-	5.41	-	-	-	-	-	-	-	-	-	-	-	-
MURRIETA	Open Space	-	-	0.63	-	-	-	-	-	-	-	-	-	-	-	-
MURRIETA	Pasture / Hay	-	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-
MURRIETA	Roadway	-	-	2.17	-	-	-	-	-	-	-	-	-	-	-	-
MURRIETA	Sewered Residential	-	-	97.32	-	-	-	-	-	-	-	-	-	-	-	-

Owner	Land Use	Zone 1 TN (kg/yr)	Zone 2 TN (kg/yr)	Zone 3 TN (kg/yr)	Zone 4 TNshed (kg/yr)	Zone 4 TN (kg/yr)	Zone 5 TNshed (kg/yr)	Zone 5 TN (kg/yr)	Zone 6 TNshed (kg/yr)	Zone 6 TN (kg/yr)	Zone 7 TNshed (kg/yr)	Zone 7 TN (kg/yr)	Zone 8 TNshed (kg/yr)	Zone 8 TN (kg/yr)	Zone 9 TNshed (kg/yr)	Zone 9 TN (kg/yr)
PERRIS	Commercial / Industrial	-	522.25	-	-	-	827.61	766.03	2.21	1.98	-	-	-	-	-	-
PERRIS	Forested	-	232.33	3.11	-	-	130.37	120.67	0.03	0.03	-	-	-	-	-	-
PERRIS	Non-Irrigated Cropland	-	-	-	-	-	0.00	0.00	-	-	-	-	-	-	-	-
PERRIS	Open Space	-	44.51	0.00	-	-	24.33	22.52	0.07	0.06	-	-	-	-	-	-
PERRIS	Orchards / Vineyards	-	0.35	-	-	-	0.21	0.20	-	-	-	-	-	-	-	-
PERRIS	Pasture / Hay	-	0.12	-	-	-	1.36	1.26	-	-	-	-	-	-	-	-
PERRIS	Roadway	-	45.11	-	-	-	84.46	78.17	-	-	-	-	-	-	-	-
PERRIS	Sewered Residential	-	428.91	-	-	-	1,011.09	935.86	-	-	-	-	-	-	-	-
PERRIS	Unsewered Residential	-	3.79	-	-	-	0.17	0.16	-	-	-	-	-	-	-	-
PERRIS	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RIVERSIDE	Commercial / Industrial	-	-	-	-	-	10.63	9.84	-	-	-	-	-	-	-	-
RIVERSIDE	Forested	-	-	-	-	-	0.22	0.21	-	-	-	-	-	-	-	-
RIVERSIDE	Open Space	-	-	-	-	-	1.02	0.95	-	-	-	-	-	-	-	-
RIVERSIDE	Sewered Residential	-	-	-	-	-	203.07	187.96	-	-	-	-	-	-	-	-
Riverside County	Commercial / Industrial	68.86	133.79	100.20	250.93	105.74	194.65	180.17	237.50	213.27	448.36	44.39	193.97	19.20	376.37	37.26
Riverside County	Forested	227.65	628.50	200.74	1,085.74	457.54	427.99	396.15	548.84	492.87	1,277.77	126.50	707.87	70.08	1,517.46	150.23
Riverside County	Non-Irrigated Cropland	-	0.00	41.14	653.13	275.24	99.82	92.39	59.27	53.22	142.29	14.09	99.01	9.80	484.28	47.94
Riverside County	Open Space	1.18	6.89	60.62	23.05	9.71	52.49	48.58	2.43	2.18	102.25	10.12	28.60	2.83	54.54	5.40
Riverside County	Orchards / Vineyards	0.02	2.50	0.26	0.49	0.21	1.90	1.76	1.60	1.44	0.28	0.03	1.77	0.18	-	-
Riverside County	Other Livestock	27.12	69.21	50.07	501.49	211.33	50.16	46.43	228.74	205.41	17.68	1.75	26.78	2.65	724.17	71.69
Riverside County	Pasture / Hay	2.95	38.95	1.86	30.75	12.96	15.73	14.56	38.82	34.86	4.33	0.43	5.03	0.50	8.24	0.82
Riverside County	Roadway	1.03	3.44	21.03	34.42	14.50	44.82	41.49	52.54	47.18	59.25	5.87	15.58	1.54	-	-
Riverside County	Sewered Residential	516.89	1,116.35	71.07	961.49	405.18	230.54	213.39	602.72	541.25	354.56	35.10	718.85	71.17	1,402.46	138.84
Riverside County	Unsewered Residential	49.18	390.59	16.57	197.07	83.05	112.97	104.57	222.54	199.85	26.19	2.59	14.78	1.46	242.98	24.06
Riverside County	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SAN JACINTO	Commercial / Industrial	-	-	-	11.69	4.93	-	-	-	-	681.65	67.48	9.21	0.91	-	-
SAN JACINTO	Forested	-	-	-	5.78	2.43	-	-	3.21	2.89	247.28	24.48	57.00	5.64	-	-
SAN JACINTO	Non-Irrigated Cropland	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	-	-
SAN JACINTO	Open Space	-	-	-	1.43	0.60	-	-	-	-	41.84	4.14	13.92	1.38	-	-
SAN JACINTO	Orchards / Vineyards	-	-	-	-	-	-	-	-	-	0.46	0.05	0.08	0.01	-	-
SAN JACINTO	Other Livestock	-	-	-	-	-	-	-	-	-	178.51	17.67	-	-	-	-
SAN JACINTO	Pasture / Hay	-	-	-	-	-	-	-	-	-	5.66	0.56	-	-	-	-
SAN JACINTO	Roadway	-	-	-	-	-	-	-	-	-	40.13	3.97	9.27	0.92	-	-
SAN JACINTO	Sewered Residential	-	-	-	1.60	0.68	-	-	-	-	1,273.47	126.07	93.92	9.30	-	-
SAN JACINTO	Unsewered Residential	-	-	-	-	-	-	-	-	-	7.12	0.71	-	-	-	-
SAN JACINTO	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
State Land	Commercial / Industrial	-	0.19	-	-	-	5.70	5.28	-	-	-	-	5.95	0.59	1.35	0.13
State Land	Forested	-	22.92	-	-	-	105.77	97.90	9.44	8.47	40.00	3.96	14.73	1.46	688.07	68.12
State Land	Non-Irrigated Cropland	-	-	-	-	-	6.88	6.36	-	-	-	-	-	-	-	-
State Land	Open Space	-	-	-	-	-	26.28	24.32	-	-	-	-	-	-	4.03	0.40
State Land	Orchards / Vineyards	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
State Land	Roadway	-	-	-	-	-	0.43	0.40	-	-	-	-	-	-	-	-
State Land	Sewered Residential	-	0.31	-	-	-	6.20	5.74	-	-	-	-	0.55	0.05	2.75	0.27
