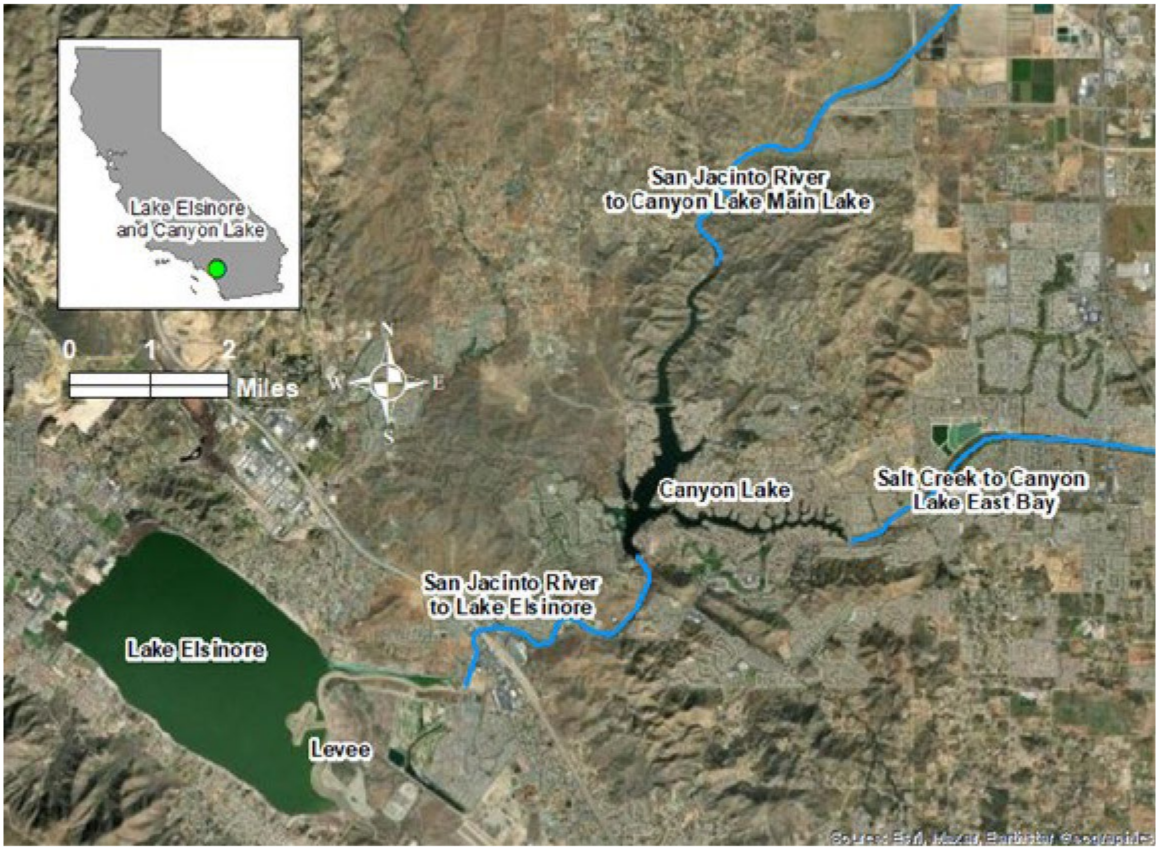
Revised TMDL Technical Report – Revision to the Lake Elsinore and Canyon Lake Nutrient TMDLs



Prepared for

Lake Elsinore & San Jacinto Watersheds Authority *in collaboration with* the Lake Elsinore and Canyon Lake Task Force

Prepared by

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Acknowledgements

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

Revision of the TMDLs was a collaborative effort of the Lake Elsinore and San Jacinto Watersheds Project Authority (LESJWA), LECL Task Force and Santa Ana Regional Water Quality Control Board (Santa Ana Water Board). The LECL Task Force is comprised of the following entities that work in partnership under a Task Force Agreement:

- California Department of Fish and Wildlife (CDFW)
- 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
- March Air Force Reserve Joint Powers Authority (JPA)
- Riverside County Flood Control & Water Conservation District
- United States Air Force March Air Reserve Base
- Western Riverside County Agriculture Coalition (on behalf of the participating Dairy Operators and participating Agricultural Operators in the San Jacinto River Basin)

Working through a collaborative stakeholder process, this TMDL Technical Report was prepared by a project team selected by the LESJWA Board. Project contributions were made by the following:

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- Rachel Gray – Task Force Chair and representative to the LESJWA Board
- Mark Norton (Retired) – Prior Task Force Chair and representative to the LESJWA Board

- Rick Whetsel – Project Manager and budget oversight for all Task Force activities
- Zyanya Ramirez – Administrative support

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- Bernadette Kolb – Water quality technical review

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- Other Agency Representatives – Ankita Vyas (California Department of Transportation [Caltrans]); Natasha Thandi (representing Caltrans); Alex Christie (City of Moreno Valley); Rae Beimer (representing City of Moreno Valley); Dan Cortese, Jilleen Ferris and Noah Rau (City of Hemet); Adam Gufarotti, Ben Foster and Carlos Norvani (City of Lake Elsinore); Maria Arreguin, Jessica Galloway and Shirley Colvin (City of Perris); Cynthia Gabaldon (representing the Cities of Menifee and Perris); Haile Ford (City of Menifee); Mike Roberts and Stormy Osifeso (City of Riverside); Lynn Merrill (representing the City of San Jacinto); Dustin Christensen and Siomara Giroux (City of Beaumont); Anthony Budicin (Eastern Municipal Water District); Lauren Sotelo (March JPA); Dale Welty and Kelsey Reed (representing City of Canyon Lake); Jason Farag and Kris Hanson (representing City of Wildomar); Scott Bruckner (Riverside County); and Scott Sewell (CDFW); Yung Nguyen and Vivian Chikhalhaddaden (March U.S. Air Reserve Base)
- NV5 – Garth Engelhorn

Project information is managed by SAWPA and can be found at: https://sawpa.gov/task-force/lake-elsinore-and-canyon-lake-tmdl-task-force/

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Acronyms

Acronym	Definitions
0-D	Zero Dimensional
1-D	One Dimensional
2-D	Two Dimensional
3-D	Three Dimensional
ACOE	Army Corps of Engineers
AED2	Aquatic Ecodynamics Model
AEM3D	Aquatic Ecosystem Model 3-D
AFA	*Aphanizomenon flos-aquae*
AFY	Acre feet/year
AF	Acre feet
AF/day	Acre feet/day
AgNMP	Agricultural Nutrient Management Plan
Agricultural General Order	General Waste Discharge Requirements (WDRs) for Irrigated Lands in the San Jacinto River Watershed (R8-2023-0006)
AGR	Agriculture Water Supply
AQMP	Air Quality Management Plan
Alum	Aluminum sulfate
ARB	Air Reserve Base
AWT	Advanced Wastewater Treatment
AWTF	Advanced Wastewater Treatment Facility
BASINS	Better Assessment Science Integrating Point and Non-Point Sources
Basin Plan	Water Quality Control Plan for the Santa Ana River Basin
BMPs	Best Management Practice
BOD	Biological Oxygen Demand
°C	Degrees Celsius
CAEDYM	Computational Aquatic Ecosystem Dynamics Model
CAF	Confined Animal Facility
CCC	Criterion Continuous Concentration (chronic)
CCHAB	California Cyanobacteria and Harmful Algal Bloom
CDF	Cumulative Distribution Frequency
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
CDWR	California Department of Water Resources
CEDEN	California Environment Data Exchange Network
CEQA	California Environmental Quality Act

Acronym	Definitions
CFR	Code of Federal Regulation
cfs	cubic feet per second
CIMIS	California Irrigation Management Information System
CWCCIS	Civil Works Construction Cost Index System
cm	centimeter
CMC	Criterion Maximum Concentration (acute)
C:N	Carbon to Nitrogen Ratio
CNRP	Comprehensive Nutrient Reduction Plan
COD	Chemical Oxygen Demand
COMM	Commercial and Sport Fishing
Cs	Cesium
CSTR	Continuous Stirred Tank Reactor
CWA	Clean Water Act
CWAD	Conditional Waiver for Agricultural Discharges
Water Code	California Water Code
CY	Cubic Yards
$	Dollars
D_L	Shoreline Development Number
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
EMC	Event Mean Concentration
EMWD	Eastern Municipal Water District
ENR	Engineering News-Record
ERS	Economic Research Service
EQIP	Environmental Quality Incentive Program
EVMWD	Elsinore Valley Municipal Water District
°F	Degrees Fahrenheit
Fe^{2+}	Iron (II) or Ferrous Iron
ft	Feet or Foot
GHG	Greenhouse Gas Emissions

Acronym	Definitions
GLM	General Lake Model
GWR	Groundwater Recharge
$g/m^2/d$	Grams/square meter/day
HAB	Harmful Algal Bloom
HBI	Hilsenhoff Biotic Index
Ha	Hectare
HOS	Hypolimnetic Oxygenation System
HP	Horsepower
hr	Hour
HRT	Hydraulic Residence Time
HRU	Hydrologic Response Unit
H_2S	Hydrogen Sulfide
IMP	Imperviousness
IPR	Indirect Potable Reuse
in/yr	Inch/year
JPA	Joint Powers Authority
kg	Kilogram
kg/ac/yr	Kilograms/acre/year
kg/ha	Kilograms/hectare
$kg/km^2/yr$	Kilograms/square kilometer/year
kg/yr	Kilograms/year
LA	Load Allocation
lb	Pound
lbs/yr	Pounds/year
lbs/ac/yr	Pounds/acre/year
LC_{50}	Lethal Concentration with 50% mortality
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
LOI	Loss of Ignition
LSE	Lake Surface Elevation
LSPC	Loading Simulation Program in C+
m	Meter

Acronym	Definitions
MANAGE	Measured Annual Nutrient Loads from Agriculture Environment
MEP	Maximum Extent Practicable
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
mL	Milliliters
Mm	millimeter
Mn^{2+}	Manganese (II) or Manganous
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristics Consortium
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 or n	Sample size
NA	Not Available
ND	Non-Detect
NAWQA	National Water Quality Assessment
NH_3	Un-ionized fraction of total ammonia
NH_4	Ionized fraction of total ammonia
NH_4-N	Ammonia Nitrogen
NNC	Numeric Nutrient Criteria
NNE	Numeric Nutrient Endpoint
NO_3-N	Nitrate Nitrogen
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NSQD	National Stormwater Quality Database
O&M	Operation and Maintenance
OD	Offset Demand
OP	Organic Phosphorus
Org/L	Organisms/Liter

Acronym	Definitions
Ortho-P	Orthophosphate
OWTS	Onsite Wastewater Treatment System
PBIAS	Percent Bias
PLOAD	Pollutant Loading Estimator
PO_4-P	Phosphate (as phosphorus)
POA	Property Owners Association
ppm	Parts per million
ppt	Parts per thousand
QAPP	Quality Assurance Project Plan
RARE	Rare, Threatened and Endangered Species
RC	Runoff Coefficient
RCFC&WCD	Riverside County Flood Control and Water Conservation District
RE	Relative Error
REC1	Water Contact Recreation
REC2	Non-Contact Water Recreation
RL	Reporting Limit
RMSE	Relative Mean Square Error
RSR	Root Mean Standard Deviation Ratio
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
SCAG	Southern California Association of Governments
SCAQMD	South Coast Air Quality Management District
SCCWRP	Southern California Coastal Water Research Project
SDR	Sediment Delivery Ratio
SED	Substitute Environmental Document
SJCG	San Jacinto Coalition Group
SJNF	San Jacinto National Forest
SLAM	Simplified Lake Analysis Model
SM	Standard Method
SMAV	Species Mean Acute Value
SMP	Surveillance and Monitoring Program
S_{MAX}	Maximum Storage Capacity
SOD	Sediment Oxygen Demand

Acronym	Definitions
spp	Species
SRP	Soluble Reactive Phosphorus
SSD	Species Sensitivity Distribution
SSURGO	Soil Survey Geographic Database
STEPP	Stormwater Testing and Evaluation for Products and Practices
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
Total Ammonia	Sum of unionized ammonia (NH_3) and ionized ammonia (NH_4^+)
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TN:TP	Ratio of Total Nitrogen to Total Phosphorus Concentrations
TP	Total Phosphorus
TSS	Total Suspended Solids
State Water Board	State Water Resources Control Board
UC	University of California
UCR	University of California, Riverside
UIA	Un-ionized Ammonia
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USDI	United States Department of Interior
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish & Wildlife Service
USGS	United States Geological Survey
USLE-M	Modified Universal Soil Loss Equation
W/m^2	Watts/square meter
WARM	Warm Freshwater Habitat
WDRs	Waste Discharge Requirements
WILD	Wildlife Habitat
WLA	Wasteload Allocation
WQI_{ag}	Water Quality Index for Agriculture
WQMP	Water Quality Management Plan

Acronym	Definitions
WQO	Water Quality Objective
WRCAC	Western Riverside County Agricultural Coalition
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant
Yr	Year

Executive Summary

Section 1: Introduction

Lake Elsinore and Canyon Lake are located in the San Jacinto River watershed in southern California. The Santa Ana Regional Water Quality Control Board (Santa Ana Water Board) established a nutrient Total Maximum Daily Load (TMDL) on each of these lakes in 2004. Since then, the Lake Elsinore and Canyon Lake Task Force (LECL Task Force), administered by the Lake Elsinore and San Jacinto Watersheds Authority (LESJWA), has been working for more than 20 years on the issues associated with the management of water quality in these waterbodies, including completing numerous technical studies in the watershed and the lakes. Study results coupled with the institutional knowledge of watershed stakeholders has demonstrated the need to revise the 2004 TMDLs. Moreover, because the San Jacinto River watershed is not a typical watershed in many respects, the revision of the existing TMDLs has been a challenging and complex process. Given these complexities, this extensive executive summary has been prepared to provide an overview of the contents of this lengthy TMDL Technical Report.

Lake Elsinore and Canyon Lake are located in western Riverside County in southern California. Lake Elsinore is a natural waterbody in the lower part of the San Jacinto River watershed. Canyon Lake, upstream of a Lake Elsinore, is an artificial reservoir that was created when the San Jacinto River was dammed in 1928 (**Figure ES-1**).

Lake Elsinore is a large (~3,000 acres after levee construction), relatively shallow lake (~ 30 feet at its deepest part) located in an area with a hot dry climate (< 12 inches rain/year). Each year nearly four billion gallons of water evaporate causing the lake level in Lake Elsinore to drop by about 4 feet. Average precipitation is not sufficient to make up for such losses and during prolonged droughts Lake Elsinore had sometimes dried up completely (**Figure ES-2**).

The Santa Ana Water Board's first Basin Plan, which was adopted in 1975, acknowledged that Lake Elsinore historically dried up completely due to high rates of evaporation (approximately 4 feet/year) and recurring droughts. As water in the lake evaporates, residual salt concentrations slowly increase and, at times, exceed the salinity of ocean water. High salinity concentrations are toxic to most freshwater organisms. When Lake Elsinore experienced historical extended drought conditions and dried up, all beneficial uses in Lake Elsinore, including warm freshwater aquatic habitat and recreational resources, ceased to exist.

To address water level and associated water quality concerns in Lake Elsinore, and to better maintain beneficial uses in Lake Elsinore, various efforts have been implemented over its history, which have modified Lake Elsinore's historical footprint. Between 1989 and 1995, implementation of the Lake Elsinore Management Project (LEMP) occurred, which included: (1) construction of a levee that separated the main lake from the back basin, permanently reducing the lake size from approximately 6,000 acres to 3,000 acres; (2) realignment of the lake inlet channel to bring in natural runoff from the San Jacinto River watershed when Canyon Lake overflows; and (3) lowering of the outlet channel to increase outflow to downstream Temescal Creek when the lake level exceeds an elevation of 1,255 feet (ft).

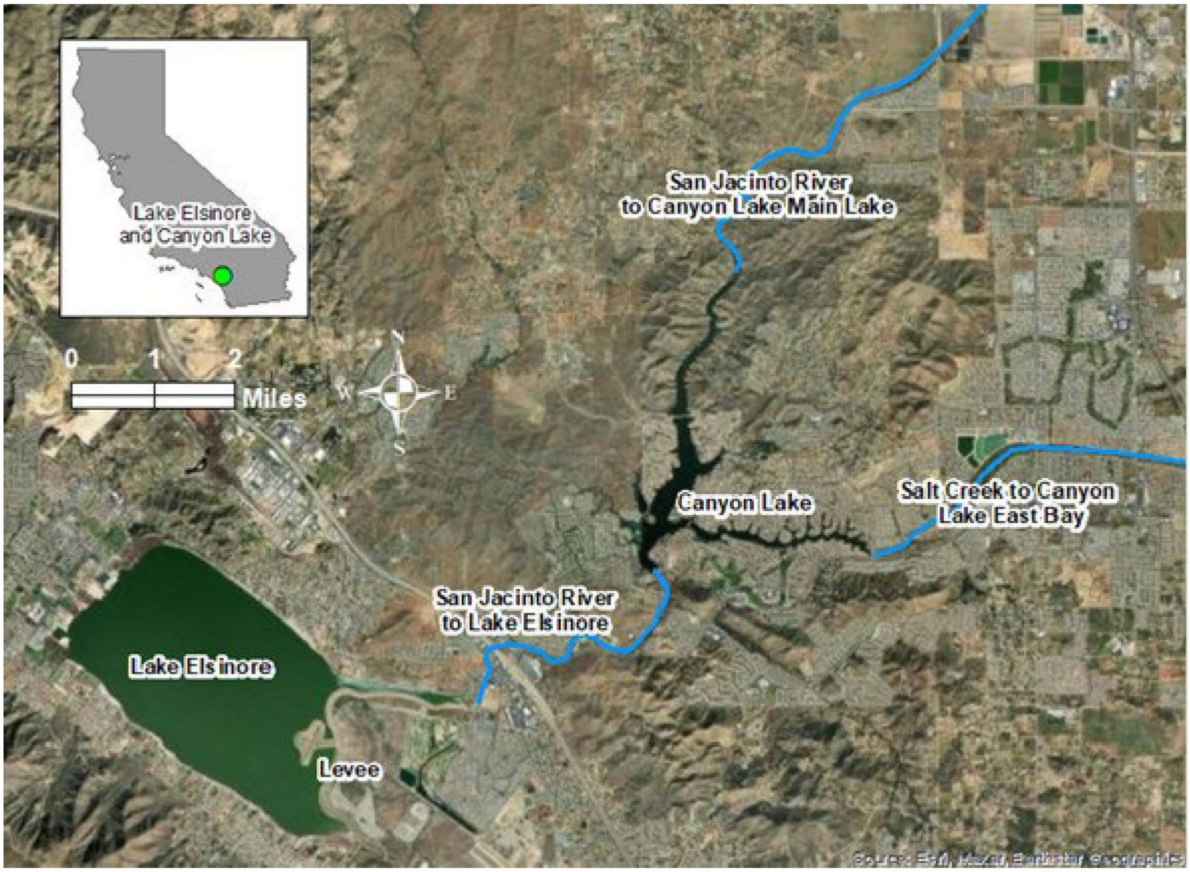


Figure ES-1. Lake Elsinore and Canyon Lake in Southern California

Today, as a result of LEMP, Lake Elsinore with a surface area of 3,000 acres has an average depth of 27 ft. While LEMP helped to stabilize water levels in Lake Elsinore, lake levels still vary substantially due to seasonal fluctuations. To help mitigate fluctuating lake levels, Elsinore Valley Municipal Water District (per an agreement with the City of Lake Elsinore) provides an average of 4,700-acre feet (AF) of recycled water to the lake each year. The addition of supplemental recycled water, which started in 2007, is added to the lake to maintain lake levels above an elevation

Figure ES-2. Mostly Evaporated Lake Elsinore circa 1956

of 1,240 feet above mean sea level (msl). However, supplemental recycled water inputs are suspended if they will cause the lake to exceed an elevation of 1,247 feet. Inputs of supplemental recycled water are resumed once lake levels recede to lower levels.

Currently Lake Elsinore essentially acts as the terminus of the San Jacinto River watershed; the last overflow from the lake to Temescal Creek occurred in 1993. The local tributary area to Lake Elsinore, consisting of drainage from the Santa Ana Mountains and the City of Lake Elsinore, is 47 square miles (mi^2). After construction of the Canyon Lake Dam, Lake Elsinore is only hydrologically connected to the upper San Jacinto River watershed when there are overflows from Canyon Lake.

Canyon Lake was originally named Railroad Canyon Reservoir. The lake was formed by the construction of Railroad Canyon Dam in 1928 and it is located approximately 5 miles upstream of Lake Elsinore. Approximately 735 mi^2 of the 782 mi^2 San Jacinto River watershed drains into Canyon Lake. During some years, runoff from the watershed terminates at Canyon Lake without spilling over the dam and reaching Lake Elsinore. Thus, the creation of Canyon Lake directly impacts water levels in Lake Elsinore.

Canyon Lake is unusual in that it is very small (< 450 acres) compared to the size of the watershed (> 450,000 acres) which drains to the lake. This 1,000-to-1 size ratio, coupled with the highly variable natural precipitation in the area, poses an extreme challenge to lake management. During wet years, the volume of runoff into the reservoir can exceed the total storage capacity of Canyon Lake by 500-600%. In such years, Canyon Lake overflows into Lake Elsinore.

This TMDL Technical Report provides the technical basis to support a revision to the 2004 LECL nutrient TMDLs using a reference watershed approach and serves as part of the California Environmental Quality Act (CEQA) substitute environmental document. Key sections include:

- Basis for adoption of the 2004 nutrient TMDLs, characterization of watersheds and waterbodies that flow to LECL and existing water quality (Section 2);
- Description of the reference watershed condition and use of cumulative distribution functions (CDFs) to establish revised in-lake numeric water quality targets to address water quality impairments (Section 3);
- Nutrient source assessment to create a new baseline for internal and external loading (Section 4);
- Linkage analysis to translate the reference watershed condition to expected lake water quality (Section 5);
- Allocations for point and non-point nutrient sources that are compared with the baseline load to determine required reductions (Section 6);
- A detailed Implementation Plan involving a series of projects, studies, and assessments to guide an adaptive management approach to achieve milestones and allocations and the in-

lake numeric water quality targets for Phase II (TMDLs' effective date to 20 years after the effective date) and Phase III (20 years after the TMDLs' effective date to 30 years after the effective date) (Section 7);

- An update to the existing TMDLs' monitoring program in the San Jacinto River watershed, including Lake Elsinore and Canyon Lake (Section 8);
- CEQA Environmental Checklist (Section 9); and
- Consideration of economics (Section 10).

Following is an executive summary of each of the key sections of this TMDL Technical Report.

Section 2: Problem Statement

This section provides a summary of the basis for adoption of the 2004 nutrient TMDLs, and a baseline characterization of the physical, chemical and biological conditions in the San Jacinto River watershed, Lake Elsinore and Canyon Lake. In addition, this section describes the current status of attainment of the numeric targets in the 2004 TMDLs.

Adoption of the 2004 Nutrient TMDLs

In accordance with the federal Clean Water Act (CWA), Lake Elsinore was placed on the State's 303(d) list of impaired waterbodies in 1994. Canyon Lake was added to that list in 1998. The Lakes' 303(d) listing was for impairment caused by low dissolved oxygen (DO) levels and the presence of excess algal growth. Elevated nutrient concentrations were cited as the primary cause of these impaired water quality conditions in both lakes. To address these impairments, as required by the CWA, the Santa Ana Water Board adopted TMDLs for nutrient discharges to Lake Elsinore and Canyon Lake in 2004 (Santa Ana Water Board 2004a). The 2004 TMDLs specified numeric targets for DO, chlorophyll-*a*, ammonia, Total Phosphorus (TP) and Total Nitrogen (TN) in both lakes (**Table ES-1**) and Load Allocations (LAs) and Wasteload Allocations (WLAs) (**Table ES-2**) to govern the discharge of excess nutrients from non-point sources and point sources, respectively. The adopted TMDLs, approved by the United States Environmental Protection Agency (USEPA) in 2005, included a detailed Implementation Plan which described the activities that must be undertaken to address water quality impairments in each lake.

Since USEPA approval, stakeholders in the San Jacinto River watershed have been working collaboratively through the LECL Task Force to address TMDL implementation requirements, as set forth in the TMDLs' Implementation Plan. The LECL Task Force was formed in 2005 by LESJWA to coordinate and share the cost of TMDL implementation efforts. The LECL Task Force is comprised of nearly all dischargers identified in the 2004 TMDLs as responsible entities, 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, and tribal agencies that own land or operate facilities that discharge nutrients into the San Jacinto Watershed.

Table ES-1. Final Numeric Targets for 2004 TMDLs1

Indicator	Lake Elsinore	Canyon Lake
Total Phosphorus (mg/L)	Annual average no greater than 0.1 mg/L	Annual average no greater than 0.1 mg/L
Total Nitrogen (mg/L)	Annual average no greater than 0.75 mg/L	Annual average no greater than 0.75 mg/L
Ammonia Nitrogen (mg/L)	Calculated concentrations not to exceed more than once in three years for Criterion Maximum Concentration (CMC) (acute criteria), where CMC = $0.411/(1+10^{7.204-pH}) + 58.4/(1+10^{pH-7.204})$ and 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 not to exceed more than once in three years for CMC (acute criteria), where CMC = $0.411/(1+10^{7.204-pH}) + 58.4/(1+10^{pH-7.204})$ and 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* (µg/L)	Summer average no greater than 25 µg/L	Annual average no greater than 25 µg/L
Dissolved Oxygen (mg/L)	No less than 5 mg/L 1 meter (m) above lake bottom	Daily average in hypolimnion no less than 5 mg/L

[1] Adapted from Table 6-1n in the Water Quality Control Plan for the Santa Ana River Basin (Basin Plan)

Table ES-2. 2004 TMDL Wasteload and Load Allocations for Canyon Lake and Lake Elsinore

TMDL	Specific Allocations	TP (kg/yr)[1,2]	TN (kg/yr)[1,2]
Canyon Lake			
Wasteload Allocations	Supplemental Water	48	366
	Urban	306	3,974
	Confined Animal Facility (CAF)[4]	132	1,908
Load Allocation	Internal Sediment	4,625	13,549
	Atmospheric Deposition	221	1,918
	Agriculture	1,183	7,583
	Open/Forest	2,037	3,587
	Septic Systems	139	4,850
	Total Canyon Lake TMDL	**8,691**	**37,735**
Lake Elsinore			
Wasteload Allocations	Supplemental Water[3]	3,721	7,442
	Urban	124	349
	Confined Animal Facility (CAF)[4]	0	0
Load Allocation	Internal Sediment	21,554	197,370
	Atmospheric Deposition	108	11,702
	Agriculture	60	213
	Open/Forest	178	567
	Septic Systems	69	608
	Allocation to Canyon Lake Overflows	2,770	20,774
	Total Lake Elsinore TMDL	**28,584**	**239,025**

[1] Final allocation compliance 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 met as soon as possible as a 5-year running average
[4] If the Santa Ana Water Board determines at any time during Phase II or Phase III that any facilities regulated in Order R8-2018-0001 as CAFOs (as defined in 40 CFR 122.23(b)(2)) should instead be regulated as nonpoint sources, the wasteload allocation for such facilities shall be deemed a load allocation and shall continue to apply

After approximately 20 years of TMDL implementation, stakeholders determined that important elements of the 2004 TMDLs, including the water quality targets and the WLAs/LAs, should be revisited to ensure that they are appropriate and achievable. Further, updating the 2004 TMDLs provides the opportunity to consider changes in the watershed, e.g., changes in land use, benefits from best management practice implementation, including application of low impact development requirements, restrictions on dairy discharges, and water quality benefits from in-lake treatment projects. Accordingly, the LECL Task Force petitioned the Santa Ana Water Board in June 2015 to reopen and revise the 2004 TMDLs based on new information developed since their adoption (LESJWA 2015). Agreeing that revision of the 2004 TMDLs was a high priority (Santa Ana Water Board 2015a,b), the Santa Ana Water Board staff has been working collaboratively with the LECL Task Force to develop the documentation needed to update and amend the nutrient TMDLs for each lake as well as the Implementation Plan.

The implementation period for the 2004 TMDLs (Phase I: 2004 to 2023) has been a period of planning, monitoring, and scientific research. Findings from these efforts have been used to support the implementation of watershed-wide (e.g., sewer system expansion, urban stormwater Best Management Practices [BMPs]) and in-lake projects (e.g., aeration and mixing in Lake Elsinore, fishery management in Lake Elsinore, alum additions in Canyon Lake), studies to evaluate the effectiveness of the projects and, where appropriate, refinement or reassessment of 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 in the lakes. Accordingly, these prior work products serve as the primary resources for updating and revising the 2004 TMDLs.

San Jacinto River Watershed

Lake Elsinore and Canyon Lake lie within the San Jacinto River watershed (**Figure ES-3**), an area encompassing approximately 780 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 western 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 12 inches, occurring primarily as rain during winter and spring seasons. Within the higher elevation portions of the watershed, the precipitation averages 18.7 inches annually. Historically, land use in the San Jacinto River watershed has been associated with agricultural activities. However, a significant shift from agricultural to urban land use has been occurring for many years. **Table ES-3** shows the change in land use acreage that has occurred since development of the 2004 TMDLs.

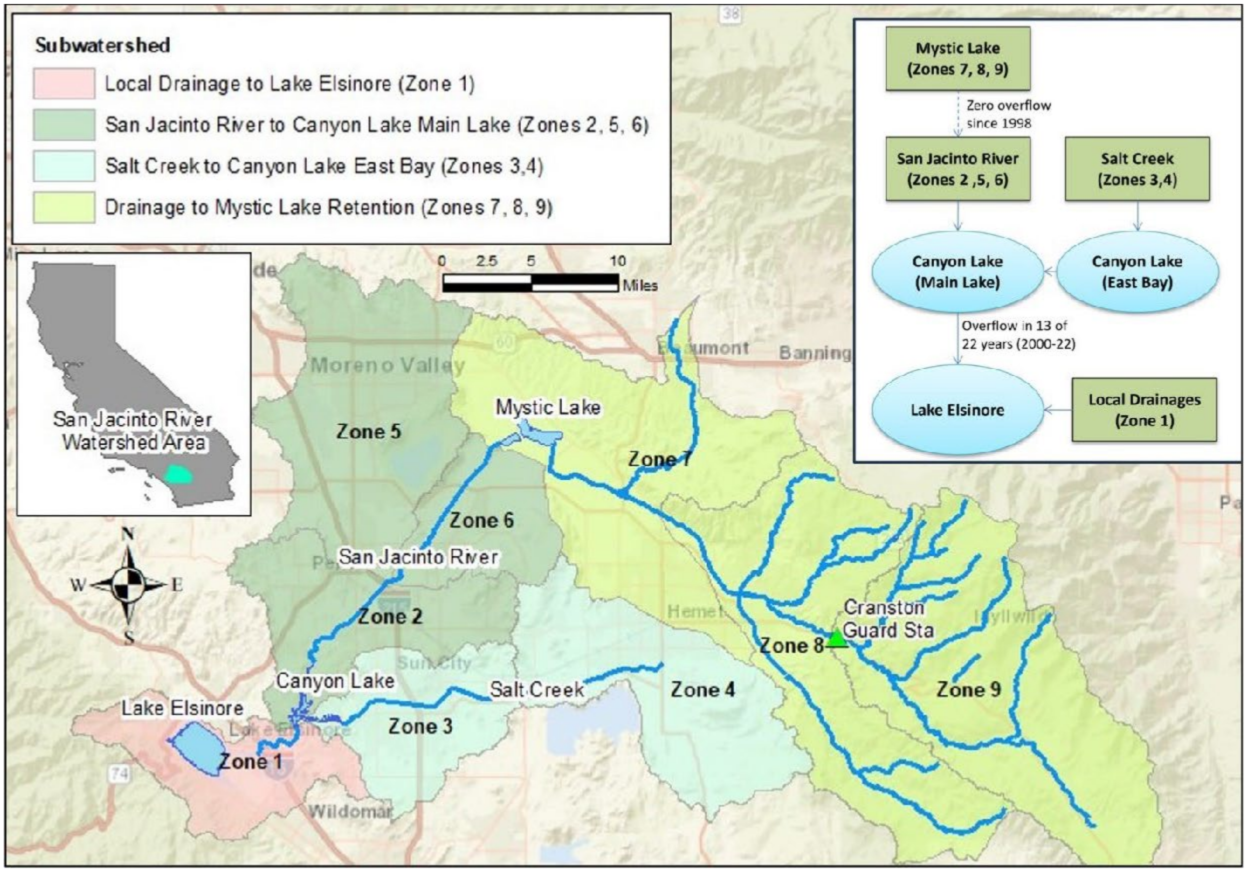


Figure ES-3. Location of Lake Elsinore and Canyon Lake in the San Jacinto River Watershed and Subwatershed Delineation for Key Tributaries (Schematic in top right provides a representation of watershed runoff routing)

Table ES-3. Comparison of Agricultural, Urban, and Open Space Land Use Acreage: Basis for the 2004 TMDLs' Source Assessment Versus Proposed TMDL Revisions

Year	Urban (Acres)[1]	Agricultural (Acres)[2]	Other Land Use (Acres)[1,3]	Open/Forest (Acres)[1]
2005-2007	76,281	47,822	31,184	321,883
2020 - 2022[4]	106,186	22,148	30,943	318,033
Change	29,905	-25,674	-241	-3,850

[1] Acreage used in the 2010 watershed model updated based on Southern California Association of Governments (SCAG) 2005 data

[2] Includes irrigated cropland and non-irrigated cropland greater than 20 acres based on detailed mapping supported by WRCAC (reported as Aerial Information Systems [AIS] 2023 and WRCAC 2007)

[3] Other land uses include dairy, other livestock, non-jurisdictional agriculture and vacant lands

[4] Mapping used to support source assessment based on SCAG 2019 with refinements for agricultural areas based on AIS 2023

For the revised TMDLs, the watershed was divided into nine distinct subwatershed zones that differentiate flowpaths from the watershed to the lakes. Figure ES-3 portrays the hydrological connections between distinct subwatershed zones within the San Jacinto River watershed and identifies the two key tributaries to Canyon Lake. The portion of the San Jacinto River below Canyon Lake receives flow from the watershed when Canyon Lake overflows.

There are several impoundments in the San Jacinto River watershed upstream of Canyon Lake that retain most runoff from their respective drainage areas, most notably Mystic Lake. Mystic Lake is a large seismically induced depression area that captures runoff from the upper watershed, which accounts for 51 percent of the total San Jacinto River watershed (Subwatershed Zones 7, 8, and 9, see Figure ES-3). Mystic Lake overflow to the San Jacinto River last occurred in 1998-1999 water years (Hamilton and Boldt 2015a,b). Long term hydrologic analysis estimates that Mystic Lake retains 96 percent of long-term average annual runoff from the upper watershed. For purposes of the TMDLs, it is assumed that future overflows from Mystic Lake would deliver nutrient load to Lake Elsinore, with Canyon Lake as a flow through in such hydrologic conditions.

The San Jacinto River at Cranston Guard Station, located in Subwatershed Zone 8, serves as the monitoring location to provide nutrient wet weather monitoring data representative of background or reference conditions for this watershed. With more than 97% of the watershed upstream of the Cranston Guard Station undeveloped, both the 2004 and revised TMDLs relied on data from this site to support TMDL development. **Figure ES-4** illustrates long-term wet weather TP and TN monitoring results from this reference site. Generally, the San Jacinto River watershed has highly erodible calcareous soils that are prone to episodes of extreme sediment and associated nutrient loading to the downstream lakes, which explains the occurrence of few very high (> 1 mg/L TP, > 5 mg/L TN) nutrient concentrations measured at Cranston Guard Station.

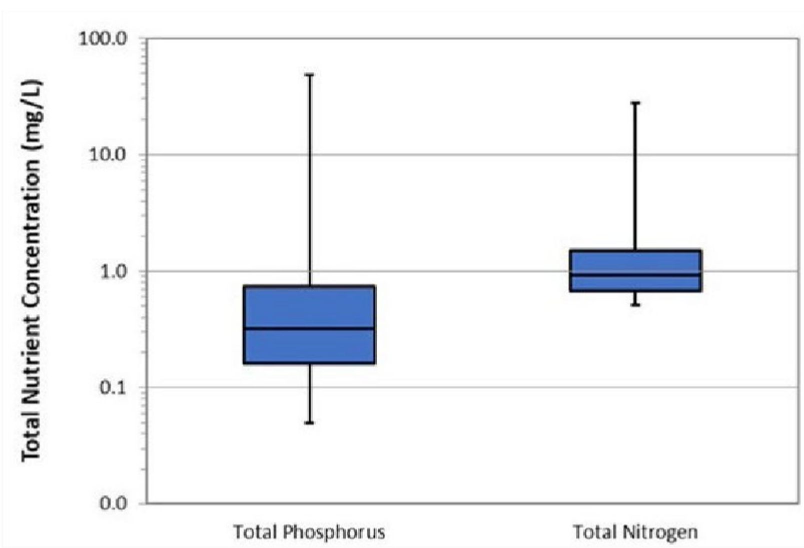


Figure ES-4. Box-Whisker Plots of Samples (n = 51) Collected from Ten Wet Weather Events at the San Jacinto River at Cranston Guard Station (Reference Watershed Site)

Canyon Lake

Canyon Lake was constructed in 1928 to store water from the San Jacinto River for agricultural irrigation in the area. The Railroad Canyon Reservoir Dam is located approximately five river miles upstream from Lake Elsinore. The surface area of Canyon Lake is approximately 450 acres, with an estimated current storage capacity of 8,760 AF. For the purposes of these TMDLs, Canyon Lake is divided into two key areas: (1) Main Lake, which is the deepest part of the lake upstream of the dam (over 50 feet near the Dam) and the North Ski Area, which is the north portion of the lake above the causeway; and (2) the East Bay, the relatively shallow east arm of the lake upstream of the causeway located near where East Bay enters the Main Lake (East Bay is approximately eight feet deep at the upper end near the Salt Creek inflow). Canyon Lake receives inflows from two sources: (1) San Jacinto River, which drains to the North Ski Area above the Main Lake; and (2) Salt Creek, which drains to the East Bay.

Canyon Lake has a high watershed to lake surface area ratio of over 1000:1 which means that variations in annual nutrient loads from watershed runoff are likely to play an important role in water quality within the lakes. The impact of external sediment load can be observed in measurements of lake bottom sediment depth that show that accumulation rates in East Bay are 1.3 - 3.6 inches of sediment/year, which is 65 times greater than values from more typical lakes (Horne 2002). These unique conditions were considered when developing milestones, allocations and numeric targets for Canyon Lake in the revised TMDLs.

Lake Elsinore

In its natural state, Lake Elsinore is highly dynamic with extreme lake level fluctuation and a wide range of water quality conditions. A detailed historical account of over 200 years of hydrology and water quality impairment in Lake Elsinore shows extreme fluctuations in water levels **(Figure ES-5**). In the modern era, a wet lake management strategy has been adopted, involving construction of a levee in 1980s to reduce evaporative losses and addition of recycled water (beginning in 2006) by Elsinore Valley Municipal Water District to maintain water levels.

Recycled water has effectively prevented desiccation of the lakebed that would have naturally occurred as recently as 2016 during extreme drought conditions. However, supplementing lake water with recycled water brings nutrients that must be addressed through the TMDLs. In addition, the recycled water has a cumulative impact of increased total dissolved solids (TDS). 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 highly vulnerable to rises in TDS, as is suggested in observations from Lake Elsinore (**Figure ES-6**).

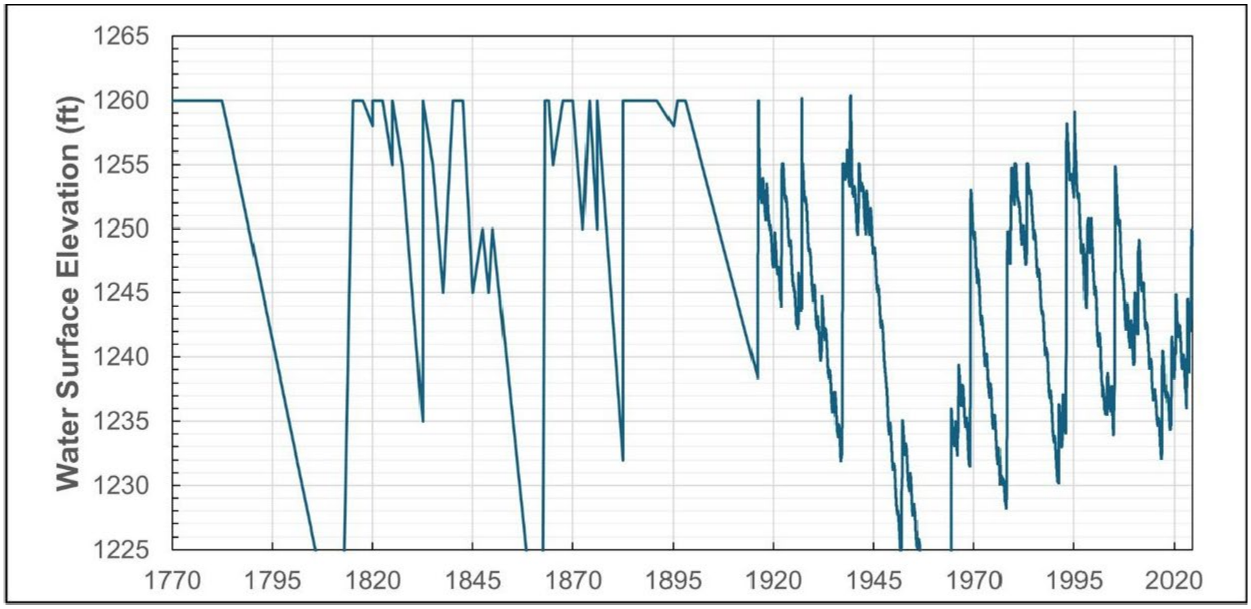


Figure ES-5. Water Level in Lake Elsinore over 250 Years

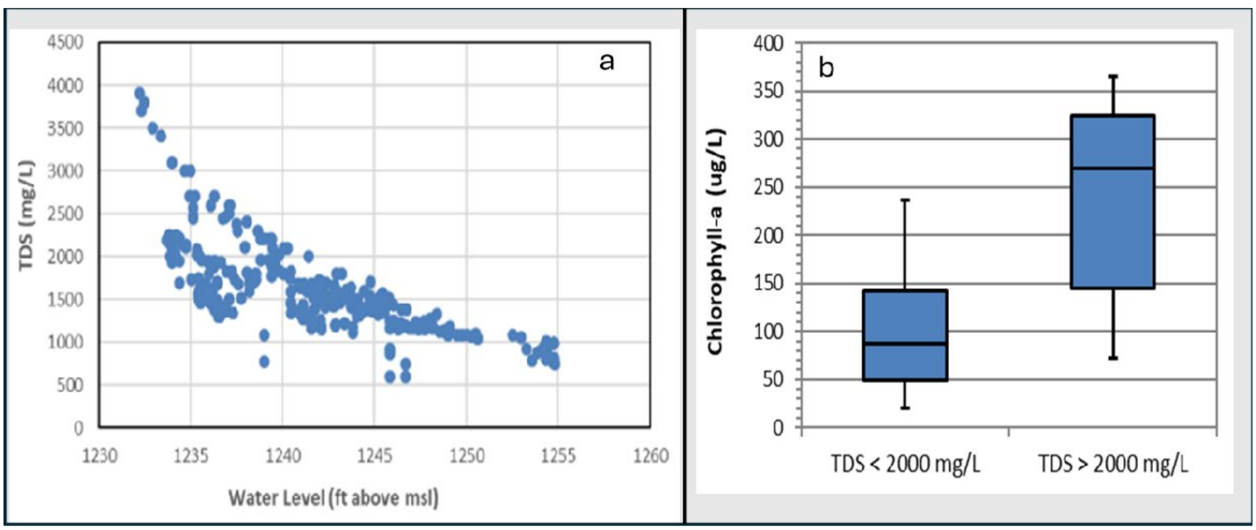


Figure ES-6. Relationship Between TDS (mg/L) and Lake Elevation (ft) in Lake Elsinore and TDS (mg/L) and Chlorophyll-*a* (µg/L) (2000-2020)

Compliance with the 2004 TMDLs

Evaluation of compliance with the 2004 TMDLs is based on a 10-year running average. The 2020 Compliance Report (LESJWA 2021) demonstrated that the 2004 TMDLs were being met as a 10-year running average (see Implementation Section below). However, while total loads were shown to be achieved, in-lake numeric targets in the 2004 TMDLs continue to be exceeded in both lakes (**Table ES-4**, compare the 2016-2020 annual average concentrations with the numeric targets provided in Table ES-1).

Table ES-4. Average Annual Water Quality Data from Canyon Lake and Lake Elsinore (2016-2020) Compared to 2004 TMDL Targets

Lake	Parameter	2004 TMDL Target	2016	2017	2018	2019	2020	Average (2016 2020)
Canyon Lake East Bay	TP (mg/L)	0.1	0.10	0.20	0.05	0.15	0.15	0.13
	TN (mg/L)	0.75	1.51	1.22	1.31	1.56	1.77	1.47
	Ammonia (mg/L)	CCC (1.03 – 5.39)	0.06	0.17	0.16	0.40	0.66	0.29
	Chl-*a* (ug/L)	25	30	36	35	26	25	30
	DO - Surface (mg/L)	5	9.90	7.90	10.40	8.60	9.10	9.18
	DO – Bottom (mg/L)	5	2.30	0.50	0.20	0.20	0.05	0.65
Canyon Lake Main Lake	TP (mg/L)	0.1	0.08	0.27	0.03	0.14	0.13	0.13
	TN (mg/L)	0.75	1.43	1.37	1.44	1.44	1.45	1.43
	Ammonia (mg/L)	CCC (0.38 – 4.86)	0.41	0.42	0.54	0.54	0.80	0.54
	Chl-*a* (ug/L)	25	29	23	21	18	21	22
	DO - Surface (mg/L)	5	8.70	7.70	9.70	7.10	9.30	8.50
	DO – Bottom (mg/L)	5	0.50	0.20	0.40	0.40	0.02	0.30
Lake Elsinore	TP (mg/L)	0.1	0.42	0.18	0.16	0.15	0.22	0.23
	TN (mg/L)	0.75	7.28	4.68	5.56	4.50	3.99	5.20
	Ammonia (mg/L)	CCC (0.15 – 1.63)	0.09	0.12	0.10	0.30	0.31	0.18
	Chl-*a* (ug/L)	25	258	148	87	89	212	159
	DO - Column (mg/L)	5	5.30	7.20	6.20	5.00	4.80	5.70
	DO - Bottom (mg/L)	5	4.20	4.90	3.20	3.30	2.80	3.68

[1] CCC = Criterion Continuous Concentration: Chronic criteria that are compared to individual samples rather than annual averages

Section 3: Numeric Targets

This proposed revision to the 2004 TMDLs includes development of revised numeric targets. The primary objective in the development of these targets is to establish water quality conditions that are equal to or better than what would be expected to occur, over time, in Lake Elsinore and Canyon Lake if the San Jacinto River watershed was returned to a reference watershed condition. Lake water quality models that were developed to predict dynamic in-lake water quality response for a reference watershed condition are based on the following assumptions:

- The current bathymetry of Lake Elsinore resulting from construction of a levee to reduce the size of the lake in the 1980s.
- Presence of Railroad Canyon Dam to create Canyon Lake.
- Reference or background nutrient conditions in wet weather runoff (external flows) from undeveloped areas of the San Jacinto River watershed based on data from the Cranston Guard Station. The data from this site were used as follows:

- TP in external flows based on 0.32 mg/L for interim milestones and 0.16 mg/L for final allocations, corresponding to the median and 25th percentile of the Cranston Guard dataset.
- TN in external flows based on 0.92 mg/L for interim milestones and 0.68 mg/L for final allocations, corresponding to the median and 25th percentile of the Cranston Guard dataset.

- Wet weather runoff volume inflows to Lake Elsinore and Canyon Lake are based on the following:
  - Runoff volume inflows to Lake Elsinore based on measured data from San Jacinto River near Elsinore United States Geological Survey (USGS) gauge 11070500 from 1916-2022, plus estimated runoff from local watershed for current hydrology.
  - Runoff volume inflows to Canyon Lake East Bay based on measured data from Salt Creek at Murrietta Road USGS gauge 11070465 from 2000-2016.
  - Runoff volume inflows to Canyon Lake Main Lake based on measured data from San Jacinto River at Goetz Road USGS gauge 11070365 from 2000-2016.
- Internal sediment flux from core-flux studies in Lake Elsinore (Anderson 2001) and Canyon Lake (Anderson and Oza 2003) scaled downwards for a reference condition based on data analysis from paleolimnology studies.
- Reference watershed condition scenario for TMDL development assumes no operation of existing watershed BMPs or in-lake projects.

To establish revised interim milestone and final numeric targets, water quality model results from the reference watershed condition scenario based on historical hydrology and the assumptions above are converted to a cumulative distribution function (CDF). Under a reference watershed condition, a CDF plots statistical distributions for sets of data that characterizes spatial and temporal variability in water quality that can then be used in future assessments of the frequency of different water quality conditions relative to the numeric target. Conversion of model results to a CDF (**Figure ES-7**) results in numeric targets that consider waterbody responses to future patterns of hydrologic and water quality conditions.

The numeric targets proposed in the revised TMDLs include CDFs for surface chlorophyll-*a* (top 2 meters), depth integrated total ammonia-N, and fraction of lake volume > 5 mg/L DO in Lake Elsinore, Canyon Lake Main Lake and Canyon Lake East Bay. Figure ES-7 provides an example CDF for Canyon Lake Main Lake chlorophyll-*a*. Figures 3-10 through 3-18 in the Technical Report provide the CDFs for all waterbodies and water quality constituents.

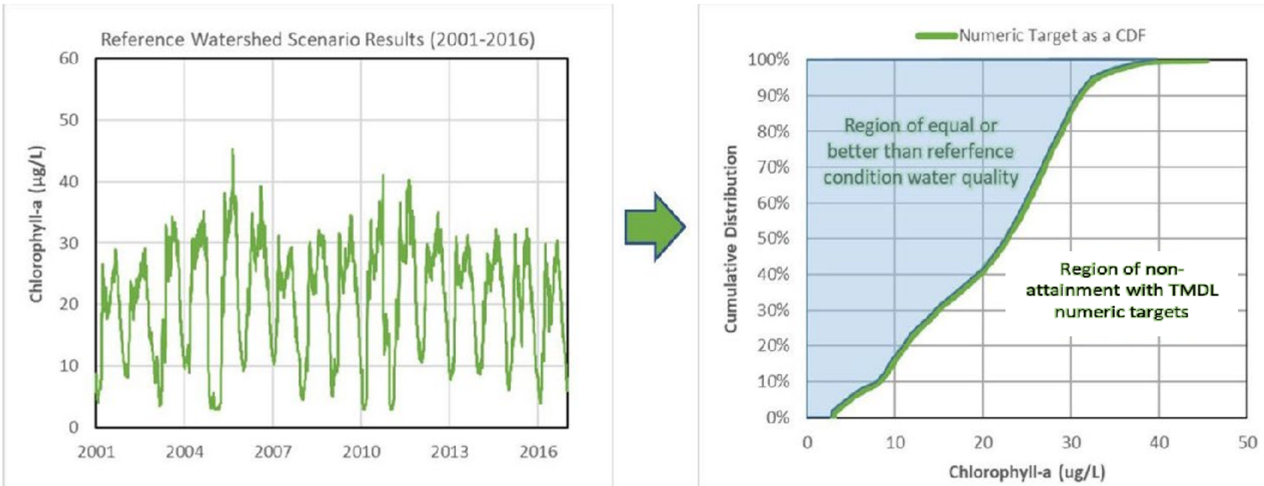


Figure ES-7. Conversion of Dynamic Model Output to a CDF Curve – Example Presented is for Chlorophyll-*a* in Canyon Lake Main Lake

Section 4: Source Assessment

Sources of nutrients to Lake Elsinore and Canyon Lake vary seasonally and are subject to inter-annual climate patterns. To support development of WLAs/LAs for the revised TMDLs, the long-term average loading of nutrients to each lake from external (watershed runoff and supplemental water deliveries) and internal (via sediment nutrient flux and atmospheric deposition) sources was quantified. A brief summary of the methods used to estimate nutrient loads from each of the key sources follows:

Watershed Runoff – A static model of average annual runoff and nutrient loads was developed using a spreadsheet comparable to USEPA's Pollutant Loading Estimator (PLOAD) model. Key elements include:

- Runoff estimates and nutrient washoff were computed for 209 hydrologic response units or HRUs (i.e., unique combinations of jurisdiction, subwatershed zone, and land use).
- Key model parameters that impact nutrient washoff from watershed land areas include percent imperviousness (for runoff volume) and land use category (for nutrient concentration).
- Application of 2022 land use data.
- Assumptions for land use based nutrient washoff concentrations were based on locally collected data where available and literature values as needed.
- Water balance methods were used to estimate factors to account for retention of significant runoff volume and nutrient load from headwater subwatershed zones at Mystic Lake (Subwatershed Zones 7-9) and through unlined channel bottom recharge (Subwatershed Zones 4-6).