State Land	Unsewered Residential	-	1.17	-	-	-	-	-	-	-	-	-	-	-	0.03	0.00
State Land	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tribal Reservations	Commercial / Industrial	-	-	-	-	-	-	-	-	-	-	-	36.70	3.63	-	-
Tribal Reservations	Forested	-	-	-	-	-	-	-	-	-	44.93	4.45	414.13	41.00	29.36	2.91
Tribal Reservations	Non-Irrigated Cropland	-	-	-	-	-	-	-	-	-	0.20	0.02	-	-	-	-
Tribal Reservations	Open Space	-	-	-	-	-	-	-	-	-	-	-	3.69	0.37	-	-
Tribal Reservations	Pasture / Hay	-	-	-	-	-	-	-	-	-	-	-	0.42	0.04	-	-
Tribal Reservations	Sewered Residential	-	-	-	-	-	-	-	-	-	-	-	61.37	6.08	-	-
Tribal Reservations	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Western Riverside County Regional Conservation Aut	Commercial / Industrial	-	-	-	-	-	-	-	-	-	3.27	0.32	-	-	-	-
Western Riverside County Regional Conservation Aut	Forested	-	-	-	54.99	23.17	27.35	25.32	8.32	7.47	67.65	6.70	-	-	-	-
Western Riverside County Regional Conservation Aut	Non-Irrigated Cropland	-	-	-	-	-	-	-	-	-	31.46	3.11	-	-	-	-
Western Riverside County Regional Conservation Aut	Open Space	-	-	-	-	-	-	-	-	-	2.90	0.29	-	-	-	-
Western Riverside County Regional Conservation Aut	Sewered Residential	-	-	-	0.85	0.36	0.05	0.04	-	-	-	-	-	-	-	-
Western Riverside County Regional Conservation Aut	Unsewered Residential	-	-	-	0.00	0.00	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Commercial / Industrial	111.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Forested	151.18	-	0.38	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Open Space	1.67	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Orchards / Vineyards	0.23	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Pasture / Hay	2.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Roadway	34.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Sewered Residential	541.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Unsewered Residential	48.42	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WILDOMAR	Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Owner	Land Use	Zone 1 TP (kg/yr)	Zone 2 TP (kg/yr)	Zone 3 TP (kg/yr)	Zone 4 TPshed (kg/yr)	Zone 5 TPshed (kg/yr)	Zone 6 TPshed (kg/yr)	Zone 7 TPshed (kg/yr)	Zone 8 TPshed (kg/yr)	Zone 9 TPshed (kg/yr)
Ag-CWAD Non-irrigated	Commercial / Industrial	0.03	0.00	0.25	0.60	0.06	1.89	2.82	0.56	
Ag-CWAD Non-irrigated	Forested		0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Ag-CWAD Irrigated	Irrigated Cropland		34.40	39.16	31.55	17.79	123.40	146.28	6.64	
Ag-CWAD Non-irrigated	Non-Irrigated Cropland	0.32	38.97	45.10	41.70	37.95	13.63	51.13		
Ag-CWAD Non-irrigated	Open Space					0.14				
Ag-CWAD Irrigated	Orchards / Vineyards		0.02	0.05	2.23	0.18	0.26	10.98	48.74	3.05
Ag-CWAD Non-irrigated	Other Livestock		2.68	2.55	5.88	0.02	6.11	11.14		8.79
Ag-CWAD Non-irrigated	Pasture / Hay			0.21				0.06		0.33
Ag-CWAD Non-irrigated	Roadway						0.00	0.00	0.00	
Ag-CWAD Non-irrigated	Sewered Residential		0.00		0.00		0.00	0.00	0.00	0.00
Ag-Small	Commercial / Industrial	0.14	0.13	0.27	1.08	0.75	0.47	0.36	0.48	
Ag-Small	Irrigated Cropland		4.95	2.65	2.91	4.14	9.23	4.57	0.28	
Ag-Small	Non-Irrigated Cropland	0.12	6.17	11.77	7.87	9.76	3.44	3.62	0.04	
Ag-Small	Orchards / Vineyards	0.88	0.69	0.66	1.03	0.45	0.27	3.05	4.80	0.74
Ag-Small	Other Livestock				0.48		0.25	0.00		
Ag-Small	Pasture / Hay		0.24	0.18	0.24	0.02	0.25	0.09		
BANNING	Commercial / Industrial							1.05		
BANNING	Forested							1.53		
BANNING	Open Space							0.99		
BANNING	Roadway							0.03		
BANNING	Sewered Residential							3.09		
BANNING	Water							0.02		
BEAUMONT	Commercial / Industrial							14.63		
BEAUMONT	Forested							44.17		
BEAUMONT	Open Space							1.90		
BEAUMONT	Roadway							0.22		
BEAUMONT	Sewered Residential							28.89		
CAFO	Dairy	0.08					4.25	13.41		
CAFO	Pasture / Hay	0.05		2.54	0.28		3.95	23.72		
California Department of Fish and Wildlife	Commercial / Industrial					0.03		0.05		
California Department of Fish and Wildlife	Forested					9.57	65.53	310.28	2.66	
California Department of Fish and Wildlife	Non-Irrigated Cropland							0.72		
California Department of Fish and Wildlife	Other Livestock							0.00		
California Department of Fish and Wildlife	Roadway					0.00		0.00		