Calibration of the PLOAD model was conducted for average annual rainfall and downstream mass emissions (measured at USGS gauges co-located with nutrient mass emission monitoring sites) over the 17-year period of 2006-2022 to achieve a reasonable fit of average annual runoff volume and nutrient loading (**Figure ES-8**). The calibrated PLOAD model was then used to estimate long-term average baseline nutrient loads for various jurisdictions located within the San Jacinto River watershed, based on annual rainfall from 1948-2022 (**Table ES-5**).

Supplemental Recycled Water – Since 2002, addition of over 80,000 AF of supplemental recycled water to Lake Elsinore has supported stabilization of water levels in the lake and prevented the complete desiccation in 2016 following extended drought conditions. The use of recycled water to maintain Lake water elevations creates an additional external source of nutrient loads in excess of reference conditions. **Table ES-6** summarizes the annual volumes and estimated TP and TN loads of recycled water discharged to Lake Elsinore. The estimated nutrient load is based on monthly measured nutrient concentrations and monthly metered volume of treated effluent discharged to the lake.

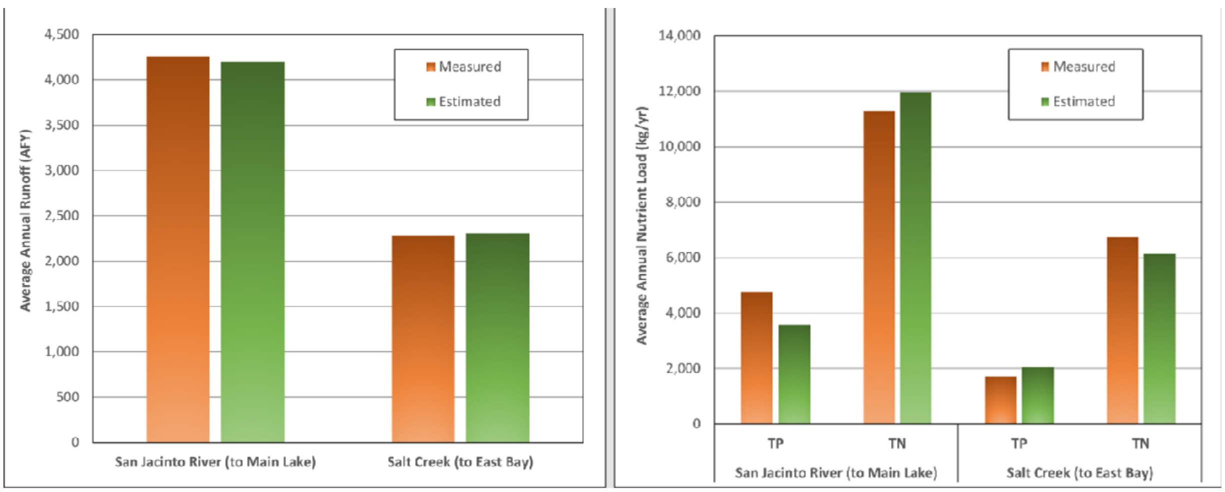


Figure ES-8. Calibration of Long-Term Annual Average Runoff Volume (Left) and Nutrient Load (Right) to Canyon Lake from the San Jacinto River Watershed

Table ES-5. Long-Term Average Annual Baseline Nutrient Load at Jurisdictional Boundaries and at Downstream Lake Inflows

Responsible Agency or Jurisdiction (all values in kg/yr)	Jurisdiction Load[1]		Load to Canyon Lake (Zones 2 6)[1]		Load to Lake Elsinore (Zones 1 & 7 9)[2]	
	TP	TN	TP	TN	TP	TN
MS4 Jurisdiction Runoff (WLA)	11,774	38,585	6,273	21,385	888	3,245
Caltrans Jurisdiction Runoff (WLA)	136	833	62	454	16	113
March JPA Jurisdiction Runoff (WLA)	76	329	72	312	0	0
March ARB Jurisdiction Runoff (WLA)	78	516	74	489	0	0

Table ES-5. Long-Term Average Annual Baseline Nutrient Load at Jurisdictional Boundaries and at Downstream Lake Inflows

Responsible Agency or Jurisdiction (all values in kg/yr)	Jurisdiction Load[1]		Load to Canyon Lake (Zones 2 6)[1]		Load to Lake Elsinore (Zones 1 & 7 9)[2]	
	TP	TN	TP	TN	TP	TN
CAF (WLA)	41	62	9	14	1	2
Irrigated Agriculture (LA)	699	637	313	294	14	12
Non-Irrigated Agriculture (LA)	757	963	419	533	12	15
Other State/Federal/Tribal Jurisdictions (LA)	3,347	9,472	139	382	187	531
Total Watershed Baseline Load	**16,908**	**51,398**	**7,360**	**23,864**	**1,117**	**3,918**

[1] Loads are total delivered as inflow to Canyon Lake accounting for upstream losses by channel bottom recharge in Subwatershed Zones 4, 5 and 6. Overflows to Lake Elsinore are not subtracted from inflow load.

[2] Loads are total delivered to Lake Elsinore from the local subwatershed (Zone 1) and from Subwatershed Zones 7-9 that are assumed to entirely pass through Canyon Lake to Lake Elsinore during storm events that cause a Mystic Lake overflow (~4 percent of long-term watershed runoff volume). Estimated loads from Canyon Lake to Lake Elsinore associated with runoff from Subwatershed Zones 2-6 are not shown in this table and represent co-mingled loads reduced by natural settling and ongoing implementation of in-lake controls in Canyon Lake.

Table ES-6. Volume (acre feet/year or AFY) and Estimated Nutrient Load (kilograms/year, or kg/yr) in Supplemental Water Additions to Lake Elsinore

Year[1]	Recycled Water (AFY)	Island Wells (AFY)	Total Supplemental Volume (AFY)	Estimated TP Load (kg/yr)	Estimated TN Load (kg/yr)
2013-2022 Average	5,251	212	5,450	3,900	31,622
Projected at 7.5 MGD[1]	8,400	200	8,600	5,500	49,900

[1] Population growth and expansion of the recycled water discharge to Lake Elsinore is anticipated to increase to 7.5 MGD prior to 2030

Internal Load – A fraction of nutrients from external sources that settle to the bottoms of Lake Elsinore and Canyon Lake are not immediately bioavailable for algae growth. Instead, these nutrients undergo decomposition within the lake bottom which results in nutrients changing from bound to bioavailable forms. Anoxic conditions and higher temperatures in the lake bottom sediments increase the rate of decomposition and nutrient release into the water column. Dynamic simulation of nutrient release from the lake bottom for current levels of enrichment in lake water quality estimated long-term average annual internal load for Canyon Lake (2,997 kg/yr TP and 11,023 kg/yr TN) and Lake Elsinore (22,103 kg/yr TP and 183,777 kg/yr TN).

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. In both lakes, for both TP and TN, less than 5 percent of nutrient load is associated with atmospheric deposition.

Summary - A comparison of each source to the total nutrient load shows that watershed runoff represents the highest nutrient loads in Canyon Lake (71% TP and 66%TN), followed by internal load (29% TP and 30% TN), and atmospheric deposition (<1% TP and 4% TN). For Lake Elsinore, internal load from bottom sediment represents the highest nutrient loads (74% TP and 77% TN) followed by recycled water (13% TP and 13% TN) watershed runoff (11% TP and 6% TN), and atmospheric deposition (1% TP and 4% TN).

Section 5: Linkage Analysis

The primary function of a TMDL linkage analysis is to establish a link between nutrient pollutant loading from multiple external sources and water quality in receiving waters. To support the linkage analysis in the revised TMDLs, coupled water quality and hydrodynamic models were selected as follows for each lake:

- *Lake Elsinore* – Given a simple shape and lateral mixing, a 1-D lake model, the Generalized Lake Model (GLM), was developed to allow for a multidecadal simulation period to capture the full range of temporal and water level variability, including a period of known lakebed desiccation.
- *Canyon Lake* – Given its relatively complex bathymetry, a 3-D lake model, the Aquatic Ecosystem Model (AEM3D), was developed to allow for assessment of temporally and spatially variable water quality response to external nutrient load, including during periods of vertical stratification and consideration of unique lake segments that have limited mixing.

Key input data to the models included meteorological variables (shortwave solar radiation, air temperature, relative humidity, precipitation and windspeed), hydrologic variables (runoff inflows, direct rainfall, evaporation, and overflow), and lake specific data (bathymetry, initial conditions, sediment oxygen demand, and internal nutrient flux rates). Models were calibrated for water level, temperature, TDS, nutrients, and chlorophyll-*a* (a measure of algal biomass). **Figure ES-9** illustrates performance for key water quality parameters for Lake Elsinore GLM and **Figure ES-10** provides results for Canyon Lake AEM3D. The calibrated model was used to evaluate a reference watershed scenario of reduced external nutrient load. Outputs of the reference watershed scenario simulation were converted to CDFs to serve as TMDL numeric targets.

Section 6: Allocations

TMDLs for Lake Elsinore and Canyon Lake are calculated as the sum of average annual WLAs for point sources, average annual LAs for non-point sources minus annual losses of watershed nutrient loads in upstream basins, e.g., retained by Mystic Lake, or channel bottoms. Calculation of a TMDL may be shown as follows: **TMDL= WLA + LA – Retention.** A margin of safety (MOS) was provided in the determination of WLAs and LAs (discussed in section below) and is therefore not included in the formula for the TMDL above.

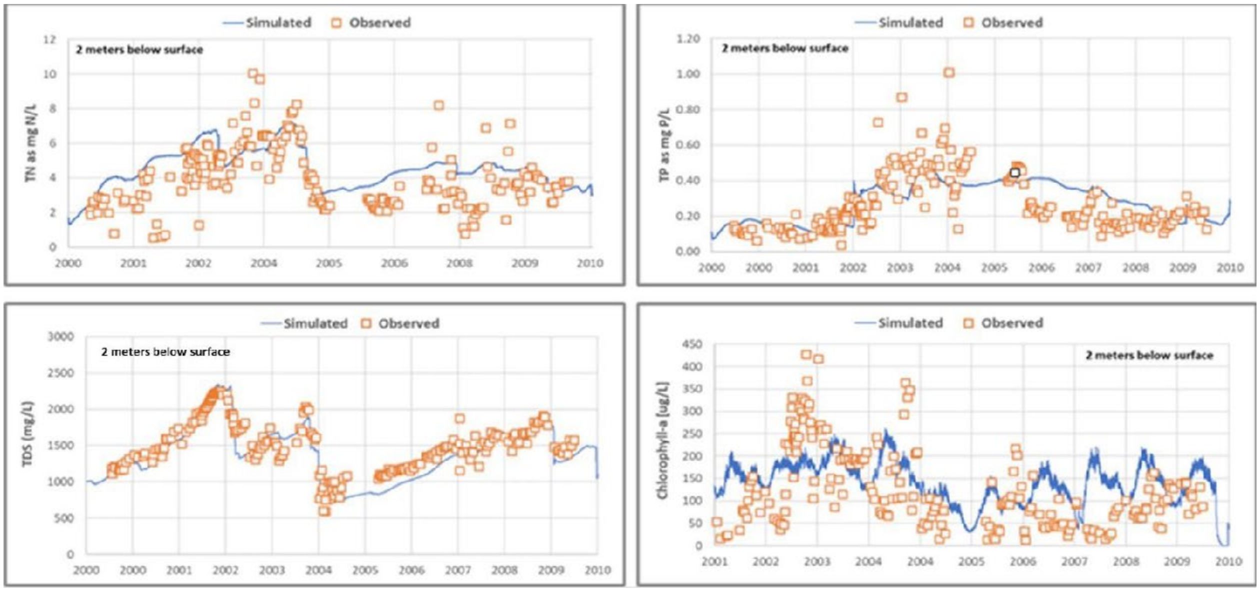


Figure ES-9. Calibration of Lake Elsinore GLM for TN, TP, TDS, and Chlorophyll-*a*

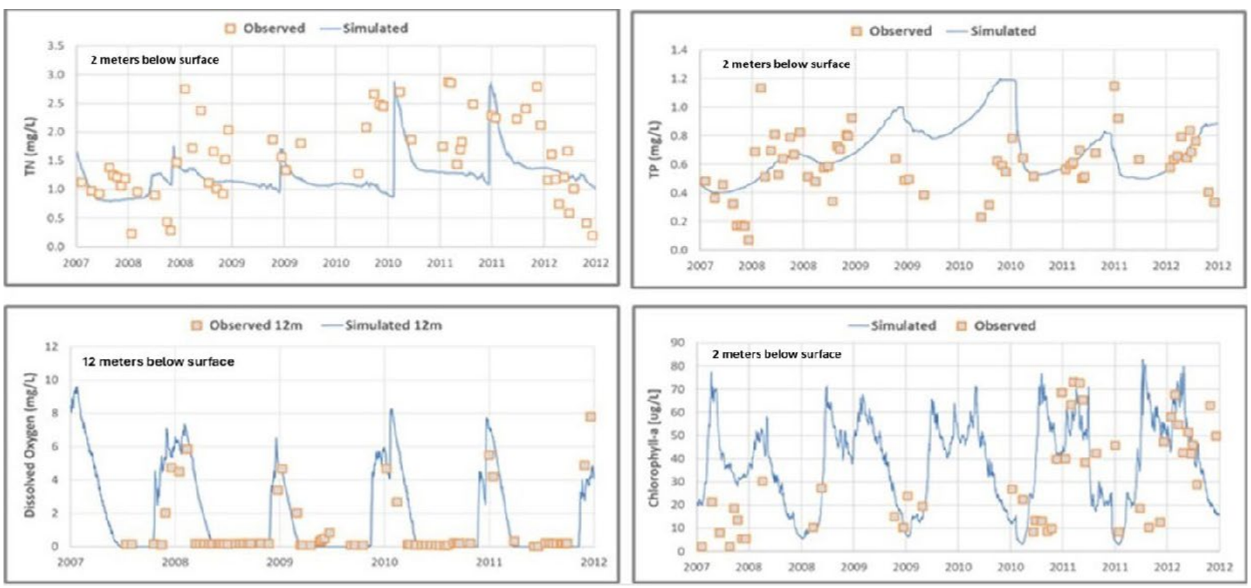


Figure ES-10. Calibration of Canyon Lake AEM3D for TN, TP, Lake Bottom DO, and Chlorophyll-*a*

For all external nutrient sources, WLAs and LAs are determined from nutrient concentrations in wet weather runoff from a reference watershed ($C_{reference}$). Due to the benefits realized with increased lake volume, current volumes (V_{annual}) of runoff and supplemental recycled water additions are accounted for in the estimation of WLAs and LAs, as follows: **WLA or LA = V_{annual}* $C_{reference}$.** Allocations for external loads were developed based on assumptions of reference nutrient concentrations at the 25th percentile of all wet weather samples in the Cranston Guard Station dataset (TP: 0.16 mg/L and TN: 0.68 mg/L). The revised TMDLs include a milestone nutrient load (aligned with Phase II Implementation Plan – see Section 7 below) to demonstrate progress toward meeting the allocations. These milestones are calculated based on the median of all wet weather samples in the Cranston Guard Station dataset (TP: 0.32 mg/L and TN: 0.92 mg/L). TMDLs and allocations are presented for each of the following sources:

Canyon Lake:

- Watershed runoff from jurisdictions in San Jacinto River downstream of Mystic Lake (i.e., Subwatershed Zones 2 - 6), including (a) WLAs for urban runoff from urban MS4s, California Transportation Department (Caltrans), CAFs, March Joint Powers Authority (JPA), and March Air Reserve Base (ARB); I(b) LAs for irrigated and non-irrigated agriculture (> 20 acre operators); and (c) state and federal lands.
- Losses from channel bottom recharge in Salt Creek, San Jacinto River, and Perris Valley Channel.
- Internal nutrient load from lake bottom sediment releases estimated (with AEM3D) to occur when external loads are reduced to reference watershed condition.
- Atmospheric deposition at existing estimated loading.

Lake Elsinore:

- Watershed runoff from the local Lake Elsinore watershed downstream of Canyon Lake (i.e., Subwatershed Zone 1, including WLAs for MS4 and Caltrans, and LAs for federal lands).
- Addition of supplemental recycled water to maintain lake levels.
- Overflows from Canyon Lake to Lake Elsinore.
- Watershed runoff from the Mystic Lake watershed (i.e., Subwatershed Zones 7 - 9) including WLAs for MS4, Caltrans, and CAFs, and LAs irrigated and non-irrigated agriculture (> 20 acre operators) and state and federal lands.
- Losses from retention in Mystic Lake.
- Internal nutrient load from lake bottom sediment releases estimated (with GLM) to occur when external loads are reduced to reference watershed condition.
- Atmospheric deposition at existing estimated loading

The basis for how the WLAs/LAs were developed for the revised TMDLs is summarized in the following sections.

Watershed Runoff: Allocations, both WLAs and LAs, for nutrient loads from watershed runoff are calculated as the product of estimated annual runoff volume under current conditions (using PLOAD for 209 HRUs) and the reference watershed concentration (see Section 3 above). These allocations for watershed runoff represent a snapshot based on 2022 jurisdictional boundaries across the San Jacinto River watershed. As the characteristics of jurisdictional areas change, which is anticipated to be largely a conversion of undeveloped or agricultural land uses to urban land uses, the allocation of loads (and need to reduce existing loads) would be transferred to the jurisdiction or entity that becomes responsible for the watershed area. Thus, allocations as well as existing loads will need to be reconsidered with future updates to land use mapping. The total allocation to watershed sources after accounting for losses (as summarized below) is as follows:

- To Canyon Lake (Milestones for Watershed Loads) – 3,804 kg/yr TP and 10,937 kg/yr TN
- To Canyon Lake (Total Allocations for Watershed Loads) – 1,902 kg/yr TP and 8,084 kg/yr TN
- To Lake Elsinore from local watershed (Milestones for Watershed Loads) – 623 kg/yr TP and 1,791 kg/yr TN
- To Lake Elsinore from local watershed (Total Allocations for Watershed Loads) – 311 kg/yr TP and 1,324 kg/yr TN
- To Lake Elsinore from Mystic Lake overflow (Milestones for Watershed Loads) – 201 kg/yr TP and 579 kg/yr TN
- To Lake Elsinore from Mystic Lake overflow (Total Allocations for Watershed Loads) – 101 kg/yr TP and 428 kg/yr TN

Losses from Channel Bottom Recharge: Not all rainfall that runs off into surface waters in the watershed reaches Canyon Lake because of recharge that occurs in bottom sediments of unlined channel bottoms in Salt Creek, the San Jacinto River and the Perris Valley Channel. Under dry weather conditions, all flows in these waterbodies typically infiltrate into the channel bottom. Estimates of annual loss of runoff within these channel bottoms were developed using areal extent of unlined segments, assumed percolation rates, and analysis of long-term flow gauge data. Losses of runoff volume and associated nutrient load from these channels are reflected in the source assessment and accounted for in the TMDLs for Canyon Lake.

Losses from Mystic Lake Retention: Watershed runoff in the upper San Jacinto River is captured in Hemet Lake within the San Jacinto National Forest and ultimately Mystic Lake. In years when Mystic Lake's storage volume is filled, runoff may be delivered downstream to Canyon Lake and ultimately Lake Elsinore from the upper watershed, i.e., Subwatershed Zones 7-9. Mystic Lake overflows are known to have occurred in water years 1993-1994, 1995-1996, and 1998-1999 (Hamilton and Boldt 2015a,b), but not in subsequent wet years (notable being the 2004-2005 and 2010-11 wet seasons) when flow gauge data show no overflows.

A reservoir water budget analysis spanning the period from 1929-2022 was developed to approximate the volume of overflow in each wet season from Mystic Lake based on water budget components of runoff inflow, storage, and evaporative loss. The analysis predicted that overflows from Mystic Lake downstream to Canyon Lake and ultimately Lake Elsinore may have occurred in 6 of 93 years (average of ~4,000 AFY in overflow years), with long-term volume retention of ~96 percent. Accordingly, losses of runoff volume and associated nutrient load from retention in Mystic Lake is reflected in the source assessment and accounted for in

TMDLs for Lake Elsinore assuming that Canyon Lake functions as a pass through in extreme wet years for overflows from Mystic Lake.

Overflows from Canyon Lake to Lake Elsinore: A USGS flow gauge (San Jacinto River near Elsinore Station 11070500) measures discharge that is comprised of overflows from Canyon Lake with the exception of a small drainage area just downstream of Railroad Canyon Dam. Analysis of data from this gauge was conducted to develop an estimate of annual average overflow volumes from Canyon Lake to Lake Elsinore of ~ 6,200 AFY based on the period from 2000 - 2022. Milestones and allocations for overflows are computed based on this volume of overflow at the reference watershed nutrient concentrations:

- Interim Milestone – 2,471 kg/yr TP and 7,104 kg/yr TN
- Final Allocation – 1,235 kg/yr TP and 5,251 kg/yr TN

Supplemental Recycled Water: The WLA for discharge of supplemental recycled water to Lake Elsinore is based on a reference watershed runoff nutrient concentration and projected discharge of up to 7.5 MGD to maintain lake levels during drought periods. Thus, for an annual discharge of 7.5 MGD (~8,400 AFY), the milestones and WLAs are as follows:

- Interim Milestone – 3,317 kg/yr TP and 9,535 kg/yr TN
- Final Allocation – 1,658 kg/yr TP and 7,048 kg/yr TN

Internal Loads: Implementation of the TMDLs to reduce external loads will over time reduce the pool of nutrients settled to the lake bottom and thereby reduce internal load. A significant lag of 15-30 years is expected for legacy nutrient enrichment to cycle through the system based on analysis of sediment nutrients (Anderson 2012). The lake water quality model used in the linkage analysis was adjusted to account for reduced internal load associated with the reference watershed condition as a key step in the application of the models to produce in-lake TMDL numeric targets. The adjustment was based on a paleolimnology study by Kirby et al. (2005), which showed that enrichment in most the recent 200 years (assumed to be representative of existing conditions) is about double that of the preceding 9,800 years (assumed to be representative of reference condition). Model outputs were generated from daily simulations and summarized to create milestones and LAs for internal nutrient load as follows:

- Canyon Lake AEM3D – Interim Milestone [1,190 kg/yr TP; 3,955 kg/yr TN]
- Canyon Lake AEM3D – Final Allocation [683 kg/yr TP; 2,741 kg/yr TN]
- Lake Elsinore GLM – Interim Milestone [17,629 kg/yr TP; 121,053 kg/yr TN]
- Lake Elsinore GLM – Final Allocation [11,568 kg/yr TP; 103,251 kg/yr TN]

Atmospheric Deposition: LA was made equal to the existing estimate of nutrient load from atmospheric deposition (see Section 4 summary above).

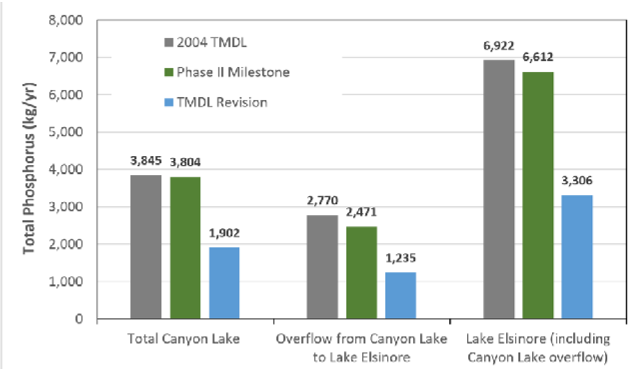
Margin of Safety: When establishing TMDLs, federal regulations require a margin of safety that takes into account lack of knowledge concerning the relationship between allocations and the quality of the receiving water. For these TMDLs, the margin of safety is incorporated into the TMDLs through conservative data analysis when establishing the reference watershed condition. As explained above, numeric targets and allocations are being established for a reference watershed condition based on data collected from the San Jacinto River at the Cranston Guard Station. The data set includes wet weather monitoring results for 10 storm events between 2001 and 2010. The number of grab samples collected during each monitoring event varied from one to nine. The total data set includes 51 data points each for TP and TN. The sampling methodology used was not developed to facilitate flow-weighted composite event mean concentrations to be computed for these nutrients.

In evaluating the data to establish an appropriate reference watershed condition, multiple statistical analyses were performed. To weigh each event more evenly, average nutrient concentrations were computed from multiple grab samples taken during each event – creating one TP and TN value per sampling event. Then, the median and 25th percentiles were computed from the average of the 10 event nutrient concentrations. These values were determined to be appropriate for calculating milestones and allocations. However, to provide a margin of safety, the median and 25th percentile from the 51 grab samples was selected to serve as the basis for the reference watershed concentrations. By using lower values based on computations from all 51 grab samples, the resulting margins of safety for the reference watershed conditions ranges between 16-31% - depending upon the specific nutrient and milestone and allocation.

Total Maximum Daily Load: The LECL TMDLs are comprised of allocations for 10-yr average annual nutrient loads to account for temporal variability associated with naturally occurring weather patterns in the delivery of nutrient loads to the lakes. A complete summary of allocations and retention losses are combined to determine the TMDLs for Canyon Lake (**Table ES-7**) and Lake Elsinore (**Table ES-8**) with milestones and allocations.

The milestones and allocations in the revised TMDLs were compared with the 2004 TMDLs to characterize the proposed change in the allowable nutrient load to Canyon Lake and Lake Elsinore. With internal loads from lake bottom sediment and atmospheric deposition removed from both TMDLs, **Figure ES-11** shows that a reduction in allocations for external nutrients is proposed for both lakes with the reference watershed condition approach.

The difference between existing load and the allocation represents the reduction in TP and TN loads that must be achieved to meet WLAs and LAs (**Table ES-9**). Notably, as discussed in Section 7, a critical element for attaining the milestones and TMDLs is the use of in-lake projects to help control the release of internal sediments that offset external watershed runoff loads. Without the use of offsets, some dischargers may find it difficult to meet applicable WLAs and LAs.



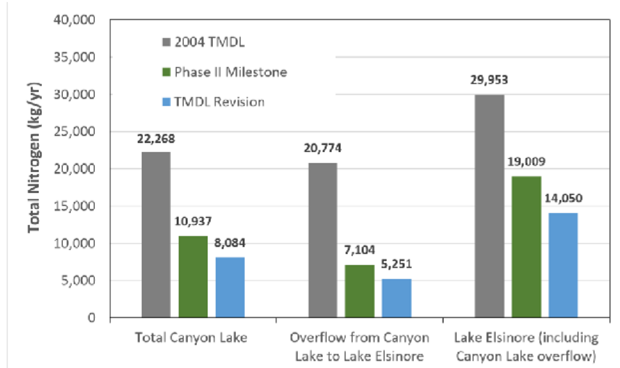


Figure ES-11. Comparison of Total WLAs and LAs for External Nutrient Sources Between the Proposed Revised TMDLs and Existing 2004 TMDLs

Table ES-7. Summary of Milestones, WLAs and LAs for Major Categories of Nutrient Sources to Canyon Lake from Subwatersheds Below Mystic Lake

Source	Phase II Milestone (kg/yr as 10 yr running average)		Phase III Final Allocation (kg/yr as 10 yr running average)	
	TP	TN	TP	TN
MS4 Jurisdiction Runoff (WLA)	3,939	11,326	1,970	8,371
Caltrans Jurisdiction Runoff (WLA)	52	151	26	111
March JPA Jurisdiction Runoff (WLA)	53	153	27	113
March ARB Jurisdiction Runoff (WLA)	55	158	28	117
CAF (WLA) [1]	1	2	0.4	2
Irrigated Agriculture (LA)	105	302	53	223
Non-Irrigated Agriculture (LA)	41	119	21	88
Other State/Federal/Tribal Jurisdictions (LA)	147	421	73	311
Reference Watershed Retention	-590	-1695	-295	-1253
Subtotal Watershed Allocation (below Mystic Lake)	3,804	10,937	1,902	8,084
Atmospheric Deposition (LA)	23	1,406	23	1,406
Sediment Nutrient Flux (LA)	1,190	3,955	683	2,741
Canyon Lake TMDL	5,017	16,298	2,608	12,230

[1] If the Santa Ana Water Board determines at any time during Phase II or Phase III that any facilities regulated in Order R8-2018-0001 as CAFOs (as defined in 40 CFR 122.23(b)(2)) should instead be regulated as nonpoint sources, the wasteload allocation for such facilities shall be deemed a load allocation and shall continue to apply.

Table ES-8. Summary of Milestones, WLAs and LAs for Major Categories of Nutrient Sources to Lake Elsinore

Source	Phase II Milestone (kg/yr as 10 yr running average)		Phase III Allocation (kg/yr as 10 yr running average)	
	TP	TN	TP	TN
Local Lake Elsinore Watershed				
MS4 Jurisdiction Runoff (WLA)	548	1,575	274	1,164
Caltrans Jurisdiction Runoff (WLA)	11	33	6	24
Other State/Federal/Tribal Jurisdictions (LA)	64	183	32	135
Subtotal Watershed Allocation (local watershed)	623	1,791	311	1,324
Watershed Above Mystic Lake				
MS4 Jurisdiction Runoff (WLA)	1,890	5,434	945	4,016
Caltrans Jurisdiction Runoff (WLA)	42	120	21	89
CAF (WLA) [1]	3	8	1	6
Irrigated Agriculture (LA)	119	342	59	253
Non-Irrigated Agriculture (LA)	26	75	13	55
Other State/Federal/Tribal Jurisdictions (LA)	3,050	8,769	1,525	6,481
Minus Reference Watershed Retention	-4,928	-14,168	-2,464	-10,472
Subtotal Watershed Allocation (above Mystic Lake)	201	579	101	428
Canyon Lake to Lake Elsinore (LA)	2,471	7,104	1,235	5,251
Supplemental Water	3,317	9,535	1,658	7,048
Atmospheric Deposition	156	9,682	156	9,682
Sediment Nutrient Flux	15,227	104,559	10,221	91,232
Lake Elsinore TMDL	21,995	133,250	13,683	114,964

[1] If the Santa Ana Water Board determines at any time during Phase II or Phase III that any facilities regulated in Order R8-2018-0001 as CAFOs (as defined in 40 CFR 122.23(b)(2)) should instead be regulated as nonpoint sources, the wasteload allocation for such facilities shall be deemed a load allocation and shall continue to apply.

Table ES-9. Reduction of Existing External Nutrient Load Needed to Meet Final Allocations for External Loads

Lake	Nutrient	Existing External Load (kg/yr)	External Allocations (kg/yr)	Reduction (kg/yr)	Reduction (%)
Canyon Lake	TP	7,360	1,902	5,458	74%
	TN	23,864	8,084	15,780	66%
Lake Elsinore	TP	8,636	3,306	5,330	62%
	TN	50,241	14,050	36,191	72%

Section 7: Implementation Plan

The LECL TMDLs are being established and implemented as phased TMDLs, which includes a phased Implementation Plan designed to return water quality in Lake Elsinore and Canyon Lake to the reference condition, as represented by applicable numeric targets. The Implementation Plan has three phases:

- *Phase I (2005-2020)* – The previous 2004 TMDLs are referred to as Phase I and required attainment as soon as possible but no later than December 31, 2020, as a 10-year running average. Based on data and information obtained during implementation of Phase I, it was determined that the Nutrient TMDLs needed to be revised. The 2004 TMDLs and associated Implementation Plan are being replaced in their entirety and will no longer be applicable upon the effective date of the 2024 Nutrient TMDLs. Actions undertaken to implement the 2004 TMDL will be updated and enhanced as part of Phase II of the revised TMDL.
- *Phase II (effective date to 20 years after effective date)* – Phase II establishes milestones and interim numeric targets that are to be achieved as soon as possible but no later than 20 years from the effective date of the revised TMDLs. The Phase II milestones and interim numeric targets are necessary because the final numeric targets and TMDLs, waste load allocations and load allocations are set at very conservative levels that may not reflect actual watershed conditions. During Phase II, significant studies and data collection will be performed to review the appropriateness of the conservative final numeric targets and final load allocations. Further, because of the length of Phase II, the Implementation Plan for these TMDLs includes reconsideration of the revised TMDLs by the Santa Ana Water Board twice during the twenty-year period. Subject to resource constraints, the Santa Ana Water Board's first process for reconsideration is expected to occur no later than 10 years from the effective date; and the second process for reconsideration is expected to occur no later than 18 years from the effective date.
- *Phase III – (20 years from effective date to 30 years after effective date)* - Phase III establishes final numeric targets and allocations (WLAs and LAs) that must be attained as soon as possible but no later than 30 years from the effective date of the revised TMDLs. If reconsideration of the revised TMDLs at years 10 and 18 do not revise or alter the TMDLs or

do not occur within 20 years of the effective date, Phase III actions will commence 20 years from the effective date.

Phase I Program

During implementation of Phase I (2005 to present), responsible entities, as applicable, implemented (and continue to implement) a combination of watershed and in-lake controls. These activities include: (1) completing studies to support future management and policy decisions; (2) constructing and operating watershed and in-lake projects; (3) implementation of BMPs; and (4) conducting monitoring to support periodic TMDL compliance assessments.

TMDL stakeholders have satisfactorily completed the Phase I Implementation Plan. The 2020 TMDL compliance assessment demonstrated that collectively the stakeholders have met the 2004 TMDL WLA/LAs for both Lake Elsinore and Canyon Lake (**Table ES-10**).

Table ES-10. Demonstration of Compliance with 2004 TMDL Allocations (LESJWA 2021)

Average Annual Nutrient Load over 2011 2020 (kg/yr)	Canyon Lake		Lake Elsinore	
	TP	TN	TP	TN
Measured External Load	5,871	15,743	5,250	33,060
Allocation to Watershed in TMDL[1]	-3,845	-22,268	-6,922	-29,953
In-Lake Offsets	-2,079	0	-7,030	-44,000
Additional Load Reduction Required[2]	-53	-6,525	-8,702	-40,893

[1] TMDL minus allocations for internal sediment and atmospheric deposition

[2] If ≤ zero, compliance with final allocations in TMDL for all watershed sources is effectively demonstrated

A key component of the Phase I program has been the implementation of in-lake projects to improve water quality. For Lake Elsinore, these projects have included operation of the Lake Elsinore Aeration and Mixing System (LEAMS) to improve DO conditions and fishery management to reduce the number of Common Carp. Common Carp and other benthivorous fish species cause physical resuspension of sediment and porewater by foraging within the lake bottom, a process referred to as bioturbation. Further, lake levels in Lake Elsinore are being stabilized through addition of recycled water. In Canyon Lake, alum additions have occurred twice per year since 2013.

The LEAMS projects are operated and maintained by the LEAMS operators, which include Elsinore Valley Municipal Water District (EVMWD), the City of Lake Elsinore and Riverside County. Offset credits from the implementation of LEAMS are administered through the LECL Task Force via a licensing agreement between LESJWA and the LEAMS operators. The addition of supplemental recycled water is implemented through an agreement between EVMWD and the City of Lake Elsinore. The remaining in-lake projects (alum and fisheries management) are administered through the LECL Task Force, which divides cost shares according to the proportional need to offset current external nutrient loads to the lakes in excess of TMDL allocations.

With respect to recycled water additions to Lake Elsinore, over 80,000 AF has been added to the lake since 2007, effectively avoiding a lakebed desiccation event predicted by the GLM model to have otherwise occurred in 2016 (**Figure ES-12**). The revised TMDLs assume that supplemental recycled water will continue to be used to maintain minimum water levels in Lake Elsinore due to the existing agreements and understandings between the City of Lake Elsinore and EVMWD. This precludes future lakebed desiccation events from occurring. Thus, the natural reset process of lakebed desiccation cannot be relied upon as a water quality improvement mechanism.

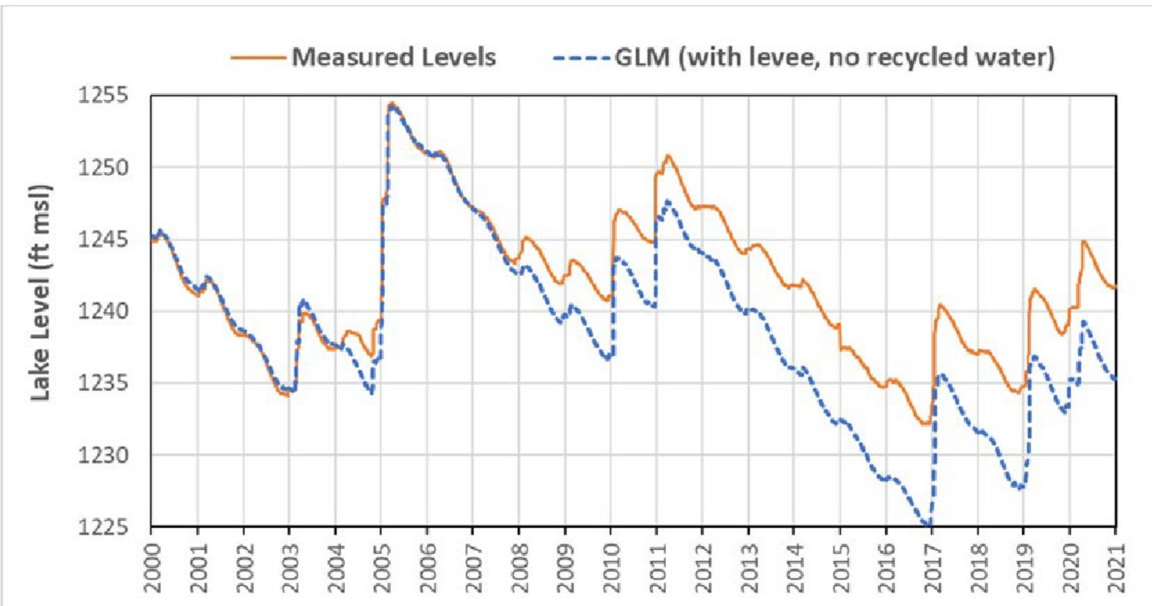


Figure ES-12. Lake Elsinore Measured Water Level Versus Simulated Water Level for Scenario with No Recycled Water Addition

Phase II Program

The Phase II Implementation Plan updates and enhances the current Phase I program in its entirety and begins implementation upon the effective date of the revised TMDLs. Phase II tasks range from continued implementation over the Phase II implementation period of existing tasks (e.g., operation of existing in-lake projects, stakeholder coordination and monitoring and reporting) to new tasks that involve focused studies or planning efforts that occur over a specific year. These focused studies and planning activities are designed to provide the LECL Task Force and the Santa Ana Water Board with the information they need to assess the status of attainment with the revised TMDLs, measure the long-term performance of watershed controls, evaluate the potential need to consider revising the Lake Elsinore water quality criteria, and evaluate what constitutes appropriate reference concentrations for nutrients (i.e., the median, the 25th percentile, or some other value).

Phase II Implementation Plan Tasks

In all there are eighteen tasks that comprise the Phase II Implementation Plan. The tasks are as follows:

- *Task 1 – Stakeholder Coordination*: LECL Task Force collaboration at a frequency determined appropriate by the Task Force.
- *Task 2 – Revise Existing Permits and Other Regulatory Actions*: Update permits or other regulatory actions to support TMDL implementation. As described in Section 7.2.2.1, TMDLs are not self-executing. This document therefore refers to "meeting" or "attaining" TMDLs, allocations, and water quality standards; and "complying with" TMDL-based requirements that have been incorporated into Santa Ana Water Board or State Water Board orders.
- *Task 3 – Revise Existing Watershed Implementation Plan(s)*: Revise existing Riverside County MS4 Program Comprehensive Nutrient Reduction Program (CNRP) or submit an equivalent Watershed Management Plan.
- *Task 4 – Review and Re-Authorize Existing In-Lake Project(s) for Canyon Lake, and/or Approve New In-Lake Projects*: Evaluate effectiveness of the Canyon Lake Alum Project and potential feasibility of implementation of other water quality control options.
- *Task 5 – Evaluate In-Lake Projects to Improve Water Quality in Lake Elsinore*: Identify and evaluate feasible water quality control options that may be implemented to improve and maintain water quality in Lake Elsinore; identify preferred option or set of options.
- *Task 6 – Implementation of Preferred Option or Options for Lake Elsinore*: Prepare schedule to implement findings from Task 5.
- *Task 7 – Revise Lake Elsinore Water Quality Criteria Based on Implementation of In-Lake Treatment Controls, if necessary*: Develop Work Plan to revise water quality criteria applicable to Lake Elsinore.
- *Task 8 – Study to Evaluate Cyanobacteria in Lake Elsinore*: Evaluate Harmful Algal Bloom conditions in Lake Elsinore and options to manage cyanobacteria and toxicity.
- *Task 9 – Study to Define and Identify Minor Sources and Identify Responsibility Levels of TMDL Implementation for Such Sources*: Evaluate contributions of TP and TN from minor sources and determine if there is a level of discharge that should be defined as minor; identify appropriate level of TMDL obligations or recommendation to exclude from TMDL obligations for minor sources that meet proposed minor threshold.
- *Task 10 – Study of Performance of Watershed Controls*: Evaluate performance of updated watershed controls included in the revised and approved CNRP and Agricultural General Order and AgNMP.
- *Task 11 – Study for Evaluating Reference Watershed Conditions*: Conduct study to validate basis for Phase II interim milestones being representative of reference watershed conditions.

- *Task 12 - Study of Lake-bottom Sediment Sampling and Core Flux Experiments*: Evaluate status of nutrient enrichment in lake sediments.
- *Task 13 – Fishery Management*: Evaluate status of Common Carp population in Lake Elsinore fishery.
- *Task 14 – Evaluate Status of TMDL Attainment with Interim Targets and Milestones*: Evaluate status of attainment with interim numeric targets and Phase II milestones.
- *Task 15 – Re-evaluate Final TMDL Numeric Targets, WLAs and LAs*: Re-evaluate final numeric TMDL targets, WLAs, LAs, and approaches to demonstrate compliance.
- *Task 16 – Identify Possible Revisions to the TMDLs*: As appropriate, prepare necessary documentation to support revisions to the TMDLs.
- *Task 17 – Review and Reconsider Lake Elsinore/Canyon Lake Nutrient TMDLs*: Santa Ana Water Board will review and reconsider the TMDLs as they determine appropriate and necessary based on implementation of the Phase II tasks and other information that becomes available. Review and reconsideration of the TMDLs by the Santa Ana Water Board should occur no later than years 10 and 18 after the effective date of the TMDLs.
- *Task 18 – Surveillance & Monitoring Program (SMP)*: Update existing monitoring program currently being implemented under the Phase I Implementation Plan.
- *Task 19 – Annual Water Quality Reports*: Prepare annual water quality report.

Figure ES-13 illustrates the relationships among Phase II tasks and how they are coordinated to provide the information needed to assess progress being made towards attainment with the interim numeric targets and milestones over the 20-year Phase II schedule. A multi-decadal assessment process is necessary to allow time for expected changes in the watershed that could affect nutrient loads to the downstream lakes to occur, including: (a) ongoing conversion of agricultural lands to an urban landscape; (b) continued addition of supplemental recycled water to Lake Elsinore; and (c) continued reduction of nutrients in the lake sediments.

Phase II Attainment Demonstrations

Demonstrations of progress towards attainment of the TMDLs must be submitted every 3 years by entities with an allocation (see Phase II, Task 14). With respect to evaluating attainment of milestones, attainment may be evaluated via different options depending on the type of discharge. These options may be evaluated using four alternative methods. The revised TMDLs guide how data collected through implementation of the monitoring program, or data collected by individual entities, may be used to assess attainment with the interim milestones in the revised TMDLs. Each method is briefly described below:

- *Approach 1 - Monitoring Data Compared to Numeric Targets*: In-lake water quality data collected over a 10-year period may be plotted as a CDF and compared to the interim numeric target CDFs to assess whether the range of measured data is equal to or better than water quality for the reference condition associated with interim numeric targets.

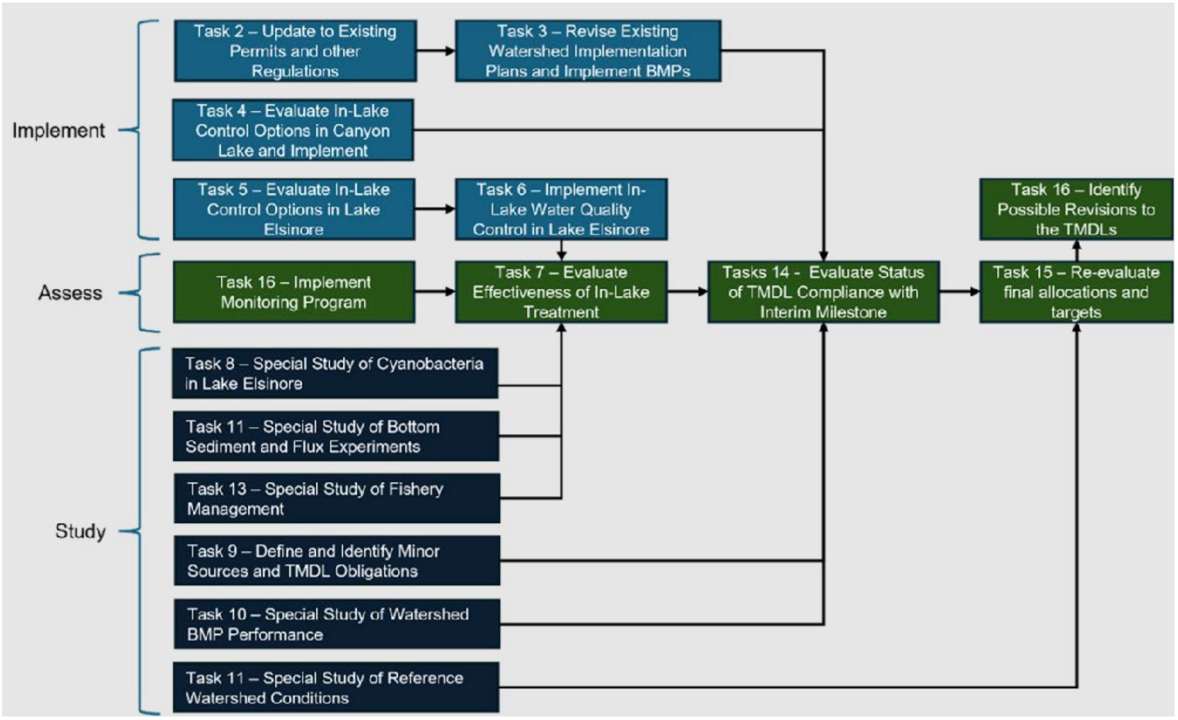


Figure ES-13. Adaptive Management Approach with Phase II Implementation Plan Tasks

- *Approach 2 - Reference Condition Model*: Extension of the reference condition lake water quality models into the attainment assessment period. Model results for a reference watershed could be compared with measured data over concurrent periods. This approach is most suitable in Lake Elsinore where the numeric targets were developed from a 105-year simulation period to account for multi-decadal climate variability, thus the preceding 10-year period of measured data may not be representative of the long-term simulation period used to create the interim numeric target CDFs.
- *Approach 3 - External Load Reduction*: Milestones achieved within the watershed through BMP deployments. Two options for use of this approach are provided: (1) Option 3A (10-year Average Nutrient Concentration) relies on demonstrating attainment by showing nutrient concentrations in runoff, from monitoring data, is reduced such that they are equal to or below the milestones; and (2) Option 3B (Volume Retention) relies on retaining sufficient runoff volume such that it may be demonstrated that the downstream load from a given drainage area is equal to or less than what would occur in a zero impervious reference watershed.
- *Approach 4 - In-Lake Offsets*: If the external load arriving at the lakes exceeds collective milestones for watershed runoff sources, then the excess external load can be offset with participation in a regional in-lake project that reduces the internal in-lake nutrient load. Demonstrating attainment involves computing the excess nutrient load from external sources, individually or collectively. This determines the individual and collective need for nutrient reduction credits through participation in an offset program involving implementation of in-lake projects.

Phase III Program

Phase III tasks are similar to those implemented during Phase II. These tasks apply an iterative approach to compliance, repeating or improving activities as needed to achieve compliance with the revised TMDLs final targets and allocations. Waste discharge requirements must include final compliance deadlines for load- and wasteload allocations that are no later than 30 years after the effective date of the revised TMDLs (or within 10 years from the beginning of Phase III). Attainment of numeric targets may be evaluated via different options depending on the type of discharge, as described in this Technical Report. Unless revised in the future, these options may be evaluated using the same four alternative methods described above for the Phase II Implementation Plan.

Fourteen specific tasks are proposed for implementation during Phase III. However, prior to the initiation of Phase III, the TMDL numeric targets and allocations should be re-evaluated (Phase II Task 15) to determine if they are appropriate given the outcome of Phase II implementation activities. The re-consideration of the final TMDL targets and allocation will evaluate and assess knowledge gained during Phase II and other information that could affect how loads are allocated or the timing of attainment of the final targets, e.g., outcome of anticipated climate change impacts or changes in regional water management strategies or reference watershed characteristics.

Section 8: Monitoring Requirements

The Phase I TMDL Implementation Plan includes a comprehensive monitoring program that includes sampling in the San Jacinto River watershed, Canyon Lake, and Lake Elsinore. The proposed revision to the TMDLs recommends minor updates to the Phase I monitoring program (**Table ES-11**). These recommendations and the revision of the monitoring program will occur under Phase II Task 18.

Table ES-11. Summary of Elements for Inclusion in Revised TMDL Monitoring Program

Waterbody	Elements Recommended for Inclusion in Revised TMDL Monitoring Program
San Jacinto River Watershed	• Continue sample collection per the existing SMP and Quality Assurance Project Plan (QAPP) at a minimum. Consider enhancements to the SMP and QAPP to generate data needed to support future compliance demonstration. • 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-hrs. The January 1 through April 30 mobilization criteria remain the same.