Owner	Land Use	Zone 1 TP (kg/yr)	Zone 2 TP (kg/yr)	Zone 3 TP (kg/yr)	Zone 4 TPshed (kg/yr)	Zone 5 TPshed (kg/yr)	Zone 6 TPshed (kg/yr)	Zone 7 TPshed (kg/yr)	Zone 8 TPshed (kg/yr)	Zone 9 TPshed (kg/yr)
Caltrans	Commercial / Industrial	0.36	0.98	0.04	1.05	0.33		1.61	0.32	1.15
Caltrans	Forested	1.69	1.73	0.34	1.41	0.38		3.61	1.90	21.40
Caltrans	Non-Irrigated Cropland				0.02				0.03	0.08
Caltrans	Open Space	0.16	0.01		0.07	0.03		0.37	0.17	0.28
Caltrans	Orchards / Vineyards		0.00							
Caltrans	Other Livestock					0.00				0.05
Caltrans	Pasture / Hay				0.00					0.00
Caltrans	Roadway	2.43	3.19	4.21	0.01	8.50		3.71	0.00	
Caltrans	Sewered Residential	0.23	0.83	0.00	0.40	0.24		0.20	0.42	2.91
Caltrans	Unsewered Residential		0.02		0.01			0.00	0.00	0.06
Caltrans	Water								0.01	
CANYON LAKE	Commercial / Industrial	0.50	0.19	0.41						
CANYON LAKE	Forested	2.15	1.50	1.10						
CANYON LAKE	Non-Irrigated Cropland			0.00						
CANYON LAKE	Open Space	1.59	0.67	0.90						
CANYON LAKE	Other Livestock		0.16							
CANYON LAKE	Roadway	0.17	0.08	0.27						
CANYON LAKE	Sewered Residential	2.09	9.10	15.04						
CANYON LAKE	Water		5.91	2.63						
CR&R	Open Space							4.35		
Federal - DOD	Commercial / Industrial					9.79				
Federal - DOD	Forested					0.06				
Federal - DOD	Irrigated Cropland					0.04				
Federal - DOD	Open Space					20.91				
Federal - DOD	Roadway					9.24				
Federal - DOD	Sewered Residential					0.00				
Federal - National Forest	Commercial / Industrial								0.25	2.78
Federal - National Forest	Forested	105.35			7.52				606.59	2,668.07
Federal - National Forest	Non-Irrigated Cropland								0.00	2.01
Federal - National Forest	Open Space								0.27	4.76
Federal - National Forest	Other Livestock									0.09
Federal - National Forest	Pasture / Hay	0.08								0.08
Federal - National Forest	Sewered Residential	0.26							0.04	5.19
Federal - National Forest	Unsewered Residential	0.01							0.00	0.23
Federal - National Forest	Water								0.09	5.29

Owner	Land Use	Zone 1 TP (kg/yr)	Zone 2 TP (kg/yr)	Zone 3 TP (kg/yr)	Zone 4 TPshed (kg/yr)	Zone 5 TPshed (kg/yr)	Zone 6 TPshed (kg/yr)	Zone 7 TPshed (kg/yr)	Zone 8 TPshed (kg/yr)	Zone 9 TPshed (kg/yr)
Federal - Other	Commercial / Industrial		0.00				0.18	0.03	0.02	
Federal - Other	Forested		40.48	2.44	22.07	1.14	4.31	148.33	167.46	
Federal - Other	Non-Irrigated Cropland			0.00	1.08				0.00	
Federal - Other	Open Space		0.00						0.04	
Federal - Other	Orchards / Vineyards								0.02	
Federal - Other	Pasture / Hay				0.00				0.04	
Federal - Other	Roadway		0.00							
Federal - Other	Sewered Residential		0.10	0.01	0.02		0.00		0.21	
Federal - Other	Unsewered Residential		0.01							
Federal - Other	Water		1.56							
Federal - Wilderness	Forested								272.68	371.57
Federal - Wilderness	Pasture / Hay									0.01
HEMET	Commercial / Industrial				32.82			14.90	0.39	
HEMET	Forested				61.33			12.62	0.41	
HEMET	Non-Irrigated Cropland				19.93			2.81	0.06	
HEMET	Open Space				18.32			2.14	0.52	
HEMET	Orchards / Vineyards							0.01		
HEMET	Other Livestock				0.07			0.70		
HEMET	Pasture / Hay				0.10			0.85	0.00	
HEMET	Roadway				3.47			0.05	0.00	
HEMET	Sewered Residential				77.34			43.19	5.55	
HEMET	Unsewered Residential				0.19			0.45		
HEMET	Water				0.41					
LAKE ELSINORE	Commercial / Industrial	28.82	0.26	2.95						
LAKE ELSINORE	Forested	116.29	14.53	4.43						
LAKE ELSINORE	Open Space	8.71	0.51							
LAKE ELSINORE	Other Livestock		0.00							
LAKE ELSINORE	Pasture / Hay	0.03								
LAKE ELSINORE	Roadway	1.16								
LAKE ELSINORE	Sewered Residential	58.48	6.19	1.47						
LAKE ELSINORE	Unsewered Residential	0.12		0.00						
LAKE ELSINORE	Water	63.17								
March Joint Powers Authority	Commercial / Industrial					10.13				
March Joint Powers Authority	Forested					27.92				
March Joint Powers Authority	Open Space					3.46				
March Joint Powers Authority	Roadway					0.18				
March Joint Powers Authority	Sewered Residential					2.17				