Table ES-11. Summary of Elements for Inclusion in Revised TMDL Monitoring Program

Waterbody	Elements Recommended for Inclusion in Revised TMDL Monitoring Program
Lake Elsinore	• Continue sample collection per the existing SMP and QAPP at a minimum. Consider enhancements to the SMP and QAPP to generate data needed to support future compliance demonstration. • 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. • In the annual report, characterize data from two EVMWD multi-depth in-lake water quality sondes in combination with fixed depth dissolved oxygen 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. • Consider incorporating 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	• Continue sample collection per the existing SMP and QAPP at a minimum. Consider enhancements to the SMP and QAPP to generate data needed to support future compliance demonstration. • 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. • Install in-lake dissolved oxygen 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. • Consider incorporating 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)

Section 9: CEQA

As a state 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 technical TMDL Report serves as a component of the Substitute Environmental Document (SED). Section 9 evaluates the potential environmental effects of the proposed action to amend the Basin Plan to revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake (Proposed Project). Consistent with the State Water Board's CEQA regulations, the environmental analysis identifies a range of reasonably foreseeable attainment strategies, presents an Environmental Checklist that evaluates reasonably foreseeable environmental effects and, if applicable, mitigation measures, and discusses alternatives to the Proposed Project. The environmental analysis found that there are no potential significant environmental impacts associated with the Proposed Project or reasonably foreseeable methods of compliance.

Because no potential environmental impacts were identified which could be reduced by an alternative to the Proposed Project or alternative means of compliance with the Proposed Project, the only alternative addressed by the CEQA analysis is the No Project Action Alternative, which entails leaving the current 2004 TMDLs in place. Under the "No Project" 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 at levels sufficient to attain allocations established by the 2004 TMDLs. However, several of the 2004 TMDL response targets would likely continue to be exceeded despite compliance with the allocations. This outcome is likely to occur due to problems that have been identified with the linkage analysis that was conducted during development of the 2004 TMDLs. Therefore, revisions to the TMDLs will likely be required at some point.

Section 10: Economic Considerations

Compliance with the proposed revised TMDLs will likely require, at a minimum, continued implementation of current (or equivalent) level of regional controls, which are estimated to cost ~$1.2 million/yr to operate (LEAMS, Canyon Lake alum addition, Lake Elsinore carp removal, monitoring, and Task Force administration). The revised TMDLs will require more nutrient reductions than those needed to meet the 2004 TMDLs; therefore, supplemental water quality control projects (e.g., oxygenation, wetland treatment, chemical additions) will likely be needed to assure compliance. Supplemental water quality projects will include both a capital and operation and maintenance (O&M) cost.

As part of the development of this TMDL Technical Report, multiple supplemental water quality treatment options were considered at a planning level to assess whether economically viable paths to compliance may be available. This analysis determined that the ability to continue to use in-lake water quality controls to offset excess external nutrient loads provides highly cost-effective alternatives ($100 - $1,000/kg/yr for TN and TP, respectively) relative to capture of nutrients in the watershed (e.g., urban stormwater: $1,000 - $7,000/kg/yr for TN and TP, respectively, or agricultural field BMPs: ~$8,000/kg/yr for TP and TN). Continued implementation of in-lake projects also supports the overall wet lake strategy inherent in the TMDLs' Implementation Plan.

Managing Lake Elsinore and Canyon Lake to improve water quality will result in attainment of recreational and aquatic life beneficial uses. This outcome will provide significant economic value to the region, including visitors to Lake Elsinore and Canyon Lake that enjoy fishing, boating, swimming, and other outdoor recreation activities.

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 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 (USEPA) 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 included a detailed Implementation Plan which described a variety of activities that must be undertaken to meet water quality standards in Lake Elsinore and Canyon Lake. In the decades following USEPA's approval, stakeholders throughout the watershed initiated a number of programs and projects to meet 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 Lake Elsinore. 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, confined animal facilities (CAFs), 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 MS4 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).
- From 2013 to 2023, the LECL Task Force has implemented 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 May 2023, almost 3,000 metric tons of alum have been applied and an estimated 20,000 kilograms (kg) (44,000 pounds [lb]) of phosphorus have been neutralized in Canyon Lake. Water quality has improved significantly since the program began with average annual chlorophyll-*a* reduced from ~60 micrograms/liter (µg/L) in 2011-2012 to 22 µg/L in 2019-2020 and annual average TP reduced from 0.60 milligram/liter (mg/L) in 2011-2012 to 0.14 mg/L in 2019-2020.
- In 2019, the LECL Task Force conducted comprehensive fish, zooplankton and phytoplankton surveys in Lake Elsinore. Study findings showed that carp biomass density continues to remain low, similar to that observed in 2008 at approximately 55.3 lbs/acre (LESJWA 2020).
- In 2020, the LECL Task Force completed a TMDL compliance assessment report demonstrating that the 2004 TMDL WLAs/LAs were achieved collectively based on findings from mass emission monitoring for the 10-year period from 2011-2020, offset credits generated by implementation of the alum program in Canyon Lake and LEAMS operation in Lake Elsinore (LESJWA 2021). However, the assessment report also showed that several causal and response numeric targets have not been achieved.

The LECL Task Force has supported various supplemental scientific studies in the 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 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, Lake Elsinore and San Jacinto Watersheds Authority (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 (Anderson 2016a; Anderson 2012a). 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) Water quality models showed that Canyon Lake is unlikely to achieve the current response targets for DO in the lake bottom even after the stakeholders achieve attainment of the WLAs and LAs specified in the TMDLs. This is principally due to sediment oxygen demand within the hypolimnion during periods of thermal stratification.

(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 attain 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 percent and by the addition of more than 75,000 acre feet (AF) of recycled water to the lake from 2007 through 2023. Both projects 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. 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. TMDLs should be revised to account for the nutrient load reductions that have resulted from Best Management Practice (BMPs) implementation, low impact development (LID) requirements, restrictions on dairy discharges, changes in certain water quality standards (e.g., ammonia), and in-lake remediation projects that have occurred since TMDLs adoption. Finally, revision to the TMDLs is also needed because the linkage analysis in the adopted 2004 TMDLs significantly overestimated the overflow volume from Canyon Lake to Lake Elsinore in 1998.[1] This overestimation translated into a greater than intended flow volume and allowable nutrient load to reach Lake Elsinore, which affected the TMDL allocations of nutrients to watershed sources.

The report findings do not imply that the original 2004 TMDLs were deficient or defective. Rather, the 2004 TMDLs were based on the best data available at that time. Today, however, we know more than we did in 2004 when the TMDLs were adopted because of extensive implementation of hydrologic measurements, water quality monitoring, modeling, and scientific studies. For example, we now have 20 years of flow gauge data at the inflows to Canyon Lake. 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. We also have identified important remaining data gaps and created a series of implementation tasks to conduct focused studies to improve the confidence in the basis for the revised TMDLs and guide adaptive management at future milestones.

According to USEPA, updating TMDLs to reflect newly available information will "*facilitate better watershed planning and adaptive implementation*" (USEPA 2012). In addition, the 2004 TMDL Implementation Plan included a task to reevaluate the TMDLs 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.

Given the need to update the TMDLs, the LECL Task Force prepared its first Technical Report with recommended TMDL revisions in 2018 (LESJWA 2018). These recommendations were based on findings from: (a) more than 10 years of studies and data collection from the watershed and lakes following the 2004 adoption of the TMDLs; and (b) the use of updated modeling tools.

[1] The 2004 TMDL used a frequency weighted average of volumes from representative dry, moderate, and wet hydrologic years to approximate runoff inflows to Lake Elsinore for setting allocations. The year selected to be representative of the "wet" condition was 1998 and was given a frequency weight of 16 percent based on 14 of 87 years exceeding the USGS gauge measured volume of 17,230 acre feet per year (AFY) in 1998. The Environmental Fluid Dynamics Code (EFDC) model used in the linkage analysis estimated flows from Canyon Lake to Lake Elsinore during 1998 to be 133,981 AFY (see Section 6.2 of the 2004 TMDL Technical Staff Report [Santa Ana Water Board 2004b]). This higher volume served as the basis for frequency weighted load watershed allocations to both Canyon Lake and Lake Elsinore in the 2004 TMDLs.

Since the development of the 2018 TMDL Technical Report, water quality models used for the linkage analysis in both Lake Elsinore and Canyon Lake were migrated from sunsetted modeling software platforms to currently supported software. Results of the new models reproduced the outputs of the sunsetted tools closely and provide the basis for the linkage analysis in this 2024 update of the TMDL Technical Report (CDM Smith 2022).

Following detailed technical and regulatory reviews and consideration of additional data and modeling analyses, the LECL Task Force has prepared this revised Technical Report with updated recommendations to revise the TMDLs. The TMDL revision involved a reference watershed approach and incorporates interim (within 20 years of the TMDL effective date) and final (within 30 years of the TMDL effective date) attainment deadlines. In addition, special studies are required to further improve the scientific basis for the TMDL and allow for potential reopeners, guidance is provided for how future data can be used to demonstrate attainment of the TMDL through a variety of options, and guidance is provided for how to incorporate the revised TMDL into future National Pollutant Discharge Elimination System (NPDES) permit updates.

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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 TMDLs 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.

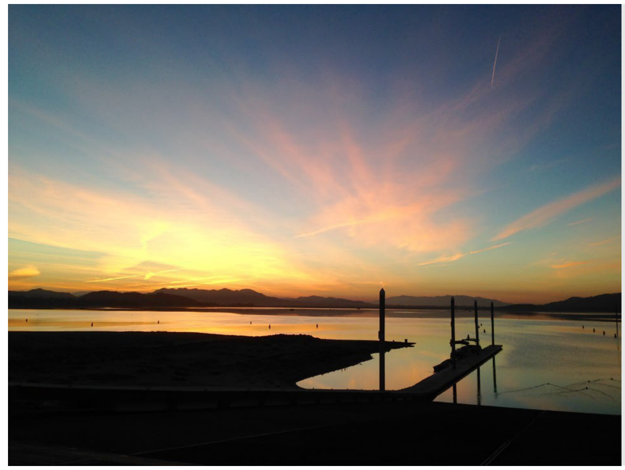

Figure 2-1. Sunrise on Lake Elsinore, 2016 (Source: Wood Environment and Infrastructure Solutions, Inc.)

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 3 and 4 of the Water Quality Control Plan for the Santa Ana River Basin (Basin Plan; Santa Ana Water Board 2019, 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.)

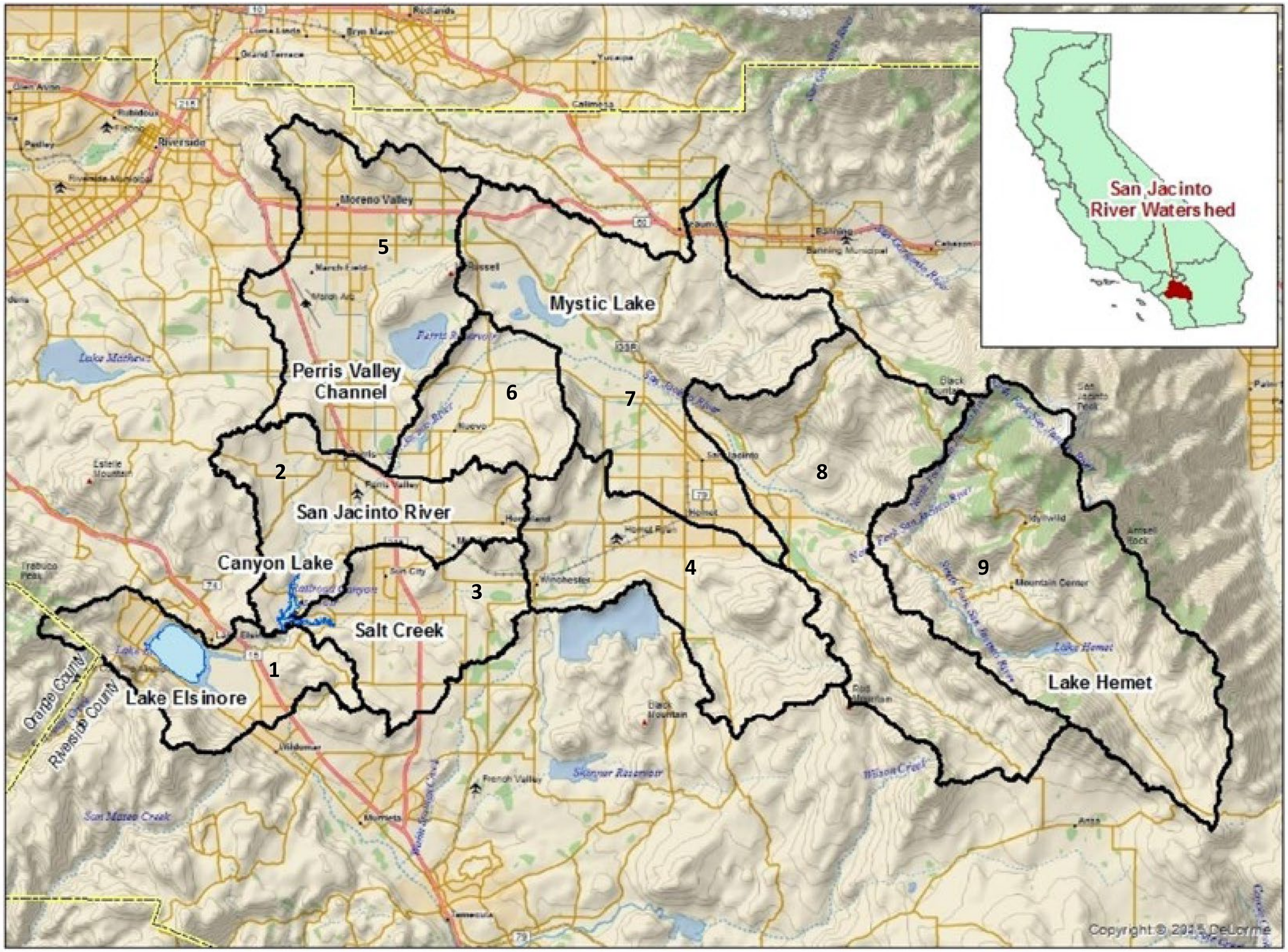

Figure 2-3. San Jacinto River Watershed with Key Subwatersheds Highlighted

Table 2-1. Lake Elsinore and Canyon Lake Beneficial Uses and Water Quality Objectives (Santa Ana Water Board 2019, as amended)

<table>
<tr><th>Lake</th><th>Constituent</th><th>Relevant Water Quality Objectives</th></tr>
<tr><td rowspan="5">Lake Elsinore
Warm Freshwater Aquatic Habitat – (WARM)
Water Contact Recreation (REC1)
Non-Contact Recreation (REC2)
Wildlife Habitat (WILD)
Commercial and Sportfishing (COMM)
Rare, Threatened and Endangered Species (RARE)</td><td>Total Inorganic Nitrogen (TIN)[1]</td><td>1.5 mg/L</td></tr>
<tr><td>Algae</td><td>Waste discharges shall not contribute to excessive algal growth in receiving waters</td></tr>
<tr><td>Un-ionized Ammonia (UIA)[2]</td><td>Acute (1-hour) Objective = 0.822 [0.87/FT/FPH/2]
Chronic (4-day) UIA-N Objective = 0.822 [0.87/FT/FPH/RATIO]</td></tr>
<tr><td>Dissolved Oxygen (DO)</td><td>DO content of surface waters shall not be depressed below 5 mg/L for waters designated WARM</td></tr>
<tr><td>Total Dissolved Solids (TDS)</td><td>2,000 mg/L TDS</td></tr>
<tr><td rowspan="10">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)</td><td>Total Inorganic Nitrogen (TIN)[1]</td><td>8 mg/L</td></tr>
<tr><td>Algae</td><td>Waste discharges shall not contribute to excessive algal growth in receiving waters</td></tr>
<tr><td>Un-ionized Ammonia (UIA)[2]</td><td>Acute (1-hour) Objective = 0.822 [0.87/FT/FPH/2]
Chronic (4-day) UIA-N Objective = 0.822 [0.87/FT/FPH/RATIO]</td></tr>
<tr><td>Dissolved Oxygen (DO)</td><td>DO content of surface waters shall not be depressed below 5 mg/L for waters designated WARM</td></tr>
<tr><td>Total Dissolved Solids (TDS)</td><td>700 mg/L</td></tr>
<tr><td>Hardness</td><td>325 mg/L</td></tr>
<tr><td>Sodium</td><td>100 mg/L</td></tr>
<tr><td>Chloride</td><td>90 mg/L</td></tr>
<tr><td>Sulfate</td><td>290 mg/L</td></tr>
</table>

[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 2022 assessment for the region (State Water Board 2024) for toxicity, nutrients, and organic enrichment/low DO. Uses impaired include warm freshwater habitat (WARM), water contact recreation (REC1) and non-contact water 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 numerous newly completed studies as referenced in the document (Santa Ana Water Board 2004b). These findings provided additional information for 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 the recreational uses of the lake. In addition, massive populations of algal cells in the water column cause high turbidity in the lake, making the water an aesthetically unpleasing murky green color at times.

2.1.2.2 Canyon Lake

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

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 numerous studies that provided additional understanding of 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 USEPA approved the TMDLs on September 30, 2005.

2.1.3 Basis for TMDL Revision

The post-TMDL implementation period from 2004 to 2023 has been a period of planning, investigating, 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.

The LECL Task Force petitioned the Santa Ana Water Board in June 2015 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 (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 each 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.

Table 2-2. Numeric Targets for 2004 TMDLs (Table 5-9n in Santa Ana Water Board 2004a; also Table 6-1n in the Basin Plan [Santa Ana Water Board 2019])

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 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; also Table 6-1r in the Basin Plan [Santa Ana Water Board 2019])

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
	CAF[4, 5]	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/rolling average (a calculation to analyze data points by creating a series of averages of different selections of the full dataset. A running average is an average that continually changes as more data points are collected)

[3] WLA for supplemental water should be met as soon as possible as a five-year running average

[4] Allocation only applies to where this land use occurs downstream of Canyon Lake

[5] If the Santa Ana Water Board determines at any time during Phase II or Phase III that any facilities regulated in Order R8-2018-0001 as CAFOs (as defined in 40 CFR 122.23(b)(2)) should instead be regulated as nonpoint sources, the wasteload allocation for such facilities shall be deemed a load allocation and shall continue to apply.

Table 2-4. 2004 TMDL Wasteload and Load Allocations for Canyon Lake (adapted from Table 5-9q in Santa Ana Water Board 2004a; also Table 6-1q in Basin Plan [Santa Ana Water Board 2019])

TMDL	Specific Allocations	Final Total Phosphorus Allocations (kg/yr)[1,2]	Final Total Nitrogen Allocations (kg/yr)[1,2]
Wasteload Allocations	Supplemental Water	48	366
	Urban[3]	306	3,974
	CAF[3. 4]	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
[4] If the Santa Ana Water Board determines at any time during Phase II or Phase III that any facilities regulated in Order R8-2018-0001 as CAFOs (as defined in 40 CFR 122.23(b)(2)) should instead be regulated as nonpoint sources, the wasteload allocation for such facilities shall be deemed a load allocation and shall continue to apply.

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 significant shift from agricultural to urban land use has been occurring for many years as shown in **Table 2-5** when comparing the basis for 2004 TMDL source assessment to this TMDL revision (e.g., see WRCAC 2011 versus WRCAC 2018a).

Table 2-5. Comparison of Agricultural, Urban, and Open Space Land Use Acreage: Basis for the 2004 TMDLs' Source Assessment Versus Proposed TMDL Revisions

Year	Urban (Acres)[1]	Agricultural (Acres)[2]	Other Land Use (Acres)[1,3]	Open/Forest (Acres)[1]
2005-2007	76,281	47,822	31,184	321,883
2020 - 2022[4]	106,186	22,148	30,943	318,033
Change	29,905	-25,674	-241	-3,850

[1] Acreage used in the 2010 watershed model updated based on Southern California Association of Governments (SCAG) 2005 data
[2] Includes irrigated cropland and non-irrigated cropland greater than 20 acres based on detailed mapping supported by WRCAC (reported as Aerial Information Systems [AIS] 2023 and WRCAC 2007)
[3] Other land uses include dairy, other livestock, non-jurisdictional agriculture and vacant lands
[4] Mapping used to support source assessment based on SCAG 2019 with refinements for agricultural areas based on AIS 2023

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 2-3**):

- *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 (SJNF) 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 (Subwatershed Zones 7, 8, and 9 shown in **Figure 2-3** above). 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. However, in those years when Mystic Lake's storage volume is filled, the lake may overflow, sending large volumes (> 1,000 AF) 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 (e.g., 2004-2005 wet season). The storage capacity of Mystic Lake is changing. United States 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 storage capacity increased by approximately 200-acre feet/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 4.1.2.5).
- *Confined Animal Facilities* – Dairies and dairy-related facilities regulated under Order R8-2018-0001 must retain runoff from up to a 25-year return period storm event on-site. Retention ponds within these 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 or is used on dairy farms in accordance with their Nutrient Management Plans. Detailed data is currently being developed to demonstrate this condition (personal communication, Pat Boldt, July 8, 2023). The TMDL revision proposes to account for successful compliance with

CAFO Permits based on a record of 100 percent compliance over the last 15 years. Non-dairy CAFs exist in the San Jacinto River watershed such as chicken farms and horse ranches. The Santa Ana Water Board is currently in the process of developing a new discharge permit with management requirements for non-dairy CAFs.

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 Tribes.

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).

In 1818, Leandro Serrano settled in the Lake Elsinore area referred to by the Spanish as Laguna Grande. He is the first known non-indigenous person to have settled in the area. The settlement he established, Glen Ivy Hot Springs, is today located in 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 2-4. Historic Drawing of Laguna Grande (Source: Online Archive of California, https://oac.cdlib.org/ark:/13030/hb4k4005ht/?brand=oac4)

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.

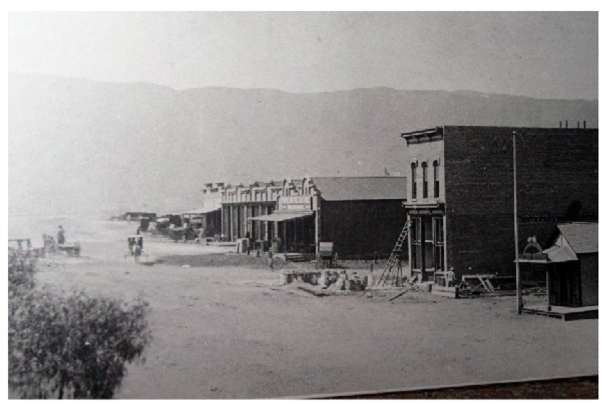

Figure 2-5. Streets of Elsinore in the 1880s (Source: City of Lake Elsinore, http://www.lake-elsinore.org/visitors/history/city-timeline)

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.

Table 2-6. Population Changes in the City of Lake Elsinore, 1900 – 2023

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
2023	71,973

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 2-6** summarizes population growth in the area since 1900 (City of Lake Elsinore [2011a] for 1900-2011; State of California Dept. Finance 2023).

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

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 2-7** summarizes the published findings. In addition, the USGS published a summary of anecdotal descriptions of Lake Elsinore water levels for generally the same time period (USGS 1917):

Table 2-7. 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 ever 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."

A comparison between the noted high lake levels in the above USGS descriptions and **Table 2-7** 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.

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

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 2-8** summarizes this information.

Table 2-8. Anecdotal Descriptions of Lake Elsinore, 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 AF 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."*

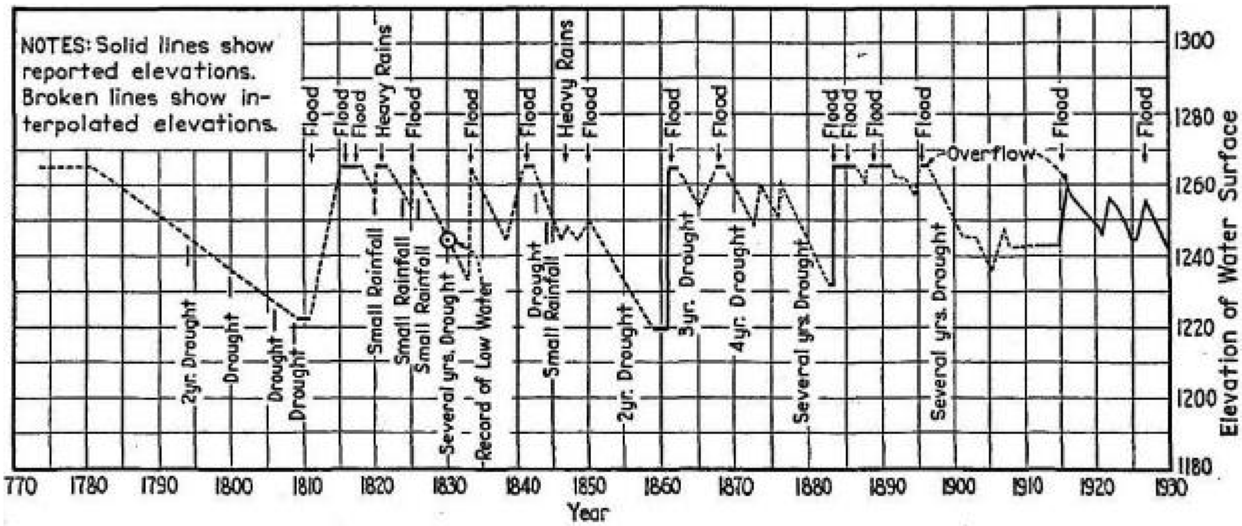

Figure 2-8. Estimated Lake Elsinore Lake Levels Based on Historical Records (from Figure 8, Lynch 1931)

Based on this reconstruction, the periods of time with the lowest lake elevations were 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 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 cover more than two mi^2 and at elevation 1,234 ft the lake covers more than four mi^2.
- 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 ft.

The work of Lynch (1931) was updated and extended in United States Army Corps of Engineers (USACE) (1987) through the addition of information provided by the Riverside County Flood Control & Water Conservation District (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 lakebed that occurred off and on in the 1950s and 1960s. The figure also illustrates the dramatic change that occurred during a very wet period that began in 1978 (USACE 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, descriptions of the lake illustrate how poor conditions can become, e.g., 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…"*

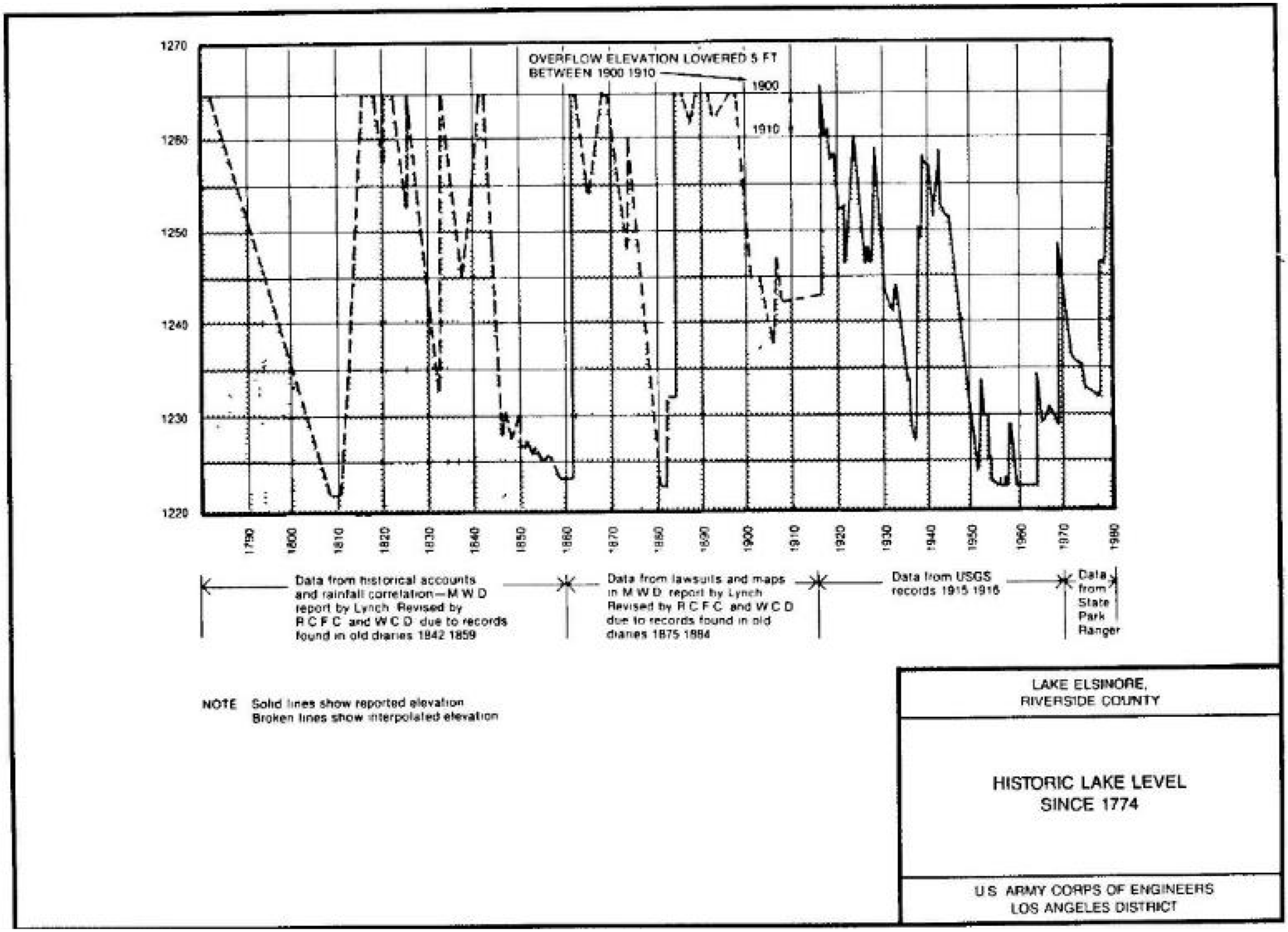

Figure 2-9. Historic Lake Levels in Lake Elsinore Based on Revision of Lynch (1931) and Additional Information (Figure 6 in USACE 1987)

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."*

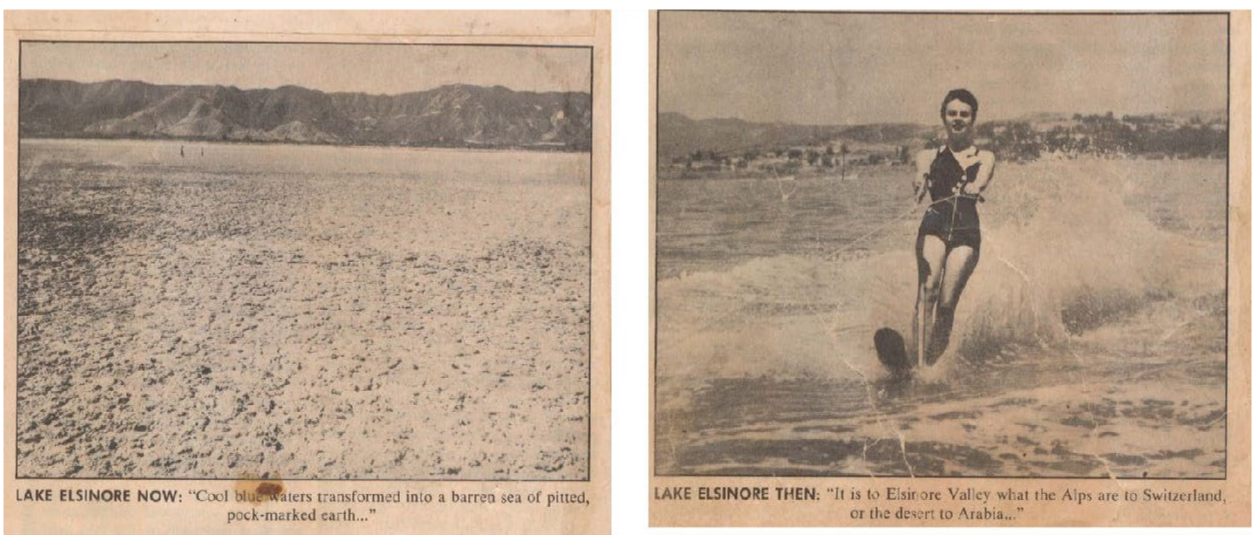

Figure 2-10. Comparison of Lake Level Extremes in Lake Elsinore (Source: Fortnight: The Magazine of California 1954)

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…"*

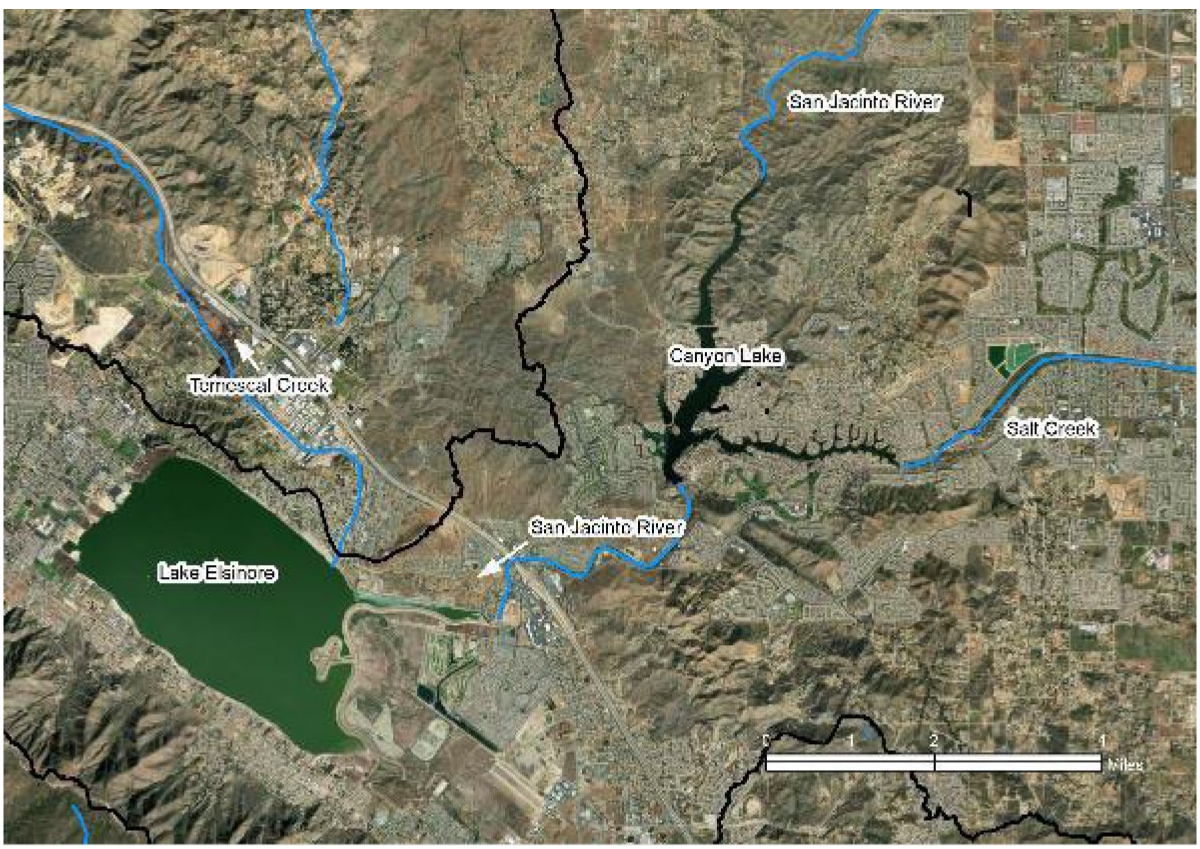

Figure 2-11. Proximity of Canyon Lake Reservoir to Lake Elsinore

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).

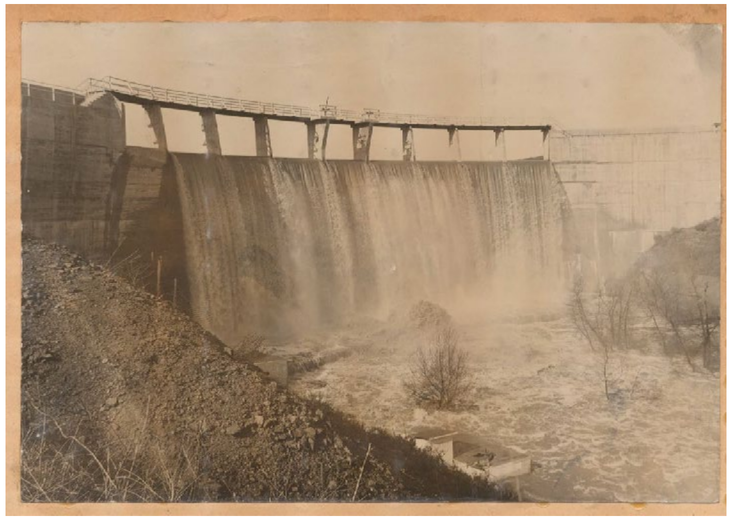

Figure 2-12. Overflow of Canyon Lake Dam, approximately 1936-1937 (Source: Lake Elsinore Naval School)

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:

> *"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 provide 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 2-9 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);
- 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).

Table 2-9. 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-year floodplain), extensive flood damage will occur

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):

> *"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."*

As a result of LEMP, Lake Elsinore now has current approximate surface area of 3,000 acres (approximately 50 percent 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 Recycled 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 recycled water since 2007 to maintain lake levels at an adopted operation range of 1,240 to 1,247 ft. Sources of supplemental water since 2007 include EVMWD recycled 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 recycled water (CDM Smith 2022). 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 – Prior to TMDL Adoption

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 2-10**). 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, USEPA conducted a eutrophic survey among 24 lakes and reservoirs in the western United States, including Lake Elsinore (USEPA 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 USEPA 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 (USEPA 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 (CWA) section 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).

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….*"

Table 2-10. Water Quality Data for Lake Elsinore Under Low Water Level (1975) and High Water Level (1981) Conditions (adapted from Engineering-Science 1984)

		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 (USEPA 1976)
[3] Conductivity results from extremely low water levels ranged from 28,000 to 30,000 µS/cm (see Figure 2-13)

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 (H_2S).

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 2-13 from Engineering-Science (1984) illustrates the relationship between lake levels and salinity as known at the time when the LEMP project was under development.

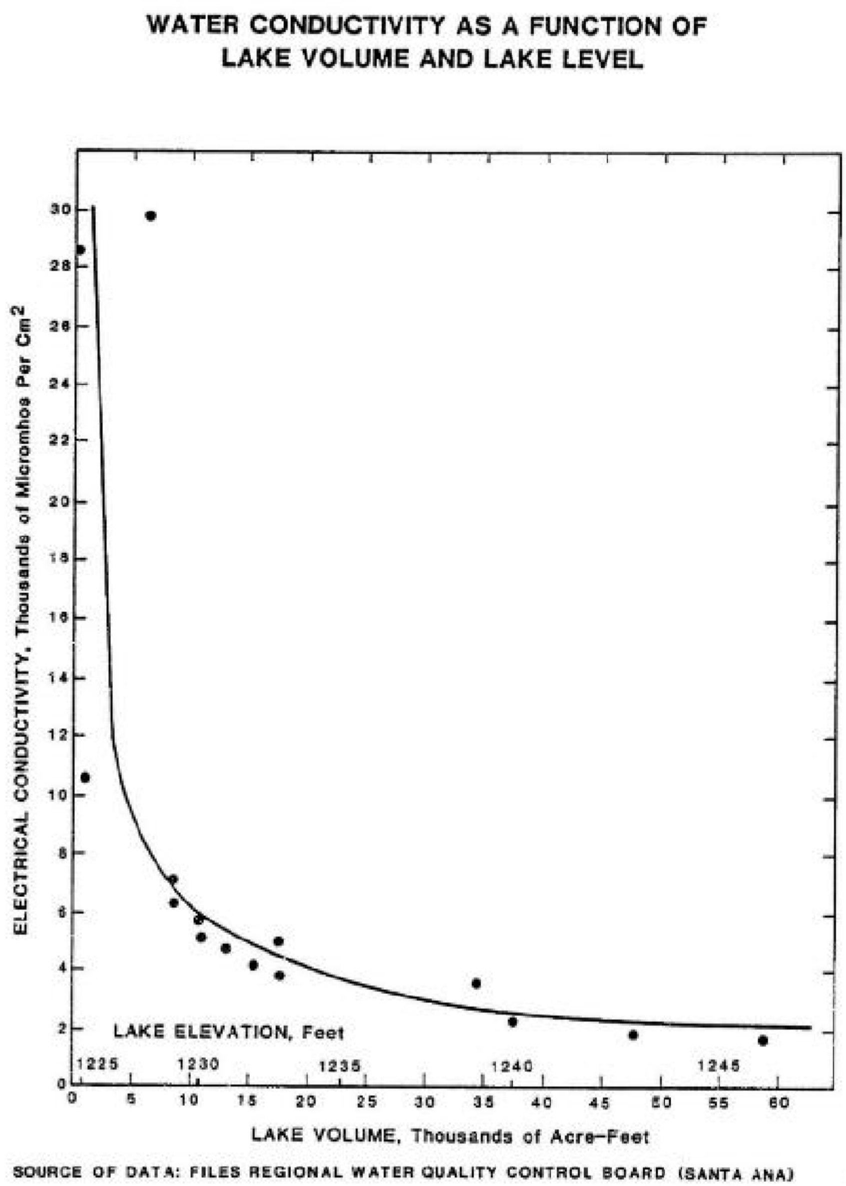

Figure 2-13. Relationship Between Electrical Conductivity (EC) and Lake Elevation in Lake Elsinore (from Figure 2-4 in Engineering-Science [1984]) (Note: TDS equals ~0.64 * EC)

This information was further developed in LESJWA (2005a) from water quality work completed by LEMA (1996). 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 and in association with changes to water level over the period from 2000 to 2020 (**Figure 2-14**). These data shows that when water levels are maintained above 1240 ft, TDS is less than 2000 mg/L.

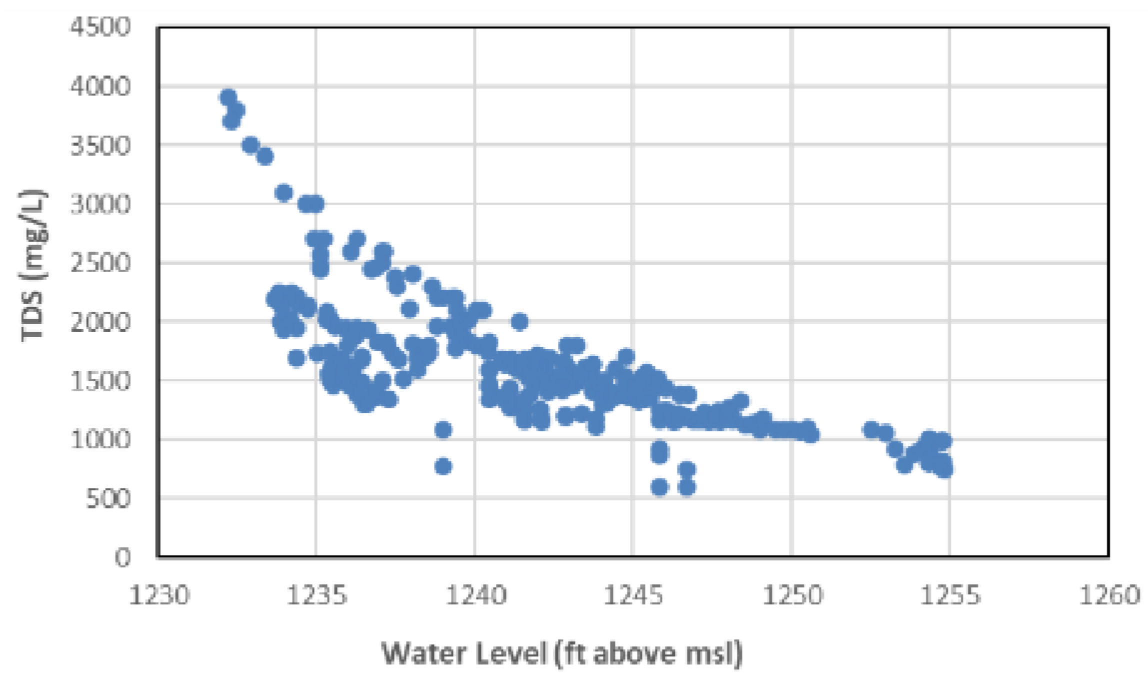

Figure 2-14. Relationship Between TDS (mg/L) and Lake Elevation (ft) in Lake Elsinore (2000-2020)

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 (CDFG 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 United States Fish and Wildlife Service (USFWS) survey (USFWS 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 2-15**):

> *"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."*

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)."*

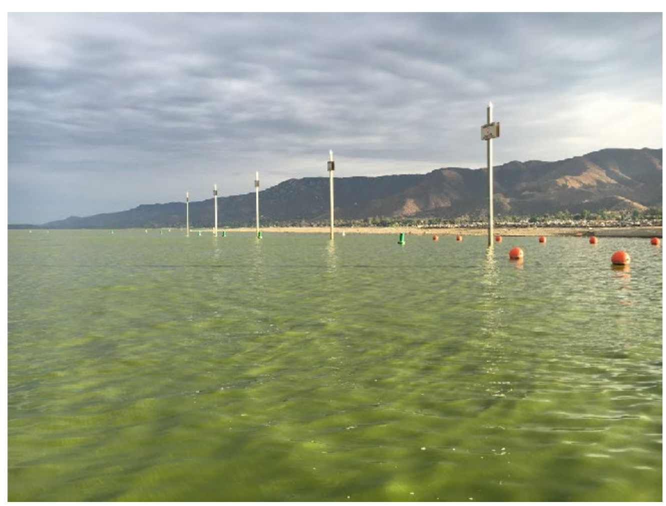

Figure 2-15. Algal Bloom in Lake Elsinore, 2016 (Source: Wood Environment and Infrastructure Solutions, Inc.)

There were about 30 fish kill events from 1883 up to 2002. An additional nine fish kill events have been documented since adoption of the 2004 TMDL with the most recent event occurring in August 2015 (**Table 2-11** summarizes the documented history of fish kills in Lake Elsinore from 2006 to 2015). 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 percent 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 United States Department of Interior (USDI) (as documented in EDAW (1974) (**Figure 2-16**):

> *"…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…"*

Figure 2-16. Illustration of September 5, 1948 Fish Kill in Lake Elsinore (Original Source: Associated Press Wirephoto; contributed by Ms. Pat Boldt, WRCAC)

Table 2-11. 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, DO 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 temperature resulting in oxygen reduction[7]	Couch (1952); Hudson (1978); Bovee (1989)

Table 2-11. Summary of Known Fish Kills in Lake Elsinore, 1883-2018

Date	Dissolved Oxygen (mg/L)		Duration of Fish Kill	Lake Water Surface Elevation	Lake Volume	Fish Species	Estimated Weight of Fish	Comments	Reference
	Initial	Final	(days)	(ft)	(AF)		(tons)		
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]	DO 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 DO	North County Times (August 22, 2002); MWH (2002)
1996								"in August, smaller fish die off"	Press Enterprise
1997								On April, 7 tons of shad died of oxygen depletion	Press Enterprise

Table 2-11. Summary of Known Fish Kills in Lake Elsinore, 1883-2018

Date	Dissolved Oxygen (mg/L)		Duration of Fish Kill	Lake Water Surface Elevation	Lake Volume	Fish Species	Estimated Weight of Fish	Comments	Reference
	Initial	Final	(days)	(ft)	(AF)		(tons)		
November 11, 1998*				~1,250	76,000	Threadfin Shad	240	Migratory birds stressing high density shad population during period of low DO	Kilroy (1998)
August 2001				1,239	35,000	Carp			LESWA (2005a)
August 22, 2002			2	1,236		Primarily Carp	50	Low DO	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		Threadfin Shad mostly; some Carp and other sport fish	17.44		City of Lake Elsinore (2018)
August 17-19, 2015							5.87		City of Lake Elsinore (2018)

Table 2-11. Summary of Known Fish Kills in Lake Elsinore, 1883-2018

Date	Dissolved Oxygen (mg/L)		Duration of Fish Kill	Lake Water Surface Elevation	Lake Volume	Fish Species	Estimated Weight of Fish	Comments	Reference
	Initial	Final	(days)	(ft)	(AF)		(tons)		
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 USDI 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 USDI 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 ft 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 2004b).

** In Hudson (1978)

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, 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)."*

2.2.2.5 Recent Water Quality Conditions

This section provides the following: (a) an overview of recent water quality conditions observed in Lake Elsinore (primarily since 2002); and (b) findings from the 2020 assessment that evaluated attainment of the existing 2004 TMDL targets (TP, TN, DO, chlorophyll-*a* and ammonia) and WLAs/LAs for TP and TN (LESJWA 2021).

2.2.2.5.1 Water Quality Observations

A significant body of monitoring data has been collected for Lake Elsinore since development of the original TMDLs began in May 2000. This section summarizes water quality observations from approximately 2002 through 2024. 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 Niño 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 2-17**). The highest frequency of monitoring occurred at the most central location, LEE2. The proposed revisions to the TMDLs include a task to update the existing LECL Surveillance and Monitoring Program (SMP) (see Section 7.2.2, Phase II Task 18). This update may consider further whether this central station is representative of the lake as a whole or if multiple stations are needed to characterize spatial variability. This may become more important in the future when evaluating the effectiveness of new or enhanced in-lake controls.

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, EC, and water clarity were also measured at three-ft intervals at the time of sample collection.

Figure 2-17. Location of Lake Elsinore Sample Locations (LE01 [LEE1]; LE02 [LEE2]; and LE03 [LEE3])

Between 2000 and 2012 a number of other 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 recycled 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 2-18**).

Figure 2-18. Lake Elsinore, September 2016 (Source: Wood Environment and Infrastructure Solutions, Inc.)

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 numeric 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, and EC 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 (morning and afternoon) to assess temporal variability associated with daily photosynthesis and respiration cycles of algae which can substantially alter DO concentrations over short periods of time.

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.

Phosphorus

Phosphorus in water exists in either a dissolved or particulate phase. Dissolved inorganic phosphate (orthophosphate or Ortho-P) is the soluble reactive form of phosphorus that is readily available to algae (bioavailable); 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.

The 2004 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**). TP and Ortho-P concentration data (1992 through 1997) are shown in the 2004 TMDL Problem Statement for Lake Elsinore (Santa Ana Water Board 2000). These data showed that wet weather in January 1993 caused a large Canyon Lake overflow and 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. Section 2.2.2.5.2 below provides the findings from the TMDL compliance assessment completed in 2021 (LESJWA 2021) based on TP concentrations in 2010-2020.

Figure 2-19 shows a graphical summary of available TP data from 2002 to 2024, representing depth-integrated water column average concentrations. **Table 2-12** provides the associated range, average, and median values of TP from 2002 to 2024. For the summaries that follow, only TP is presented for direct comparability to Basin Plan objectives and the existing TMDL targets (Note: TP measurement includes concentrations associated with algal biomass since collected samples are unfiltered). In general, a majority of the TP is in the organic form and trends between TP and dissolved inorganic Ortho-P are tightly coupled. Overall, annual average TP ranged between 0.1 and 0.4 mg/L in Lake Elsinore between 2002 and 2016. Annual averages were generally lower between 2017 and 2024. These lower TP concentrations in recent years may be an indirect benefit of ongoing twice per year additions of alum to Canyon Lake (see LESJWA 2021; also see Sections 2.2.2.5.2 and 2.2.3.3.2).

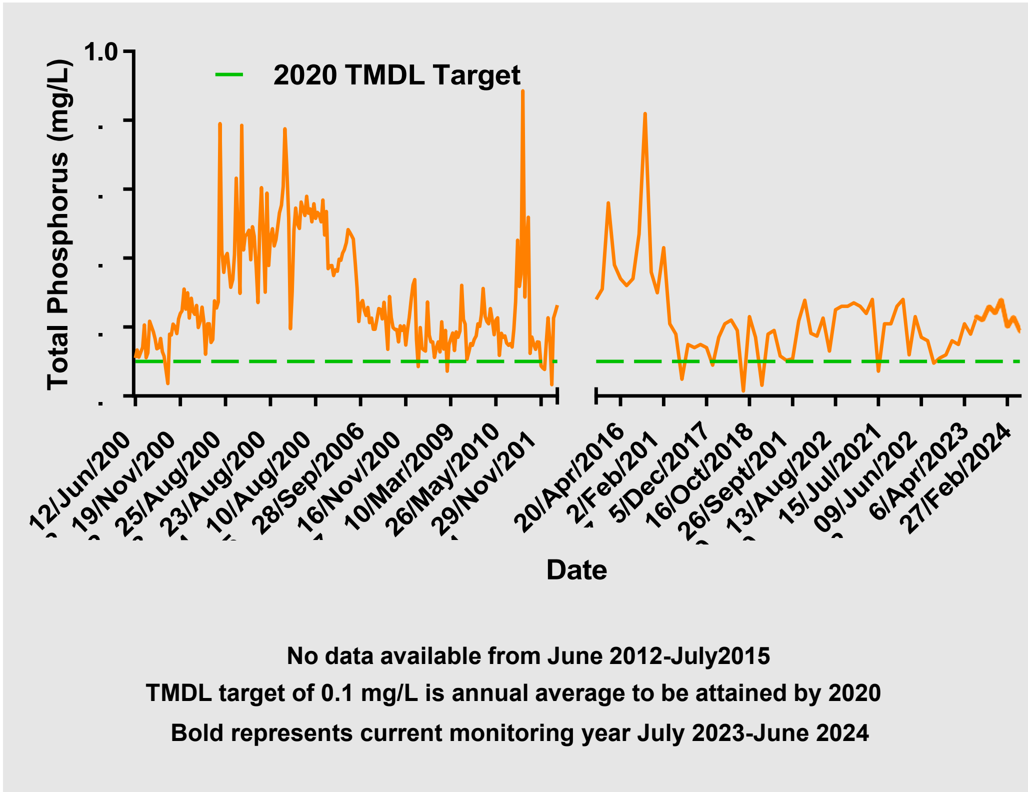

Figure 2-19. Depth-Integrated Average Total Phosphorus Concentrations in Lake Elsinore: 2002-2024 (Note discontinuous data record on x-axis)

Table 2-12. Dissolved Oxygen, Nutrient, Chlorophyll-*a*, and TDS Summary for Lake Elsinore TMDL Compliance Monitoring: 2002-2012 and 2015-2024 (N = Number of Samples)

Parameter	Date Type	2002 2012					2015 2024				
		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	70	0.20	11.49	5.59	5.13
	Bottom 1-m	113	0.02	10.5	4.2	4.2	70	0.00	11.05	3.55	3.10
Chlorophyll-*a* (µg/L)	Depth-Integrated	178	6.2	440	137	116	66	24	349	138	116
Total Nitrogen (mg/L)	Depth-Integrated	226	0	9.9	4.1	3.8	70	1.20	9.80	4.87	4.60
Total Phosphorus (mg/L)	Depth-Integrated	235	0.03	0.89	0.29	0.23	70	ND	0.82	0.22	0.21
Total Ammonia (mg/L)	Depth-Integrated	187	< 0.05	1.52	0.18	0.11	70	ND	1.30	0.26	0.12
Un-ionized Ammonia (mg/L)	Depth-Integrated	187	0	0.28	0.04	0.02	64	ND	0.20	0.04	0.03
TDS (mg/L)	Depth-Integrated	188	427	2,240	1,376	1,433	70	1,500	3,900	2,381	2,250

Nitrogen

In Lake Elsinore, the major form of nitrogen exists as organic nitrogen as shown in annual monitoring program reports. **Figure 2-20** shows a graphical summary of available TN data from 2002 to 2024. **Table 2-12** above provides the associated range, average, and median values of TN from 2002 to 2024. Between 2002 and 2024, TN concentrations were generally between 2 and 6 mg/L with an average of approximately 4.0 mg/L. The predominant form of nitrogen in Lake Elsinore is organic N (LESJWA 2023). As opposed to TP, there appears to be no visually discernable long-term trend in TN concentrations. This provides a line of evidence that the ongoing twice per year alum additions (that only treat TP) are causing an indirect benefit of reduced TP in Lake Elsinore. 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. These spikes have occurred in periods with lower lake levels and could be caused by wind driven resuspension of lake bottom sediments that are rich in nitrogen. The very wet 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.

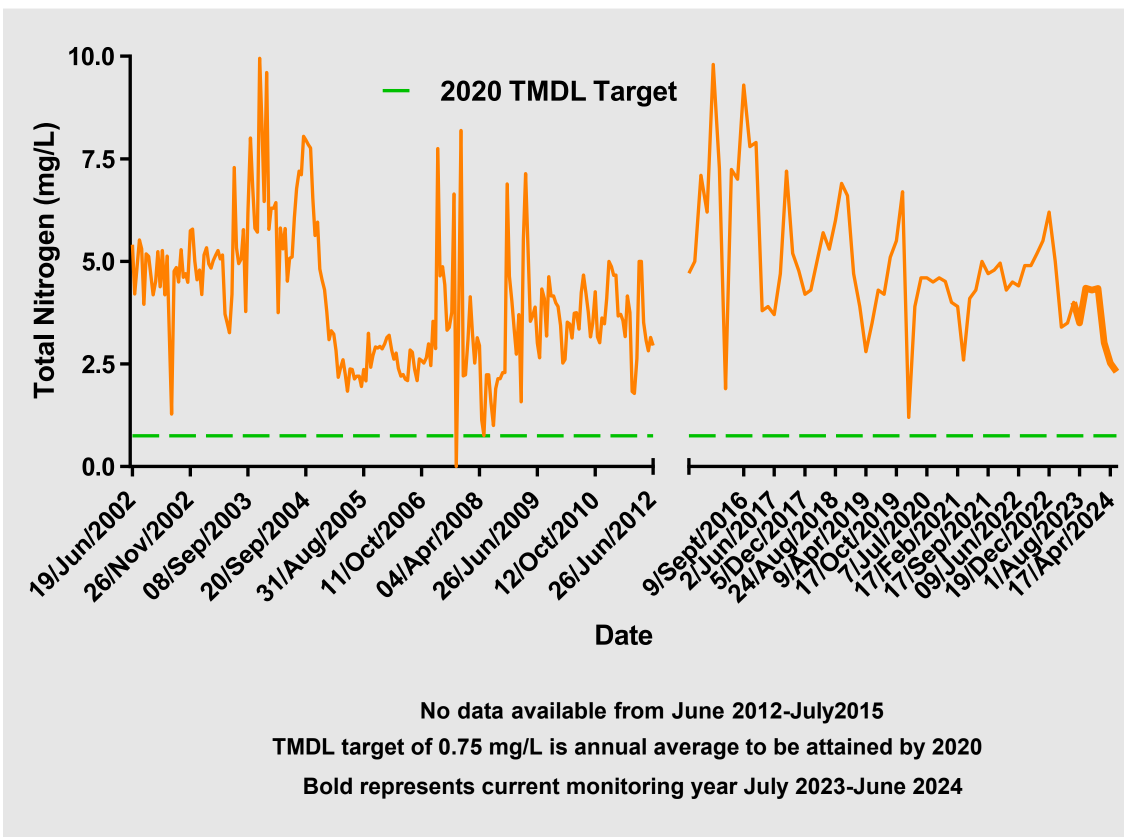

Figure 2-20. Depth Integrated Average Total Nitrogen Concentrations in Lake Elsinore: 2002-2024 (Note discontinuous data record on x-axis)

An evaluation of the ratio of TN to TP (TN:TP) 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 (USEPA 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 1993 before the overflows of both Canyon Lake and Lake Elsinore. 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 continued to vary strongly from 2002-2016 (**Figure 2-21**). 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. Since 2013, alum additions in Canyon Lake have significantly reduced concentrations of TP in overflows from Canyon Lake to Lake Elsinore making Lake Elsinore more strongly phosphorus limited even in wetter years (LESJWA 2021).

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. Lake depth was found to be the most important covariables for chlorophyll-*a* in statistical analysis conducted based on data from 2000-2002, 2008-2010, and 2015-2020 (Horne and Anderson 2021).

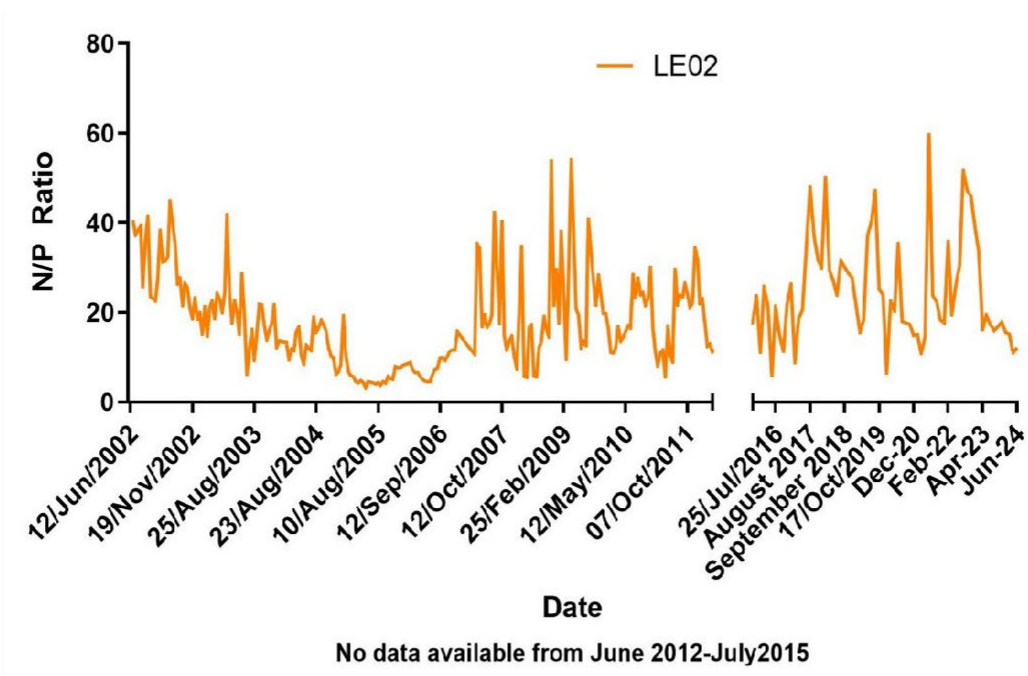

Figure 2-21. Nitrogen to Phosphorus Ratios in Lake Elsinore: 2002-2024 (Note discontinuous data record on x-axis)

Ammonia

Ammonia is a toxic component of the nitrogen cycle, formed and released from the breakdown of organic material. Acute and chronic objectives for total ammonia (total ammonia is the sum of unionized ammonia (NH_3) and ionized ammonia (NH_4^+)) 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.

Ammonia concentrations were not reported in studies summarized in the 2000 TMDL Problem Statement that included results from the 1975 USEPA 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 2-22** and **2-23**) representing depth-integrated water column average concentrations. **Table 2-12** above provides the associated range, average, and median values of total and un-ionized ammonia from 2002 to 2024.

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 USEPA 1999 criterion (USEPA 1999b), as well as updated more stringent values developed by USEPA in 2013 (USEPA 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.

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 (USEPA 1974). The current TMDL compliance threshold target for chlorophyll-*a* in Lake Elsinore is a summer average value of $\leq$40 µg/L in 2015 and $\leq$ 25 µg/L in 2020 (see **Table 2-2**). The 2004 TMDL evaluated historical data including a USEPA study performed in 1975 (USEPA 1976), which found chlorophyll-*a* in Lake Elsinore ranged from 42 to 118 µg/L (**Table 2-13**). 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.

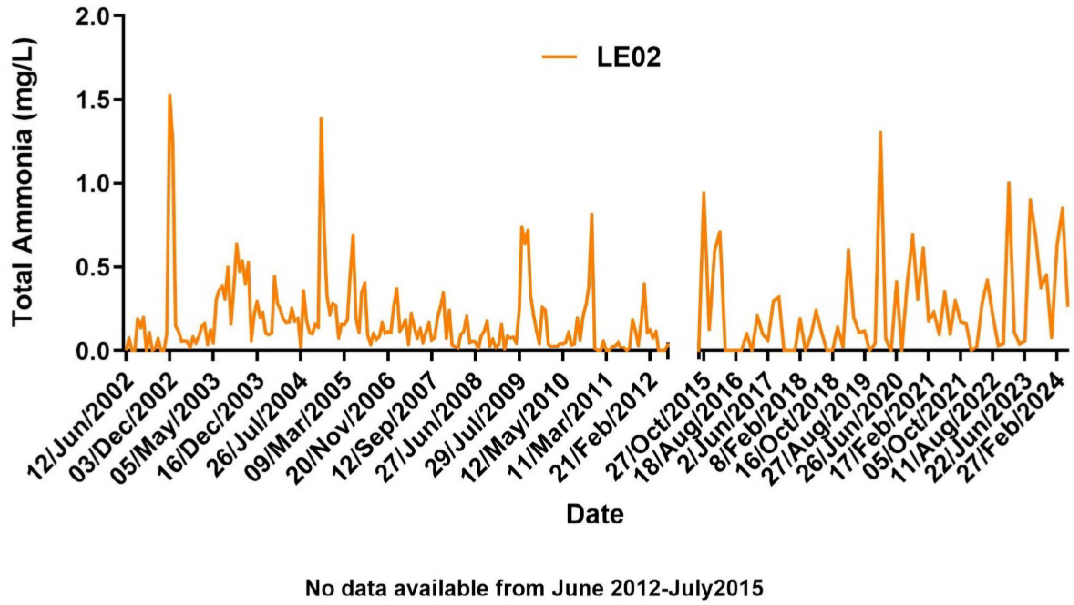

Figure 2-22. Depth-Integrated Average Total Ammonia Concentrations in Lake Elsinore: 2002-2024 (Note discontinuous data record on x-axis)

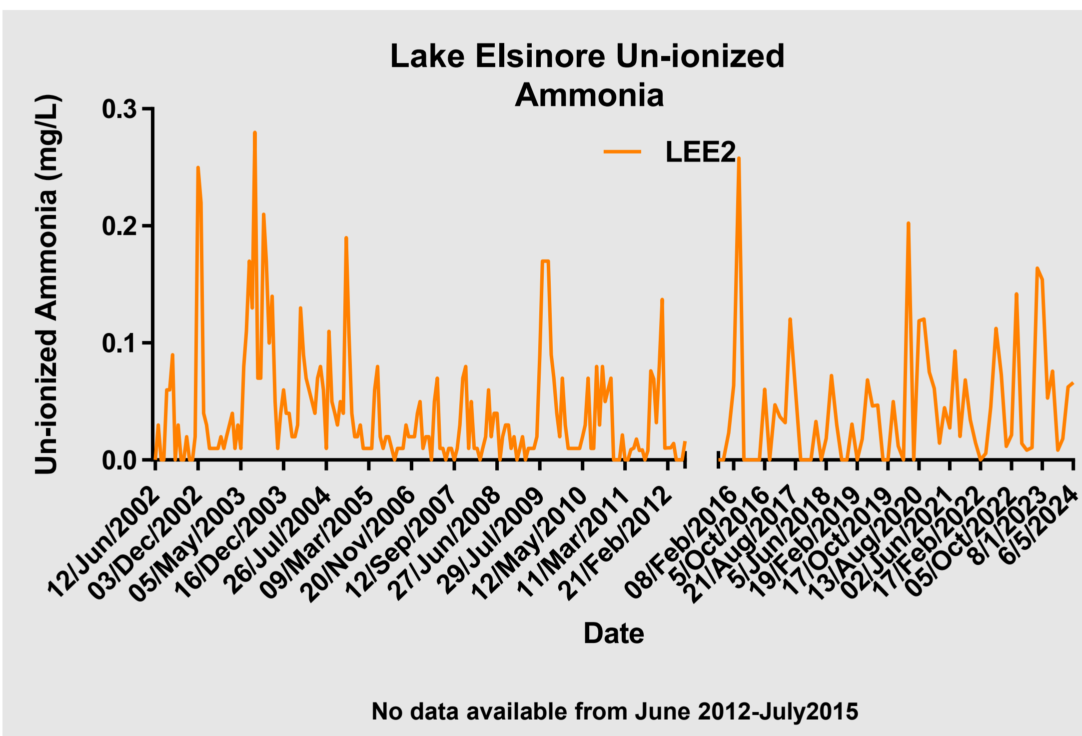

Figure 2-23. Depth-Integrated Average Un-ionized Ammonia Concentrations in Lake Elsinore: 2002-2024 (Note discontinuous data record on x-axis)

Table 2-13. USEPA 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 2-24 shows available chlorophyll-*a* data for TMDL compliance monitoring studies performed from 2002 to 2024. **Table 2-12** above provides the associated range, average, and median values of chlorophyll-*a* during this same period of time. Values presented in **Figure 2-24** and **Table 2-12** 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 2005 and 2008 following a large rise in lake level in January 2005. Concentrations of chlorophyll-*a* increased from 2008 through 2016 corresponding with drier conditions overall. Since 2016, concentrations of chlorophyll-*a* declined with rising lake levels over the period between 2016 and 2024. Overall, these concentrations are frequently well above the current 2004 TMDL summer average target of 25 µg/L by 2020.

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 2024 are shown graphically in **Figure 2-25** as a top to bottom depth-integrated measure, and in **Figure 2-26** for the portion of the water column approximately 1-m from the bottom of the lake. **Table 2-12** above provides the associated range, average, and median values from 2002 to 2024.

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.

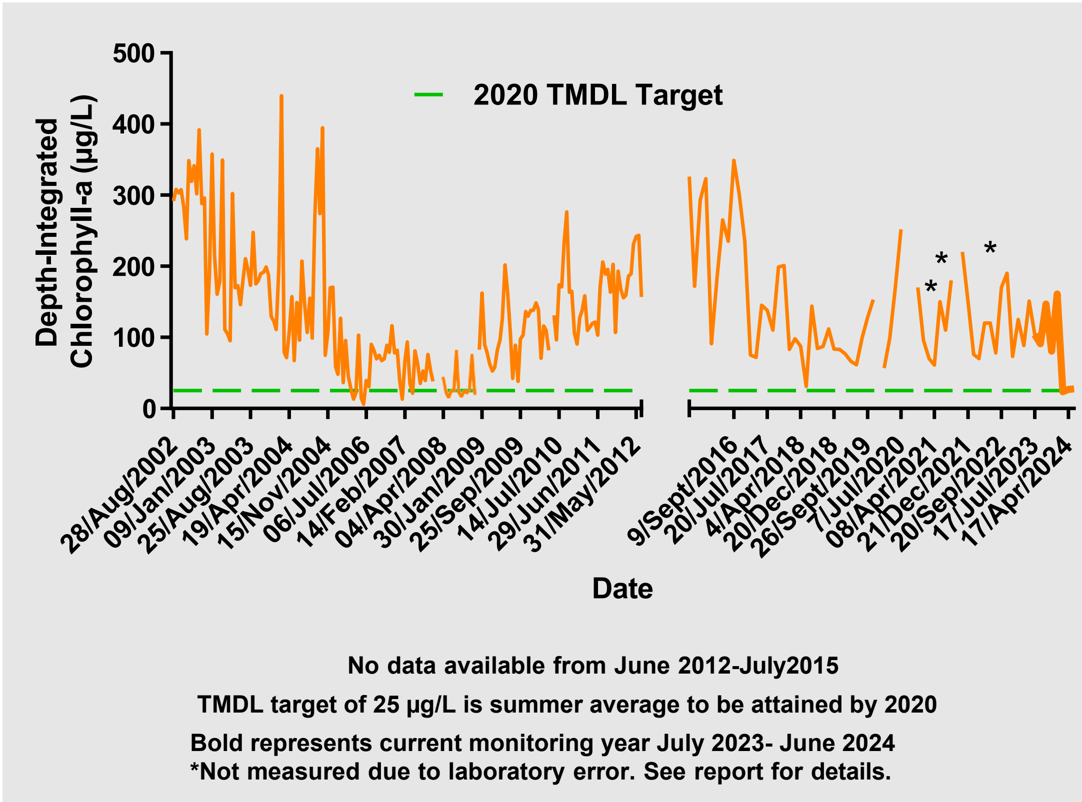

Figure 2-24. Depth-Integrated Average Chlorophyll-*a* Concentrations in Lake Elsinore: 2002-2024 (Note discontinuous data record on x-axis)

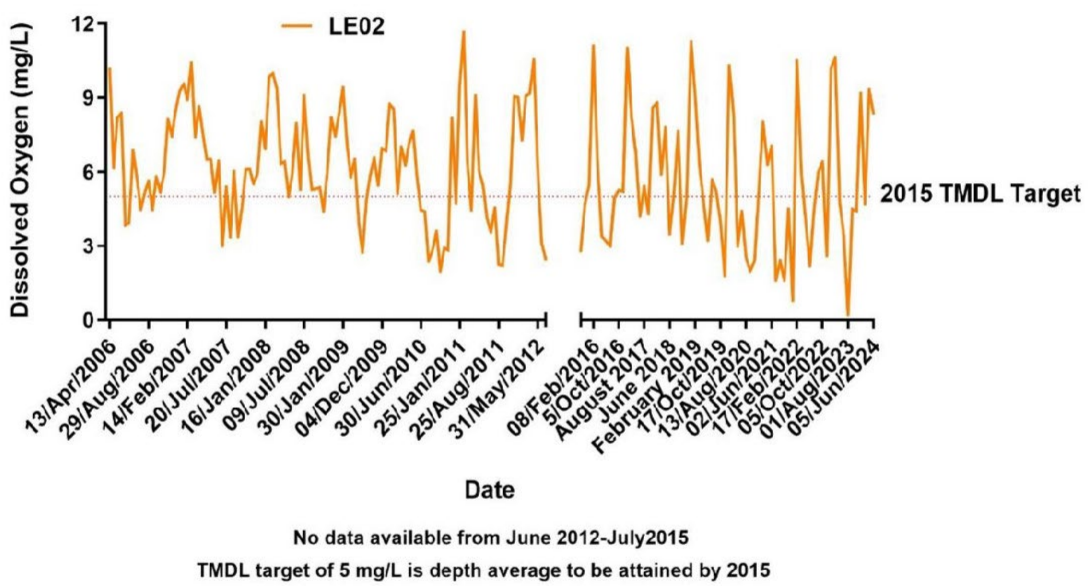

Figure 2-25. Depth-Integrated Average Dissolved Oxygen Concentrations in Lake Elsinore: 2006-2024 (Note discontinuous data record on x-axis)

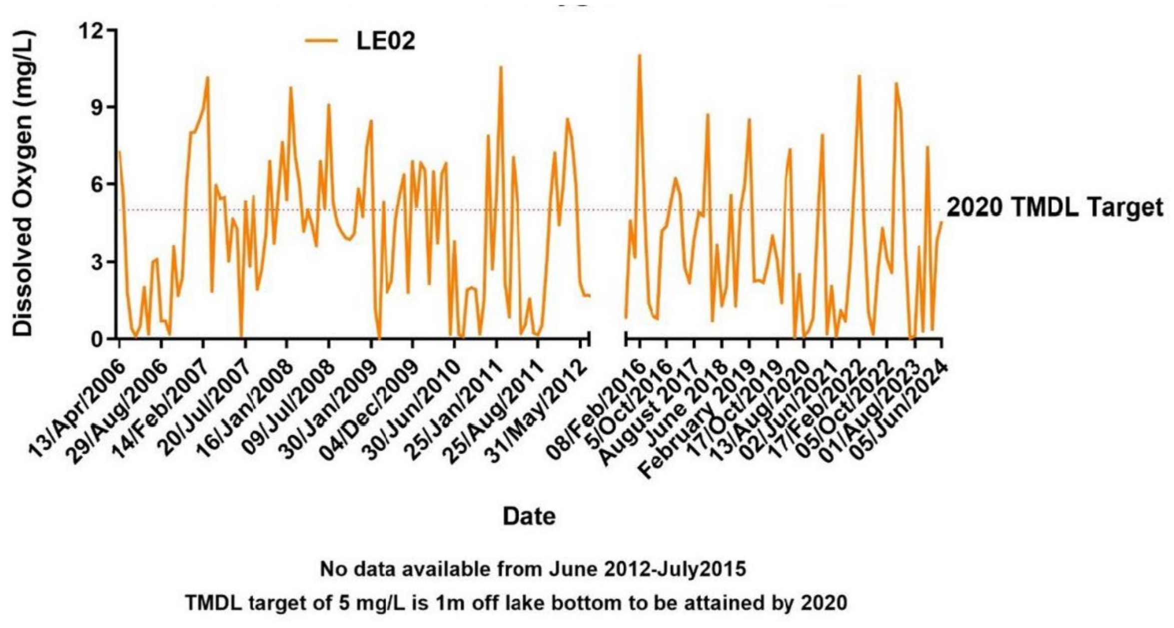

Figure 2-26. Dissolved Oxygen Concentrations (1-m from Bottom) in Lake Elsinore: 2006-2024 (Note discontinuous data record on x-axis)

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 USEPA 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 2024 (**Figure 2-27**). **Table 2-12** provides the associated range, average, and median values of TDS from 2003 to 2024.

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 2-27**). In the midst of a severe drought, concentrations of TDS in the lake remained above 2,000 mg/L between July 2015 and October 2019. A further reduction in TDS has been recorded with several wet years and elevated lake levels with concentrations as low as 1,400 in April 2024.

Thresholds for TDS and EC 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.

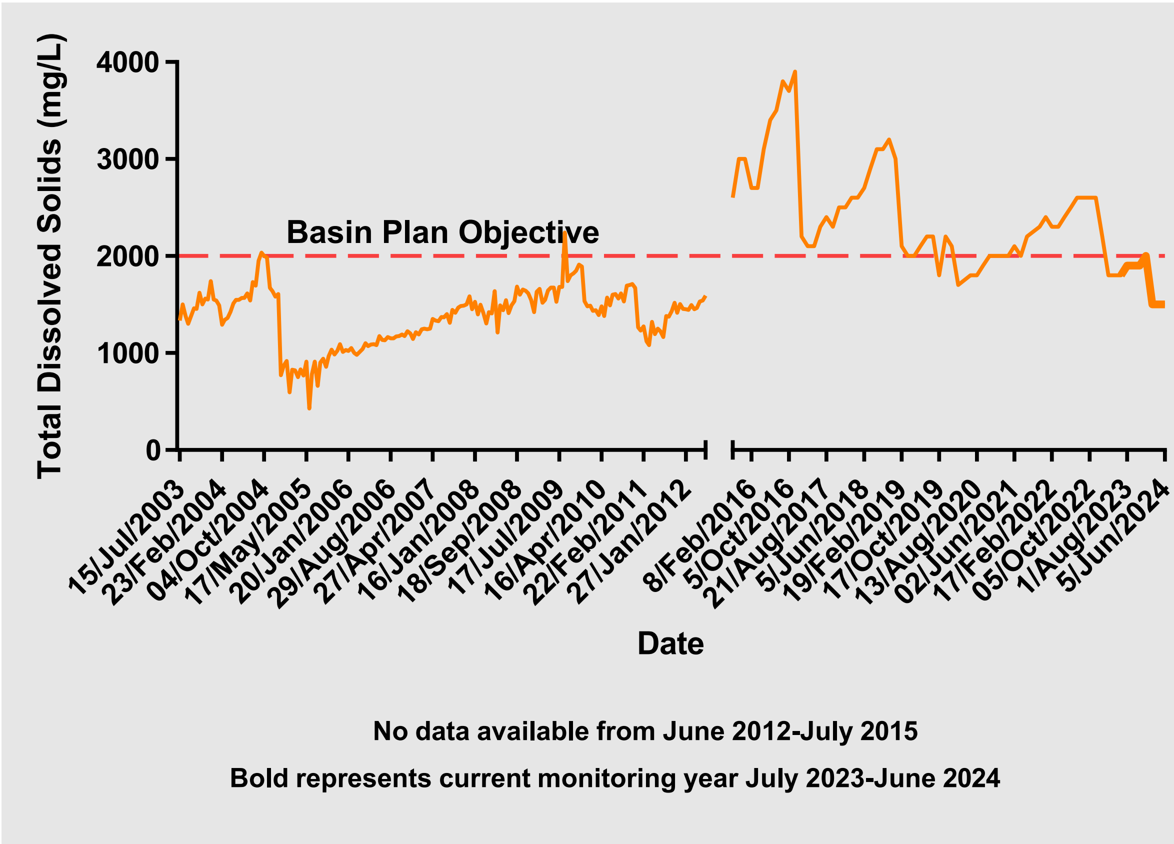

Figure 2-27. Depth-Integrated Average TDS Concentrations in Lake Elsinore: 2003-2024 (Note discontinuous data record on x-axis)

2.2.2.5.2 2020 TMDL Compliance Assessment

To meet various permitting and reporting obligations, the LECL Task Force prepared a LECL TMDL Compliance Assessment Report to evaluate water quality data collected over the 10-year period from January 1, 2011 through December 31, 2020 to evaluate compliance with TMDL numeric targets and the TMDL's WLAs/LAs (LESJWA 2021). **Table 2-2** above summarizes the in-lake numeric water quality targets for Lake Elsinore for TP, TN, total ammonia, chlorophyll-*a* and DO. **Tables 2-14** to **2-17** below provide a compliance summary for each of these parameters. Specifically, these tables provide: (a) the annual mean values for each parameter compared to the TMDL numeric targets; and (b) the calculated frequency of exceedance of each numeric target. Overall findings from the 10-year assessment period include:

- TN and TP continue to be at elevated levels representative of a hypereutrophic lake (Carlson 1977), exceeding the TMDL targets 100 percent of the time based on an annual average (**Table 2-14**). A few samples have occasionally had TP concentrations below the water quality targets, but none for TN. Data over the 10-year period suggest some reduction in water column TP/TN over time, but not sufficient to bring nutrients down to causal targets.

- DO (water column mean) has met the 2015 target (> 5.0 mg/L) 75 percent of the time based on annual means, averaging 5.7 mg/L over the 10-year period (**Table 2-15**). The 2020 DO target (> 5.0 mg/L) 1-m from the bottom of the lake has not been met in any of the past 10 years; however, the 10-year average (3.7 mg/L) is greater than historically reported (Horne 2020). The increase in DO has reduced the extent of anoxia in the lake bottom and thereby reduced internal loading as demonstrated in routine effectiveness demonstrations for the LEAMS (e.g., Stillwater Sciences and Alex Horne Associates 2022)
- Total ammonia over the past 10 years has exceeded the acute water quality target once based on annual averages but has exceeded chronic criterion during five of the last 10 years based on the 2013 criterion calculations (**Table 2-16**).
- The chlorophyll-*a* response targets are both regularly exceeded (2015 annual average target of < 40 µg/L during the summer months (June – September); < 25 µg/L summer average target in 2020) (**Table 2-17**). Annual summer averages have ranged from 87 to 326 µg/L over the past 10 years. Concentrations of chlorophyll-*a* based on annual averages are similar, ranging from 91 to 264 µg/L over the past 10 years. Within year variability is often substantial for chlorophyll-*a*, frequently spanning more than 2-3 times depending on the day of sampling.

Based on analysis of all available data, even though numeric targets are not always met, the compliance assessment found that the 2004 TMDL final watershed-based WLAs and LAs for Lake Elsinore were being met as a 10-year running average prior to the final attainment date, as required by the Basin Plan (LESJWA 2021) (**Table 2-18**). No additional load reductions were needed to meet watershed allocations for Lake Elsinore.

Table 2-14. Lake Elsinore - 2020 TMDL Summary for Total Phosphorus and Total Nitrogen, January 2011 – December 2020[a] (bold values indicate an exceedance of a 2020 TMDL target)

Parameter	TMDL Target	Monitoring Year	No. of Samples Collected	Annual Average (mg/L)[b]	Percent of Annual Means > TMDL Targets
Total Phosphorus	< 0.1 mg/L (Annual Average)	2011	14	**0.294**	**100%**
		2012	9	**0.162**	
		2013	0	NA	
		2014	0	NA	
		2015	3	**0.383**	
		2016	8	**0.416**	
		2017	8	**0.181**	

		2018	8	**0.162**	
		2019	8	**0.154**	
		2020	8	**0.219**	
Total Nitrogen	< 0.75 mg/L (Annual Average)	2011	14	**3.88**	**100%**
		2012	9	**3.32**	
		2013	0	NA	
		2014	0	NA	
		2015	3	**6.10**	
		2016	8	**7.28**	
		2017	8	**4.68**	
		2018	8	**5.56**	
		2019	8	**4.50**	
		2020	8	**3.99**	

[a] Data presented herein for all compliance summary tables for both lakes goes through December 2020

[b] Number of samples collected and analyzed are included in annual average calculations for the corresponding parameter within each calendar year. Monitoring for certain constituents was temporarily suspended from June 2012-July 2015; this absence of data is presented as "NA", not applicable

Table 2-15. Lake Elsinore - 2020 TMDL Summary for Total Ammonia, January 2011 – December 2020.[a] Chronic criteria: CCC- Criterion Continuous Concentration; or acute criteria: CMC- Criterion Maximum Concentration (see text) (bold values indicate years with at least one exceedance of a 2020 TMDL target of 2004 ammonia criteria; 2013 USEPA criteria provided for comparison purposes)

TMDL Target[b] (mg/L)	Monitoring Year	No. of Samples Collected	Annual Average (mg/L)	Percent of Annual Means > TMDL Target
• 2004 - CMC: 0.447-2.45; CCC: 0.112-0.856 • 2013 - CMC: 0.181-2.18; CCC: 0.051-0.453	2011	15	0.049	2004 - CMC: 0% CCC: **37.5%** 2013 - CMC: 12.5%; CCC: **62.5%**
• 2004 - CMC: 0.749-2.52; CCC: 0.192-0.880 • 2013 - CMC: 0.312-2.23; CCC: 0.087-0.463	2012	9	**0.096**	
NA	2013	0	NA	
NA	2014	0	NA	

• 2004 - CMC: 1.28-1.69; CCC: 0.273-0.473 • 2013 - CMC: 0.440-1.18; CCC: 0.124-0.256	2015	3	0.35	
• 2004 - CMC: 0.671-1.91; CCC: 0.150-0.683 • 2013 - CMC: 0.233-1.71; CCC: 0.683-0.363	2016	8	0.088	
• 2004 - CMC: 0.832-2.65; CCC: 0.186-0.450 • 2013 - CMC: 0.309-1.01; CCC: 0.085-0.220	2017	8	**0.124**	
• 2004 - CMC: 1.14-2.20; CCC: 0.283-0.524 • 2013 - CMC: 0.453-1.14; CCC: 0.129-0.254	2018	8	0.097	
• 2004 - CMC: 0.940-5.10; CCC: 0.201-1.63 • 2013 - CMC: 0.316-4.63; CCC: 0.092-0.876	2019	8	**0.300**	
• 2004- CMC: 0.916-2.81; CCC: 0.170-0.791 • 2013 - CMC: 0.267-1.86; CCC: 0.077-0.397	2020	7	**0.312**	

[a] See footnote a on Table 2-14

[b] CCC and CMC criteria calculated using both 2004 TMDL and 2013 USEPA updated formulas (USEPA 2013). The 2013 CMC calculation assumes the absence of *Oncorhynchus species (spp.)*

Table 2-16. Lake Elsinore - 2020 TMDL Summary for Depth-Integrated Chlorophyll-*a*, Summer Only, January 2011 – December 2020[a] (bold values indicate an exceedance of a 2020 TMDL target)

TMDL Target	Monitoring Year	No. of Samples Collected	Annual Average (µg/L)	Percent of Annual Means > TMDL Targets
2020: ≤ 25 µg/L (Summer Only)	2011	8	**169**	2020: **100%**
	2012	2	**200**	
	2013	0	NA	
	2014	0	NA	
	2015	1	**326**	
	2016	4	**258**	
	2017	4	**148**	
	2018	4	**87**	
	2019	4	**89**	
	2020	2	**212**	

[a] – See footnote a on Table 2-14

Table 2-17. Lake Elsinore - 2020 TMDL Summary for Dissolved Oxygen, January 2011 – December 2020[a] (bold values indicate an exceedance of a 2020 TMDL target; compliance with 2015 TMDL target provided for comparative purposes)

TMDL Target	Monitoring Year	No. of Samples Collected	Annual Average (mg/L)	Percent of Annual Means < TMDL Targets
2015: ≥ 5 mg/L - Water Column Mean	2011	15	5.8	**25%**
	2012	8	7.1	
	2013	0	NA	
	2014	0	NA	
	2015	3	**4.3**	
	2016	8	5.3	
	2017	8	7.2	
	2018	8	6.2	
	2019	8	5.0	
	2020	8	4.8	
2020: ≥ 5 mg/L - 1-m from lake bottom	2011	15	**3.4**	**100%**
	2012	8	**4.8**	
	2013	0	NA	
	2014	0	NA	
	2015	3	**2.9**	
	2016	8	**4.2**	
	2017	8	**4.9**	
	2018	8	**3.2**	
	2019	8	**3.3**	
	2020	8	**2.8**	

[a] See footnote a on Table 2-14

Table 2-18. Compliance with Final Lake Elsinore WLA/LAs for all Watershed Sources (values are in kg/yr)

Nutrient	2011 2020 Average External Load			Offset[c]	Total External Load Allocation in TMDL[d]	Additional Reduction Required[e]
	Canyon Lake Overflow	Modeled Local Runoff[a]	Supplemental Water[b]			
Total Phosphorus	1,775	923	2,552	7,030	6,922	-8,702
Total Nitrogen	9,083	4,458	19,519	44,000	29,953	-40,893

[a] Local Lake Elsinore watershed average annual runoff nutrient load estimate from USEPA's Pollutant Loading Estimator tool (PLOAD) (USEPA 2001) for the proposed TMDL revision (see Table 4-11 in Section 4)

[b] Estimated from EVMWD inflows in Table 2-2 above and average concentrations in effluent of 0.37 mg/L TP and 2.83 mg/L TN

[c] TP reduction credit from aeration and mixing system operation was assumed to be 11,606 kg/yr TP in the TMDL. A portion of this credit (4,576 kg/yr TP) is not available to offset other sources as it was needed to create assimilative capacity under the TMDL. Thus, operation of LEAMS has created 7,030 kg/yr of net TP offset credit (Risk Sciences 2019).

[d] TMDL minus allocations for internal sediment, atmospheric deposition

[e] If ≤ zero, compliance with final allocations in TMDL for all watershed sources is effectively demonstrated

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 when 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 Threadfin Shad 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 considered nuisance species that are known to reside in the lake currently or in the past include the Common Carp Threadfin Shad (*Dorosoma petenense*) and Silverside Minnows (*Menidia* spp.).

The most recent fish survey was conducted in 2019 (LESJWA 2020). This study not only provided an update on the characteristics of the Lake Elsinore fish community but also documented what is known regarding how the fish community has changed over time in the lake, especially with regards to nuisance species which may aggravate 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. Threadfin 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. Silverside minnows also feed on zooplankton among other invertebrates, but are considered to be much less efficient as feeders on zooplankton than the Threadfin Shad.

Efforts have been made to reduce the populations of carp and shad 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 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). The most recent survey found that the carp population remains low in Lake Elsinore with an estimate of 55.3 lbs of carp per acre. In addition, the shad population was found to be very low during the 2019-2020 surveys (i.e., out of almost 4,800 fish captured during various surveys, only one Threadfin Shad was observed). However, the abundance of silverside minnow populations was high, having the second largest observed biomass, percent biomass, and biomass density of fish species in the lake (LESJWA 2020).

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 2019 fish survey was the most comprehensive survey of the lake conducted to date given that it included data collection from multiple habitats and depth layers (LESJWA 2020). Results from the 2019 survey were compared with findings from other surveys dating back to 2002 (see report for detailed summary of previous survey findings). Overall, the most recent survey showed that there has been a significant shift in the most abundant fish species (percent) observed. Key changes documented over time include:

- 2002 – Four fish species dominated the fish community with Common Carp (34 percent), Threadfin Shad (23 percent), Channel Catfish (22 percent) and Largemouth Bass (10 percent) comprising almost 90 percent of the observed abundance of fish during the survey.
- 2003 – Common Carp dominated with this species representing approximately 88 percent of the fish observed during that year's survey. Channel Catfish represented the second most common fish comprising 8.7 percent of observed abundance.
- 2008-2009 – Comprising ~80 percent of fish, Common Carp and Bluegill dominated. Threadfin Shad were common in 2008, but were not observed in the 2009 survey.
- 2015 – Threadfin Shad dominated the fish community comprising about 96 percent of the fish observed during that survey (Note: 2015 results were from a hydroacoustic survey [reported in Anderson 2016b], and based on previous history it was assumed that the small fish were Threadfin Shad rather than silverside minnows or Mosquitofish).

- 2019 – Community had shifted significantly with silverside minnows and Mosquitofish comprising more than 90 percent of fish abundance. Neither species was collected in previous surveys. Carp represented only about 7 percent of the abundance of fish in the 2019 survey.

There is a long history of fish kills in Lake Elsinore documented back to 1883 (see **Table 2-11**). The severity of these fish kills has been minor, consisting of 300 lbs (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; 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* spp.), chironomid species (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**). Surveys have been conducted at various times over a number of years:
  - 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.
- LESJWA (2020) reported the findings of zooplankton surveys conducted during three separate events: July 2019, October 2019 and February 2020. Zooplankton density and biomass varied by season with the highest observed in October. A total of fourteen zooplankton taxa (representing Cladocera, Copepoda and Rotifera), were observed across the three survey periods. The October results showed much higher zooplankton density and biomass than was observed during other survey events. Copepods and rotifers equally dominated the zooplankton community in July 2019. Rotifers dominated the community in October 2019 while copepods strongly dominated the community in February 2020. Cladocera represented a very small portion of the zooplankton community during all survey events.

A review of previous zooplankton surveys dating back to 2003 shows similar variability as was observed in the most recent surveys. In general, the lowest densities are observed in the winter and the highest densities are observed in late summer or fall. Total zooplankton density as well as the densities of major zooplankton groups were generally lower in 2009 and 2010 (as much as an order of magnitude in some seasons), than zooplankton densities observed in 2003, 2004 and 2019 (however, some of these differences among surveys may be the result of differences in the mesh size of the collection net).

Taxa richness has ranged from about 3 to 10 per survey date over the period of record; the 2019-2020 observations tended toward the higher richness values observed over time (7 to 9 taxa). Species diversity (Simpson's Diversity Index) has ranged from approximately 0.13 to

0.78 over the period of record with the highest diversity being recorded in the most recently completed surveys in 2019-2020.

Phytoplankton Community

Sources of phytoplankton community data for Lake Elsinore have been studied by Dr. Michael Anderson's UCR laboratory (Veiga-Nascimento 2004 and Tobin 2011) and the recent 2019-2020 LESJWA surveys (LESJWA 2020). Findings to date include:

- 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 (Horne and Goldman 1994).
- Veiga-Nascimento (2004) noted a similar pattern as described by Tobin (2011) 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/milliliter (mL), even in the presence of adequate food supplies (Infante and Abella 1985).
- 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, UCR, personal communication), three potentially toxic cyanobacteria were present during the 2010 sampling season: *Planktothrix agardhii, Pseudanabaena catenata, Cylindrospermopsis raciborskii* (Tobin 2011).
- LESJWA (2020) conducted phytoplankton surveys at the same time zooplankton surveys were conducted in July 2019, October 2019 and February 2020. Over the entire study, a total of 76 phytoplankton taxa were observed, categorized into eight major algal groups:
  - Blue-green algae (Cyanobacteria) were by far the most dominant group during all sample events.
  - Diatoms (Bacillariophyta) were the second most common group, with the most diatoms observed during the February 2020 survey event.
  - Green algae (Chlorophyta, Chrysophyta, and Cryptophyta) were the third most common algae, but at a very low density compared to Blue-green algae.
- Key findings from the 2019-2020 phytoplankton surveys included:
  - Highest algal densities were observed in July and October, during the period of warmer water temperatures.

– Blue-green algae were dominant during all sample events in 2019-2020, consistent with previous surveys.
– Several of the blue-green algae taxa observed in the current survey have the potential to produce harmful cyanotoxins; however, many other blue-green algae that were relatively abundant during various seasons in the 2019-2020 survey are not known to be harmful.

A pattern of seasonal succession observed in previous long-term surveys in Lake Elsinore (dominance of diatoms in the winter and spring to a community dominated by blue-green algae in the summer and fall), was not observed in the 2019-2020 surveys. This previously observed seasonal successional pattern of shifting to a population to high levels of cyanobacteria over the summer was believed to 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 (California Cyanobacterial and Harmful Algal Bloom [CCHAB] Network 2016; State Water Board 2016). These trigger levels were developed to protect human and animal (dogs, livestock) health from cyanobacteria harmful algal blooms (HAB) (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 2016). Based on these findings, monitoring of HABs 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 cyanotoxin found, as it was detected in all months except February 2018 (**Figure 2-28).** 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 (Smucker et al. 2021); however, cyanobacteria do not always produce toxins for reasons that are currently not well understood (Christensen et al. 2024; 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).

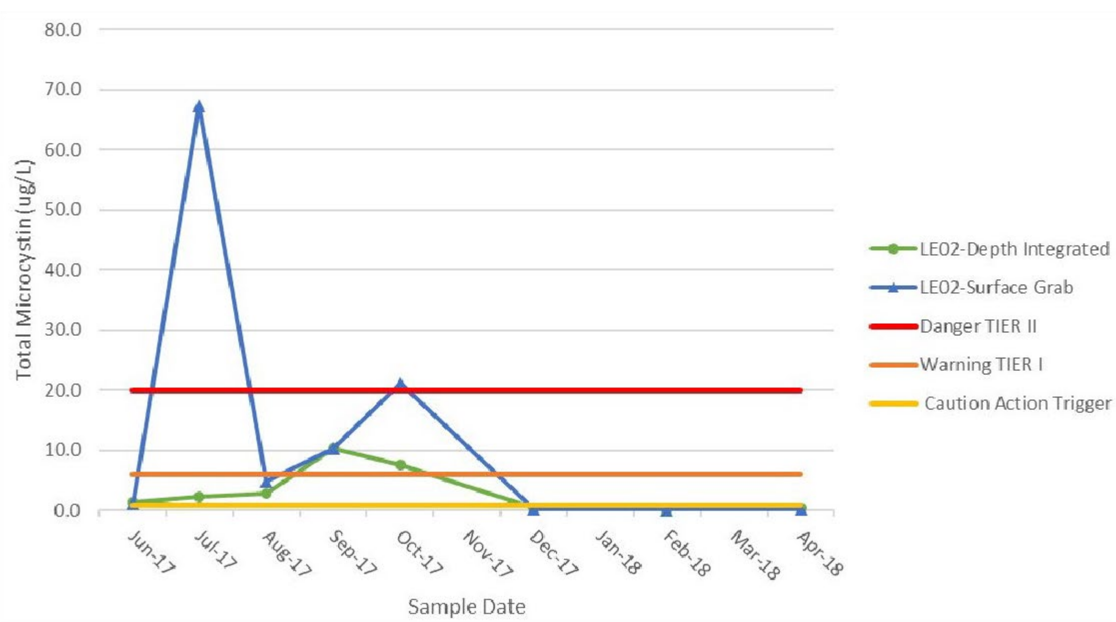

Figure 2-28. Microcystin Concentrations in Lake Elsinore from June 2017 to April 2018 (The trigger levels or thresholds to protect recreation shown with the yellow, orange and red horizontal lines, are those currently recommended by CCHAB [2016])

Routine monitoring for cyanotoxins is ongoing through a collaboration between the City of Lake Elsinore the CCHAB and now includes five stations at various points on the lake with incidents reported and used for public notification.[2] Concentrations of microcystin have been observed to exceed trigger levels frequently, which has resulted in multiple beach notifications and closures.

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 2-29**). 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 2-29. Canyon Lake Reservoir (Source: Wood Environment and Infrastructure Solutions, Inc.)

The City of Canyon Lake has documented the establishment of the Railroad Canyon Reservoir, now known as Canyon Lake. Following are excerpts of this early history (**Figure 2-30**):[3]

> *"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…"*

[2] https://mywaterquality.ca.gov/habs/where/freshwater_events.html

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

"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 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."

Figure 2-30. Undated Photograph of the Evans Camp that Supported Fishermen at Railroad Canyon Reservoir (Source: USGenweb Archives, http://www.usgwarchives.net/ca/riverside/postcards/evcamp.jpg)

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 2-31**). 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, 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 Dept. Finance 2023) (**Table 2-19**).

Table 2-19. City of Canyon Lake Population Since Incorporation in 1990

Census Date	Population
1991	10,292
2000	9,978
2010	10,561
2017	10,891
2023	10,949

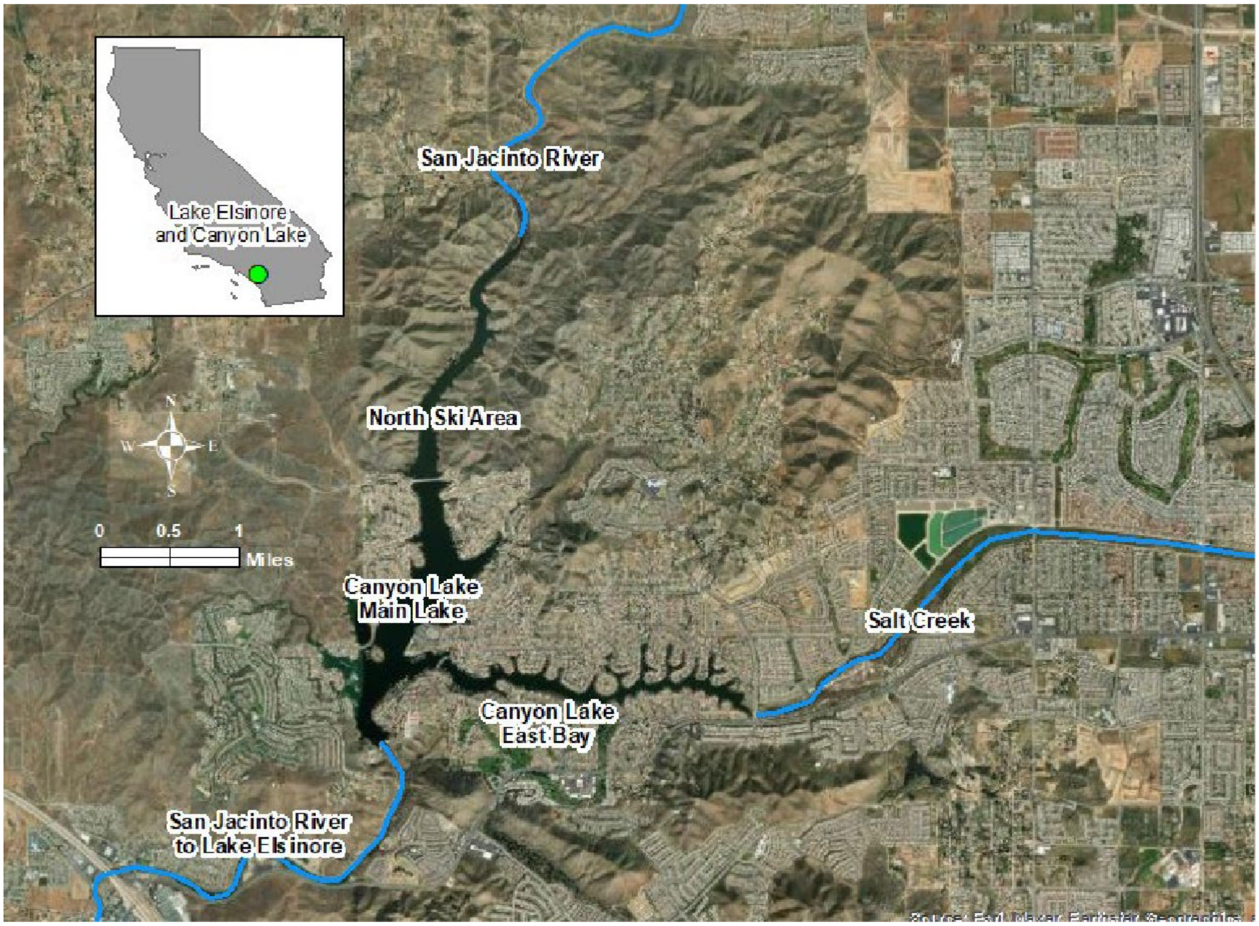

Figure 2-31. Recent Development of Property around Canyon Lake

The surface area of Canyon Lake is approximately 500 acres, with an estimated current storage capacity of 8,760 AF. The lake is divided into two key areas: (1) Main Lake, which is the deepest part of the lake upstream of the dam (over 50 feet near the Dam) and the North Ski Area, which is the north portion of the lake above the causeway; and, (2) the East Bay, the relatively shallow east arm of the lake upstream of the causeway located near where East Bay enters the Main Lake (East Bay is approximately eight feet deep at the upper end near the Salt Creek inflow). 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 2-32**) (Anderson 2016c).