Owner	Land Use	Zone 1 TP (kg/yr)	Zone 2 TP (kg/yr)	Zone 3 TP (kg/yr)	Zone 4 TPshed (kg/yr)	Zone 5 TPshed (kg/yr)	Zone 6 TPshed (kg/yr)	Zone 7 TPshed (kg/yr)	Zone 8 TPshed (kg/yr)	Zone 9 TPshed (kg/yr)
MENIFEE	Commercial / Industrial		17.36	38.10						
MENIFEE	Forested	5.62	37.13	110.01						
MENIFEE	Non-Irrigated Cropland	0.14	1.96	14.64						
MENIFEE	Open Space		4.68	38.88						
MENIFEE	Orchards / Vineyards		0.31	1.23						
MENIFEE	Other Livestock	0.06	1.60	2.24						
MENIFEE	Pasture / Hay	0.09	1.93	4.21						
MENIFEE	Roadway		1.13	4.31						
MENIFEE	Sewered Residential	2.05	40.81	169.52						
MENIFEE	Unsewered Residential	0.49	2.80	8.19						
MENIFEE	Water		0.03	3.06						
MORENO VALLEY	Commercial / Industrial					69.36		0.88		
MORENO VALLEY	Forested					114.03		9.75		
MORENO VALLEY	Irrigated Cropland					0.00				
MORENO VALLEY	Open Space					15.20				
MORENO VALLEY	Orchards / Vineyards					1.20		0.19		
MORENO VALLEY	Other Livestock					0.27		0.09		
MORENO VALLEY	Pasture / Hay					1.46		0.08		
MORENO VALLEY	Roadway					5.94		0.06		
MORENO VALLEY	Sewered Residential					220.51		0.12		
MORENO VALLEY	Unsewered Residential					1.75		0.00		
MORENO VALLEY	Water					1.35				
MURRIETA	Commercial / Industrial			1.58						
MURRIETA	Forested			1.71						
MURRIETA	Open Space			0.17						
MURRIETA	Pasture / Hay			0.00						
MURRIETA	Roadway			0.12						
MURRIETA	Sewered Residential			3.80						
PERRIS	Commercial / Industrial		29.92			43.45	0.18			
PERRIS	Forested		76.67	1.07		41.68	0.01			
PERRIS	Non-Irrigated Cropland					0.00				
PERRIS	Open Space		15.03	0.00		7.28	0.02			
PERRIS	Orchards / Vineyards		0.49			0.27				
PERRIS	Pasture / Hay		0.02			0.22				
PERRIS	Roadway		2.19			3.58				
PERRIS	Sewered Residential		25.50			53.10				
PERRIS	Unsewered Residential		0.21			0.00				
PERRIS	Water		0.50							
RIVERSIDE	Commercial / Industrial					0.57				
RIVERSIDE	Forested					0.05				
RIVERSIDE	Open Space					0.28				
RIVERSIDE	Sewered Residential					8.00				

Owner	Land Use	Zone 1 TP (kg/yr)	Zone 2 TP (kg/yr)	Zone 3 TP (kg/yr)	Zone 4 TPshed (kg/yr)	Zone 5 TPshed (kg/yr)	Zone 6 TPshed (kg/yr)	Zone 7 TPshed (kg/yr)	Zone 8 TPshed (kg/yr)	Zone 9 TPshed (kg/yr)
Riverside County	Commercial / Industrial	3.27	9.20	7.88	16.54	10.94	16.82	32.79	13.22	28.47
Riverside County	Forested	77.05	213.68	68.47	376.44	146.13	186.86	441.39	245.05	527.66
Riverside County	Non-Irrigated Cropland		0.00	6.50	105.98	16.06	9.53	22.33	15.52	78.72
Riverside County	Open Space	0.27	2.18	20.75	7.64	17.25	0.82	35.00	9.04	17.85
Riverside County	Orchards / Vineyards	0.02	3.69	0.41	0.79	2.17	2.64	0.33	1.73	
Riverside County	Other Livestock	0.56	1.41	1.04	10.46	1.05	4.68	0.37	0.58	15.38
Riverside County	Pasture / Hay	0.50	6.59	0.31	5.28	2.66	6.52	0.72	0.84	1.42
Riverside County	Roadway	0.06	0.21	1.32	2.16	2.19	2.74	2.91	0.63	
Riverside County	Sewered Residential	35.46	102.43	6.35	76.95	21.63	53.36	22.21	39.51	149.88
Riverside County	Unsewered Residential	2.28	21.24	0.92	11.06	6.08	11.76	1.27	0.72	14.34
Riverside County	Water	2.23	0.36	2.54	0.10	0.26		0.69	3.44	15.94
SAN JACINTO	Commercial / Industrial				0.82			36.78	0.66	
SAN JACINTO	Forested				1.96		1.12	80.92	19.20	
SAN JACINTO	Non-Irrigated Cropland								0.00	
SAN JACINTO	Open Space				0.32			12.55	4.34	
SAN JACINTO	Orchards / Vineyards							0.57	0.10	
SAN JACINTO	Other Livestock							3.71		
SAN JACINTO	Pasture / Hay							0.93		
SAN JACINTO	Roadway							1.91	0.53	
SAN JACINTO	Sewered Residential				0.14			70.64	4.22	
SAN JACINTO	Unsewered Residential							0.35		
SAN JACINTO	Water				0.29			0.02	5.08	
State Land	Commercial / Industrial		0.01			0.41			0.38	0.11
State Land	Forested		7.94			36.35	3.27	13.91	5.02	239.33
State Land	Non-Irrigated Cropland					1.10				
State Land	Open Space					8.76				1.37
State Land	Orchards / Vineyards		0.00							
State Land	Roadway					0.02				
State Land	Sewered Residential		0.03			0.41			0.05	0.30
State Land	Unsewered Residential		0.07							0.00
State Land	Water					0.00				
Tribal Reservations	Commercial / Industrial								1.56	
Tribal Reservations	Forested							15.63	144.05	10.21
Tribal Reservations	Non-Irrigated Cropland							0.03		
Tribal Reservations	Open Space								1.16	
Tribal Reservations	Pasture / Hay								0.07	
Tribal Reservations	Sewered Residential								6.18	
Tribal Reservations	Water								2.15	
Western Riverside County Regional Conservation Aut	Commercial / Industrial							0.17		
Western Riverside County Regional Conservation Aut	Forested				19.13	9.49	2.87	23.52		
Western Riverside County Regional Conservation Aut	Non-Irrigated Cropland							5.12		
Western Riverside County Regional Conservation Aut	Open Space							0.73		
Western Riverside County Regional Conservation Aut	Sewered Residential				0.09	0.01				
Western Riverside County Regional Conservation Aut	Unsewered Residential				0.00					