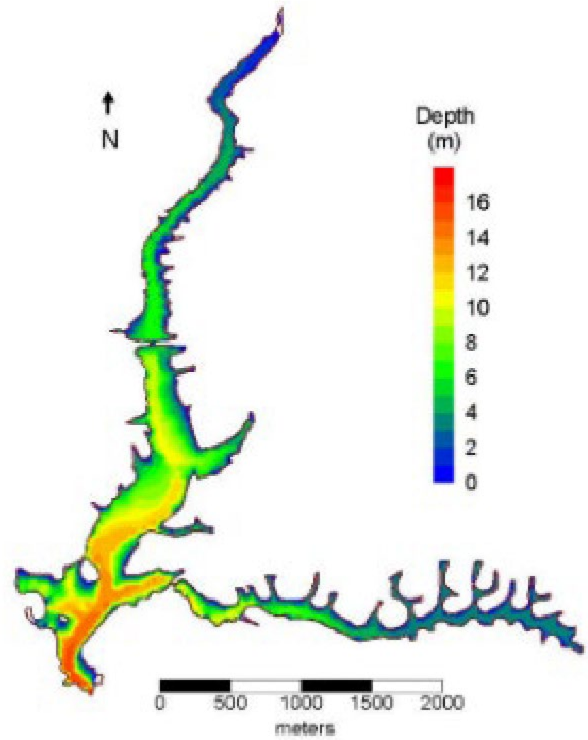

Figure 2-32. Bathymetric Map of Canyon Lake (Anderson 2016c)

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 2-20** summarizes the total depth and mean Secchi depths observed at four sampling locations within Canyon Lake.

Table 2-20. Canyon Lake Water Depth and Secchi Depth from July 15 – August 2015 (see Figure 2-34 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 (WTP), 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 WTP because algal cells can clog the water treatment filters.

2.2.3.2 Historical Water Quality – Prior to TMDL Adoption

Prior to the 1980s, limited water quality datasets were available for Canyon Lake, particularly for nutrient conditions. Since then, water quality data which were evaluated as part of development of the 2004 TMDL, 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 EC 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 Conditions

This section provides the following: (a) an overview of recent water quality conditions observed in Canyon Lake (primarily since 2001); and (b) findings from the 2020 assessment that evaluated compliance with the existing 2004 TMDL targets and WLAs/LAs for TP and TN (LESJWA 2021).

2.2.3.3.1 Water Quality Observations

Similar to Lake Elsinore a significant body of monitoring data has been collected for Canyon Lake since the Santa Ana Water Board and stakeholders began monitoring water quality of Lake in May 2000, specifically for nutrients and chlorophyll-*a*, as part of TMDL development (**Figure 2-33**). This section summarizes water quality results observed from approximately 2001 through 2024.

Figure 2-33. Water Quality Monitoring on Canyon Lake (Source: Wood Environment and Infrastructure Solutions, Inc.)

Water samples have been routinely collected for nutrient analysis at four sampling stations, CL07, CL08, CL09 and CL10 (**Figure 2-34**). 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, EC, and turbidity are also measured at three-ft intervals at the time of sample collection. This nutrient TMDL monitoring program continued through 2012.

Figure 2-34. Location of Canyon Lake Sample Locations (CL07, CL08, CL09, and CL10)

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 EC are performed twice during each monitoring event (am and pm), with these values averaged at each depth for a given day.

Canyon Lake water quality conditions based on the monitoring studies completed to date are discussed below. 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 from 2002 through 2024. These data are now available in a single CEDEN-compatible database and have 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.

Phosphorus

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 2-21** provides a tabular summary of nutrient measurements conducted by the Santa Ana Water Board in 2000-2001. **Figure 2-35** shows a graphical summary of available depth-integrated TP data collected during TMDL compliance monitoring efforts from 2001 to 2024. **Tables 2-22 and 2-23** provide the associated range, average, and median values of TP from 2001 to 2024 for the Main Basin (Sites CL07 and CL08), and East Basin (Sites CL09 and CL10) sites, respectively.

Based on TMDL compliance monitoring efforts in Canyon Lake between 2001 and 2012, the mean concentration of TP was 0.57 mg/L and 0.52 mg/L in the Main Lake and East Bay, respectively (**Tables 2-22** and **2-23**). These values encompass the range observed by the Santa Ana Water Board in 2000-2001. Spikes in TP of greater than 1.0 mg/L were recorded in August 2007, several dates between October 2010 and June 2011, and in February 2017. Notably, the mean concentrations of TP since 2015 are substantially lower than that historically observed, with an average concentration of 0.11 and 0.12 mg/L in the Main Lake and East Bay, 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.

Nitrogen

Like phosphorus, nitrogen concentrations also exhibit strong seasonal and inter-annual variations as well. **Figure 2-36** shows a graphical summary of depth-integrated TN data collected during TMDL compliance monitoring efforts from 2001 to 2024. **Tables 2-22** and **2-23** provide the associated range, average, and median values of TN from 2001 to 2024 for the Main Basin (Sites CL07 and CL08) and the East Basin (Sites CL09 and CL10), respectively.

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 2024, 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 (see **Tables 2-22** and **2-23**). 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, February 2012, and August 2021. Mean concentrations of TN since 2015 have declined by about 25 percent, with an average concentration of 2.0 mg/L in 2002-2012 and 1.5 mg/L in 2015-2024.

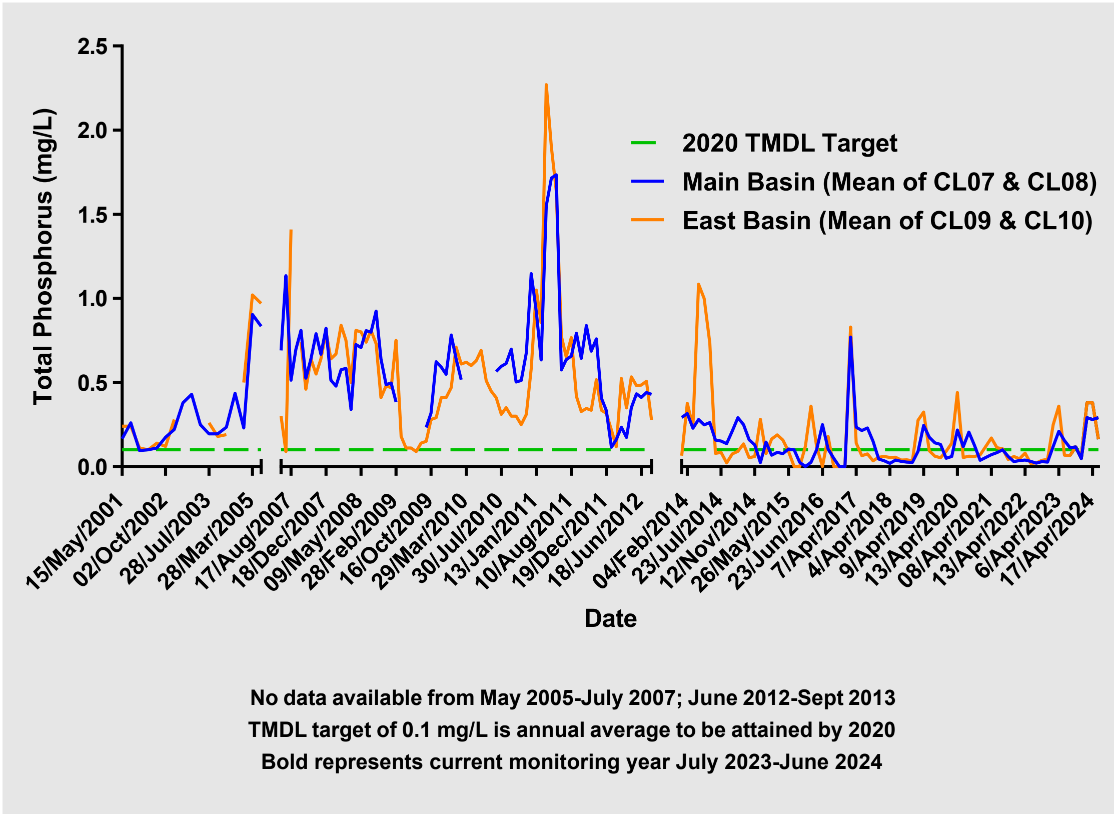

Figure 2-35. Depth-Integrated Average Total Phosphorus Concentrations in Canyon Lake: 2001-2024 (Note discontinuous data record on x-axis)

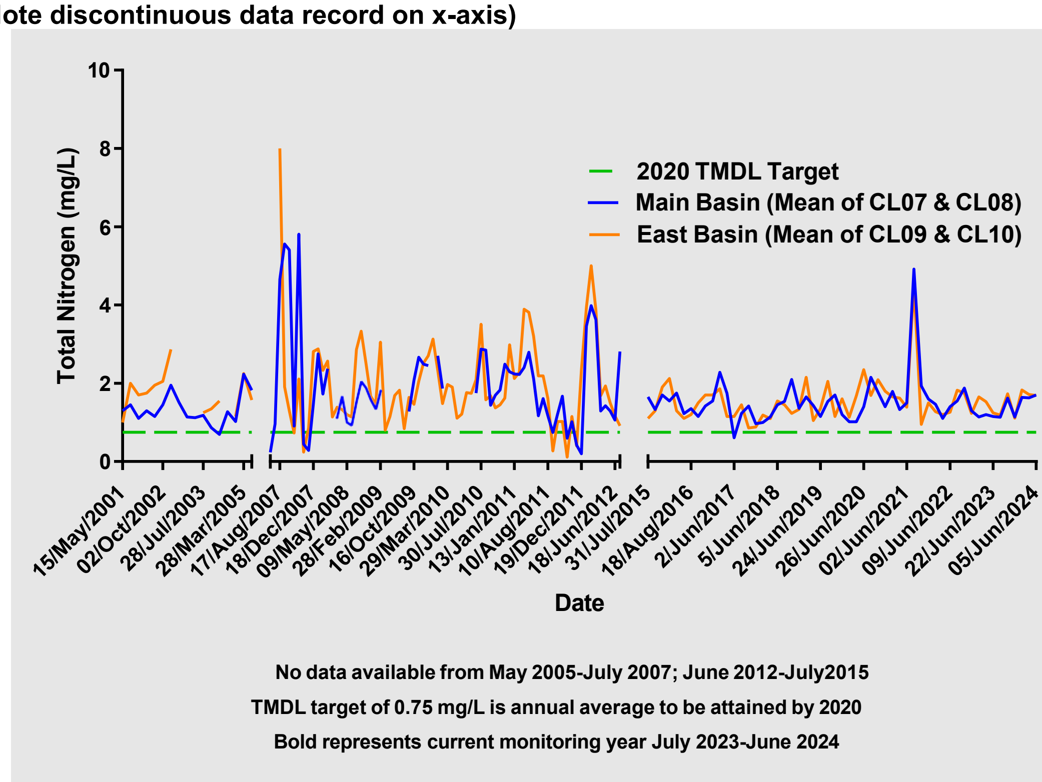

Figure 2-36. Depth-Integrated Average Total Nitrogen Concentrations in Canyon Lake: 2001-2024 (Note discontinuous data record on x-axis)

Table 2-21. 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
Total Kjeldahl Nitrogen (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

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

Table 2-22. Historical Dissolved Oxygen, Nutrient, Chlorophyll-*a*, and TDS Summary for Canyon Lake TMDL Compliance Monitoring: Sites CL07 and CL08 (Main Lake), 2002-2012 and 2015-2024

		2002 2012					2015 2024				
		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	55[1]	4.59	14.57	8.54	8.30
	Hypolimnion	74	0.0	6.3	0.59	0.21	55[1]	0.00	5.25	0.56	0.20
Chlorophyll-*a* (µg/L)	Depth-Integrated	53	5.2	459	45	40	110	0.0	102.0	22.4	18.1
Total Nitrogen (mg/L)	Depth-Integrated	61	0.20	5.81	2.0	1.7	55[1]	0.61	4.92	1.51	1.43
Total Phosphorus (mg/L)	Depth-Integrated	77	0.10	1.74	0.57	0.57	55[1]	ND	0.77	0.11	0.08
Total Ammonia (mg/L)	Depth-Integrated	75	0.03	2.88	0.84	0.83	110	ND	2.5	0.61	0.42
Un-ionized Ammonia (mg/L)	Depth-Integrated	75	0.0	0.18	0.03	0.02	110	ND	0.07	0.01	0.01
TDS (mg/L)	Depth-Integrated	101	152	985	593	593	110	260	880	517	490

[1] DO, TN, and TP results are based on daily averages of data collected from CL07 and CL08 monitoring locations

Table 2-23. Historical Dissolved Oxygen, Nutrient, Chlorophyll-*a*, and TDS Summary for Canyon Lake TMDL Compliance Monitoring: Sites CL09 and CL10 (East Bay), 2002-2012 and 2015-2024

		2002 2012					2015 2024				
		N	Min	Max	Mean	Median	N	Min	Max	Mean	Median
Dissolved Oxygen (mg/L)	Above the Thermocline	44	5.6	16	10	10	30	6.1	13.2	9.0	8.8
	Hypolimnion	44	0.0	4.0	0.59	0.24	34	0.0	10.3	1.0	0.2
Chlorophyll-*a* (µg/L)	Depth-Integrated	61	1.0	220	60	53	102	0.0	97.3	30.1	22.0
Total N (mg/L)	Depth-Integrated	73	0.11	8.0	2.0	1.7	55	0.9	4.5	1.5	1.5
Total P (mg/L)	Depth-Integrated	83	0.09	2.3	0.52	0.47	55	ND	0.83	0.12	0.07
Total Ammonia (mg/L)	Depth-Integrated	67	0.03	1.54	0.51	0.35	102	ND	2.30	0.36	0.17
Un-ionized Ammonia (mg/L)	Depth-Integrated	67	0	0.5	0.04	0.02	102	ND	0.14	0.015	0.004
TDS (mg/L)	Depth-Integrated	97	336	1206	701	671	102	310	930	602	600

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 2-37**). 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 (Schindler 2012).

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.

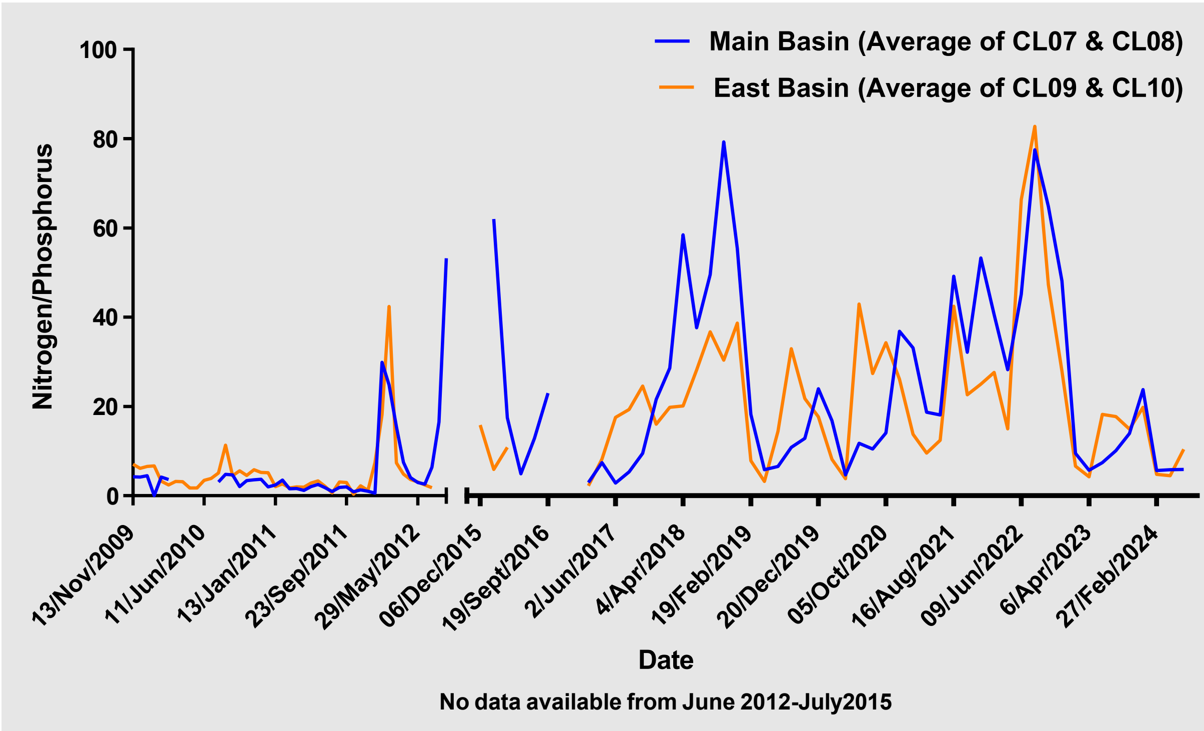

Figure 2-37. Nitrogen to Phosphorus Ratios in Canyon Lake: 2009-2024 (Note discontinuous data record on x-axis)

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 2024 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 2-38** and see **Tables 2-22** and **2-23**). 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 2024 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 2-39**; see **Tables 2-22** and **2-23**). 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.

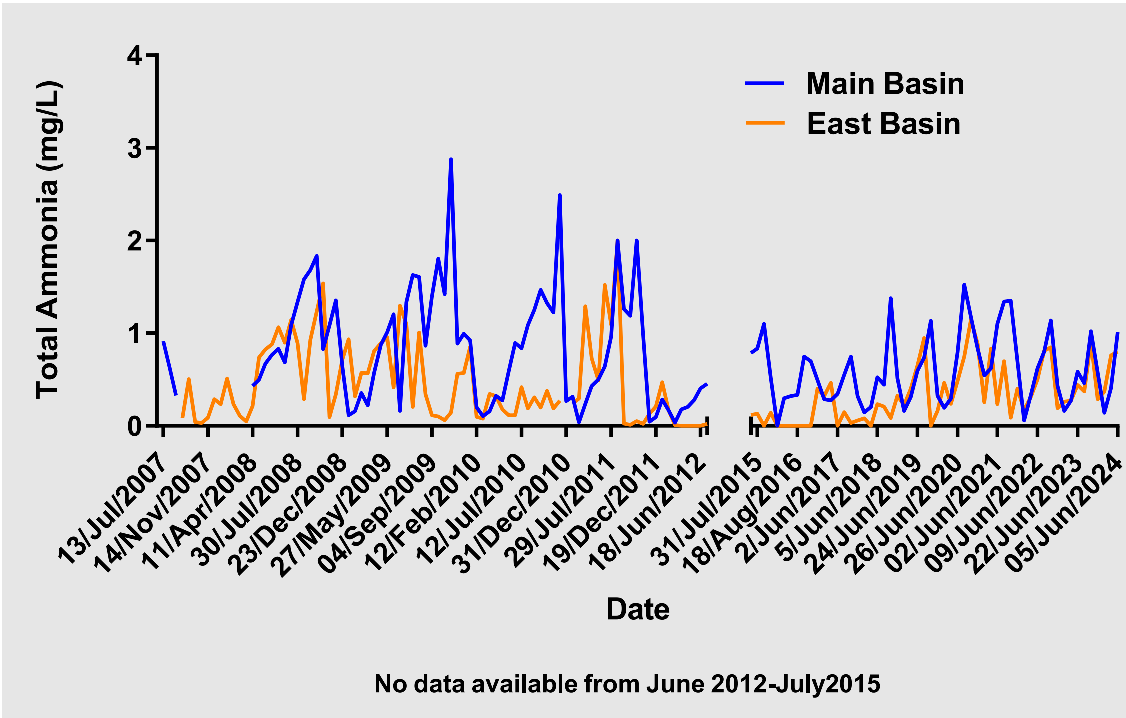

Figure 2-38. Depth-Integrated Average Total Ammonia Concentrations in Canyon Lake: 2007-2024 (Note discontinuous data record on x-axis)

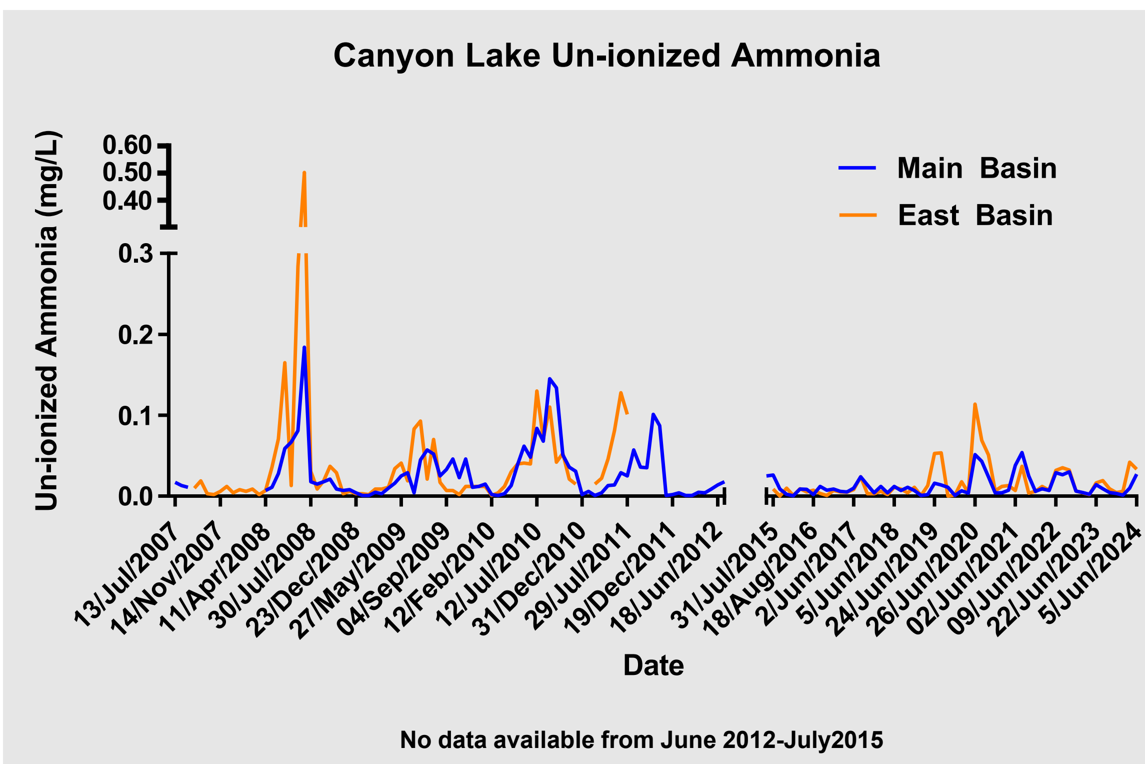

Figure 2-39. Depth-Integrated Average Un-ionized Ammonia Concentrations in Canyon Lake: 2007-2024 (Note discontinuous data record on x-axis)

Chlorophyll-*a*

The current TMDL compliance threshold target for chlorophyll-*a* in Canyon Lake is a summer average value ≤ 25 µg/L in 2020. During TMDL compliance monitoring efforts in Canyon Lake between 2001 and 2024, 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 2-40**; see **Tables 2-22** and **2-23**). 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.

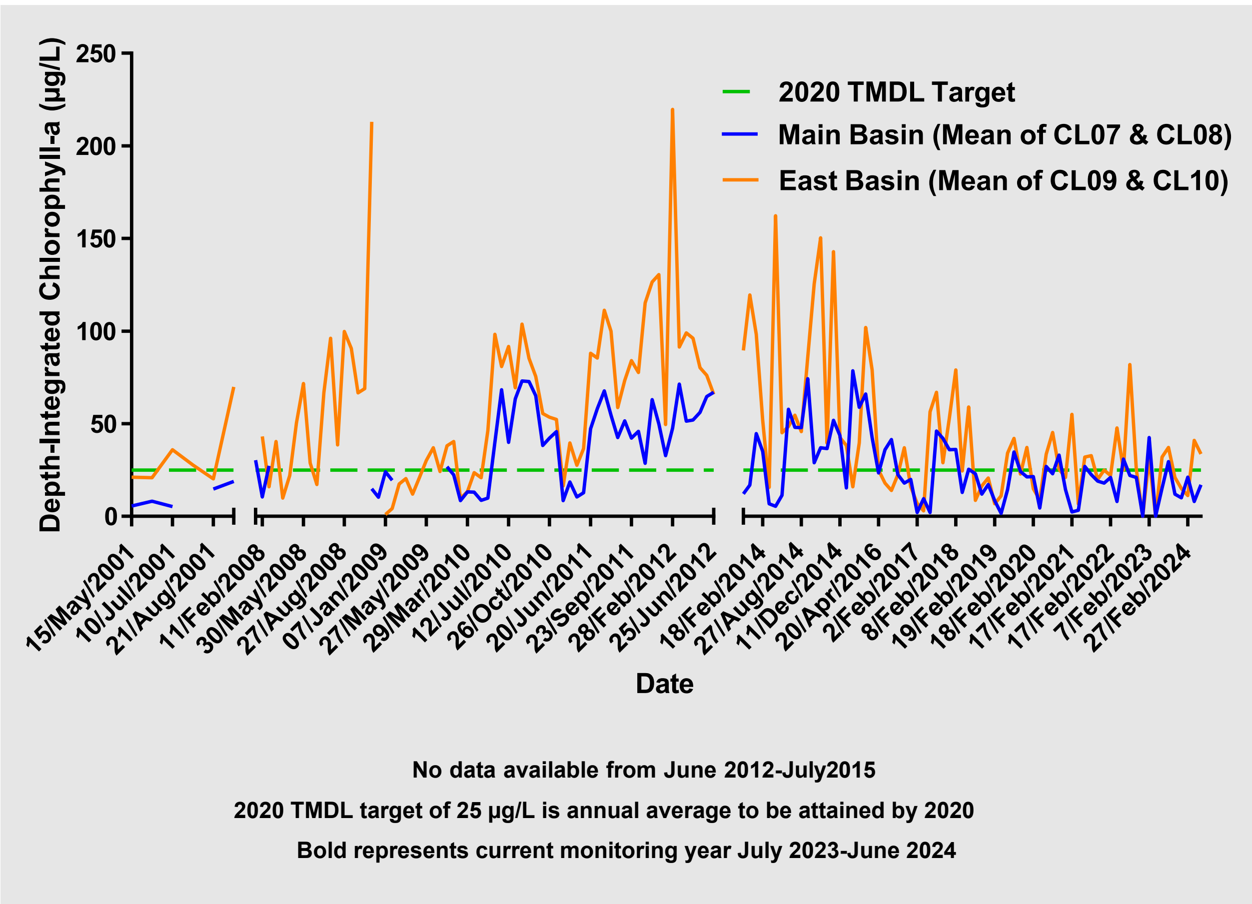

Figure 2-40. Depth-Integrated Average Chlorophyll-a Concentrations in Canyon Lake: 2001-2024 (Note discontinuous data record on x-axis)

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 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.

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 2-40**). 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 always readily available for algal growth. 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.

Dissolved Oxygen

Figures 2-41 and **2-42** 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 2-22** and **2-23** above 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.

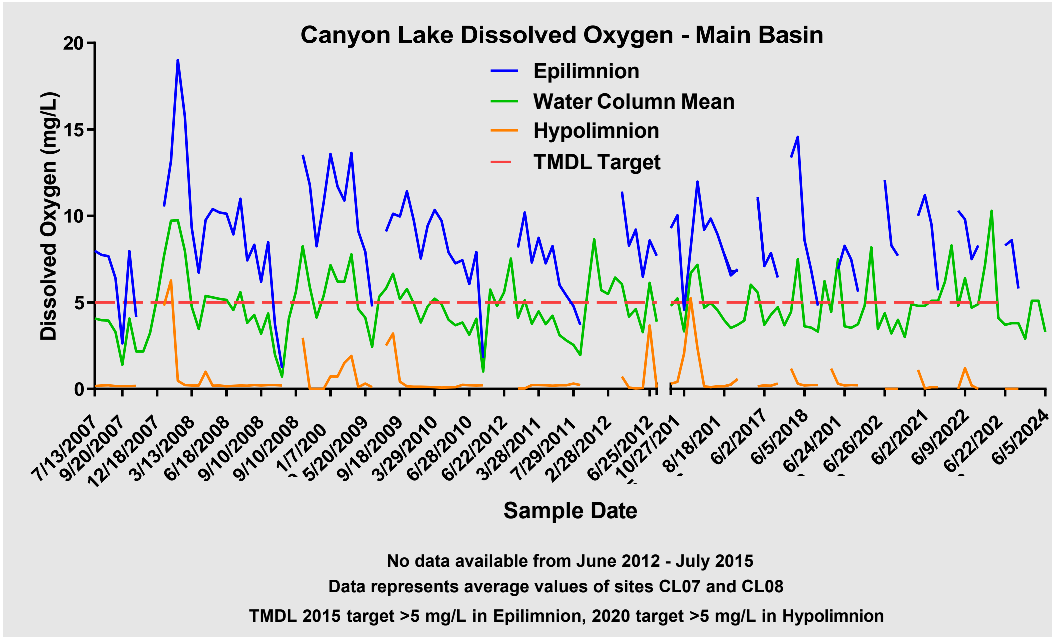

Figure 2-41. Depth-Integrated Average Dissolved Oxygen Concentrations in Canyon Lake (Main Basin): 2007-2024 (Notes: discontinuous data record on x-axis; 2020 TMDL target = daily average in hypolimnion of no less than 5 mg/L)

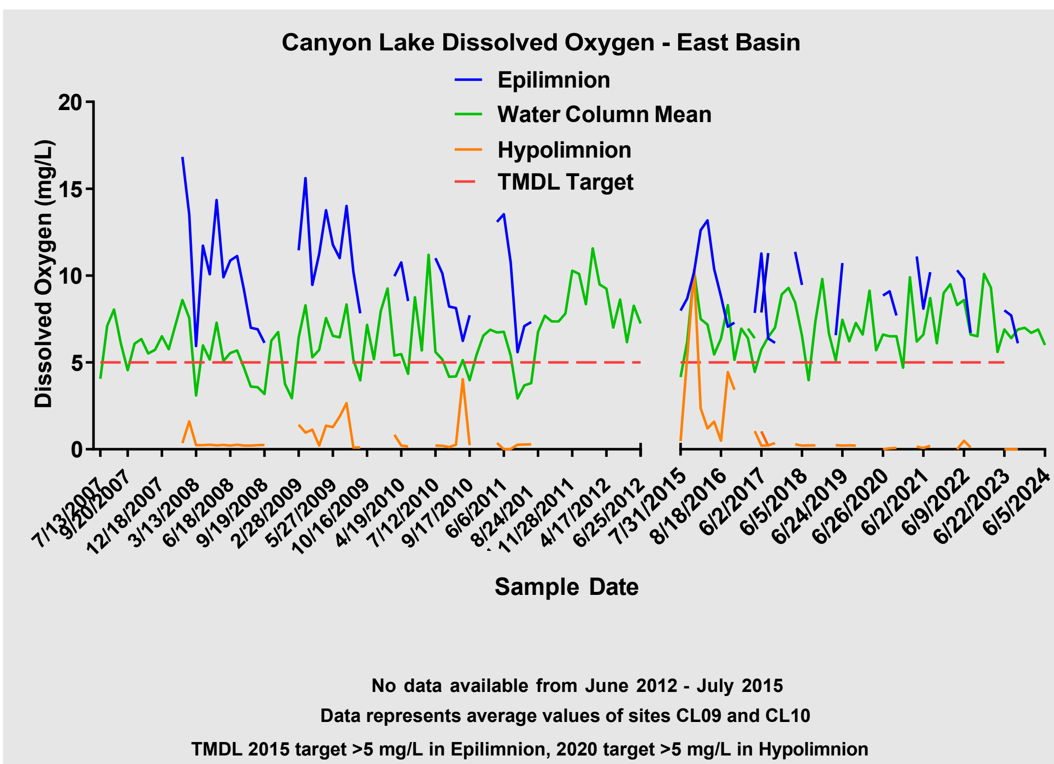

Figure 2-42. Depth-Integrated Average Dissolved Oxygen Concentrations in Canyon Lake (East Basin): 2007-2024 (Notes: discontinuous data record on x-axis; 2020 TMDL target = daily average in hypolimnion of no less than 5 mg/L)

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 2-43 Canyon Lake Reservoir (Source: Wood Environment and Infrastructure Solutions, Inc.)

Total Dissolved Solids

During TMDL compliance monitoring efforts in Canyon Lake between 2001 and 2024 (**Figure 2-43**), 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**; see **Tables 2-22** and **2-23**). 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 EC 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.

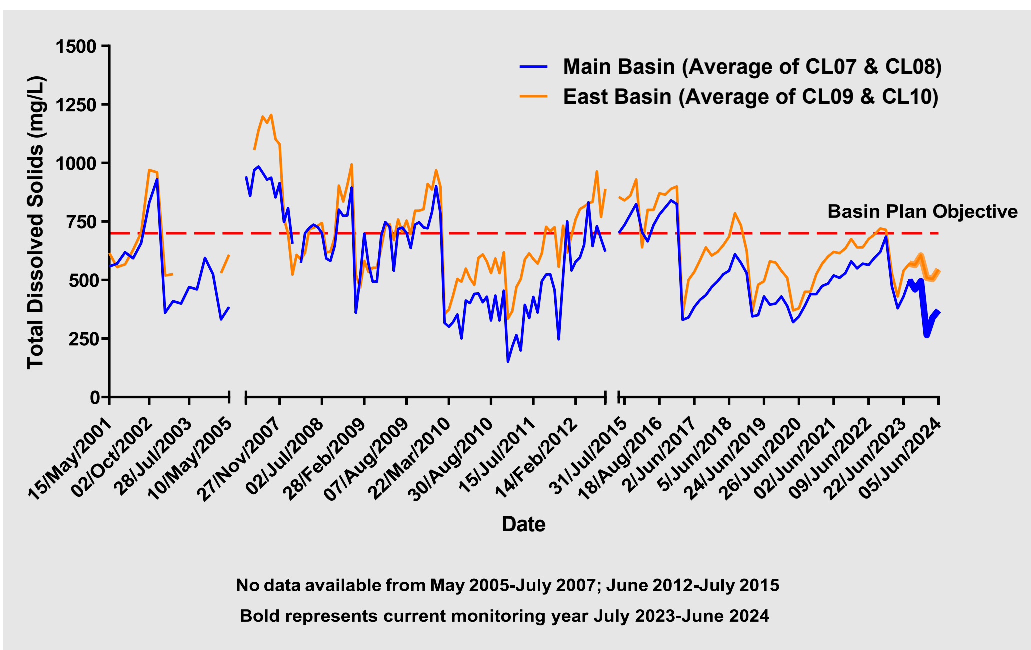

Figure 2-44. Depth-Integrated Average TDS Concentrations in Canyon Lake: 2001-2024 (Note discontinuous data record on x-axis)

Chemical Stratification

As discussed above, Canyon Lake is thermally stratified in the summer, mixes in the fall and stays mixed through the winter. 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. Current TMDL compliance monitoring methods include the collection of a single depth-integrated sample for analysis of nutrients and TDS. 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.

2.2.3.3.2 2020 TMDL Compliance Assessment

As with Lake Elsinore (see Section 2.2.2.5.2), to meet various permitting and reporting obligations, the LECL Task Force prepared a LECL TMDL Compliance Assessment Report to evaluate water quality data collected from Canyon Lake over the 10-year period from January 1, 2011 through December 31, 2020 (LESJWA 2021). **Table 2-2** above summarizes the in-lake numeric water quality targets for Canyon Lake for TP, TN, total ammonia, chlorophyll-*a* and DO. **Tables 2-24** to **2-31** provide a compliance summary for each of these parameters for the Main Basin and East Bay of Canyon Lake, i.e., the annual arithmetic mean value for each parameter compared to the numeric targets and the calculated frequency of exceedance of the numeric targets.

Improvements have been noted for several numerical targets in Canyon Lake, in particular TP, TN, and chlorophyll-*a*. A combination of upstream nutrient source controls and in-lake application of alum appear to be having a successful positive influence on the water quality and beneficial use attainment in Canyon Lake. Despite the water quality improvements over time, exceedances of the various 2004 TMDL targets continue to occur. LESJWA (2021) summarized overall water quality observations from Canyon Lake from the 10-year assessment period. For example:

- TP has exceeded the TMDL target of 0.1 mg/L 70-90 percent of the time over the past 10 years (based on annual averages for the Main Basin and East Bay) (**Tables 2-24** and **2-25**).
- TN exceeded the 0.75 mg/L target 100 percent of the time in both basins (**Tables 2-24** and **2-25**).
- Total ammonia occasionally exceeds the acute 2013 CMC (12.5 to 25 percent of the time), and chronic CCC (25 to 37.5 percent of the time) in the Main Basin and East Bay, respectively based on annual averages (**Tables 2-26** and **2-27**). However, despite these exceedances, the measured concentrations of total ammonia (and calculated unionized ammonia) are well below levels found to be toxic to largemouth bass which is the most sensitive fish species known to inhabit the lake (USEPA 2013).

Table 2-24. Canyon Lake Main Basin - 2020 TMDL Summary for Total Phosphorus and Total Nitrogen, January 2011–December 2020 [a,b] (bold values indicate exceedance of 2020 TMDL target)

Parameter	TMDL Target	Monitoring Year	No. of Samples Collected	Annual Average (mg/L)	Percent of Annual Means > TMDL Targets
Total Phosphorus	≤ 0.1 mg/L (Annual Average)	2011	15	**0.859**	**70%**
		2012	8	**0.290**	
		2013	2	**0.361**	
		2014	14	**0.202**	
		2015	7	0.065	
		2016	7	0.076	
		2017	6	**0.274**	
		2018	6	0.029	
		2019	6	**0.139**	
		2020	6	**0.127**	
Total Nitrogen	≤ 0.75 mg/L (Annual Average)	2011	15	**1.44**	**100%**
		2012	8	**2.37**	
		2013	5	**1.53**	
		2014	12	**2.75**	
		2015	5	**1.42**	
		2016	7	**1.43**	
		2017	6	**1.37**	
		2018	6	**1.44**	
		2019	6	**1.44**	
		2020	6	**1.45**	

[a] The data presented herein for all compliance summary tables for both lakes goes through December 2020.

[b] The number of samples collected and analyzed are included in annual average calculations for the corresponding parameter within each calendar year. Monitoring for certain constituents was temporarily suspended from June 2012 - July 2015; this absence of data is presented as “NA”, not applicable.

Table 2-25. Canyon Lake East Bay - 2020 TMDL Summary for Total Phosphorus and Total Nitrogen, January 2011 – December 2020[a] (bold values indicate an exceedance of a 2020 TMDL target)

Parameter	TMDL Target	Monitoring Year	No. of Samples Collected	Annual Average (mg/L)	Percent of Annual Means > TMDL Targets
Total Phosphorus	< 0.1 mg/L (Annual Average)	2011	15	**0.83**	**90%**
		2012	8	**0.40**	
		2013	2	**0.17**	
		2014	14	**0.31**	
		2015	7	**0.10**	
		2016	7	**0.10**	
		2017	6	**0.20**	
		2018	6	0.047	
		2019	6	**0.15**	
		2020	6	**0.15**	
Total Nitrogen	< 0.75 mg/L (Annual Average)	2011	15	**1.84**	**100%**
		2012	8	**2.50**	
		2013	5	**1.64**	
		2014	12	**2.48**	
		2015	5	**1.26**	
		2016	7	**1.51**	
		2017	6	**1.22**	
		2018	6	**1.31**	
		2019	6	**1.56**	
		2020	6	**1.77**	

[a] See footnote a on Table 2-24

Table 2-26. Canyon Lake Main Basin - 2020 TMDL Summary for Total Ammonia, January 2011 – December 2020.[a] Chronic criteria: CCC- Criterion Continuous Concentration; or acute criteria: CMC- Criterion Maximum Concentration (see text) (bold values indicate years with at least one exceedance of a 2020 TMDL target of 2004 ammonia criteria - 2013 USEPA criteria provided for comparison purposes)

TMDL Target[b] (mg/L)	Monitoring Year	No. of Samples Collected	Annual Average (mg/L)	Percent of Annual Means > TMDL Target
• 2004 - CMC: 0.58-5.73; CCC: 0.11-1.79 • 2013 - CMC: 0.17-5.37; CCC: 0.05-0.99	2011[c]	14	**0.765**	2004: CMC: **12.5%** CCC: **25%** 2013: CMC: **12.5%**; CCC: **37.5%**
• 2004 - CMC: 1.12-11.10; CCC: 0.19-2.99 • 2013 - CMC: 0.31-9.41; CCC: 0.09-1.52	2012[c]	8	**0.251**	
NA	2013	0	NA	
NA	2014	0	NA	
• 2004 - CMC: 13.1-28.7; CCC: 1.93-5.31 • 2013 - CMC: 4.89-22.2; CCC: 0.879-2.52	2015	3	0.820	
• 2004 - CMC: 9.03-21.2; CCC: 1.86-3.17 • 2013 - CMC: 4.44-11.3; CCC: 0.845-1.74	2016	7	0.414	
• 2004 - CMC: 5.99-17.6; CCC: 1.12-3.69 • 2013 - CMC: 2.41-11.5; CCC: 0.507-1.68	2017	6	0.422	
• 2004 - CMC: 10.1-23.8; CCC: 1.96-3.33 • 2013 - CMC: 4.84-10.9; CCC: 0.891-1.56	2018	6	0.536	
• 2004 - CMC: 9.61-29.5; CCC: 1.95-5.39 • 2013 - CMC: 4.87-25.8; CCC: 0.888-2.81	2019	6	0.544	
• 2004 - CMC: 4.68-25.8; CCC: 1.03-5.03 • 2013 - CMC: 2.11-20.1; CCC: 0.467-2.40	2020	6	**0.803**	

[a] See footnote a on Table 2-24

[b] CCC and CMC criteria calculated using both 2004 TMDL and 2013 USEPA updated formulas. The 2013 CMC calculation assumes the absence of *Oncorhynchus spp.*

[c] CCC and CMC values from 2011-2012 represent the entire lake, with the most conservative criteria applied

Table 2-27. Canyon Lake East Bay - 2020 TMDL Summary for Total Ammonia, January 2011 – December 2020.[a] Chronic criteria: CCC- Criterion Continuous Concentration; or acute criteria: CMC- Criterion Maximum Concentration (see text) (bold values indicate years with at least one exceedance of a 2020 TMDL target of 2004 ammonia criteria - 2013 USEPA criteria provided for comparison purposes)

TMDL Target[b] (mg/L)	Monitoring Year	No. of Samples Collected	Annual Average (mg/L)	Percent of Annual Means > TMDL Target
• 2004- CMC: 0.58-5.73; CCC: 0.11-1.79 • 2013- CMC: 0.17-5.37; CCC: 0.05-0.99	2011[c]	14	**0.579**	2004: CMC: 0**%** CCC: **25%** 2013: CMC: 12.5**%**; CCC: **37.5%**
• 2004- CMC: 1.12-11.10; CCC: 0.19-2.99 • 2013- CMC: 0.31-9.41; CCC: 0.09-1.52	2012[c]	8	0.084	
NA	2013	0	NA	
NA	2014	0	NA	
• 2004- CMC: 2.97-8.25; CCC: 0.718-1.02 • 2013- CMC: 1.35-2.63; CCC: 0.326-0.537	2015	3	0.090	
• 2004- CMC: 1.98-17.2; CCC: 0.486-3.46 • 2013- CMC: 0.897-12.4; CCC: 0.221-1.85	2016	7	0.057	
• 2004- CMC: 3.13-23.4; CCC: 0.515-3.50 • 2013- CMC: 0.930-11.5; CCC: 0.234-1.59	2017	6	0.171	
• 2004- CMC: 4.06-13.6; CCC: 1.24-2.16 • 2013- CMC: 2.74-5.57; CCC: 0.562-0.982	2018	6	0.156	
• 2004- CMC: 3.56-24.1; CCC: 0.680-4.86 • 2013- CMC: 1.31-23.1; CCC: 0.309-2.73	2019	6	**0.398**	
• 2004- CMC: 1.88-18.9; CCC: 0.378-4.21 • 2013- CMC: 0.675-16.0; CCC: 0.172-2.15	2020	6	**0.662**	

[a] See footnote a on Table 2-24

[b] CCC and CMC criteria calculated using both 2004 TMDL and 2013 USEPA updated formulas. The 2013 CMC calculation assumes the absence of *Oncorhynchus spp.*

[c] CCC and CMC values from 2011-2012 represent the entire lake, with the most conservative criteria applied

- DO shows a strong relationship with depth much of the year in Canyon Lake, with much lower concentrations in the deeper hypolimnion below the thermocline than above. This is a natural phenomenon in temperate eutrophic lakes where thermal stratification prevents mixing of the upper and lower waters during late spring, summer, and early fall months with decomposition at the sediment surface depleting oxygen. During thermal destratification in the fall (late October-November) when the surface waters cool, the surface and deep waters have the opportunity to mix throughout the water column. (Dodds 2010; Sadchikov and Ostroumov 2019; Su et al. 2019; Sánchez-España et al. 2017; Sahoo et al. 2010). Observations include:
  - Annual mean concentrations of DO in the epilimnion above the thermocline (8.2 to 9.2 mg/L) met the 2015 TMDL target of 5.0 mg/L 100 percent of the time (**Tables 2-28** and **2-29**).
  - The 2020 TMDL target of ≥ 5.0 mg/L DO in the hypolimnion was only achieved in one year of the 10-year period (2015) and only in the East Bay (5.4 mg/L) as would be expected for a natural deep temperate lake at this latitude (**Table 2-28** and **2-29**).
  - Immediately following lake mixing after destratification, low DO conditions throughout the water column may occur and cause stress for fish. However, during periods when thermal stratification was not present in Canyon Lake, DO was above 5.0 mg/L most of the time in the upper water column, and thus it met the target. From a biological standpoint, it is important that fish and aquatic life have sufficient access to waters with a concentration of DO greater than 5.0 mg/L in portions of key habitat areas of the lake volume to find refuge during periods of depressed DO levels.
  - Despite the noted exceedances, the primary goals to maintain fishable, swimmable waters has consistently been achieved in Canyon Lake. No major fish kills have been reported in Canyon Lake from 2011 to 2020, indicating DO and ammonia have been at acceptable levels to support fish populations, and few significant algae blooms have been reported.
- Assessment of direct beneficial use impairment of recreational use due to algae is conducted through a measure of chlorophyll-*a*, a primary pigment in green algae use for photosynthesis (Carter 1996). Observations include (**Tables 2-30** and **2-31**):
  - In Canyon Lake mean depth-integrated annual chlorophyll-*a* concentrations of 32.5 µg/L and 56.0 µg/L were observed in the Main Basin and East Bay, respectively, over the 10-year period from 2010-2020.
  - The Main Basin of Canyon Lake met the 2020 target of 25 µg/L for chlorophyll-*a* in 5 of 10 years from 2011 to 2020, with all of the last four years (2017-2020) meeting the target.
  - The much shallower and physically constrained East Bay of Canyon Lake met the 2020 chlorophyll-*a* target of 25 µg/L only once (2020) from 2011 to 2020 based on the average annual value. However, during the last five years chlorophyll-*a* had an average maximum of just 35.9 µg/L and was less than 26 µg/L during the past two years.

– Algae concentrations have declined and remained relatively stable since 2015 despite a prolonged drought between 2011 and 2018 during which natural evaporation would tend to increase the average phosphorus concentration in Canyon Lake. However, as described above, it is believed that levels of TP have been reduced and have held relatively steady over since 2015 due to watershed BMPs and multiple applications of alum.

Table 2-28. Canyon Lake Main Basin - 2020 TMDL Summary for Dissolved Oxygen, January 2011 – December 2020[a] (bold values indicate an exceedance of a 2020 TMDL target; compliance with 2015 epilimnion TMDL target provided for comparative purposes)

Parameter	TMDL Target	Monitoring Year	No. of Samples Collected	Annual Average (mg/L)[b]	Percent of Annual Means < TMDL Targets
Dissolved Oxygen (Epilimnion)	2015: ≥ 5 mg/L Epilimnion	2011	11	7.3	2015: 0%
		2012	6	8.6	
		2013	0	NA	
		2014	0	NA	
		2015	3	7.6	
		2016	7	8.7	
		2017	4	7.7	
		2018	5	9.7	
		2019	4	7.1	
		2020	3	9.3	
Dissolved Oxygen (Hypolimnion)	2020: ≥ 5 mg/L Hypolimnion (Daily Average)	2011	11	**0.2**	2020: **100%**
		2012	6	**0.8**	
		2013	0	NA	
		2014	0	NA	
		2015	3	**2.6**	
		2016	7	**0.5**	
		2017	4	**0.2**	
		2018	5	**0.4**	
		2019	5	**0.4**	
		2020	3	**0.02**	

[a] See footnote a on Table 2-24

[b]-Average epilimnion and hypolimnion calculations can only be performed when the lake is stratified. Years without data points are those in which the epilimnion and/or hypolimnion values were not reported, hence this value does not necessarily correspond to the number of sampling events performed.

Table 2-29. Canyon Lake East Bay - 2020 TMDL Summary for Dissolved Oxygen, January 2011 – December 2020.[a] (bold values indicate an exceedance of a 2020 TMDL target; compliance with 2015 epilimnion TMDL target provided for comparative purposes)

Parameter	TMDL Target	Monitoring Year	No. of Samples Collected	Annual Average (mg/L)[b]	Percent of Annual Means < TMDL Targets
Dissolved Oxygen (Epilimnion)	2015: ≥ 5 mg/L Epilimnion	2011	6	9.6	2015: 0%
		2012	9	9.5	
		2013	0	NA	
		2014	0	NA	
		2015	3	9.0	
		2016	6	9.9	
		2017	4	7.9	
		2018	2	10.4	
		2019	2	8.6	
		2020	3	9.1	
Dissolved Oxygen (Hypolimnion)	2020: ≥ 5 mg/L Hypolimnion (Daily Average)	2011	6	**0.2**	2020: **85.7%**
		2012	0	NA	
		2013	0	NA	
		2014	0	NA	
		2015	3	5.4	
		2016	6	**2.3**	
		2017	4	**0.5**	
		2018	4	**0.2**	
		2019	4	**0.2**	
		2020	3	**0.05**	

[a] See footnote a on Table 2-24

[b] Average epilimnion and hypolimnion calculations can only be performed when the lake is stratified. Years without data points are those in which the epilimnion and/or hypolimnion values were not reported, hence this value does not necessarily correspond to the number of sampling events performed.

Table 2-30. Canyon Lake Main Basin - 2020 TMDL Summary for Depth-Integrated Chlorophyll-*a*, January 2011 – December 2020a (bold values indicate an exceedance of a 2020 TMDL target)

TMDL Target	Monitoring Year	No. of Samples Collected	Annual Average (µg/L)	Percent of Annual Means > TMDL Targets
2020: ≤ 25 µg/L (Annual Average)	2011	15	**40.1**	2020: **50%**
	2012	8	**55.4**	
	2013	2	14.5	
	2014	15	**36.3**	
	2015	3	**67.8**	
	2016	7	**29.1**	
	2017	6	22.9	
	2018	6	21.1	
	2019	6	17.5	
	2020	6	20.5	

[a] See footnote a on Table 2-24

Table 2-31. Canyon Lake East Bay - 2020 TMDL Summary for Depth-Integrated Chlorophyll-*a*, January 2011 – December 2020[a] (bold values indicate an exceedance of a 2020 TMDL target)

TMDL Target	Monitoring Year	No. of Samples Collected	Annual Average (µg/L)	Percent of Annual Means > TMDL Targets
2020: ≤ 25 µg/L (Annual Average)	2011	15	**78.1**	2020: **100%**
	2012	8	**97.3**	
	2013	2	**105**	
	2014	15	**76.5**	
	2015	3	**52.5**	
	2016	7	**30.2**	
	2017	6	**35.9**	
	2018	6	**34.7**	
	2019	6	**25.7**	
	2020	6	**24.9**	

[a] See footnote a on Table 2-24

The analysis completed for the 2020 Compliance Assessment Report showed that the 2004 TMDL final watershed based WLAs and LAs for both Canyon Lake and Lake Elsinore were being met as a 10-year running average prior to the final attainment date, as required by the Basin Plan. **Table 2-32** shows that no additional load reductions were needed to meet watershed allocations for Canyon Lake.

Table 2-32. Compliance with Final Canyon Lake WLA/LAs for All Watershed Sources (values are in kg/yr)

Nutrient Load	Measured External Load	Internal Load Offset with Alum	Total Net Load	Allocation to Watershed in TMDL[a]	Additional Load Reduction Required[b]
Total Phosphorus	5,871	2,079	3,792	3,845	-53
Total Nitrogen	15,743	0	15,743	22,268	-6,525

[a] TMDL minus allocations for internal sediment and atmospheric deposition

[b] If ≤ zero, compliance with final allocations in TMDL for all watershed sources is effectively demonstrated

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

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 as 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 percent 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 EC. 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 microsiemens/centimeter (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 EC in Canyon Lake is considerably lower, measured as high as 1,719 µS/cm in the East Basin in October 2007. While this EC 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, EC is not likely a significant stressor to the biological community in Canyon Lake.

Elevated EC 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 EC 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 EC during drought periods, but also elevates the long term mean EC.

EC 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 EC (**Appendix A**, **Table A-2**). However, the EC 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 EC than cladocerans, with LC_{50} values above the highest EC 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 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 (hr) 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 20 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).
- 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 phosphorus that generate significant sediment and associated phosphorus 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 recycled 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 exacerbate 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 for example 2004-2005, 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 2-45**). Review of cumulative runoff volume delivered to Lake Elsinore from the San Jacinto River shows that up to two thirds of total inflow volume since the lake was dry in 1964 has been delivered during just five of 52 years (**Figure 2-46**).

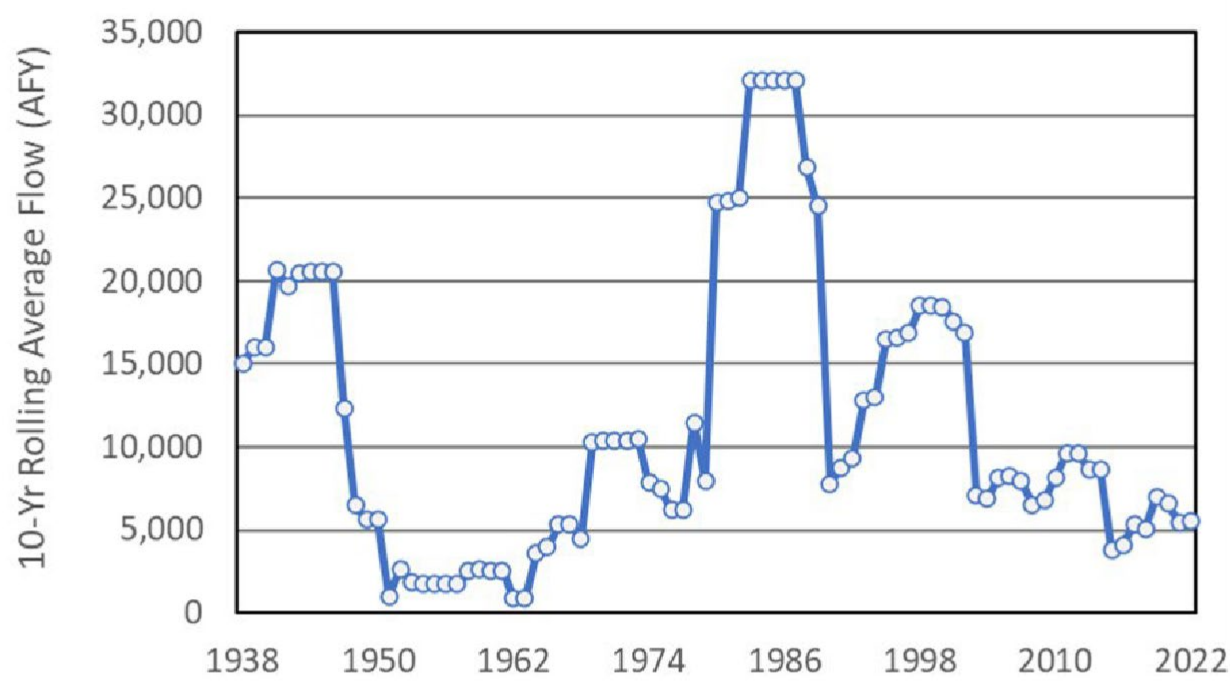

Figure 2-45. 10-Year Rolling Average Annual Runoff Inflow to Lake Elsinore from San Jacinto River Watershed (1938-2022)

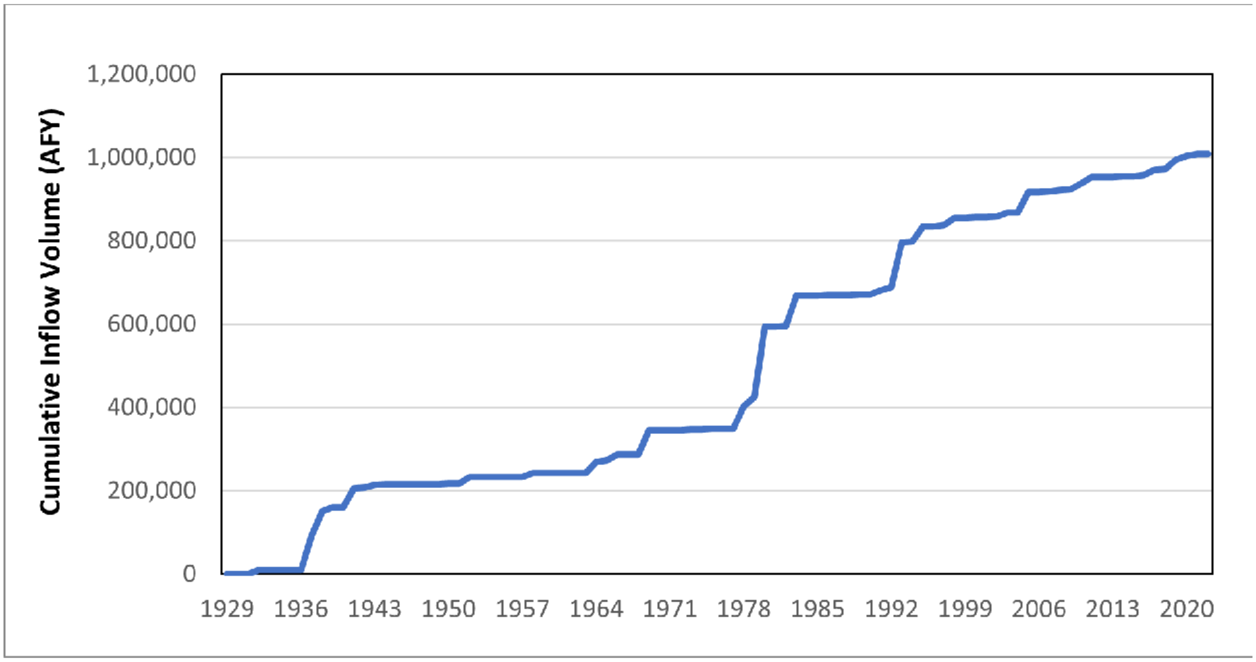

Figure 2-46. Cumulative Delivery of Runoff Volume to Lake Elsinore from the San Jacinto River (1929-2022)

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 1,255 ft, as shown by long term simulation of water levels without recycled water addition (**Figure 2-47**). Management of Lake Elsinore's water level by addition of supplemental water began in the early 2000s and has successfully avoided extremely low water levels from occurring in Lake Elsinore. The linkage analysis model for Lake Elsinore includes a 100-year water budget, which suggests that without any supplemental water additions, the current extended drought would have yielded a lake level of 1225 ft (CDM Smith 2022). 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. This is supported by recent multi-variate regression analysis spanning periods with and without recycled water addition that found the lake water depth in Lake Elsinore to be the most important covariable for concentrations of both TP and TN based on data from 2000-2002, 2008-2010, and 2015-2020 (Horne and Anderson 2021). Under the current managed wet lake condition, recycled water is added to Lake Elsinore to mitigate impacts of extended drought. Recycled water brings additional nutrients and TDS to the lake. For nutrients, continued operation of LEAMS and a potential supplemental project will offset excess nutrient loading. Regarding TDS, Anderson (2015) estimated that the cumulative impact of recycled water addition would raise long-term average TDS in the lake by 892 mg/L. These combined efforts have created a highly modified lake with elevated TDS that may limit the effectiveness of future in-lake controls to achieve the revised TMDL numeric targets.

Figure 2-47. Modeled Water Level in Lake Elsinore for Scenarios without Supplemental Water Additions

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.

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. Retention of external loads of sediment and nutrients 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 21-year period with concurrent gauge data (2001-2022), 80 percent of overflow volume from Canyon Lake to Lake Elsinore occurred during five wet seasons: 2004-2005, 2009-2010, 2010-2011, 2018-2019, and 2019-2020. The volumes delivered in these wet seasons exceeded 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 2-33**).

Table 2-33. 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 United States 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-centimeter (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 per year (1.4 in/yr). This rate is based on a Main Lake sediment core and is lower than estimates for East Bay (see **Table 2-33**).

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 (sum of iron bound and labile partitions) was correlated to the low frequency echograms, which facilitated mapping of areas with greater organic content and mobile-P across the lake bottom (**Figure 2-48**). 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.

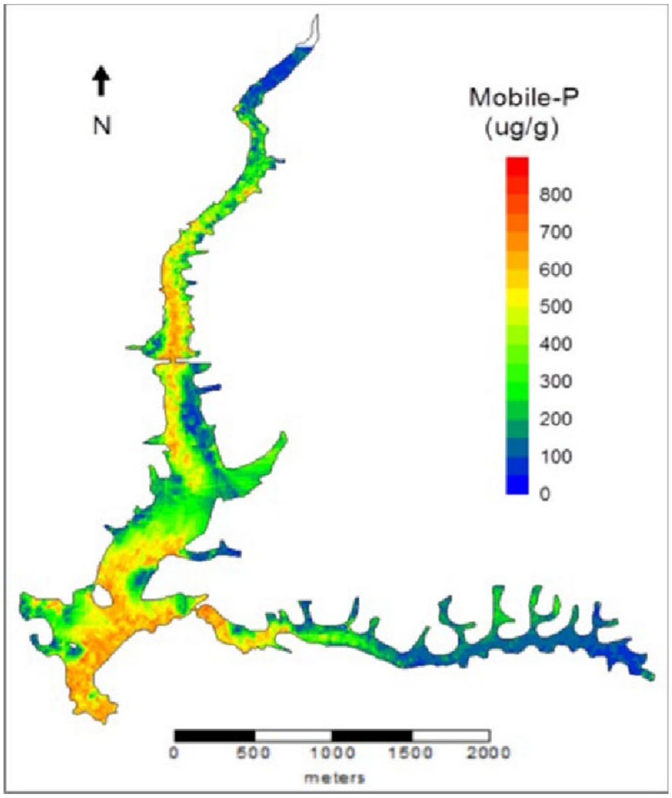

Figure 2-48. Estimated Concentration of Mobile-Phosphorus in Canyon Lake Bottom Sediments Based on 2014 Hydroacoustic Survey (from Anderson 2016c)

Historically, the sediment and nutrients retained in Canyon Lake would naturally (without Railroad Canyon 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 2022. **Figure 2-49** 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

[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.

1,381.76 ft. In nine dry years when the lake did not reach its spill elevation, outflow was assumed to be zero (Fiscal Years 2001-02, 2003-04, 2006-07, 2011-2012, 2012-13, 2013-14, 2014-15, 2015-16, and 2017-18). Results from wet weather monitoring during 55 storm events since 2001 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 61 and 39 percent of long-term average external loads of TP and TN, respectively, is retained in Canyon Lake.

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). Thus, this TMDL revision is developed to account for the mountainous and fire-prone San Jacinto River watershed by allowing for natural levels of nutrient loading to the lakes and subsequent processes of diagenesis.

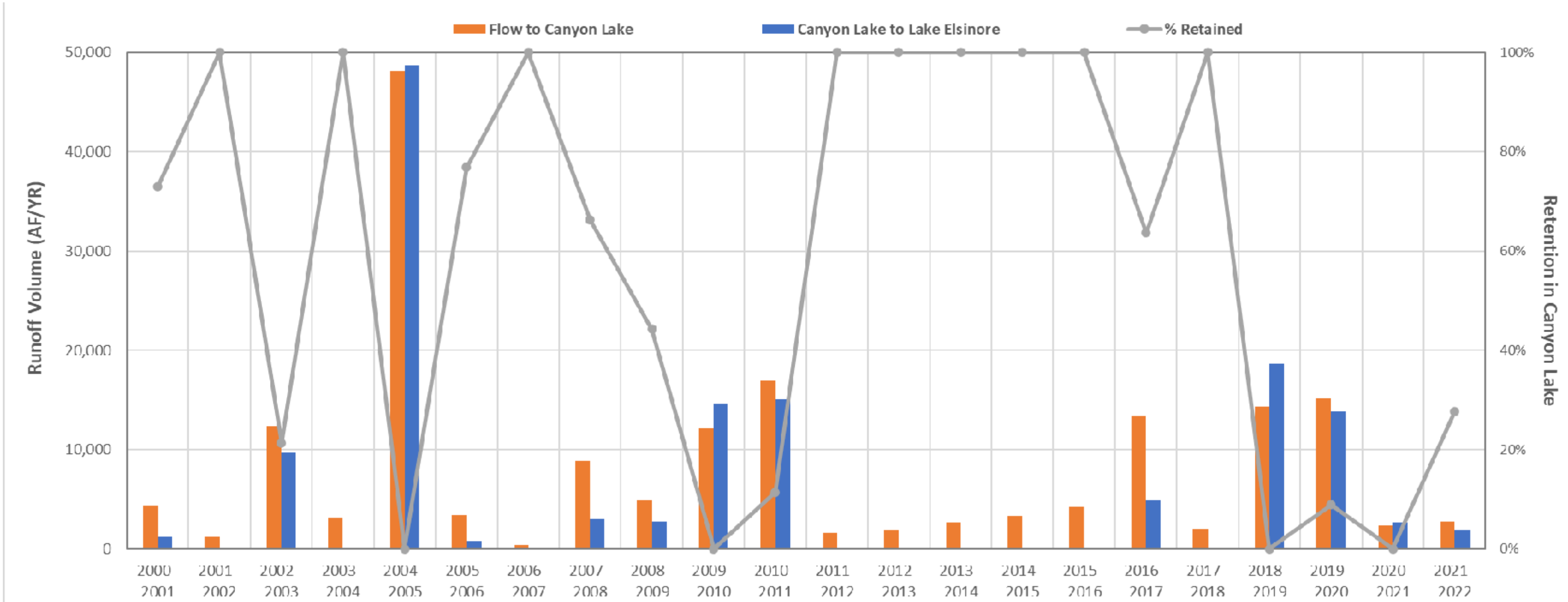

Figure 2-49. Annual Runoff Volume into Canyon Lake and Overflow to Lake Elsinore

Anderson (2012d) estimated the half-life ($t_{1/2}$) for mineralization of nutrients by analyzing changes to nutrient enrichment with depth in cores taken from bottom sediments in 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).Organic P includes organic matter that is delivered with watershed runoff as well as settling of dead algae that took up bioavailable forms of P from within the lake. Thus, implementation of controls may not provide immediate water quality improvements.

2.4.4 Canyon Lake Dynamics

The 2004 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 2-34**). 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-ft 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 2-34. 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 ft	5-15 ft
Thermal Stratification	Hypolimnion ~1,500 AF (30 percent of full pool) April – November	Hypolimnion ~200 AF (5 percent of full pool) April – September
Water Quality Drivers	Low DO, high NH_3, 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 20 years of research completed since adoption of the 2004 TMDLs. These key 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 these differences may influence water quality expectations.
- Although the 2020 compliance assessment demonstrated that the existing TMDL WLAs/LAs are being collectively met in Lake Elsinore and Canyon Lake, the reduced nutrient loads have not translated into meeting the numeric water quality targets applicable to each lake.
- Review of the original data used to develop the 2004 TMDLs and how the new data and information developed since TMDL adoption can be used to improve the existing TMDLs to better take into account reference conditions in the watershed.

These findings provide the basis for development of revisions to the TMDL WLAs/LAs and establishment of new numeric targets that take into account natural conditions in the San Jacinto River watershed and how these natural conditions affect lake water quality.

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3. Numeric Targets

A TMDL is based on numeric targets that provide a basis for quantifying the pollutant load that will allow attainment of specific WQOs and protection of impaired beneficial uses (USEPA 2022). That is, achievement of the numeric target(s) is expected to result in the waterbody of concern no longer being impaired by achieving specific WQOs.[5] Beneficial uses for WARM, REC1 and REC2 are listed as impaired in Lake Elsinore and Canyon Lake (see Sections 3.1.1 through 3.1.3 below for definitions of these beneficial uses). Where the WQOs are narrative, the TMDL translates the narrative WQO into appropriate response targets to attain the objective. This section establishes the numeric targets for the revised TMDLs and provides the technical basis for the selection of these targets.

Table 5-9n in the 2004 TMDLs (Table 6-1n in the Basin Plan) 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) (Santa Ana Water Board 2019). 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 TMDLs were adopted to revise these numeric targets for Lake Elsinore and Canyon Lake (Main Lake and East Bay). The primary objective in the development of these 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. In the reference watershed condition scenario, the current lake basins are assumed (i.e., presence of Railroad Canyon Dam and levee within Lake Elsinore). Also, the reference condition does not include simulation of recycled water addition nor operation of any existing in-lake water quality controls. Lake management involving addition of recycled water to Lake Elsinore to maintain lake levels above 1240’ and operation of existing and potential supplemental in-lake water quality controls in both Canyon Lake and Lake Elsinore are actions towards achieving the proposed TMDLs and will be evaluated in future tasks included in the Implementation Plan (see Section 7.2) 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 designations, 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.

[5] This TMDL revision addresses existing narrative WQOs for algae but does not address potential future impairment to REC1 use that may be attributed to cyanotoxins.

- *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 to describe an expected reference condition. Instead, 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 (CDF) to characterize spatial and temporal variability in water quality that may be expected in Lake Elsinore and Canyon Lake under a reference watershed condition. This section contains CDFs of model results for a reference watershed scenario for indicators of beneficial use impairments, including 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 are not protected, the waterbody is considered impaired and placed on the 303(d) List of impaired waters. 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 2004 Lake Elsinore and Canyon Lake Nutrient TMDLs were developed because of impairment of the WARM, REC1, and REC2 uses. The 2004 TMDL for Canyon Lake also considered impairment of the MUN beneficial use. This revised TMDL was developed to address nutrient related impairments of WARM, REC1, REC2, and MUN uses as a result of general eutrophication.

In 2021, USEPA issued recommended 304(a) criteria for chlorophyll-*a* and nutrients that provide a series of empirical models for states to use in the adoption of numeric nutrient criteria (NNC) for lakes and reservoirs (USEPA 2021). California is currently developing the scientific basis for potential adoption of NNC based on the EPA 304(a) criteria that could result in NNC being included as numeric WQOs in a statewide plan or the Basin Plan in the future.[6] Future reconsiderations of the LECL nutrient TMDL may be needed to account for numeric WQOs for chlorophyll-*a* and/or nutrients. At such time, if numeric WQOs were to be exceeded based on naturally occurring factors in either lake, then it could be necessary to create site-specific WQOs based on a reference condition. The TMDL numeric targets provided below could potentially provide the basis for the development of site-specific objectives in the Basin Plan.

[6] https://www.waterboards.ca.gov/water_issues/programs/biostimulatory_substances_biointegrity/

3.1.1 Warm Freshwater Habitat (WARM) Beneficial Use

The Basin Plan defines the WARM beneficial use as follows (Santa Ana Water Board 2019, page 3-4):

> *"Warm Freshwater Habitat (WARM) waters support warmwater 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 several 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 Beneficial Use Protection

Table 3-1 identifies specific metrics that may support an impairment finding for the WARM beneficial use. These metrics are listed in a hierarchy of causality ranging from direct measures of impairment of the WARM beneficial use (Levels 1 and 2) to indirect measures.[7]

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

Priority	WARM Beneficial Use Integrity Indicator	Direct or Indirect Measure[1]
Level 1	Fish kills, cyanotoxins	Direct
Level 2	Biological health indices: Species richness & abundance	Direct
Level 3	Water quality stressors: DO, un-ionized ammonia, H_2S and TDS	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.

Use of indirect measures often requires 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

[7] 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 2006).

use impairments themselves. For example, low levels of DO can directly impair the WARM beneficial use.

Direct impairment of the WARM beneficial 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 require focused snapshot surveys, using these indicators to measure progress towards attainment is challenging. The State Water Board is currently considering statewide WQOs for nutrients, other biostimulatory substances and cyanotoxins, and a program of implementation under the "Biostimulation, Cyanotoxins, and Biological Condition Provisions." The provisions could include statewide numeric or narrative WQOs for freshwater wadeable streams and rivers, non-wadeable streams and rivers, lakes, and reservoirs.[8]

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, few or no data exist to discern which of these stressors are the primary cause of impairment of the WARM beneficial 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. In Canyon Lake, turnover or mixing of bottom waters with top waters occurs 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*: 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 (USEPA 2013). Photosynthesis by algae in lakes increases pH, which in turn increases the NH_3 fraction of total ammonia nitrogen.
- *Total Dissolved Solids*: Lakes with limited flushing and significant evaporative losses relative to average runoff inflows experience increased TDS by evapoconcentration, 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 highly vulnerable to rises in TDS, as is suggested in observations from Lake Elsinore (**Figure 3-1**).

[8] https://www.waterboards.ca.gov/water_issues/programs/biostimulatory_substances_biointegrity/

- *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.

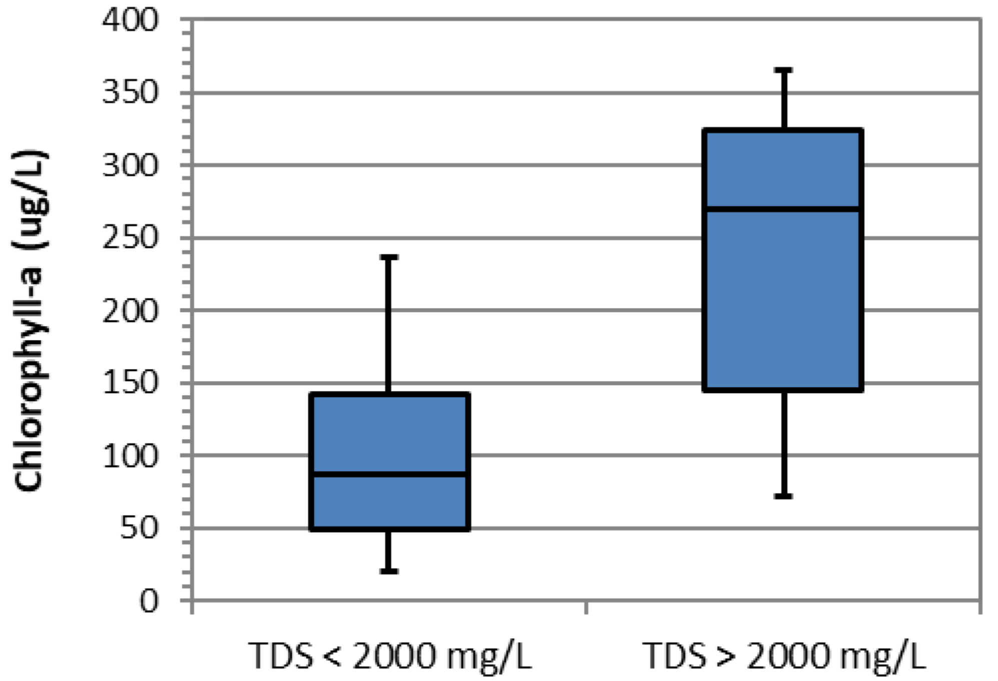

Figure 3-1. Measured Lake Elsinore Chlorophyll-a Concentrations in Samples Collected with Greater Than or Less Than 2,000 mg/L TDS (data from 2002 through 2020)

The revised TMDLs include a numeric target for chlorophyll-*a*, which is a measure of a pigment found within algae, and a commonly used indicator of algae concentration in surface waters (Horne and Goldman 1994). Algae require sunlight for photosynthesis and therefore are generally found within the photic zone of a surface water. The TMDL numeric targets for algae are for the average chlorophyll-*a* concentration within the top 1-m of the water column.

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 TMDLs, 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 the WARM beneficial use attainment involves many complex physical, chemical, and biological processes, as illustrated in **Figure 3-2**. 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 the WARM beneficial use impairment and will be used as the basis for establishing revised numeric targets in the TMDLs.

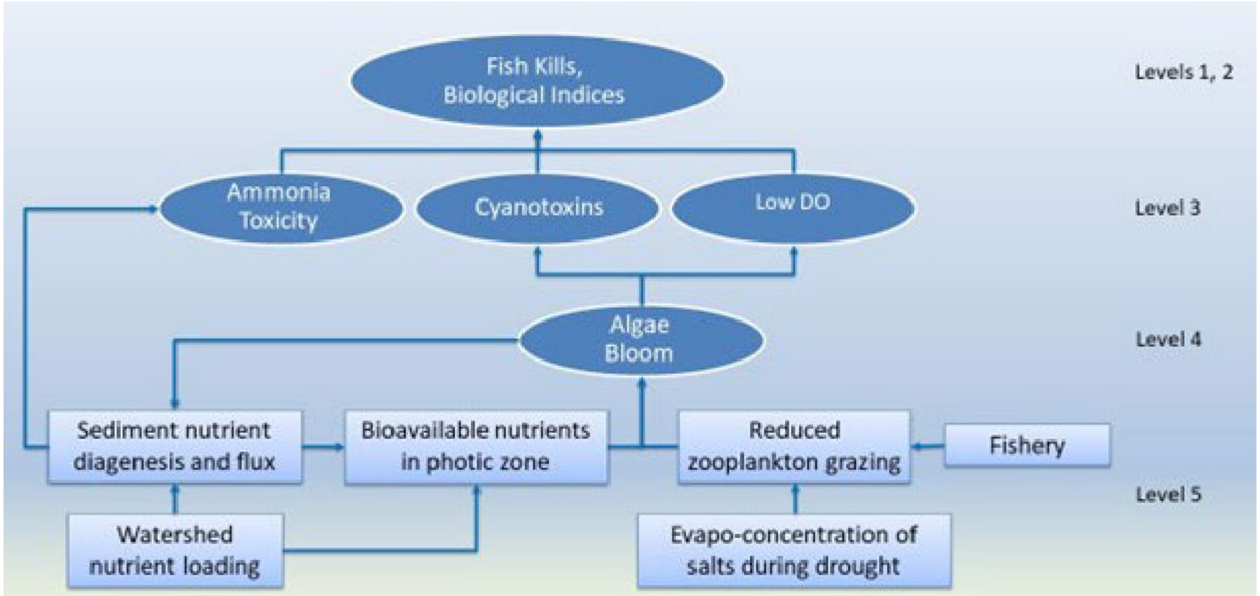

Figure 3-2. Processes that Cause Impairment of the WARM Beneficial Use Organized According to the WARM Use Hierarchy (see Table 3-1)

Not included in the WARM beneficial use attainment hierarchy (see **Table 3-1**) is the potential effects of extended drought. For example, extended drought can impact algae as depicted in **Figure 3-2**, and the influence of extended droughts in the watersheds that drain to Canyon Lake and Lake Elsinore can contribute to the severity of WARM beneficial use impairments. For example, **Figure 3-2** shows how increased salinity by evapoconcentration 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, almost complete lack of flushing, significant evaporative loss from its large surface area, and reduced inflow of freshwater from retention of runoff upstream in Lake Hemet, Mystic Lake, other recharge basins, and Canyon Lake.

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) describes 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 2019). Specifically, for inland surface waters (page 4-7):

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

Chlorophyll-*a*, a pigment found within algae, is a commonly used indicator of algae concentration in surface waters and therefore numeric targets in nutrient TMDLs are based on concentrations of chlorophyll-*a*. For the development of TMDL numeric targets in Lake Elsinore and Canyon Lake, it is presumed that if the reference condition for chlorophyll-*a* is being met then this narrative WQO is also being met (see Section 3.2 below).

Dissolved Oxygen

The Basin Plan WQO for DO in inland surface waters is as follows (Santa Ana Water Board 2019, page 4-14):

> *"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 above WQO is used to develop TMDL numeric targets based on the threshold concentration of 5 mg/L for the WARM beneficial 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, due to 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 thermal 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, page 19):

> *"The final numeric target is equivalent to the narrative water quality objective for dissolved oxygen specified in the Basin Plan. The dissolved oxygen water quality objective is an instantaneous objective to be achieved at all times; however, the Basin Plan is not specific regarding applicability of the objective to the entire water column.*

> *For the final target, Board staff proposes that the 5 mg/L dissolved oxygen objective apply to the entire water column from 1 meter above the lake bottom.”*

From a biological standpoint, it is important that fish and aquatic life have sufficient access to waters with DO 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, USEPA published final ammonia criteria (USEPA 2013) based on new scientific studies. These criteria updated the previously published 1999 criteria (USEPA 1999b). The 2013 USEPA ammonia criteria involve 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 USEPA ammonia criteria have not been adopted as WQOs in the Basin Plan. However, based upon the Basin Plan narrative objective stating, *“The concentrations of toxic pollutants in the water column, sediments or biota shall not adversely affect beneficial uses”*, the 2013 USEPA criteria are being used in the development of revisions to the Lake Elsinore and Canyon Lake TMDLs as site specific criteria. The Basin Plan includes a narrative objective for general toxic substances (Santa Ana Water Board 2019, page 4-20):

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

Lake Elsinore and Canyon Lake continue to be listed as impaired for total ammonia and nutrients; Lake Elsinore is also listed as impaired for toxicity (State Water Board 2024). Given these listings and because Lake Elsinore and Canyon Lake remain listed as impaired for nutrients, the revised TMDLs will continue to have numeric targets for ammonia. 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). Generally, the revised TMDL numeric targets for total ammonia-N are lower than chronic concentrations (computed using non-unionid mussel formulas in 2013 USEPA criteria) based on 2010-2020 conditions in Lake Elsinore (CCC range of 0.05 – 0.88 mg/L) and Canyon Lake (CCC range 0.05 – 2.81 mg/L) and therefore more protective of uses.

3.1.2 Recreational Beneficial Uses

The Basin Plan defines the REC1 and REC2 beneficial uses as follows (Santa Ana Water Board 2019, page 3-3):

- *Water Contact Recreation (REC1: Primary Contact Recreation) waters are 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.*
- *Non-contact Water Recreation (REC2: Secondary Contact Recreation) waters are 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 recreational 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 recreational purposes*" (Santa Ana Water Board 2004b, page 12).

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 developed guidance for protection of swimmers in freshwaters using three tiers of triggers (caution, warning, and danger) based on concentrations of microcystins at 0.8 µg/L, 6 µg/L and 20 µg/L, respectively (CCHAB 2016).[9] In addition, USEPA has adopted criteria for microcystin and Cylindrospermopsin for recreational waters of 8 µg/L and 15 µg/L, respectively (USEPA 2019). Historical data show exceedances of USEPA criteria and CCHAB triggers for beach postings do occur in Lake Elsinore (see discussion regarding cyanotoxin

[9] CCHAB warning threshold of 6 µg/L for microcystins was used as the basis for identifying new impairment listings in the 2024 Final Integrated Report (State Water Board 2024).

observations in Lake Elsinore in Section 2.2.2.6). Through the implementation of this TMDL revision (see Section 3.2 below), the frequency and magnitude of nutrient related impairments will be reduced to levels that would occur if the watershed were returned to a reference condition.

In 2022, new 303(d) impairment determinations were made associated with cyanotoxins and impacts to recreational use. The numeric targets and nutrient load allocations included in this revised TMDL do not directly address impairment of recreational or municipal drinking water uses by cyanotoxins. In the Phase II Implementation Plan, a study will be conducted to improve scientific understanding of the frequency and magnitude of cyanotoxins under different conditions and with ongoing lake management in Canyon Lake and Lake Elsinore. In addition, reconsideration of the TMDL in the future is a key component of the adaptive Implementation Plan and could involve revisions to address nutrient related impairments in recreational or drinking water use by cyanotoxins as more local data is collected and based on the outcome of the statewide effort to create WQOs for nutrients, other biostimulatory substances, and cyanotoxins, and a program of implementation.[10]

3.1.3 Municipal and Domestic Water Supply

The Basin Plan defines the MUN beneficial use as follows (Santa Ana Water Board 2019, page 3-2):

> *"Municipal and Domestic Supply (MUN) 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 the revision of the TMDLs relies on the use of a lake water quality modeling scenario that is representative of returning the San Jacinto River watershed to a reference watershed condition. Characteristics of the reference condition for the San Jacinto River watershed and the modeling approach employed to develop TMDL numeric targets based on this condition 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 3-3**). The process shown in **Figure 3-3** characterizes the

[10] https://www.waterboards.ca.gov/water_issues/programs/biostimulatory_substances_biointegrity/

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 TMDLs using a modified 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 if the current lake drainage areas were to be in a natural, or reference, condition.

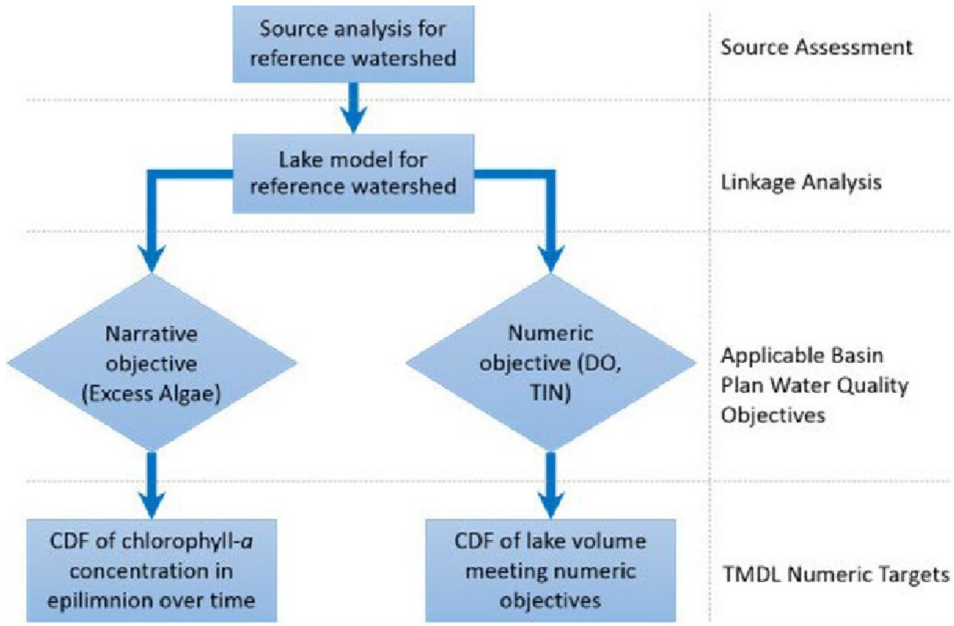

Figure 3-3. Process for Developing TMDL Numeric Targets Using a Reference Watershed Approach

The modified reference watershed approach is similar to the State Water Board Listing Policy Section 3.9 for making an impairment finding for degraded biological populations and communities (State Water Board 2015a, page 7):

> *"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 not replicated downstream of a natural watershed in the same geographic region. 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 USEPA Region 9 in Guidance for Developing TMDLs in California (USEPA 2000a). 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 (page 3):

> *"…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 the revisions to these TMDLs, 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. The allocation for external nutrient load is set to achieve runoff concentrations estimated for a reference watershed condition. 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 numeric targets for these waterbodies through the linkage analysis lake water quality models.

3.2.1.2 Spatio-temporal Variability

In a reference watershed condition for the San Jacinto River watershed, 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 food webs. For these reasons, it is inappropriate to set lake-wide average numeric targets based on a static condition. USEPA makes similar conclusions for freshwaters, stating (USEPA 2008, page 64):

> *"…it is important to evaluate the appropriate temporal and spatial scale for application to evaluate the important sources, capture the conditions of impairment and allow for comparison to applicable water quality criteria or TMDL targets."*

The TMDLs require 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 3-4** 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 3-4**. 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 for the modeled (or modified) reference condition, if no significant changes are made in the watershed or to the lakes that impact water quality in the lakes. This approach for expressing TMDL numeric targets inherently satisfies the need to address seasonal variation and critical conditions.

Using **Figure 3-4** as an example, a CDF graph should be interpreted as follows: chlorophyll-*a* observations were below 20 µg/L about 40 percent of the time based on historical monitoring over a 16-year period. With implementation of the TMDL, CDF plots of future water quality monitoring datasets should fall to the left of the TMDL numeric target.

In the case of CDF-based TMDL numeric targets, the data for the water quality parameters are the daily average model results for a modified reference watershed scenario. This expression of the targets is based on the premise that returning loads from the watershed to modified reference levels would result in the in-lake water quality parameters exhibiting the same spatial and temporal variability expected for a reference watershed condition.[11] In other words, compliance with the TMDLs will be achieved when CDFs developed from future long-term post-implementation monitoring are similar to the modified 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 based on multiple lines of evidence (USEPA 2003, page 149):

> *"The allowable frequency at which the criterion can be violated without a loss of the designated use also must be considered. Frequency is directly addressed through comparison of the generated cumulative frequency distribution with the applicable criterion reference curve. All values falling below the reference curve are considered biologically acceptable exceedances of the applicable Bay criteria. Through its derivation, the reference curve directly incorporates a biologically acceptable frequency of exceedances of the applicable Chesapeake Bay criteria."*

[11] 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.

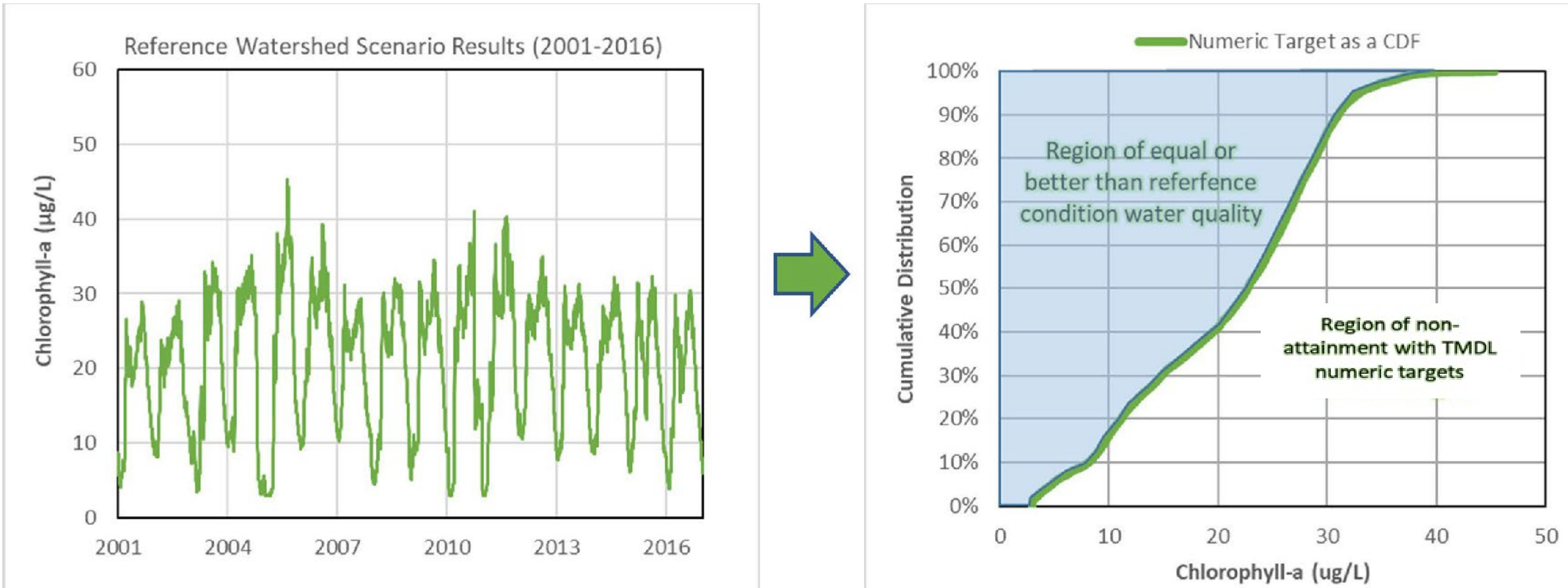

Figure 3-4. Conversion of a Long-term Routine Monitoring Dataset to a CDF Curve

The use of a reference curve approach to assess attainment with water quality criteria based on USEPA guidance (USEPA 2003) has been adopted into the State of Virginia water quality standards (Virginia Administrative Code 9VAC25-260-185) and State of Maryland water quality standards (Maryland Code of Regulations 26.08.02-03-3) for Chesapeake Bay segments.

The approach described above and illustrated in **Figure 3-4** is appropriate for situations where the WQO is narrative. **Figure 3-5** illustrates an alternative approach for using a CDF to establish a TMDL numeric target where the WQO for the constituent is numeric, e.g., the Basin Plan's WQO for DO to protect the WARM use in inland waters should not be depressed below 5 mg/L (Santa Ana Water Board 2019). For this type of target, 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 CDF's x-axis from the spatially averaged concentration to the fraction of the total lake volume that meets the numeric WQO threshold. **Figure 3-5** illustrates how the volume of lake water greater than 5 mg/L is computed at each measurement accounting for larger surface area with proximity to the surface of the lake. The single value from each vertical profile is plotted as a cumulative distribution.

USEPA (2003) provides the following description of this alternative method of expressing the CDF as a reference curve:

> *"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, by integrating the five elements of criteria definition and attainment: magnitude, duration, return frequency, space and time. The methodology summarizes 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. Acceptable and protective combinations of the frequency and spatial extent of such instances are defined using a biologically based reference curve."*

3.2.1.3 Estimation Methods

Source Assessment

The (modified) reference watershed approach (see **Figure 3-3**) begins with a source assessment for nutrients in runoff from a reference watershed. Section 4 below presents the source assessment for the revised TMDLs, including data analysis and modeling of nutrients in watershed 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.

Depth (m)	Volume (Hectares)	Profile 1	Profile 2	Profile 3	Profile 4	Profile 5	Profile 6	Profile 7	»»»	Profile 58	Profile 59	Profile 60
1.0	350	8	11	9	8	7	7	7		7	8	7
2.0	333	8	11	9	8	7	7	7		7	8	7
3.0	309	8	11	9	8	7	7	7		7	8	7
4.0	277	8	11	9	8	7	7	7		7	8	7
5.0	245	8	11	9	8	7	7	7		7	8	7
6.0	223	8	11	9	8	7	7	7	»»»	7	8	7
7.0	193	8	11	8	6	6	7	7		7	7	7
8.0	171	8	9	8	6	6	7	7		7	5	7
9.0	143	8	8	6	5	6	7	7		4	5	7
10.0	104	8	8	7	4	2	6	7		4	5	6
11.0	83	8	8	6	3	0	6	7		3	4	3
12.0	59	8	8	5	2	0	6	7		0	3	0
13.0	28	8	8	6	3	0	4	7		0	0	0
14.0	16	8	7	6	2	0	0	7		0	0	0
% of Volume > 5 mg/L DO		100%	100%	100%	89%	89%	98%	100%	»»»	83%	89%	93%

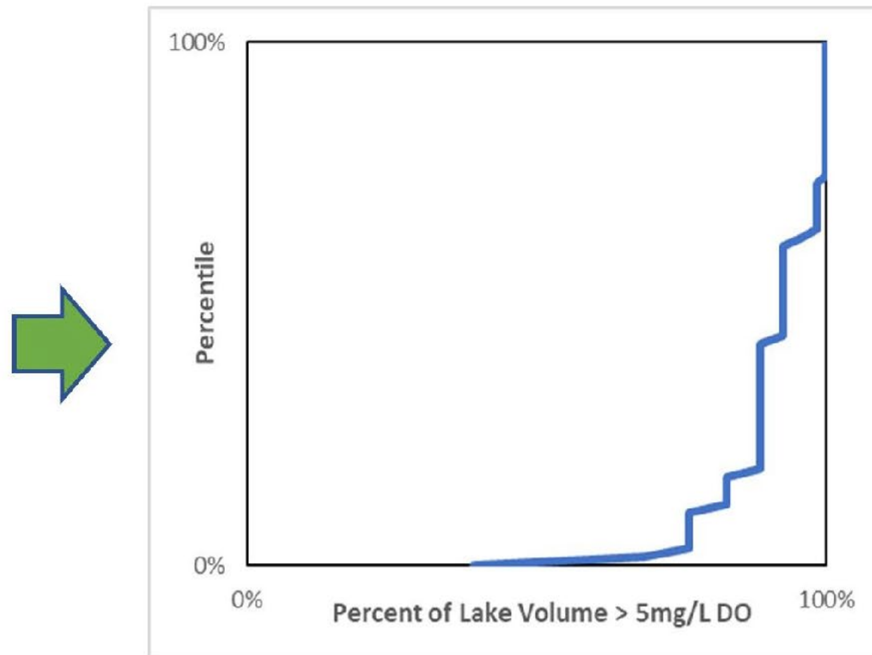

Figure 3-5. Computation of the Percent of Volume Meeting Numeric WQOs (green cells versus total cells) and Conversion to a CDF to Serve as the TMDL Numeric Target

Linkage Analysis

The linkage analysis estimates the water quality response of the lake segments to allowable external nutrient loads estimated for a reference watershed. The response of the downstream lakes to reference watershed nutrient loading is assessed using a dynamic lake water quality model (see **Figure 3-3**). This step serves as the linkage analysis when developing a TMDL using a reference watershed approach. 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 be expected to 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 appropriately account 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 WQOs include:

- *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.

Lake Elsinore and Canyon Lake numeric targets associated with numeric Basin Plan WQOs include:

- *Dissolved Oxygen* - For the revised TMDLs, the TMDL numeric target will be expressed as the volume of lake water 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 based on modeling of the reference condition,
- *Ammonia* - As described above, the fraction of total ammonia-N that is toxic is dependent upon pH and water temperature. To simplify future compliance demonstrations, development of TMDL numeric targets was based on depth average concentrations of total ammonia-N (see Section 8 regarding 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 for the ammonia numeric target will be evaluated in the future through implementation of a monitoring program and could be modified in future TMDL reconsiderations.

In-lake nutrient concentrations for TN or 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 (see **Table 3-1**). 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 in-lake response targets 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 conditions of Canyon Lake and Lake Elsinore are elements 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 3-6**); 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. The modeled reference condition is based on the current lake bathymetry (with levee) and lowered outlet elevation of

1,255 ft. None of the current in-lake water quality controls are assumed in the scenario for the reference condition.

- *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. In addition, the reference condition does not include ongoing efforts to improve lake water quality through the addition of alum or source water supply withdrawals by EVMWD.

Figure 3-6. 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.

The water quality impact of reduced water volumes reaching Lake Elsinore was evaluated using the General Lake Model (GLM) that served as the basis for the Linkage Analysis (details of model development and calibration is provided in Section 5 and use of the model for creating numeric targets is provided in Section 3.2.2.4). GLM simulated two scenarios with identical water quality inputs and parameters, but differed on daily inflow runoff as follows:

(1) Current runoff volumes as recorded at USGS gauge 11070500; and

(2) 30 percent reduction of runoff volume as recorded by USGS gauge 11070500.

Over a 105-year simulation period (1916-2020), median and peak chlorophyll-*a* concentrations were higher in the scenario involving less runoff volume (Scenario 1 - Current Runoff Volume: 75 µg/L median and 240 µg/L peak; Scenario 2 - Reduced Runoff Volume: 125 µg/L median and 475 µg/L peak). Thus, when at the same reference nutrient concentrations, increases in the total volume of freshwater (and thereby increased load) delivered from the watershed as a result of urban development to the lakes provides a greater net benefit to protection of beneficial uses than would be afforded by meeting a reference hydrologic condition (CDM Smith 2022).

When compared to current lake inflows (the basis for reference scenarios), the increased runoff volume scenario predicted the occurrence of lakebed desiccation events in the 1930s and 1970s that did not occur and extended the duration of lakebed desiccation in the 1950s and 2010s. For these reasons, the revised TMDLs are based on current inflows as measured by USGS gauges and focus on nutrient concentrations in developing allocations for a reference watershed condition.

Lake Elsinore

A 105-year 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 3-7**). Daily flows from this gauge were used as hydrologic inputs to the lake water quality model for setting numeric target CDFs in Lake Elsinore.

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. A water balance analysis from 2000-2020 was performed to estimate the runoff volume from the local Lake Elsinore watershed (Q_{local}) based on annual average volumes of overflows from Canyon Lake, evaporative losses, direct rainfall, and change in storage (measured by lake level):

$$Q_{local} = \Delta Storage + Evaporative\ Loss - Direct\ Rainfall - Canyon\ Lake\ Overflow$$

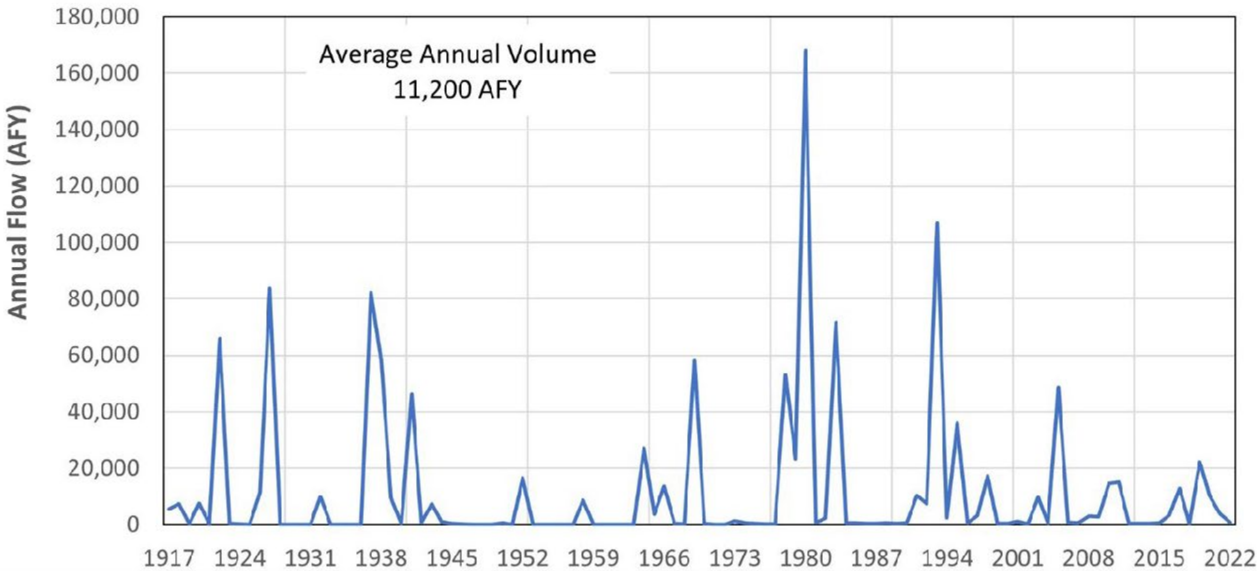

Figure 3-7. Annual Runoff from USGS Gauge Station San Jacinto River near Elsinore (USGS 11070500)

Based on this analysis, a runoff coefficient (RC) of 0.11 for the entire local Lake Elsinore watershed was computed by dividing estimated average annual runoff Q_{local} (2,502 AFY) by annual average rainfall (23,270 AFY) over the 2000-2020 water balance period. This RC was then used to convert long term rainfall at the Elsinore station (1916-2020) to estimated daily runoff to support the reference scenario model for the 100-year simulation period. **Figure 3-8** provides a plot of long-term estimated local Lake Elsinore watershed runoff inflows.