Owner	Land Use	Zone 1 TP (kg/yr)	Zone 2 TP (kg/yr)	Zone 3 TP (kg/yr)	Zone 4 TPshed (kg/yr)	Zone 5 TPshed (kg/yr)	Zone 6 TPshed (kg/yr)	Zone 7 TPshed (kg/yr)	Zone 8 TPshed (kg/yr)	Zone 9 TPshed (kg/yr)
WILDOMAR	Commercial / Industrial	4.98								
WILDOMAR	Forested	50.83		0.13						
WILDOMAR	Open Space	0.45								
WILDOMAR	Orchards / Vineyards	0.26								
WILDOMAR	Pasture / Hay	0.34								
WILDOMAR	Roadway	1.12								
WILDOMAR	Sewered Residential	38.16								
WILDOMAR	Unsewered Residential	2.32								
WILDOMAR	Water	0.02								

Owner	Land Use	Zone 1 TN (kg/yr)	Zone 2 TN (kg/yr)	Zone 3 TN (kg/yr)	Zone 4 TNshed (kg/yr)	Zone 5 TNshed (kg/yr)	Zone 6 TNshed (kg/yr)	Zone 7 TNshed (kg/yr)	Zone 8 TNshed (kg/yr)	Zone 9 TNshed (kg/yr)
Ag-CWAD Non-irrigated	Commercial / Industrial	0.09	0.00	0.73	1.73	0.18	5.44	8.12	1.61	
Ag-CWAD Non-irrigated	Forested		0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Ag-CWAD Irrigated	Irrigated Cropland		98.89	112.60	90.70	51.16	354.79	420.57	19.10	
Ag-CWAD Non-irrigated	Non-Irrigated Cropland	0.93	112.05	129.67	119.87	109.10	39.19	147.00		
Ag-CWAD Non-irrigated	Open Space					0.41				
Ag-CWAD Irrigated	Orchards / Vineyards		0.05	0.14	6.42	0.52	0.73	31.58	140.13	8.76
Ag-CWAD Non-irrigated	Other Livestock		7.70	7.34	16.90	0.06	17.56	32.02		25.27
Ag-CWAD Non-irrigated	Pasture / Hay			0.61				0.16		0.96
Ag-CWAD Non-irrigated	Roadway						0.00	0.00	0.00	
Ag-CWAD Non-irrigated	Sewered Residential		0.00		0.00		0.00	0.00	0.00	0.00
Ag-Small	Commercial / Industrial	0.40	0.36	0.77	3.09	2.16	1.35	1.05	1.39	
Ag-Small	Irrigated Cropland		14.24	7.62	8.37	11.89	26.55	13.13	0.81	
Ag-Small	Non-Irrigated Cropland	0.35	17.74	33.83	22.62	28.07	9.88	10.42	0.10	
Ag-Small	Orchards / Vineyards	2.52	2.00	1.89	2.95	1.30	0.78	8.77	13.81	2.13
Ag-Small	Other Livestock				1.39		0.71	0.00		
Ag-Small	Pasture / Hay		0.69	0.53	0.68	0.06	0.71	0.26		
BANNING	Commercial / Industrial							3.01		
BANNING	Forested							4.41		
BANNING	Open Space							2.84		
BANNING	Roadway							0.09		
BANNING	Sewered Residential							8.89		
BANNING	Water							0.07		
BEAUMONT	Commercial / Industrial							42.05		
BEAUMONT	Forested							127.00		
BEAUMONT	Open Space							5.47		
BEAUMONT	Roadway							0.63		
BEAUMONT	Sewered Residential							83.06		
CAFO	Dairy	0.24					12.21	38.56		
CAFO	Pasture / Hay	0.15		7.32	0.82		11.37	68.19		
California Department of Fish and Wildlife	Commercial / Industrial					0.10		0.13		
California Department of Fish and Wildlife	Forested					27.51	188.40	892.06	7.66	
California Department of Fish and Wildlife	Non-Irrigated Cropland							2.08		
California Department of Fish and Wildlife	Other Livestock							0.00		
California Department of Fish and Wildlife	Roadway					0.00		0.00		