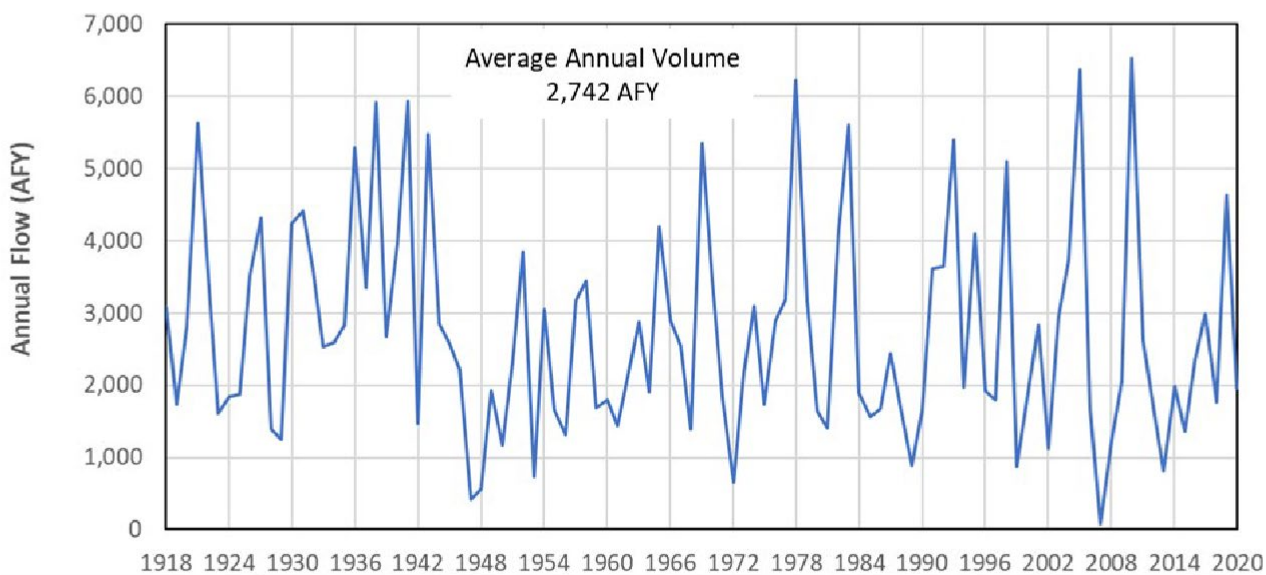

Figure 3-8. Estimated Daily Runoff from Local Lake Elsinore Watershed for Lake Water Quality Model Input

Canyon Lake

A 20-year 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 3-9**). Daily flows from these gauges were used as hydrologic inputs to the lake water quality model for setting numeric target CDFs in Canyon Lake.

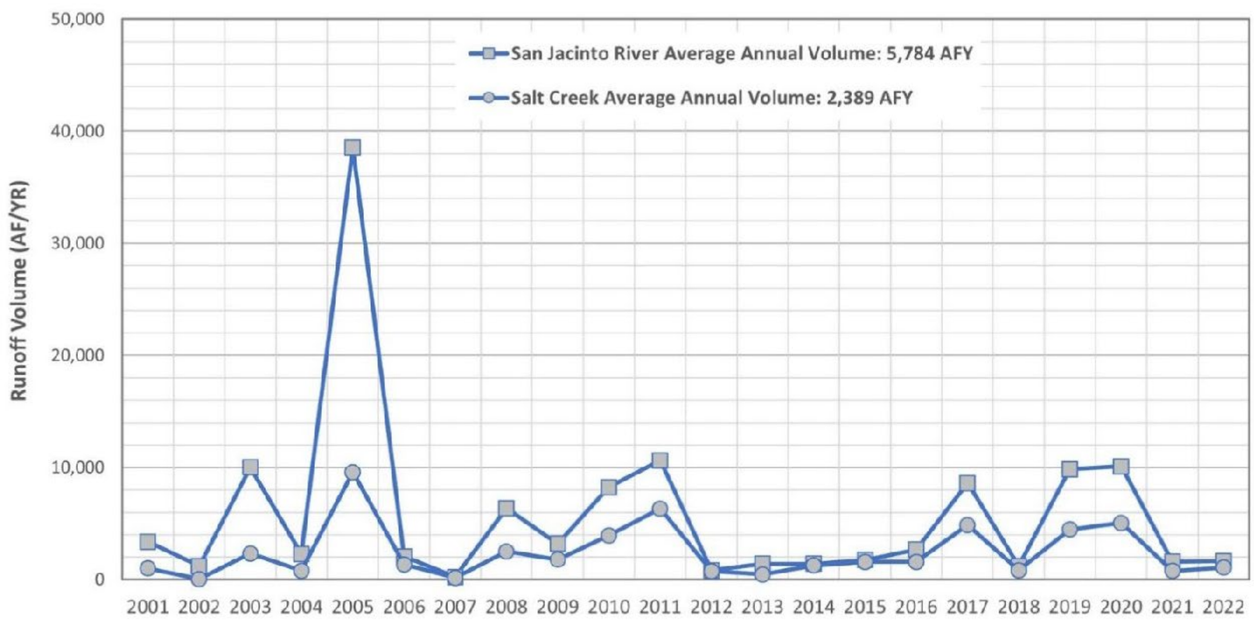

Figure 3-9. Hydrologic Record of Runoff Volumes that Reach the Main Lake of Canyon Lake from the San Jacinto River and the East Bay of Canyon Lake from Salt Creek

3.2.2.3 Nutrient Concentration in Watershed Runoff

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 watershed station. The 142 mi^2 watershed to this site is comprised of predominantly undeveloped forest or scrublands (> 95 percent of the drainage area in undeveloped land use classification (SGAG 2019); < 0.4 percent of the watershed is impervious[12]) in the SJNF. The United States Forest Service (USFS) collected 51 samples from this reference site over the course of 10 wet weather events in 2003-2005, 2008, and 2010 (**Table 3-2**) (see the water quality data stored in CEDEN under the following Station Name: San Jacinto River at Cranston Guard Station).

[12] Coleman et al. (2005) estimated that hydromodification and associated negative water quality impacts that are caused by urban development occur when a drainage area imperviousness exceeds 2-3 percent in southern California natural streams.

Table 3-2. Summary Statistics from Reference Watershed Site, San Jacinto River at Cranston Guard Station

Metric	TP (mg/L)	TN (mg/L)
Range of Samples	0.05 – 48.00	0.51 – 27.78
Range of Event Means[1]	0.11 – 10.13	0.58 – 7.09
25th Percentile of Samples	0.16	0.68
25th Percentile of Event Means[1]	0.22	1.00
Median of Samples	0.32	0.92
Median of Event Means[1]	0.39	1.15
75th Percentile of Samples	0.73	1.50
75th Percentile of Event Means[1]	1.07	2.62

[1] Number of samples per event varies

No federal or state guidance exists on how to determine wet weather nutrient washoff in a reference stream for purposes of achieving a reference condition in a downstream lake. USEPA developed guidance based on in-lake monitoring data that describes how water quality metrics at the 75th percentile of a group of lakes classified as "reference" waters (defined as a minimally impacted condition) should be used to estimate appropriate nutrient criteria for ecoregions (USEPA 2000b). In the event that monitoring data is not available from reference lakes in a given ecoregion, USEPA (2000b) recommends the use of the 25th percentile of all monitored lakes in the ecoregion to determine appropriate nutrient criteria. If this statistical threshold was applied to reference watersheds, then the 75th percentile of results reported for Cranston Guard Station (see **Table 3-2**) might be representative of a reference watershed condition. Several problems exist with such an approach:

- Wet weather runoff was only collected from a single watershed station, whereas USEPA's guidance implies statistics are computed across multiple waters;
- Guidance was developed for in-lake water quality rather than watershed runoff; and
- Measured concentrations from the San Jacinto River at Cranston Guard Station include multiple extreme values at levels greater than observed in developed watersheds that may be associated with spatially isolated natural events such as landslides or fires.

Given these data concerns, additional data collection of wet weather runoff water quality is warranted before selecting a different statistical threshold. Such data collection will occur as part of a study that is incorporated into the revised TMDLs' Implementation Plan. The study results will be used to support a decision-making process regarding the appropriateness of the final TMDL targets and WLAs/LAs.

For now, and for the purpose of setting external nutrient WLA/LAs and for parameterizing boundary inflows to the lake water quality models, the following novel basis was used to estimate loads for a hypothetical reference watershed condition in the drainage areas to Canyon Lake and Lake Elsinore (see **Table 3-2**):

- Interim allocations and associated numeric targets are based on the 50th percentile concentrations of all grab samples: 0.32 mg/L TP and 0.92 mg/L TN
- Final allocations and associated numeric targets are based on the 25th percentile concentrations of all grab samples: 0.16 mg/L TP and 0.68 mg/L TN

By selecting values at the 25th percentile of all grab samples rather than event means, from a reference watershed station, a margin of safety (MOS)[13] of at least 10 percent is accounted for in the revised TMDLs (see Section 6.1 below). As noted above, the appropriateness of the proposed percentile thresholds and MOS should be further evaluated as part of the revised TMDLs' Implementation Plan.

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 condition in the San Jacinto River watershed. Lake water quality models were calibrated to existing water quality conditions as described in detail in the linkage analysis for the revisions to the TMDLs (see Section 5). With a reference watershed approach, the linkage analysis models are 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 that assumes the San Jacinto River watershed returns to a reference condition.

For Lake Elsinore, water quality modeling to support the development of TMDL numeric targets involved a very long simulation period from 1916-2020. This was imperative to capture the full range of dynamic water quality conditions that naturally occur in Lake Elsinore (see Section 2). The GLM is an aquatic ecosystem and one dimensional (1-D) hydrodynamic model to facilitate boundary conditions and simulation of spatially varying mechanisms. For Lake Elsinore, a simple 1-D hydrodynamic model is appropriate because the lake 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 three dimensional (3-D) hydrodynamic and water quality model, Aquatic Ecosystem Model 3D (AEM3D). These tools are described in the linkage analysis provided in Section 5.

3.3 TMDL Numeric Targets

The data used to establish the numeric targets for each constituent are the daily model output from AEM3D for Canyon Lake and GLM for Lake Elsinore. Model scenarios were run for the interim and final allocations and are expressed as interim and final numeric targets accordingly.

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[13] A TMDL is the sum of the individual wasteload allocations for point sources and load allocations for non-point sources and natural background (40 Code of Federal Regulation [CFR] 130.2) with a margin of safety or MOS (CWA §303(d)(1)(c)). The MOS accounts for the uncertainty about the relationship between pollutant loads from point or non-point sources and water quality in the receiving water(s). MOS can be provided implicitly through analytical assumptions or it can be stated explicitly by reserving a portion of the total maximum daily load. See Section 6.1 for additional discussion regarding MOS for the LECL TMDLs.

For Canyon Lake, model results are extracted from two points in Main Lake (monitoring locations CL07 and CL08) and two points in East Bay (monitoring locations CL09 and CL10). Model results from these points were used to generate CDFs for chlorophyll-*a* in the surface 1-m and depth integrated DO. AEM3D output assesses all grid cells on a daily timestep to export the extent of the lake volume with greater than 5 mg/L DO for Main Lake and East Bay.

The CDF for each constituent is the TMDL numeric water quality target. Section 7.2.5 describes methods for demonstrating attainment with these CDF-based numeric targets.

3.3.1 Lake Elsinore

GLM model results of water quality for the reference watershed scenario for the period from 1916-2020 serve as the basis for setting numeric targets for chlorophyll-*a*, DO, and ammonia-N in Lake Elsinore. The CDF numeric targets for Lake Elsinore are presented as follows:

- *Chlorophyll-a*: Surface (top 1-m) average of daily model results plotted for the reference condition (**Figure 3-10**).
- *Dissolved Oxygen*: The fraction of the total volume of Lake Elsinore with daily average DO less than 5 mg/L plotted for the reference condition (**Figure 3-11**).
- *Total Ammonia-N*: Water column depth average of daily model results plotted for the reference watershed condition (**Figure 3-12**).

3.3.2 Canyon Lake

AEM3D model results of water quality for the reference watershed scenario for the period from 2000-2016 serve as the basis for setting TMDL numeric targets for chlorophyll-*a*, DO, and ammonia-N in Canyon Lake Main Lake and East Bay. The CDF numeric targets for Canyon Lake (Main Lake and East Bay) are presented as follows:

- *Chlorophyll-a*: Surface (top 1-m) average of daily refence condition model results for Canyon Lake Main Lake (**Figure 3-13**) and Canyon Lake East Bay (**Figure 3-14**) for the interim and final numeric targets.
- *Dissolved Oxygen*: The reference condition model results for the fraction of the total volume of Canyon Lake with daily average DO greater than 5 mg/L for Canyon Lake Main Lake (**Figure 3-15**) and Canyon Lake East Bay (**Figure 3-16**) for the interim and final numeric targets.
- *Total Ammonia-N*: Water column depth average of daily reference condition model results for Canyon Lake Main Lake (**Figure 3-17**) and Canyon Lake East Bay (**Figure 3-18**) for the interim and final numeric targets.

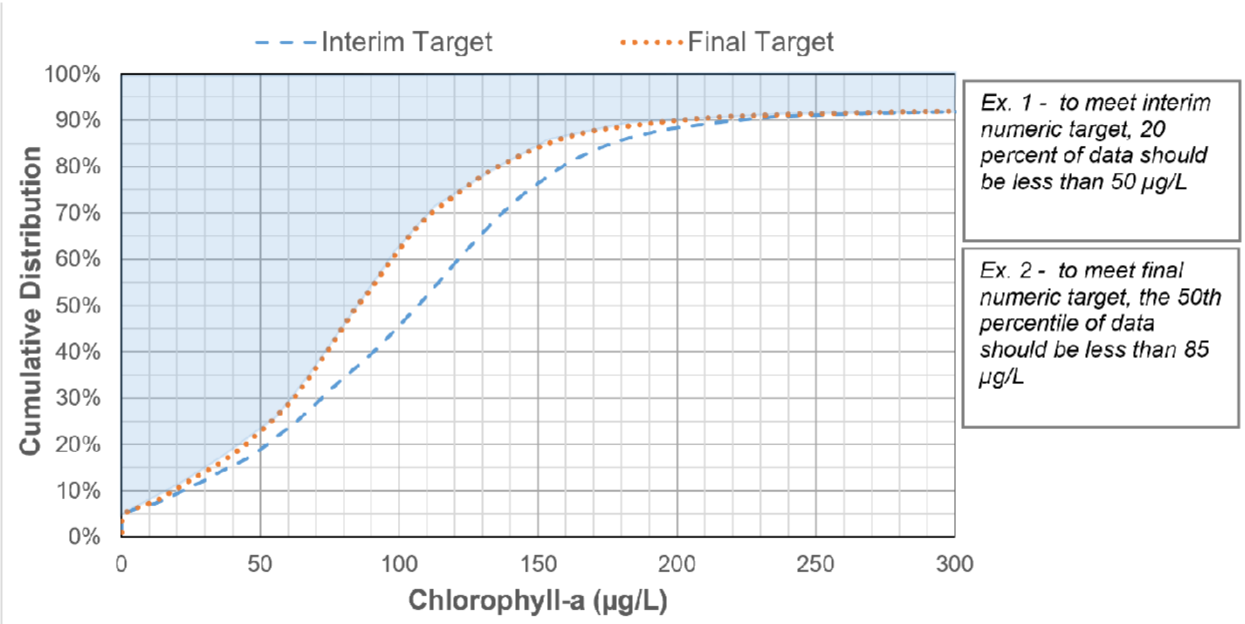

Figure 3-10. Chlorophyll-*a* Numeric Targets for Lake Elsinore (Attainment is demonstrated when future data distributions fall to the left of the interim target [dashed blue line] or final target [dotted red line])

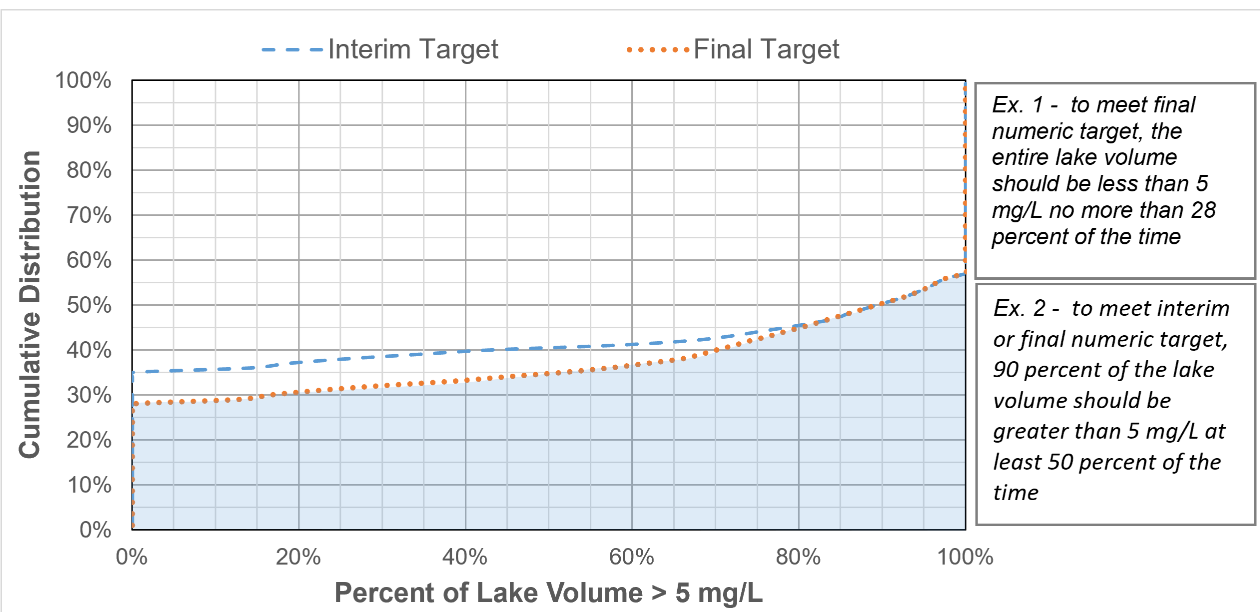

Figure 3-11. Dissolved Oxygen Numeric Targets for Lake Elsinore (Attainment is demonstrated when future data distributions fall to the right of the interim target [dashed blue line] or final target [dotted red line])

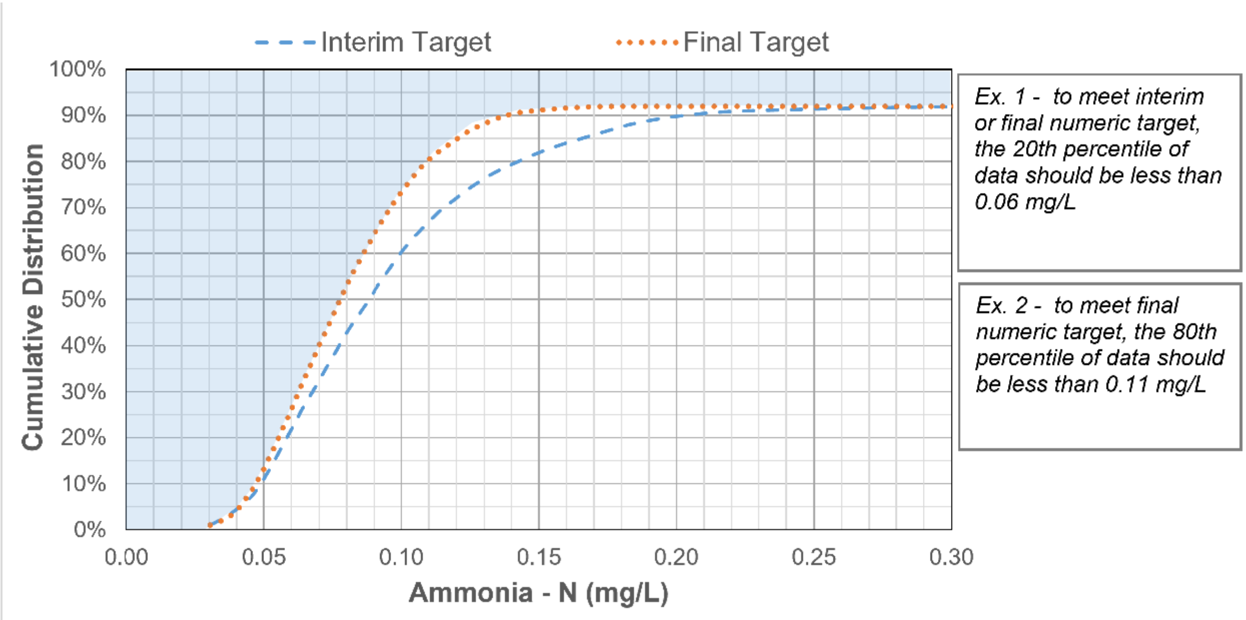

Figure 3-12. Ammonia-N Numeric Targets for Lake Elsinore (Attainment is demonstrated when future data distributions fall to the left of the interim target [dashed blue line] or final target [dotted red line])

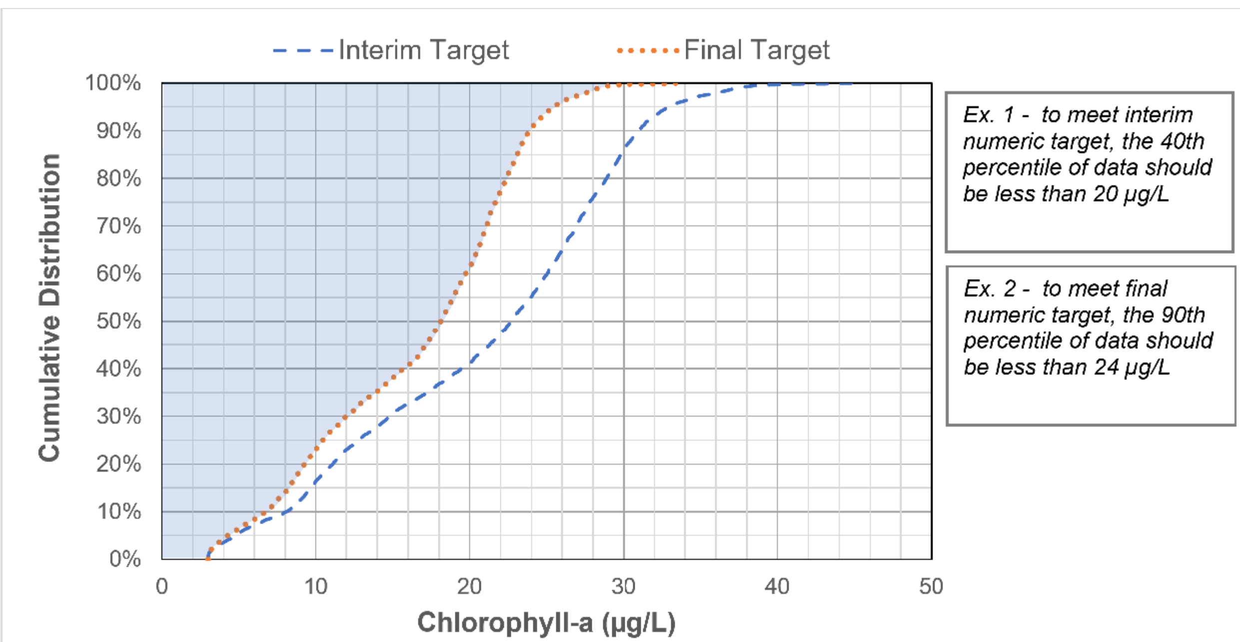

Figure 3-13. Chlorophyll-*a* Numeric Targets for Canyon Lake – Main Lake (Attainment is demonstrated when future data distributions fall to the left of the interim target [dashed blue line] or final target [dotted red line])

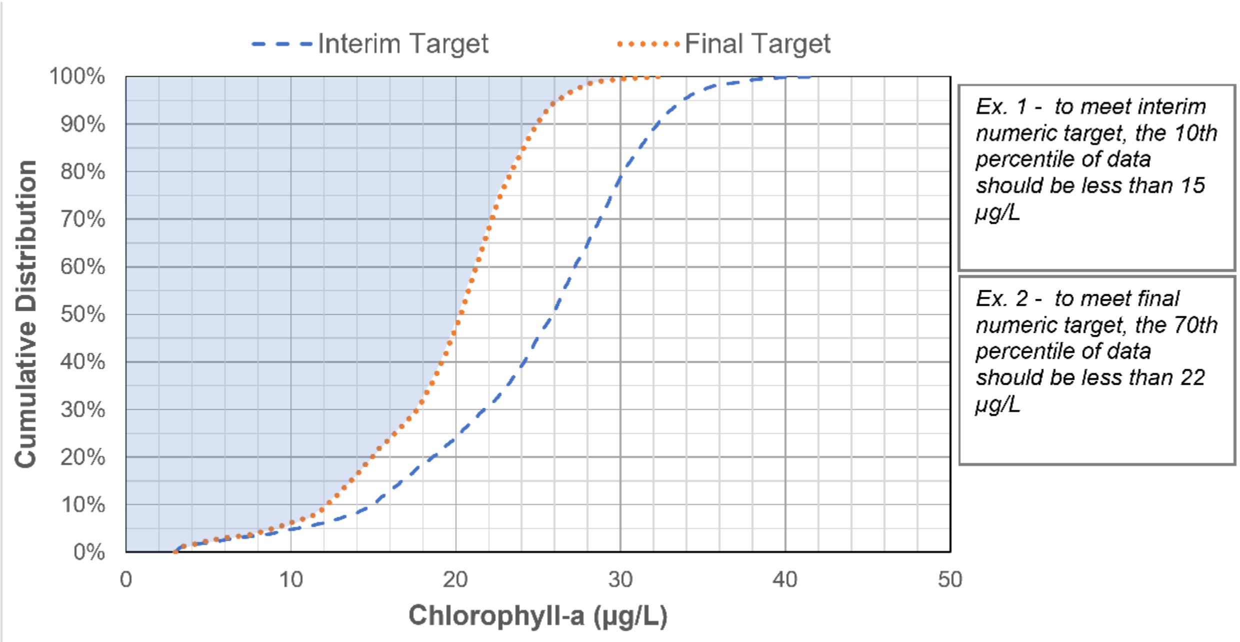

Figure 3-14. Chlorophyll-*a* Numeric Targets for Canyon Lake – East Bay (Attainment is demonstrated when future data distributions fall to the left of the interim target [dashed blue line] or final target [dotted red line])

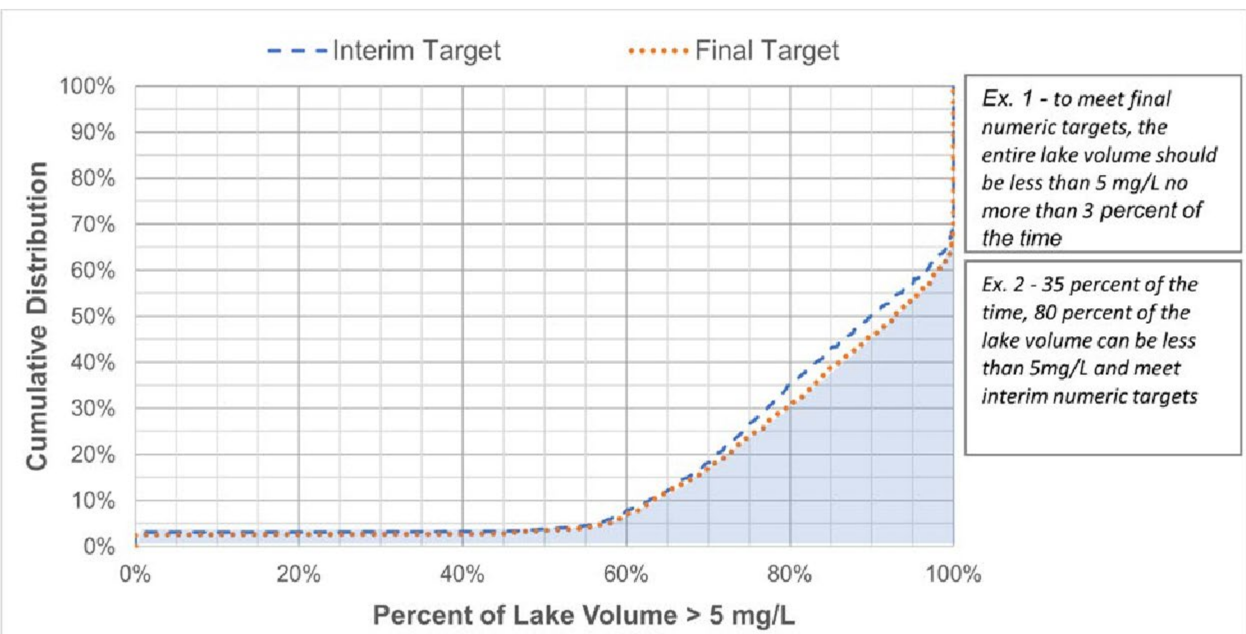

Figure 3-15. Dissolved Oxygen Numeric Targets for Canyon Lake – Main Lake (Attainment is demonstrated when future data distributions fall to the right of the interim target [dashed blue line] or final target [dotted red line])

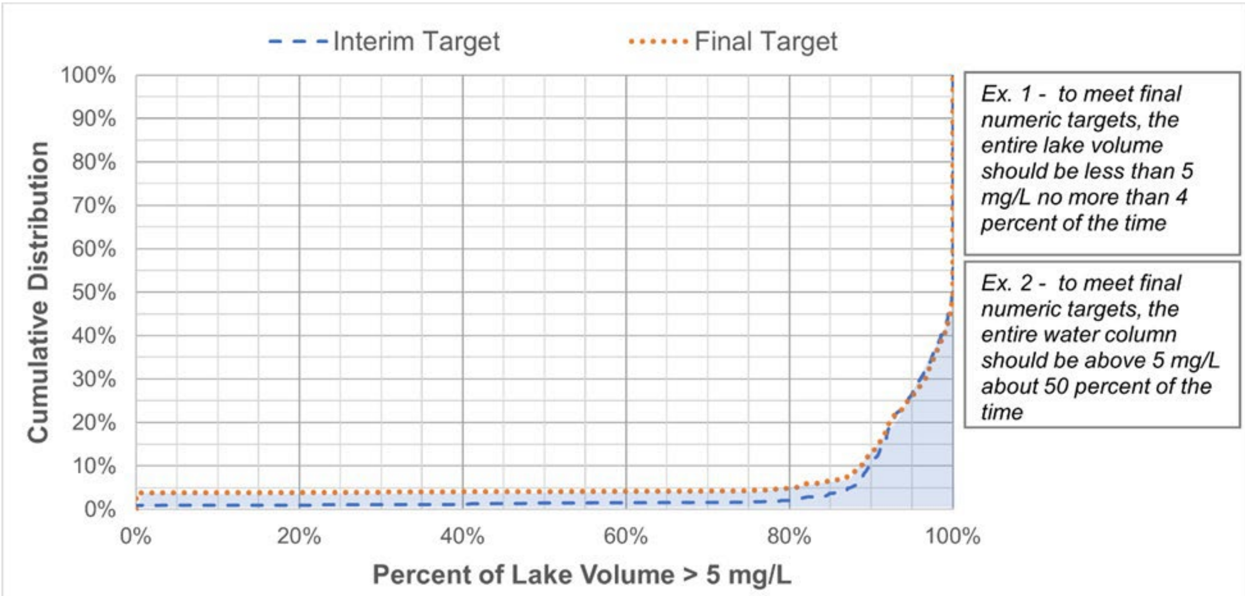

Figure 3-16. Dissolved Oxygen Numeric Targets for Canyon Lake – East Bay (Attainment is demonstrated when future data distributions fall to the right of the interim target [dashed blue line] or final target [dotted red line])

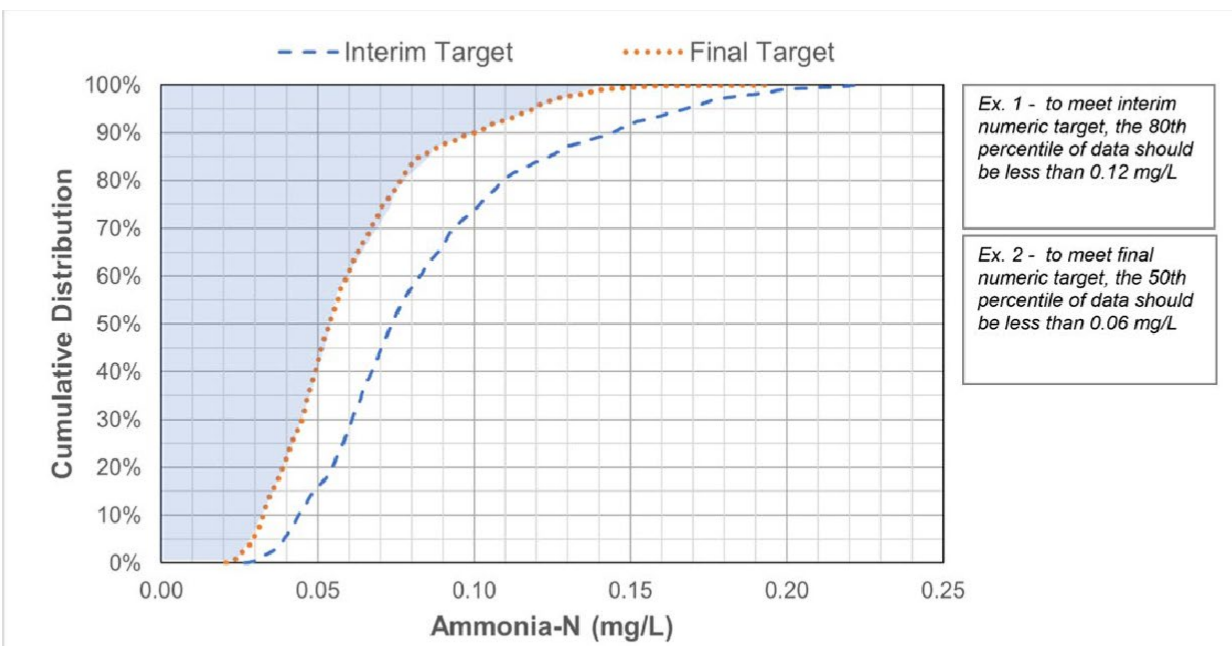

Figure 3-17. Ammonia-N Numeric Targets for Canyon Lake – Main Lake (Attainment is demonstrated when future data distributions fall to the left of the interim target [dashed blue line] or final target [dotted red line])

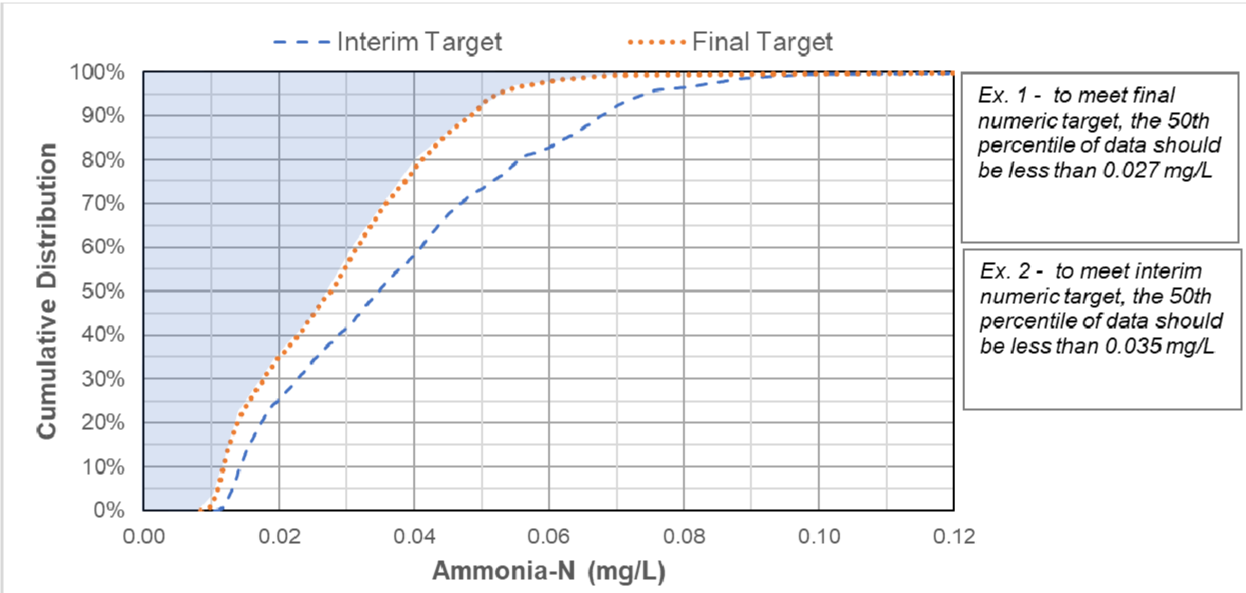

Figure 3-18. Ammonia-N Numeric Targets for Canyon Lake – East Bay (Attainment is demonstrated when future data distributions fall to the left of the interim target [dashed blue line] or final target [dotted red line])

4. Source Assessment

There are a several key sources of nutrients to Lake Elsinore and Canyon Lake. These sources vary seasonally and according to inter-annual climate patterns in their relative importance to water column nutrients. This source assessment section describes the key sources of nutrients and quantifies the long-term average loading of nutrients to each lake. Key sources of nutrients to Lake Elsinore and Canyon Lake are external (primarily watershed runoff and supplemental water deliveries) and internal (via sediment nutrient flux and atmospheric deposition). The following sections describe each of these key sources of nutrients:

- *Watershed Sources (Section 4.1) –* Based on use of a watershed model, this section provides an assessment of nutrients washed off from land areas in the watersheds to each lake; these land areas represent unique combinations of land use, jurisdiction, and subwatershed characteristics.
- *Supplemental Water (Section 4.2) –* Evaluates nutrients contained within supplemental water inputs to each lake; most notable being the addition of recycled water to Lake Elsinore by EVMWD.
- *Internal Sources (Section 4.3) –* Describes the mechanisms that influence the significance of internal sources including: 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). Nutrient deposition from the atmosphere directly on to the surfaces of Lake Elsinore and Canyon Lake is also described in this section.

4.1 Watershed Sources

Nutrients are delivered to downstream Canyon Lake and Lake Elsinore as a result of rainfall events over the watershed. During dry weather conditions, flows from irrigation excess or areas of rising groundwater do not typically reach the lakes. The nutrient load in runoff from the watershed is a function of both runoff volume (see Section 4.1.2) and water quality concentration (see Section 4.1.3). Measurements of both volume (at three USGS flow gauges) and concentration (at three watershed monitoring locations co-located with flow gauges) allow for estimation of watershed scale nutrient loading to Canyon Lake and from Canyon Lake to Lake Elsinore. A simple watershed modeling approach (described in Section 4.1.1) was used to estimate the relative contribution to downstream load from different subwatershed zones, jurisdictions, and land uses in the contributing watersheds.

4.1.1 Watershed Model

The following sections describe the selection and development of the watershed model used to estimate nutrient loading to the downstream lakes.

4.1.1.1 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 (see Section 4.1.3.2), 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.

In contrast, this source assessment does require the development of a watershed model for other important functions. In particular, the primary need for a watershed model 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 upstream sources is used in setting allocations and determining load reductions needed from individual sources to meet those allocations. Also, the watershed model is 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 nutrient loading 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 TMDLs and again in the 2010 watershed model update (LESJWA 2010) represents a more complex watershed model than what was used in this revision. LSPC 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[14] 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 this source assessment for Lake Elsinore and Canyon Lake watersheds a simple modeling approach was 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 growth during dry conditions. Eutrophication occurs at seasonal timescales in Canyon Lake. For Lake

[14] Note that "runoff" refers to volume of water running off the watershed; "washoff" refers to the mass of nutrients in the runoff.

Elsinore, bioavailable nutrients are predominantly from internal sources (see Section 4.3 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 that 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 TMDLs 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, USEPA's Pollutant Loading Estimator tool (PLOAD) (USEPA 2001), was selected to support this TMDL revision. PLOAD is a component of USEPA's TMDL development framework, Better Assessment Science Integrating Point and Non-Point Sources (BASINS) (USEPA 2017). For the revision of the TMDLs, 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 USEPA approved, dynamic, deterministic modeling tools, and robustness of mass emission data available for all major inflows to each lake. For these same reasons, allocations are developed based on 10-year average annual loading.

4.1.1.2 Establishment of Model Hydrologic Response Unit 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 is used to define distinct hydrologic response unit (HRU) subareas. Watershed runoff simulations were developed for HRU areas with common land use, jurisdiction, and subwatershed zone, referred to as model HRUs. **Figure 4-1** shows the geographic distribution of these three defining attributes for the entire watershed to Lake Elsinore and Canyon Lake.

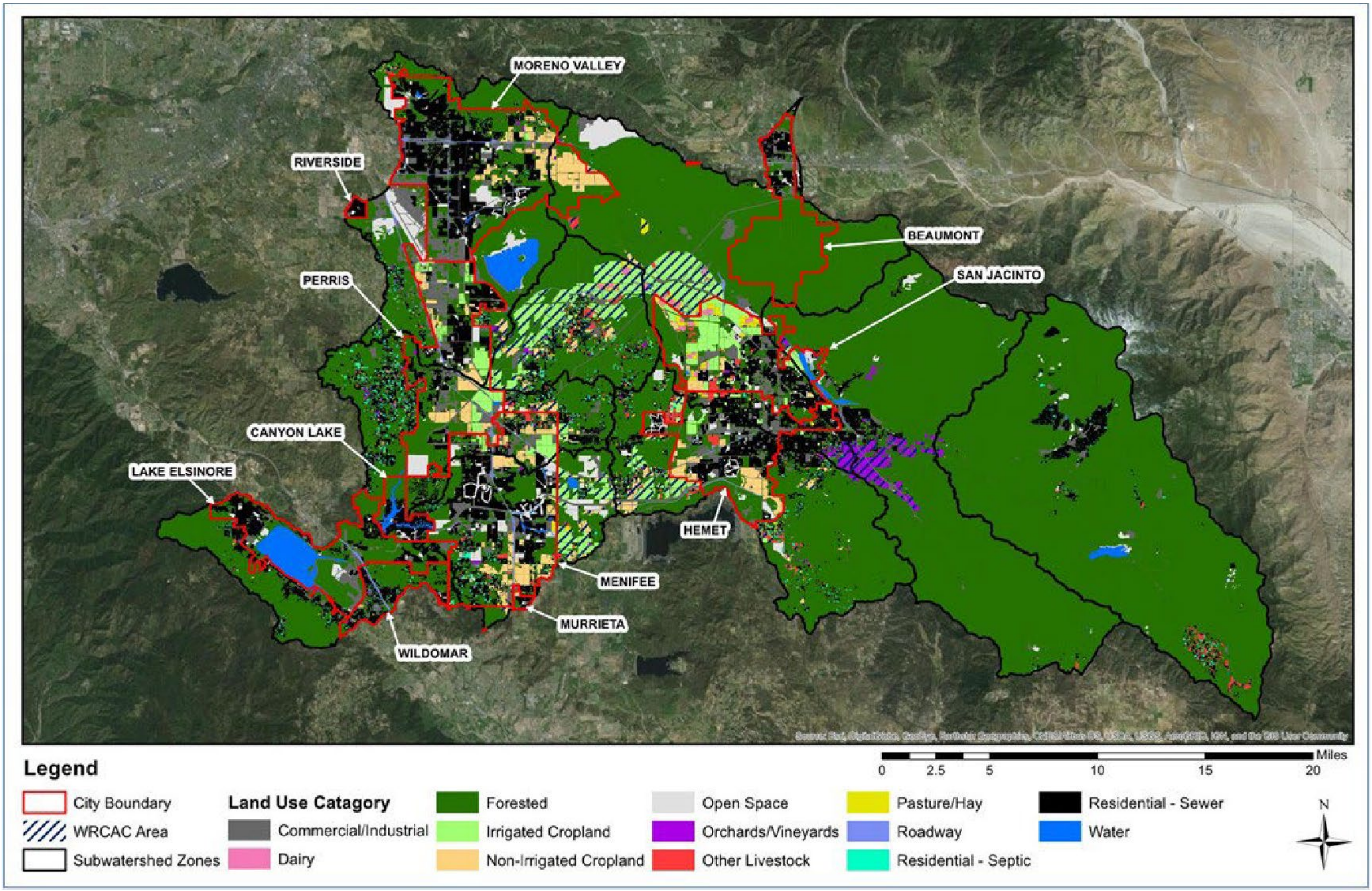

Figure 4-1. Map of Subwatershed Zones, Jurisdictions, and Land Use for Development of Watershed Model Subareas (data based on 2020 mapping)

Hydrology and water quality modeling is performed separately for each model HRU. **Figure 4-2** 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 209 distinct model HRU subareas developed to support source assessment and development of allocations. These model HRUs are not geographically contiguous, but rather they are spatially lumped portions of drainage areas with common parameter sets. For example, a single model HRU 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 HRU and reports important characteristics used for parameterizing the watershed runoff model.

The **Figure 4-2** schematic also shows how runoff is routed from model HRUs to receiving waters. Subwatershed zone delineations were developed based on this routing, as indicated in each of the blue receiving water elements. Some model HRUs drain directly to one of three lake areas: Canyon Lake Main Lake, Canyon Lake East Bay, and Lake Elsinore. Other model HRUs are routed through the San Jacinto River, Perris Valley Channel, or Salt Creek prior to reaching a lake. The position of Mystic Lake, an important impoundment to be accounted for in the source assessment, is also shown in the schematic. Model HRUs in Subwatershed Zones 7-9 draining to Mystic Lake are treated differently as discussed in Section 4.1.2.5 below.

To support revisions to the TMDLs, several subwatershed boundary revisions were incorporated to update the boundaries used in the 2004 TMDLs and TMDL model update in 2010 (**Figure 4-3**). Hatched areas in **Figure 4-3** 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:

- *Mystic Lake Tributary Area Correction* – The drainage area to Mystic Lake, Subwatershed Zones 7, 8, and 9 in the 2004 TMDLs, was re-evaluated by WRCAC as part of this 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 hatching (drainage area taken out of Zone 7) or purple (drainage area put into Zone 7) in **Figure 4-3**. 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 Road in the vicinity of the Colorado River aqueduct was modified. In total, the changes amount to a net reduction of ~5,000 drainage acres in Zone 7, and a net increase in the same amount for subwatersheds downstream of Mystic Lake.

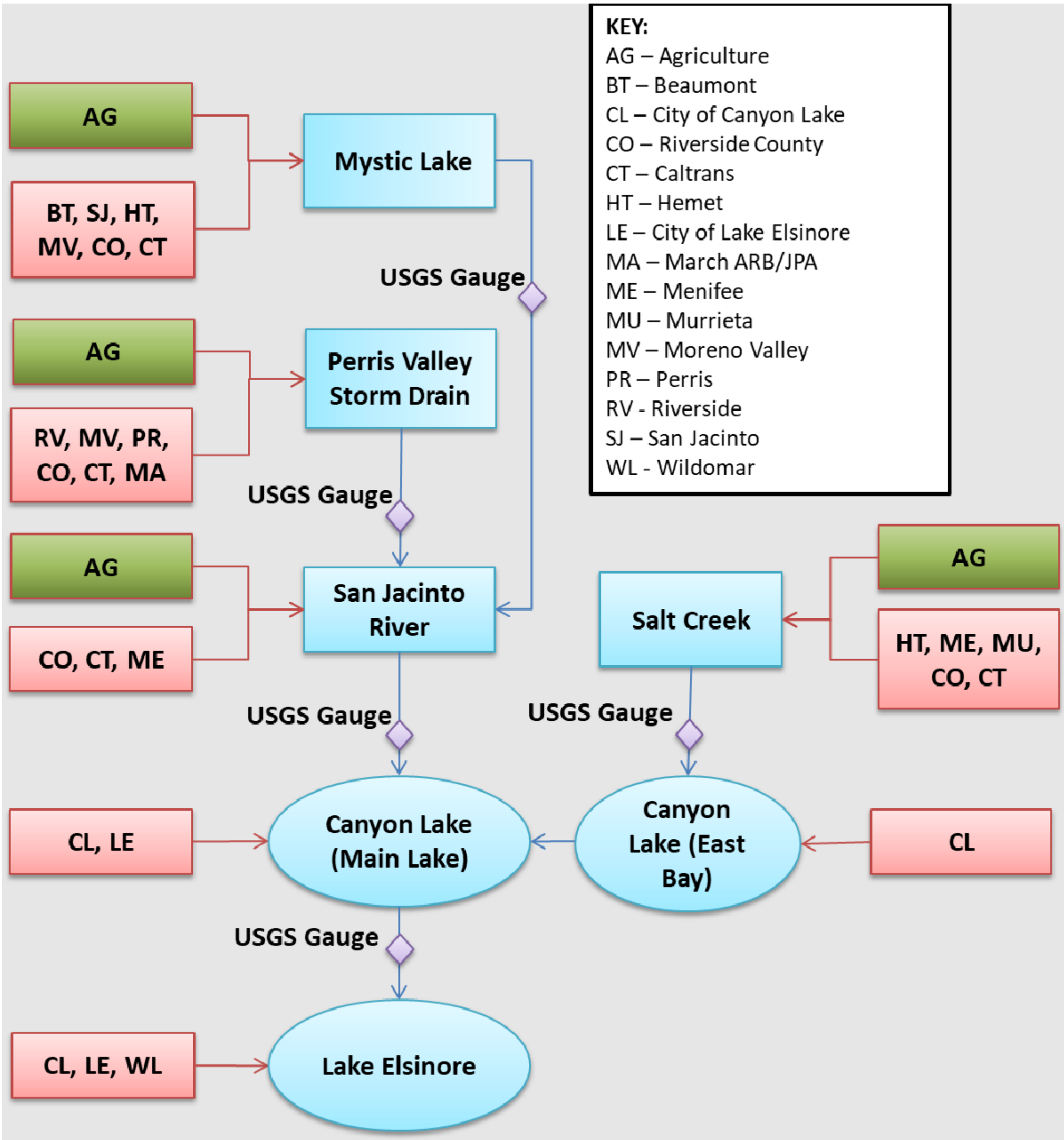

Figure 4-2. Schematic of External Runoff Loading Pathways for Watershed Runoff Sources and Receiving Waters that Retain, Convey, and Cycle Nutrients

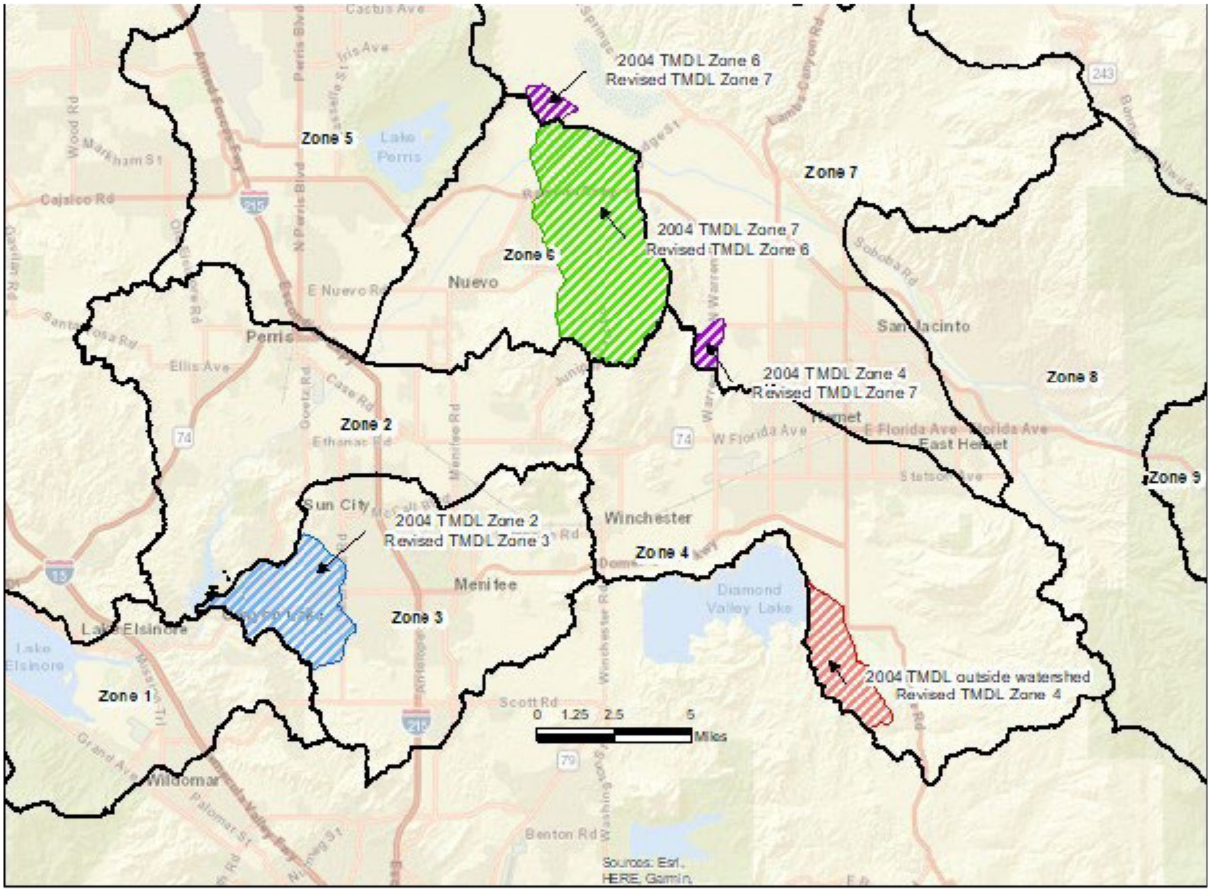

Figure 4-3. Map of Revisions to Subwatershed Zone Boundaries (Blue = area removed from Zone 2 and added to Zone 3; Green = area removed from Zone 7 and added to Zone 6; Purple = area removed from Zones 4 or 6 and added to Zone 7; Red = new watershed area added to Zone 4)

- *Local Canyon Lake Tributary Area to East Bay / Main Lake* – Subwatershed Zones 2 and 3 in the 2004 TMDLs 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 TMDLs 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 4-3** indicates the areas that were revised to properly reflect drainage to Canyon Lake's East Bay.