Owner	Land Use	Zone 1 TN (kg/yr)	Zone 2 TN (kg/yr)	Zone 3 TN (kg/yr)	Zone 4 TNshed (kg/yr)	Zone 5 TNshed (kg/yr)	Zone 6 TNshed (kg/yr)	Zone 7 TNshed (kg/yr)	Zone 8 TNshed (kg/yr)	Zone 9 TNshed (kg/yr)
Caltrans	Commercial / Industrial	1.04	2.81	0.13	3.03	0.95		4.64	0.93	3.32
Caltrans	Forested	4.87	4.97	0.99	4.07	1.10		10.39	5.47	61.52
Caltrans	Non-Irrigated Cropland				0.05				0.07	0.24
Caltrans	Open Space	0.47	0.02		0.22	0.09		1.05	0.48	0.81
Caltrans	Orchards / Vineyards		0.01							
Caltrans	Other Livestock					0.00				0.15
Caltrans	Pasture / Hay				0.01					0.00
Caltrans	Roadway	6.97	9.18	12.10	0.03	24.43		10.65	0.01	
Caltrans	Sewered Residential	0.65	2.38	0.00	1.14	0.69		0.59	1.21	8.36
Caltrans	Unsewered Residential		0.06		0.03			0.01	0.00	0.17
Caltrans	Water								0.03	
CANYON LAKE	Commercial / Industrial	1.43	0.54	1.17						
CANYON LAKE	Forested	6.18	4.30	3.17						
CANYON LAKE	Non-Irrigated Cropland			0.00						
CANYON LAKE	Open Space	4.58	1.93	2.59						
CANYON LAKE	Other Livestock		0.47							
CANYON LAKE	Roadway	0.49	0.24	0.76						
CANYON LAKE	Sewered Residential	6.02	26.17	43.25						
CANYON LAKE	Water		16.98	7.56						
CR&R	Open Space							12.51		
Federal - DOD	Commercial / Industrial					28.14				
Federal - DOD	Forested					0.17				
Federal - DOD	Irrigated Cropland					0.11				
Federal - DOD	Open Space					60.11				
Federal - DOD	Roadway					26.57				
Federal - DOD	Sewered Residential					0.01				
Federal - National Forest	Commercial / Industrial								0.72	7.99
Federal - National Forest	Forested	302.88			21.62				1,743.94	7,670.71
Federal - National Forest	Non-Irrigated Cropland								0.00	5.78
Federal - National Forest	Open Space								0.78	13.70
Federal - National Forest	Other Livestock									0.25
Federal - National Forest	Pasture / Hay	0.22								0.22
Federal - National Forest	Sewered Residential	0.75							0.12	14.93
Federal - National Forest	Unsewered Residential	0.02							0.01	0.66
Federal - National Forest	Water								0.25	15.20

Appenidix B: Allowable Watershed TN

Owner	Land Use	Zone 1 TN (kg/yr)	Zone 2 TN (kg/yr)	Zone 3 TN (kg/yr)	Zone 4 TNshed (kg/yr)	Zone 5 TNshed (kg/yr)	Zone 6 TNshed (kg/yr)	Zone 7 TNshed (kg/yr)	Zone 8 TNshed (kg/yr)	Zone 9 TNshed (kg/yr)
Federal - Other	Commercial / Industrial		0.01				0.52	0.10	0.05	
Federal - Other	Forested		116.38	7.03	63.45	3.28	12.40	426.44	481.45	
Federal - Other	Non-Irrigated Cropland			0.00	3.11				0.00	
Federal - Other	Open Space		0.00						0.13	
Federal - Other	Orchards / Vineyards								0.05	
Federal - Other	Pasture / Hay				0.01				0.13	
Federal - Other	Roadway		0.00							
Federal - Other	Sewered Residential		0.29	0.04	0.07		0.01		0.61	
Federal - Other	Unsewered Residential		0.03							
Federal - Other	Water		4.48							
Federal - Wilderness	Forested								783.95	1,068.27
Federal - Wilderness	Pasture / Hay									0.04
HEMET	Commercial / Industrial				94.35			42.85	1.12	
HEMET	Forested				176.33			36.28	1.17	
HEMET	Non-Irrigated Cropland				57.29			8.09	0.16	
HEMET	Open Space				52.68			6.15	1.50	
HEMET	Orchards / Vineyards							0.04		
HEMET	Other Livestock				0.19			2.01		
HEMET	Pasture / Hay				0.29			2.44	0.00	
HEMET	Roadway				9.96			0.15	0.00	
HEMET	Sewered Residential				222.36			124.18	15.96	
HEMET	Unsewered Residential				0.54			1.29		
HEMET	Water				1.18					
LAKE ELSINORE	Commercial / Industrial	82.86	0.75	8.49						
LAKE ELSINORE	Forested	334.32	41.77	12.75						
LAKE ELSINORE	Open Space	25.05	1.47							
LAKE ELSINORE	Other Livestock		0.00							
LAKE ELSINORE	Pasture / Hay	0.09								
LAKE ELSINORE	Roadway	3.32								
LAKE ELSINORE	Sewered Residential	168.12	17.80	4.22						
LAKE ELSINORE	Unsewered Residential	0.36		0.01						
LAKE ELSINORE	Water	181.62								
March Joint Powers Authority	Commercial / Industrial					29.12				
March Joint Powers Authority	Forested					80.27				
March Joint Powers Authority	Open Space					9.95				
March Joint Powers Authority	Roadway					0.51				
March Joint Powers Authority	Sewered Residential					6.23				

Owner	Land Use	Zone 1 TN (kg/yr)	Zone 2 TN (kg/yr)	Zone 3 TN (kg/yr)	Zone 4 TNshed (kg/yr)	Zone 5 TNshed (kg/yr)	Zone 6 TNshed (kg/yr)	Zone 7 TNshed (kg/yr)	Zone 8 TNshed (kg/yr)	Zone 9 TNshed (kg/yr)
MENIFEE	Commercial / Industrial		49.90	109.54						
MENIFEE	Forested	16.15	106.75	316.29						
MENIFEE	Non-Irrigated Cropland	0.42	5.63	42.09						
MENIFEE	Open Space		13.47	111.78						
MENIFEE	Orchards / Vineyards		0.90	3.54						
MENIFEE	Other Livestock	0.16	4.61	6.44						
MENIFEE	Pasture / Hay	0.27	5.56	12.09						
MENIFEE	Roadway		3.24	12.39						
MENIFEE	Sewered Residential	5.88	117.33	487.37						
MENIFEE	Unsewered Residential	1.40	8.04	23.54						
MENIFEE	Water		0.09	8.80						
MORENO VALLEY	Commercial / Industrial					199.40		2.53		
MORENO VALLEY	Forested					327.83		28.02		
MORENO VALLEY	Irrigated Cropland					0.00				
MORENO VALLEY	Open Space					43.70				
MORENO VALLEY	Orchards / Vineyards					3.44		0.55		
MORENO VALLEY	Other Livestock					0.78		0.27		
MORENO VALLEY	Pasture / Hay					4.21		0.22		
MORENO VALLEY	Roadway					17.07		0.17		
MORENO VALLEY	Sewered Residential					633.97		0.35		
MORENO VALLEY	Unsewered Residential					5.03		0.00		
MORENO VALLEY	Water					3.88				
MURRIETA	Commercial / Industrial			4.54						
MURRIETA	Forested			4.92						
MURRIETA	Open Space			0.50						
MURRIETA	Pasture / Hay			0.01						
MURRIETA	Roadway			0.34						
MURRIETA	Sewered Residential			10.91						
PERRIS	Commercial / Industrial		86.02			124.93	0.51			
PERRIS	Forested		220.43	3.09		119.82	0.03			
PERRIS	Non-Irrigated Cropland					0.00				
PERRIS	Open Space		43.21	0.00		20.94	0.05			
PERRIS	Orchards / Vineyards		1.41			0.78				
PERRIS	Pasture / Hay		0.06			0.65				
PERRIS	Roadway		6.30			10.30				
PERRIS	Sewered Residential		73.32			152.67				
PERRIS	Unsewered Residential		0.62			0.01				
PERRIS	Water		1.44							
RIVERSIDE	Commercial / Industrial					1.63				
RIVERSIDE	Forested					0.15				
RIVERSIDE	Open Space					0.80				
RIVERSIDE	Sewered Residential					22.99				

Owner	Land Use	Zone 1 TN (kg/yr)	Zone 2 TN (kg/yr)	Zone 3 TN (kg/yr)	Zone 4 TNshed (kg/yr)	Zone 5 TNshed (kg/yr)	Zone 6 TNshed (kg/yr)	Zone 7 TNshed (kg/yr)	Zone 8 TNshed (kg/yr)	Zone 9 TNshed (kg/yr)
Riverside County	Commercial / Industrial	9.41	26.45	22.65	47.55	31.44	48.36	94.26	38.01	81.84
Riverside County	Forested	221.51	614.33	196.86	1,082.26	420.11	537.23	1,269.01	704.52	1,517.03
Riverside County	Non-Irrigated Cropland		0.00	18.69	304.70	46.17	27.39	64.21	44.63	226.32
Riverside County	Open Space	0.78	6.26	59.64	21.96	49.60	2.35	100.63	25.99	51.32
Riverside County	Orchards / Vineyards	0.06	10.60	1.17	2.28	6.25	7.59	0.95	4.99	
Riverside County	Other Livestock	1.61	4.07	3.00	30.07	3.03	13.45	1.06	1.65	44.21
Riverside County	Pasture / Hay	1.45	18.95	0.89	15.17	7.65	18.73	2.08	2.42	4.09
Riverside County	Roadway	0.16	0.61	3.80	6.20	6.28	7.88	8.36	1.82	
Riverside County	Sewered Residential	101.95	294.48	18.25	221.22	62.18	153.41	63.85	113.59	430.91
Riverside County	Unsewered Residential	6.56	61.07	2.65	31.78	17.47	33.80	3.66	2.06	41.24
Riverside County	Water	6.41	1.02	7.30	0.30	0.76		1.99	9.90	45.83
SAN JACINTO	Commercial / Industrial				2.36			105.75	1.89	
SAN JACINTO	Forested				5.64		3.21	232.63	55.21	
SAN JACINTO	Non-Irrigated Cropland								0.00	
SAN JACINTO	Open Space				0.91			36.09	12.47	
SAN JACINTO	Orchards / Vineyards							1.63	0.28	
SAN JACINTO	Other Livestock							10.67		
SAN JACINTO	Pasture / Hay							2.66		
SAN JACINTO	Roadway							5.48	1.52	
SAN JACINTO	Sewered Residential				0.41			203.10	12.14	
SAN JACINTO	Unsewered Residential							1.01		
SAN JACINTO	Water				0.83			0.05	14.61	
State Land	Commercial / Industrial		0.03			1.18			1.11	0.31
State Land	Forested		22.82			104.52	9.41	40.00	14.44	688.06
State Land	Non-Irrigated Cropland					3.16				
State Land	Open Space					25.20				3.94
State Land	Orchards / Vineyards		0.01							
State Land	Roadway					0.07				
State Land	Sewered Residential		0.09			1.17			0.15	0.86
State Land	Unsewered Residential		0.20							0.01
State Land	Water					0.01				
Tribal Reservations	Commercial / Industrial								4.47	
Tribal Reservations	Forested							44.93	414.13	29.36
Tribal Reservations	Non-Irrigated Cropland							0.09		
Tribal Reservations	Open Space								3.34	
Tribal Reservations	Pasture / Hay								0.21	
Tribal Reservations	Sewered Residential								17.77	
Tribal Reservations	Water								6.18	
Western Riverside County Regional Conservation Aut	Commercial / Industrial							0.48		
Western Riverside County Regional Conservation Aut	Forested				54.99	27.28	8.24	67.61		
Western Riverside County Regional Conservation Aut	Non-Irrigated Cropland							14.71		
Western Riverside County Regional Conservation Aut	Open Space							2.10		
Western Riverside County Regional Conservation Aut	Sewered Residential				0.27	0.01				
Western Riverside County Regional Conservation Aut	Unsewered Residential				0.00					

Owner	Land Use	Zone 1 TN (kg/yr)	Zone 2 TN (kg/yr)	Zone 3 TN (kg/yr)	Zone 4 TNshed (kg/yr)	Zone 5 TNshed (kg/yr)	Zone 6 TNshed (kg/yr)	Zone 7 TNshed (kg/yr)	Zone 8 TNshed (kg/yr)	Zone 9 TNshed (kg/yr)
WILDOMAR	Commercial / Industrial	14.32								
WILDOMAR	Forested	146.15		0.38						
WILDOMAR	Open Space	1.28								
WILDOMAR	Orchards / Vineyards	0.73								
WILDOMAR	Pasture / Hay	0.97								
WILDOMAR	Roadway	3.22								
WILDOMAR	Sewered Residential	109.70								
WILDOMAR	Unsewered Residential	6.67								
WILDOMAR	Water	0.06								

Appenidix B: Mystic Lake Overflow

Date	San Jacinto Annual Rainfall (in/yr)	Idyllwild Annual Rainfall (in/yr)	Runoff (AF)	Initial Storage at Start of Wet Season (AF)	Overflow (AF)
1929 - 1930	13.77	30.10	6,331	-	-
1930 - 1931	10.46	22.49	811	-	-
1931 - 1932	17.91	37.03	12,170	-	-
1932 - 1933	10.19	22.36	563	4,317	-
1933 - 1934	6.39	16.69	-	-	-
1934 - 1935	16.63	30.55	8,568	-	-
1935 - 1936	9.19	26.81	1,688	715	-
1936 - 1937	24.42	55.64	24,540	-	2,540
1937 - 1938	14.87	38.59	10,634	14,000	2,634
1938 - 1939	17.61	26.04	7,403	14,000	-
1939 - 1940	11.54	23.95	2,184	13,550	-
1940 - 1941	25.71	42.82	20,156	7,881	6,037
1941 - 1942	10.50	25.93	2,263	14,000	-
1942 - 1943	15.71	31.58	8,332	8,409	-
1943 - 1944	13.32	27.85	5,076	8,888	-
1944 - 1945	15.17	34.56	9,185	6,111	-
1945 - 1946	8.92	21.14	-	7,443	-
1946 - 1947	11.30	23.39	1,783	-	-
1947 - 1948	6.70	18.20	-	-	-
1948 - 1949	9.35	25.44	1,237	-	-
1949 - 1950	7.07	21.87	-	-	-
1950 - 1951	8.10	18.38	-	-	-
1951 - 1952	19.36	39.70	14,315	-	-
1952 - 1953	10.39	20.26	-	6,462	-
1953 - 1954	10.63	24.13	1,610	-	-
1954 - 1955	10.50	22.39	795	-	-
1955 - 1956	7.18	16.87	-	-	-
1956 - 1957	11.69	21.59	1,317	-	-
1957 - 1958	23.54	38.30	16,726	-	-
1958 - 1959	5.70	11.72	-	8,872	-
1959 - 1960	9.39	20.37	-	1,019	-
1960 - 1961	5.59	7.96	-	-	-
1961 - 1962	10.23	21.94	418	-	-

Appenidix B: Mystic Lake Overflow

Date	San Jacinto Annual Rainfall (in/yr)	Idyllwild Annual Rainfall (in/yr)	Runoff (AF)	Initial Storage at Start of Wet Season (AF)	Overflow (AF)
1962 - 1963	10.20	14.11	-	-	-
1963 - 1964	8.65	24.59	383	-	-
1964 - 1965	11.38	23.57	1,916	-	-
1965 - 1966	12.80	25.69	3,808	-	-
1966 - 1967	15.63	36.35	10,255	-	-
1967 - 1968	8.86	18.84	-	2,401	-
1968 - 1969	17.29	41.80	13,700	-	-
1969 - 1970	7.85	19.10	-	5,847	-
1970 - 1971	7.31	19.51	-	-	-
1971 - 1972	6.58	16.67	-	-	-
1972 - 1973	14.34	32.73	7,828	-	-
1973 - 1974	11.23	18.81	-	-	-
1974 - 1975	10.59	21.41	458	-	-
1975 - 1976	14.87	20.70	3,229	-	-
1976 - 1977	13.27	20.01	1,793	-	-
1977 - 1978	27.76	43.83	22,041	-	41
1978 - 1979	19.23	37.60	13,350	14,000	5,350
1979 - 1980	20.56	47.30	18,320	14,000	10,320
1980 - 1981	7.97	16.56	-	14,000	-
1981 - 1982	14.40	34.40	8,564	6,147	-
1982 - 1983	22.50	50.86	21,184	6,857	6,041
1983 - 1984	8.00	22.70	-	14,000	-
1984 - 1985	9.80	23.50	754	6,147	-
1985 - 1986	12.04	27.00	3,807	-	-
1986 - 1987	9.04	16.10	-	-	-
1987 - 1988	12.23	21.70	1,752	-	-
1988 - 1989	7.38	19.74	-	-	-
1989 - 1990	9.37	18.09	-	-	-
1990 - 1991	14.33	28.99	6,271	-	-
1991 - 1992	17.41	24.32	6,548	-	-
1992 - 1993	29.32	49.85	25,647	-	3,647
1993 - 1994	10.36	20.56	-	14,000	-
1994 - 1995	23.81	48.54	21,157	6,147	5,304

Appenidix B: Mystic Lake Overflow

Date	San Jacinto Annual Rainfall (in/yr)	Idyllwild Annual Rainfall (in/yr)	Runoff (AF)	Initial Storage at Start of Wet Season (AF)	Overflow (AF)
1995 - 1996	8.52	19.90	-	14,000	-
1996 - 1997	12.56	25.63	3,618	6,147	-
1997 - 1998	24.69	44.80	20,243	1,911	154
1998 - 1999	8.60	14.90	-	14,000	-
1999 - 2000	7.82	15.50	-	6,147	-
2000 - 2001	9.92	17.50	-	-	-
2001 - 2002	4.19	9.60	-	-	-
2002 - 2003	15.65	30.60	7,886	-	-
2003 - 2004	7.63	16.80	-	32	-
2004 - 2005	25.80	34.90	16,941	-	-
2005 - 2006	9.24	22.60	-	9,088	-
2006 - 2007	3.17	10.20	-	1,234	-
2007 - 2008	10.92	29.10	3,873	-	-
2008 - 2009	8.72	18.30	-	-	-
2009 - 2010	12.03	30.17	5,112	-	-
2010 - 2011	16.69	38.37	11,849	-	-
2011 - 2012	8.42	20.42	-	3,996	-
2012 - 2013	6.38	13.19	-	-	-
2013 - 2014	6.41	13.57	-	-	-
2014 - 2015	11.55	18.75	45	-	-
2015 - 2016	8.81	26.82	1,420	-	-
2016 - 2017	14.39	35.23	8,901	-	-