4.1.2 Hydrology

As noted above, the nutrient load in runoff from the watershed is a function of both runoff volume and water quality concentration. To estimate runoff volume, a static model was developed in a Microsoft Excel spreadsheet to simulate the volume of average annual runoff in model HRUs as a result of rainfall:

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

where,

Q_{annual} = annual flow volume
$Precip_{annual}$ = average annual rainfall depth
RC = runoff coefficient
DA = drainage acres

This hydrologic method was used in the USEPA approved public domain watershed model PLOAD, as described above. The following sections describe the sources of data used to estimate average annual runoff, factors that influence watershed hydrology and hydrologic model results.

4.1.2.1 Runoff Volume

Flow gauges operated by the USGS 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)[15] to Lake Elsinore. These data characterize the annual volumes of runoff that reached each lake over the period of record. **Table 4-1** presents summary statistics for each of these gauges. Continuous flow data from these USGS gauges for the period from 2006 through 2022 was used to calibrate a watershed runoff model for the drainage areas to the lakes (described in Section 4.1.3 below).

Figure 4-4 shows runoff inflows into Canyon Lake and overflows to Lake Elsinore from the San Jacinto River. Also shown in **Figure 4-4** 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, indicating that overflows occurred (years ending in July in 2001, 2003, 2005-2006, 2008, 2011, 2017, and 2019-2022). In dry years when the lake did not reach its spill elevation, outflow was assumed to be zero equating to complete volume retention (years ending in July in 2002, 2004, 2007, 2012-2016, and 2018).

[15] USGS Gauge 11070500, San Jacinto River near Elsinore, is approximately two 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

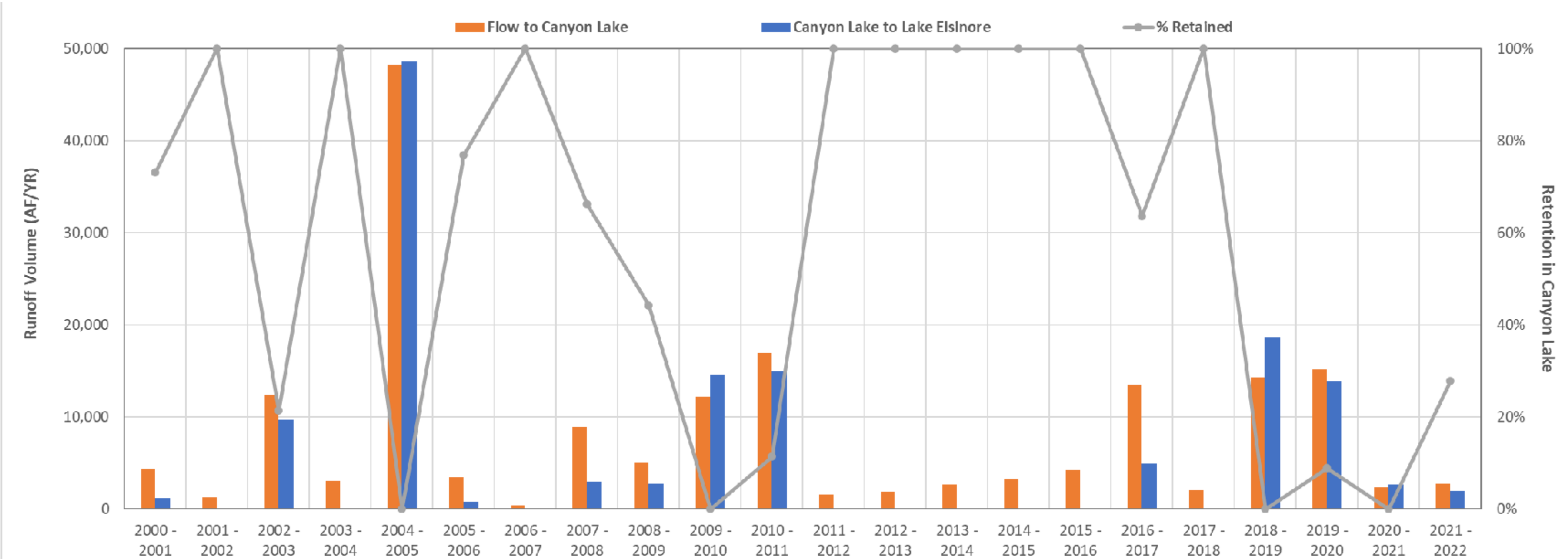

Figure 4-4. Annual Runoff Volume into Canyon Lake and Overflow to Lake Elsinore

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 – 2022	5,784	3,470
Salt Creek at Murrieta Road (11070465)	74,200	1983 – 1984; 2000 – 2022	2,389	2,550
San Jacinto River near Elsinore (11070500)	462,700	1916 – 2022	11,236	16,000

4.1.2.2 Precipitation

Precipitation input data for the model was extracted from RCFC&WCD rainfall stations distributed throughout the watershed[16] (**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 San Jacinto Station 186 was used to represent drainage areas with elevations below 3,000 ft (Subwatershed Zones 7 & 8) and rainfall from Idyllwild Station 90 was used to represent areas with elevation greater than 3,000 ft (Subwatershed Zone 9). **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 (2006-2022) is within 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 1948-2022 was selected as the period with continuous rainfall records with no missing data from all of the stations used in the watershed model.

4.1.2.3 Runoff Coefficient (RC)

The RC is a factor that expresses the ratio of rainfall to surface runoff. Simple hydrologic modeling methods, such as the Rational Method and derivations thereof, estimate the RC 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).

[16] https://content.rcflood.org/RainfallMap/

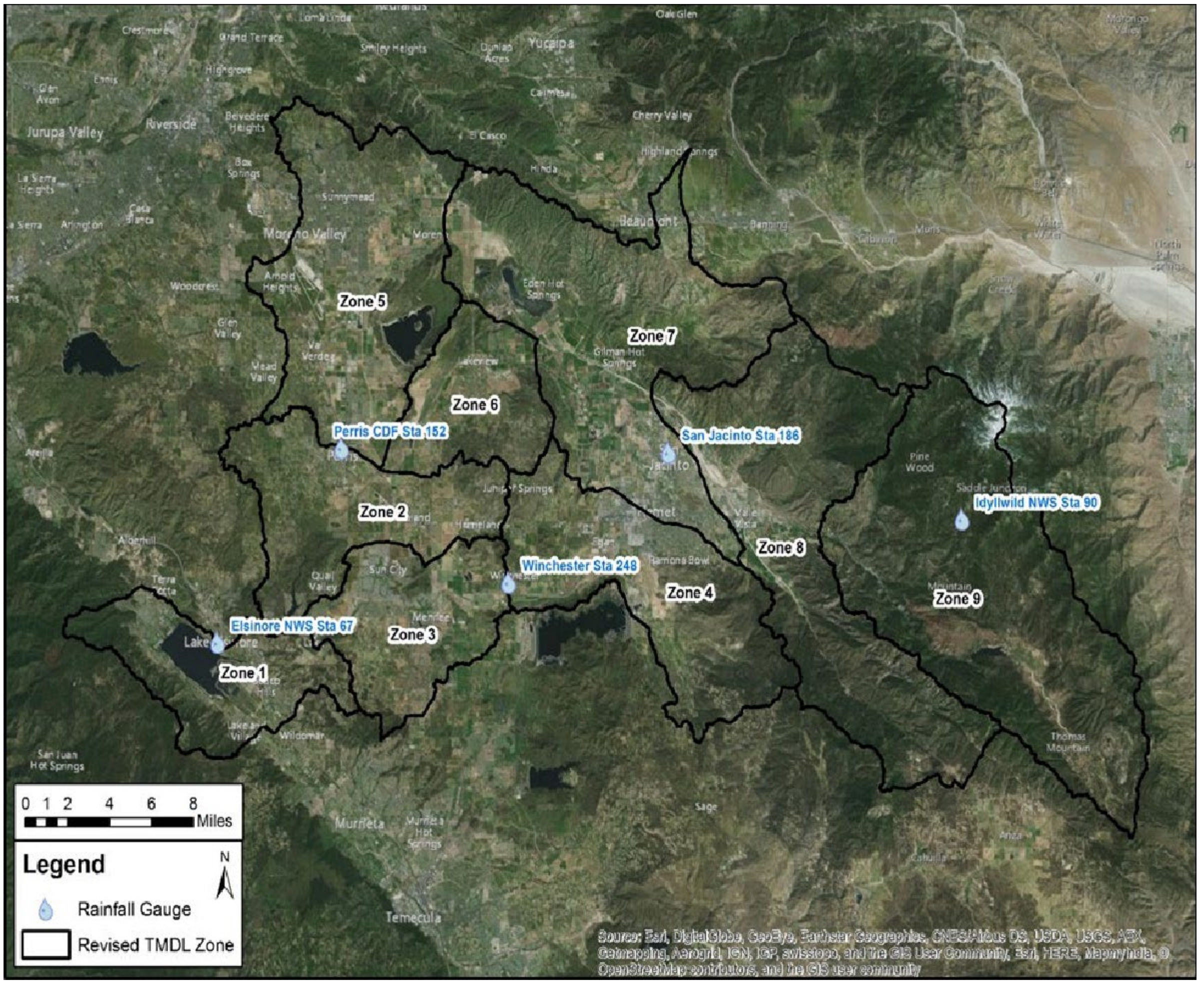

Figure 4-5. Map of Rainfall Stations Used for Long-term Rainfall Depth in Watershed Model

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

Station	Period of Record	Period of Record Average Rainfall (in/yr)	1948 2022 Average[1] Rainfall (in/yr)	2000 2022 Average[2] Rainfall (in/yr)	Subwatershed Zone
San Jacinto Station 186	1903 – Present	12.6	11.8	10.1	6, 7, 8
Elsinore NWS Station 67	1896 - Present	11.9	11.0	9.4	1, 2
Perris CDF Station 152	1910 – Present	10.3	10.0	8.5	5
Winchester Station 248	1940 - Present	10.5	10.5	9.0	3, 4
Idyllwild NWS Station 90	1929 – Present	26.2	25.0	21.4	9

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

[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 RCs that optimize the relationship between increased connectivity and 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) suggests 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 3.0 was set as the default when *a* = 0.034. These two factors provided the best fit between results of the PLOAD model and measured annual average runoff volumes as shown in Section 4.1.2.6 below.

The Multi-Resolution Land Characteristics Consortium (MRLC)[17] maintains a national map of impervious surfaces with a spatial resolution of 30-m, most recently updated in 2019 (Dewitz and USGS 2021). Imperviousness within the watersheds to Lake Elsinore and Canyon Lake was extracted from this national map and used for estimating RCs from model subareas using the above equation. **Figure 4-6** illustrates the outcome of this analysis.

4.1.2.4 Downstream Retention in Unlined Channels

Not all rainfall that runs off into a surface waterbody in the watershed reaches Canyon Lake because of groundwater 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, all flows in these waterbodies typically infiltrate into the channel bottom.

To estimate the annual loss of runoff within these channel bottoms during dry and wet conditions, 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 – 2022) was evaluated to estimate the number of days when upstream runoff actively infiltrated channel bottoms. This was

[17] https://www.mrlc.gov/

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 (>20 cfs). The final column of **Table 4-3** presents the estimated average annual yield of infiltrated runoff in each channel bottom segment.

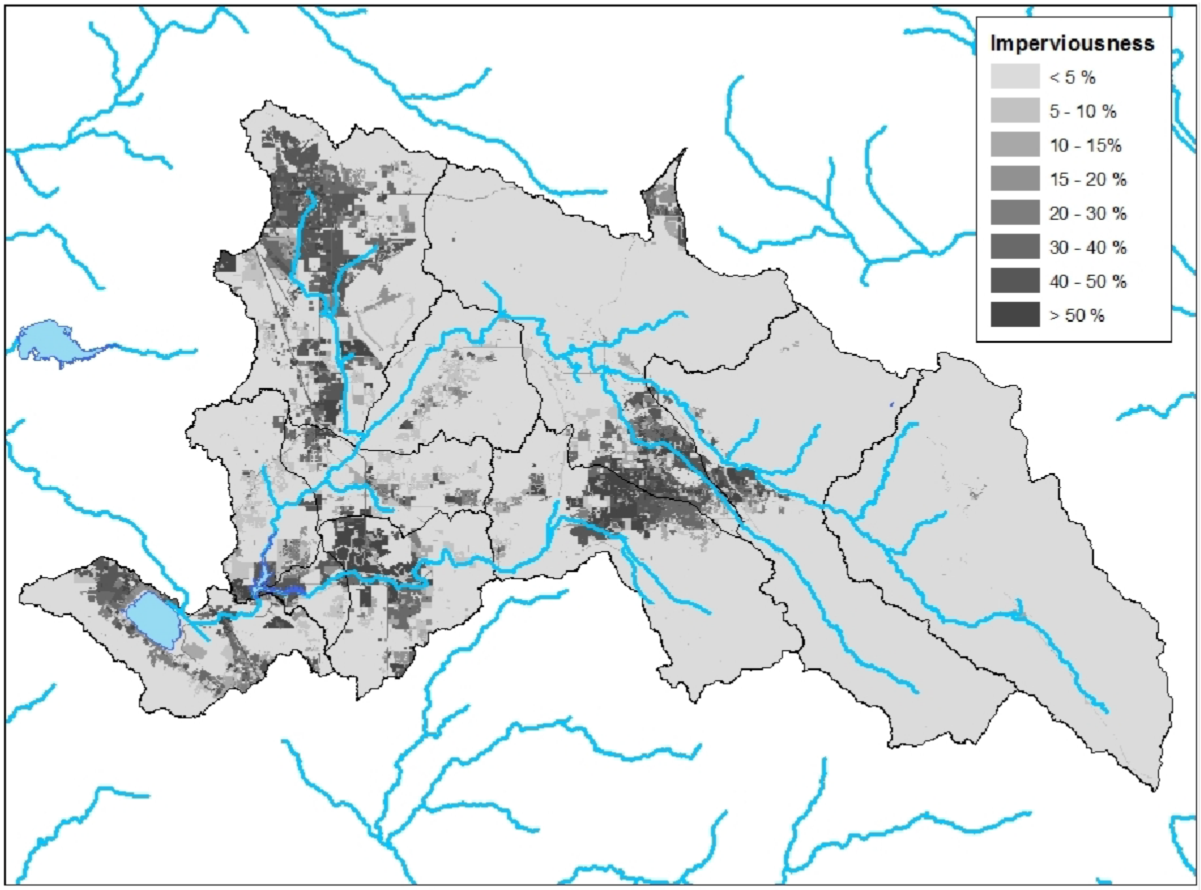

Figure 4-6. Imperviousness in the Lake Elsinore and Canyon Lake Watersheds

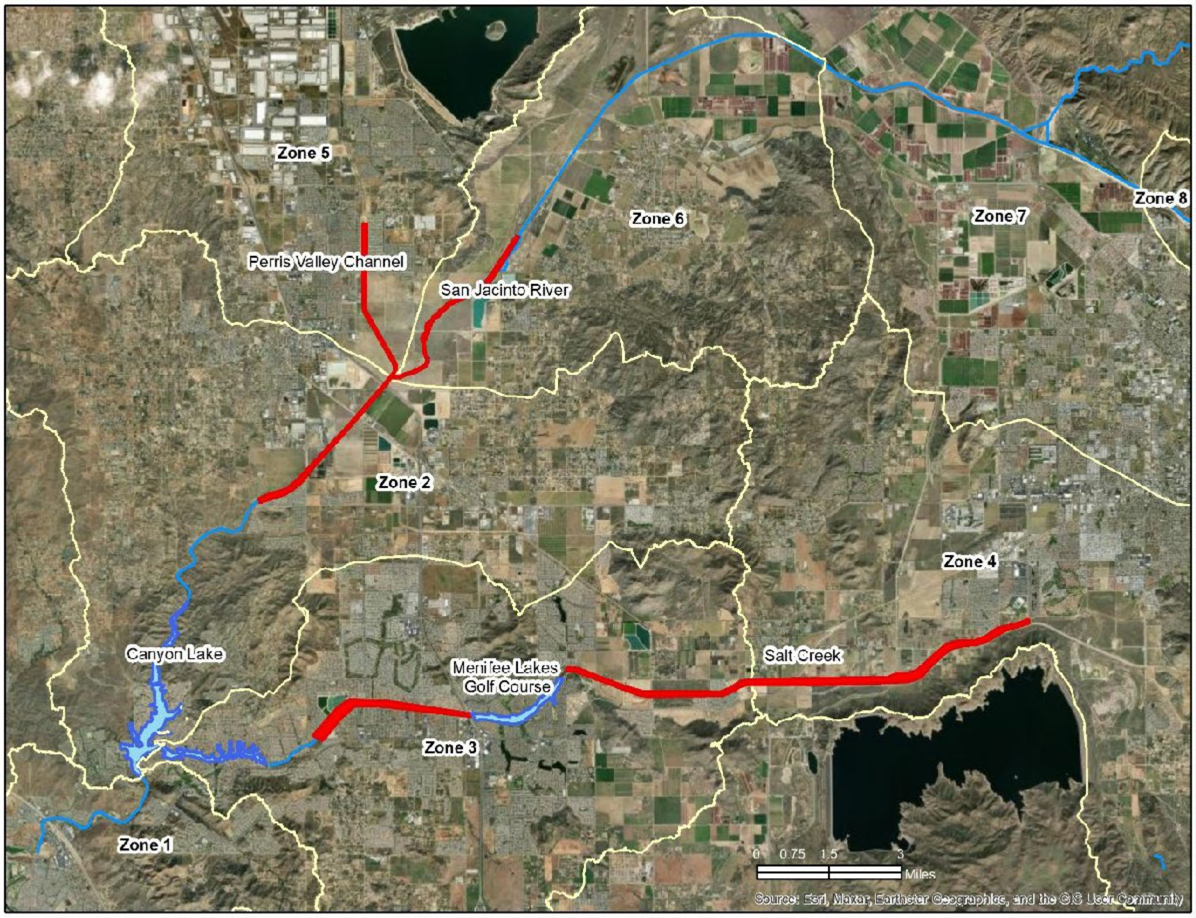

Figure 4-7. Unlined Channel Bottom Segments (shown in red) in the Lake Elsinore and Canyon Lake Watersheds

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 2022)	Estimated Annual Recharge (AFY)
San Jacinto River	111	0.1	20	380	94
Perris Valley Channel	222	0.1	20	307	151
Salt Creek	600	0.2	20	251	1,003

[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.

The estimated annual recharge volume (in AFY) for each unlined channel bottom segment is compared with modeled watershed runoff in upstream subwatersheds to estimate retention factors (**Table 4-4**). This effort includes consideration of runoff retained in lakes on the Menifee Lakes Golf Course. Retention factors were computed as follows: (a) Subwatershed Zone 5 to Perris Valley Channel; (b) Subwatershed Zone 6 to San Jacinto River; and (c) Subwatershed Zone 4 to Salt Creek. Other retention factors are computed to account for Subwatershed Zones 7-9 to Mystic Lake (as described in the following section).

Table 4-4. Estimated Retention Factors between Jurisdictional Watershed Runoff and Lake Inflows

Subwatershed	Retention Features	Annual Retention (AFY)	Retention / Watershed Runoff
Zone 1	n/a[1]	0	1.0
Zones 2-3	n/a[1]	0	1.0
Zone 4	Salt Creek Channel bottom, Menifee Lakes Golf Course	1,003	0.52
Zone 5	Perris Valley Channel bottom	151	0.05
Zone 6	San Jacinto River bottom	94	0.03
Zone 7-9	Mystic Lake	5,808	0.96

[1] Drainage features exist within these subwatershed zones that may provide retention of watershed runoff; however, the extent is relatively small and hydrologic data are needed to quantify that capture is limited

4.1.2.5 Influence of Mystic Lake

Watershed runoff in the upper San Jacinto River is captured in Lake Hemet within the SJNF and ultimately Mystic Lake, a large shallow depression in the San Jacinto Valley (**Figure 4-8**). Mystic Lake has a current 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 in a series of spreading grounds used for groundwater recharge by Eastern Municipal Water District (EMWD) (**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 water years 1993-1994, 1995-1996, and 1998-1999 (Hamilton and Boldt 2015a,b), but not in subsequent wet years when flow gauge data showed no overflows occurred (notable being the 2004-2005 and 2010-11 wet seasons). There are no downstream flow data in the San Jacinto River at Goetz Rd inflow 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 over the calibration period from 2006-2022.

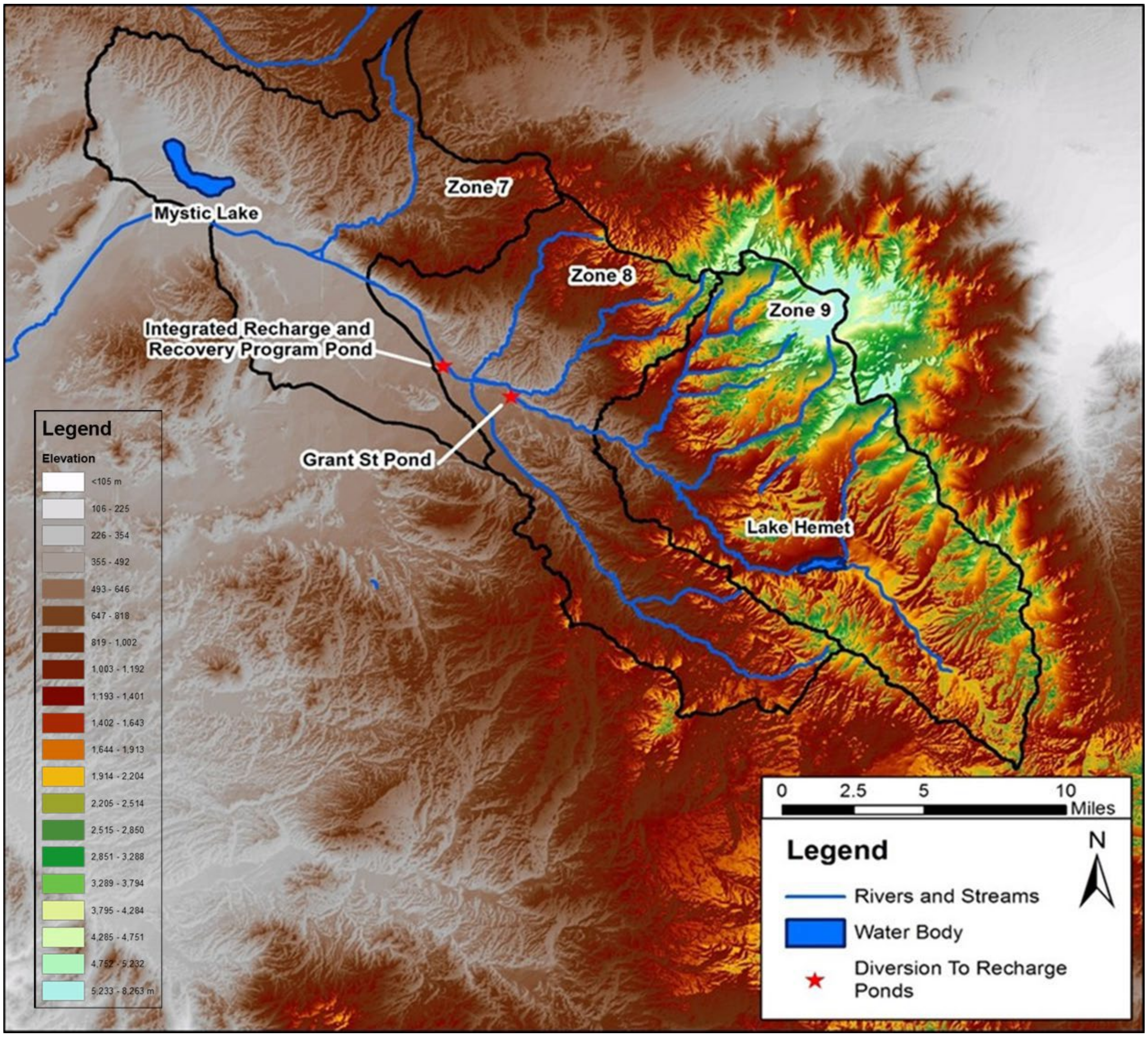

Figure 4-8. Drainage Area Upstream of Mystic Lake

Rainfall stations in the region have actively collected data for 112 years at RCFC&WCD Station 186 San Jacinto and 93 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 – 2022). Estimated runoff was reduced to account for significant attenuation in these subwatershed zones with retention in Lake Hemet and EMWD groundwater recharge basins (~6,000 AFY) that capture surface runoff from diversions in the upper San Jacinto River. Subsidence of land within the Mystic Lake basin bottom is continually adding an estimated 200 AF of storage capacity each year, based on a review of historical bathymetric maps (Morton and Miller 2006). Looking forward, an estimated 5,000 additional AF of storage capacity may exist by 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. For a 22,000 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 or 2010-11, 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**.**

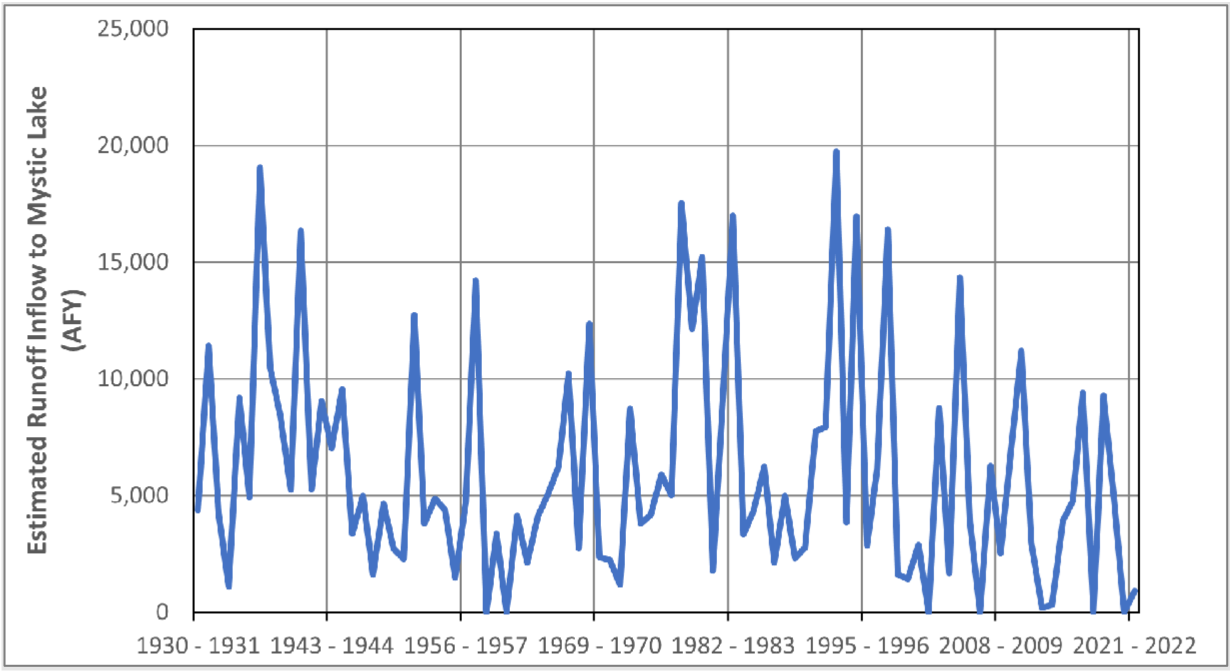

Figure 4-9. Modeled Runoff Inflow to Mystic Lake

A reservoir water budget analysis after Gilbert (1970) was developed to approximate the volume of overflow in each 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:

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

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

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 6 of 93 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 > 7,000 AFY (**Figure 4-10**).

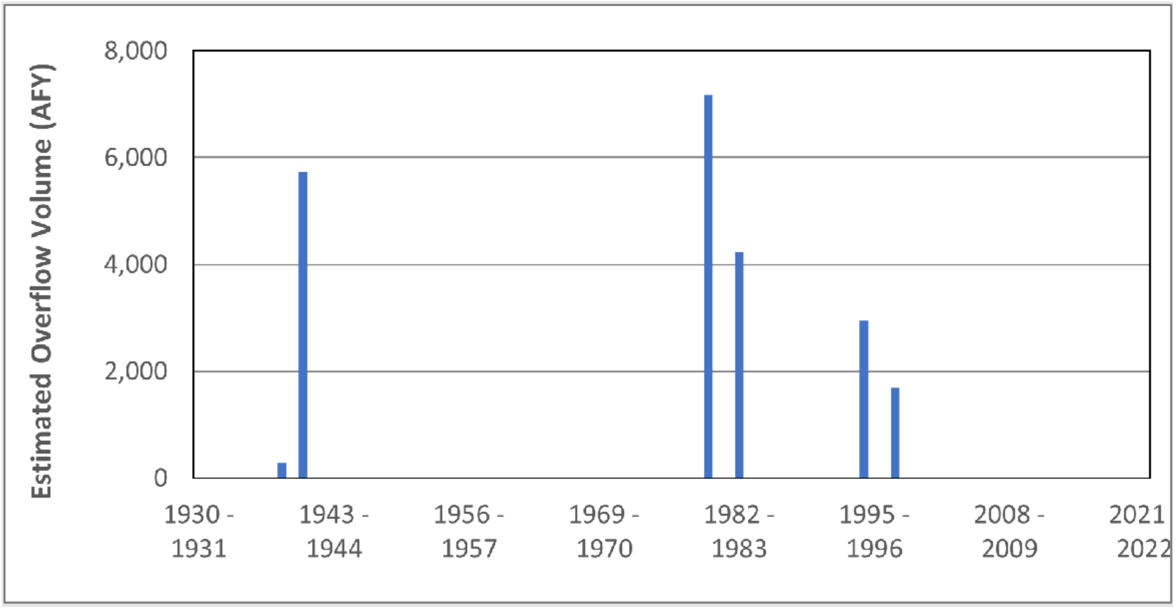

Figure 4-10. Modeled Overflow Volume from Mystic Lake to Canyon Lake (Note: Years not shown did not result in a spill from Mystic Lake)

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 annual average overflow of ~240 AFY (including years with zero overflow) to the total runoff volume from the upper watershed (into Mystic Lake) for the 93-year simulation period of ~6,000 AFY suggests that four percent of long-term runoff from Subwatershed Zones 7-9 may reach Canyon Lake. Thus, a retention factor of 0.96 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.

4.1.2.6 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 the 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, 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 4-11**).

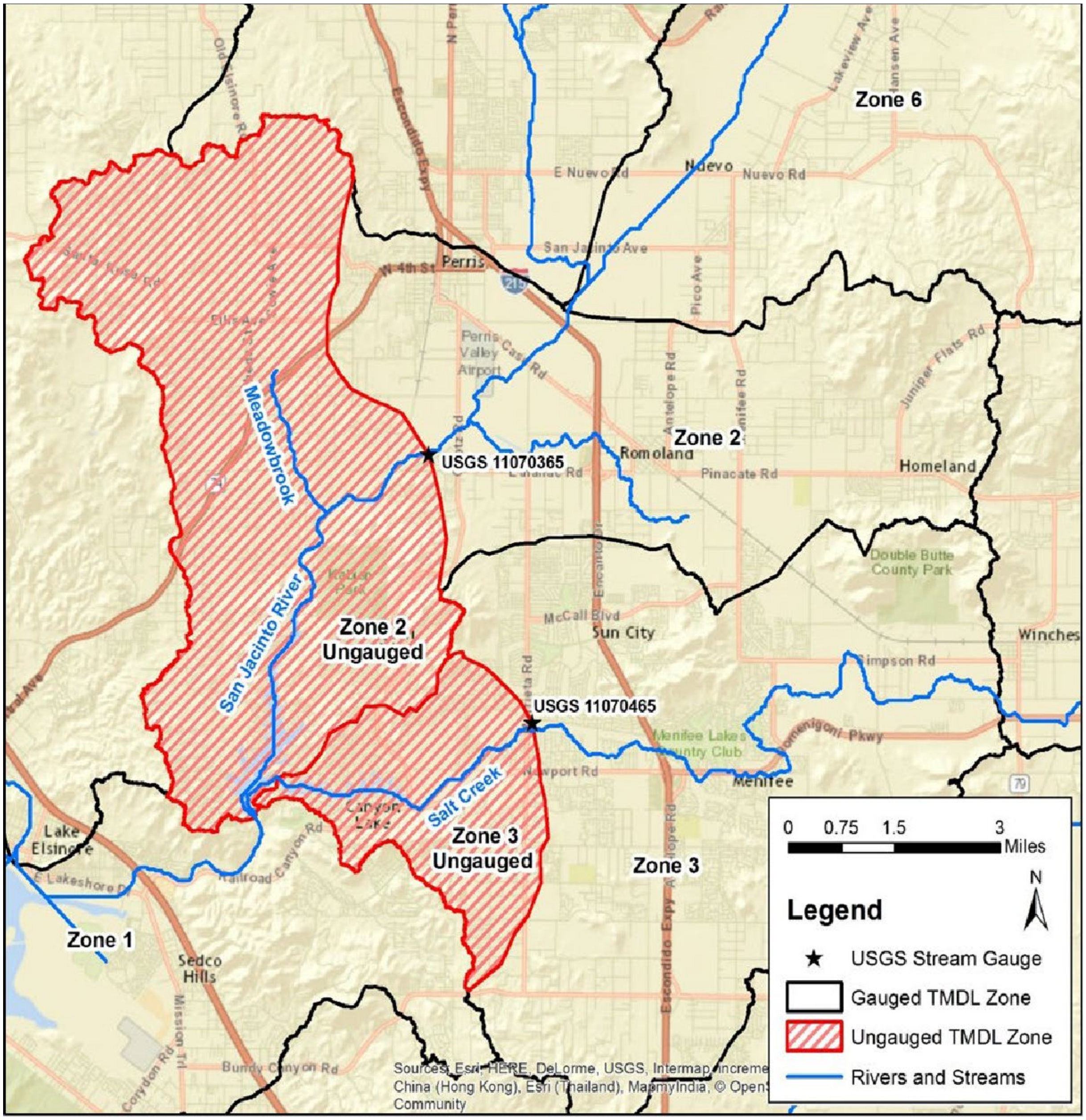

Figure 4-11. Drainage Areas Downstream of USGS Gauge Stations Not Included in Comparison of Modeled to Measured Runoff Volume

The factors used to estimate RCs as a function of subarea imperviousness were adjusted (a = 0.034, b = 3.0) to fit modeled long-term average annual runoff volume to averages from the USGS gauges (**Figure 4-12**). 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 (Relative Error [RE] < 1.5 percent for both Canyon Lake inflows).

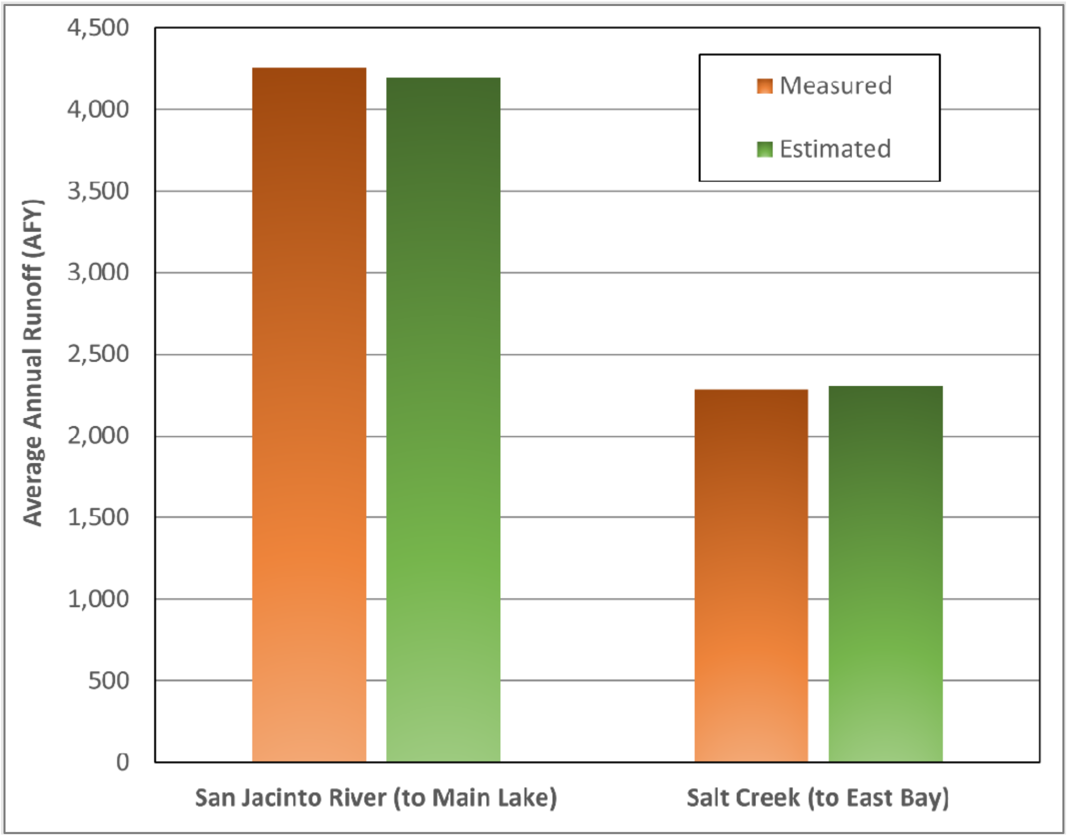

Figure 4-12. Comparison of Modeled and Measured Average Annual Runoff Volume (2006-2022) for Primary Inflows to Canyon Lake

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 1948-2022 (shown in **Table 4-2** above). **Table 4-5** provides the results which represent the estimated average annual volume of runoff delivered to Canyon Lake, Main Lake and East Bay, and Lake Elsinore from all watershed lands, including ungauged areas. 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.

Table 4-5. Estimated Long-Term (1948-2022) 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[1]	Mystic Lake Overflow to Lake Elsinore[2]	Total
Modeled - Current Land use	6,363	3,273	1,578	237	11,452

[1] Runoff from the local drainages into Lake Elsinore; does not include water received from Canyon Lake overflows

[2] All overflows from Mystic Lake are assumed to pass through Canyon Lake with minimal retention on path to Lake Elsinore

4.1.3 Water Quality

The preceding section describes a static model for estimating the average annual volume of watershed runoff generated from different model subareas that is then delivered downstream to the lakes. Watershed runoff contains nutrients, TP and TN, 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 watershed 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 lakes as external loads in watershed runoff.

4.1.3.1 Sources of Nutrients in Watershed Runoff

Specific sources of nutrients that may be available for washoff with watershed runoff include the following:

- Trash
- Fertilizers
- Green waste
- Pet waste
- Atmospheric deposition
- Farm animal waste
- Groundwater
- Septic system failure
- Detergents
- Construction sites
- Erosion of exposed sites

The source assessment estimates TP and TN 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 4-6**). Detailed land use distributions by subwatershed zone and jurisdiction are provided in Appendix B. Land use map data was compiled from SCAG (2019) with modifications using more accurate agricultural land use mapping from AIS (2022).

4.1.3.2 Nutrient Loading to Lakes

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 areas to the lakes, although adjustments are made in the modeling approach to account for ungauged drainage areas, as described in Section 4.1.3.3. The concentration of nutrients for inflows to and outflows from Canyon Lake have been monitored during 55 storm events between 2001 and 2022. This full record of watershed monitoring activities was assumed to be representative of long-term averages. **Table 4-7** presents event-based summary data. For estimating current levels of external loads, accounting for watershed BMP deployments and alum addition in Canyon Lake, summary statistics are provided for more recent monitoring events (i.e., from the 2012-2013 wet season to present).

Table 4-6. 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	15,640	5,031	1,433	22,103
Dairy	884	104	5	992
Forested	55,867	7,021	5,981	68,868
Irrigated Cropland[2]	15,022	4,150	0	19,172
Non-Irrigated Cropland[2]	13,039	9,563	35	22,637
Open Space	202,509	34,305	12,351	249,165
Orchards / Vineyards[2]	4,066	291	65	4,421
Other Livestock[2]	1,915	1,099	53	3,066
Pasture / Hay[2]	2,405	347	49	2,802
Roadway	3,338	1,131	348	4,817
Water	5,672	567	2,588	8,827
Residential – Septic[3]	8,218	2,512	213	10,944
Residential – Sewer	41,626	19,069	7,627	68,322
Total Acres	**370,200**	**85,190**	**30,747**	**486,137**

[1] Acres shown include drainage areas upstream of Mystic Lake in Subwatershed Zones 7-9

[2] Includes all agricultural land use areas, including <20 acres and other categories exempt from Agricultural General Order

[3] Residential land use on septic systems was approximated by intersecting GIS layers of Riverside County parcels containing a septic tank with 2019 land use areas mapped as residential

Table 4-7. Summary of Nutrient Concentrations (mg/L) from Composite Storm Event Samples at Watershed Monitoring Sites ("—" indicates not sampled)

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	--	--	--	--
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

Table 4-7. Summary of Nutrient Concentrations (mg/L) from Composite Storm Event Samples at Watershed Monitoring Sites ("—" indicates not sampled)

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
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	--	--
37	1/9/2018	0.58	2.10	0.48	2.50	--	--	--	--
38	2/27/2018	--	--	0.43	4.00	--	--	--	--
39	3/22/2018	0.23	1.80	0.26	1.70	--	--	--	--
40	10/13/2018	--	--	--	--	0.68	5.30	--	--
41	11/29/2018	0.45	1.80	0.31	21.50	0.96	3.74	--	--
42	12/5/2018	0.80	2.00	0.49	2.70	--	--	--	--
43	1/16/2019	--	--	--	--	0.11	1.50	--	--
44	1/31/2019	0.57	1.33	0.46	1.90	0.14	1.10	--	--
45	2/14/2019	--	--	--	--	0.32	1.60	--	--
46	11/28/2019	0.83	2.10	0.63	2.50	--	--	--	--

Table 4-7. Summary of Nutrient Concentrations (mg/L) from Composite Storm Event Samples at Watershed Monitoring Sites ("—" indicates not sampled)

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
47	3/10/2020	0.44	1.90	0.52	2.40	0.12	1.20	--	--
48	3/12/2020	--	1.50	--	--	0.15	1.10	--	--
49	3/22/2020	0.75	--	0.63	2.20	0.20	1.00	--	--
50	1/29/2021	0.56	2.00	0.53	2.40	0.07	2.10	--	--
51	3/10/2021	0.40	1.80	0.25	1.40	0.04	1.30	--	--
52	12/14/2021	0.79	2.70	0.56	3.20	--	--	--	--
53	12/29/2021	--	--	--	--	0.00	1.50	--	--
54	3/4/2022	--	--	0.43	3.10	--	--	--	--
55	3/29/2022	0.41	2.10	0.38	1.90	0.69	2.42	--	--
Median of all Events		**0.68**	**2.13**	**0.45**	**2.40**	**0.38**	**1.69**	**0.39**	**1.15**
Mean of all Events		**0.78**	**2.69**	**0.55**	**2.99**	**0.41**	**1.93**	**1.65**	**2.10**
Median (2012/2013 Wet Season to Present)		**0.58**	**2.00**	**0.43**	**2.39**	**0.15**	**1.50**	**n/a**	**n/a**
Mean (2012/2013 Wet Season to Present)		**0.64**	**2.01**	**0.48**	**3.21**	**0.27**	**0.64**	**n/a**	**n/a**

Table 4-7 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. The median values were applied to annual volumes (Q_{annual}) measured at the USGS gauges to estimate loading to the lakes from most of the watershed (L_{annual}), as follows:

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

Figures 4-13 and 4-14 show estimated annual nutrient loads based on measurements of daily flow and composited nutrient samples as reported in historical annual monitoring program reports. 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 (years ending in July in 2001, 2003, 2005-2006, 2008, 2011, 2017, 2019-2022), indicating that overflows occurred. In dry years when the lake did not overflow, all nutrient loads are assumed to be retained. The annual average (based on period of record 2000-2022) nutrient overflow from Canyon Lake to Lake Elsinore is 3,620 kg/yr TP and 14,700 kg/yr TN.

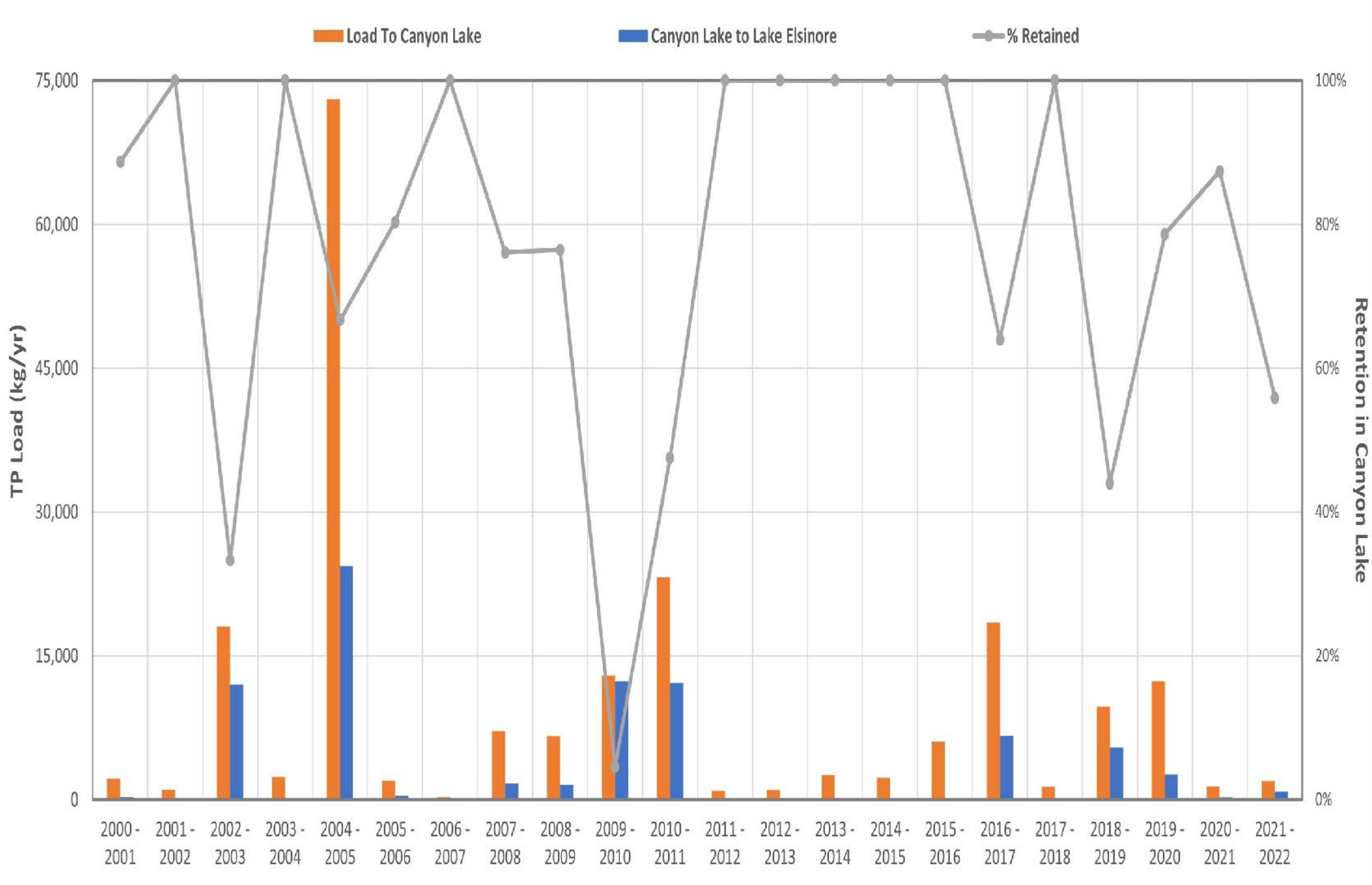

Figure 4-13. Annual Total Phosphorus Load into Canyon Lake and Overflow to Lake Elsinore

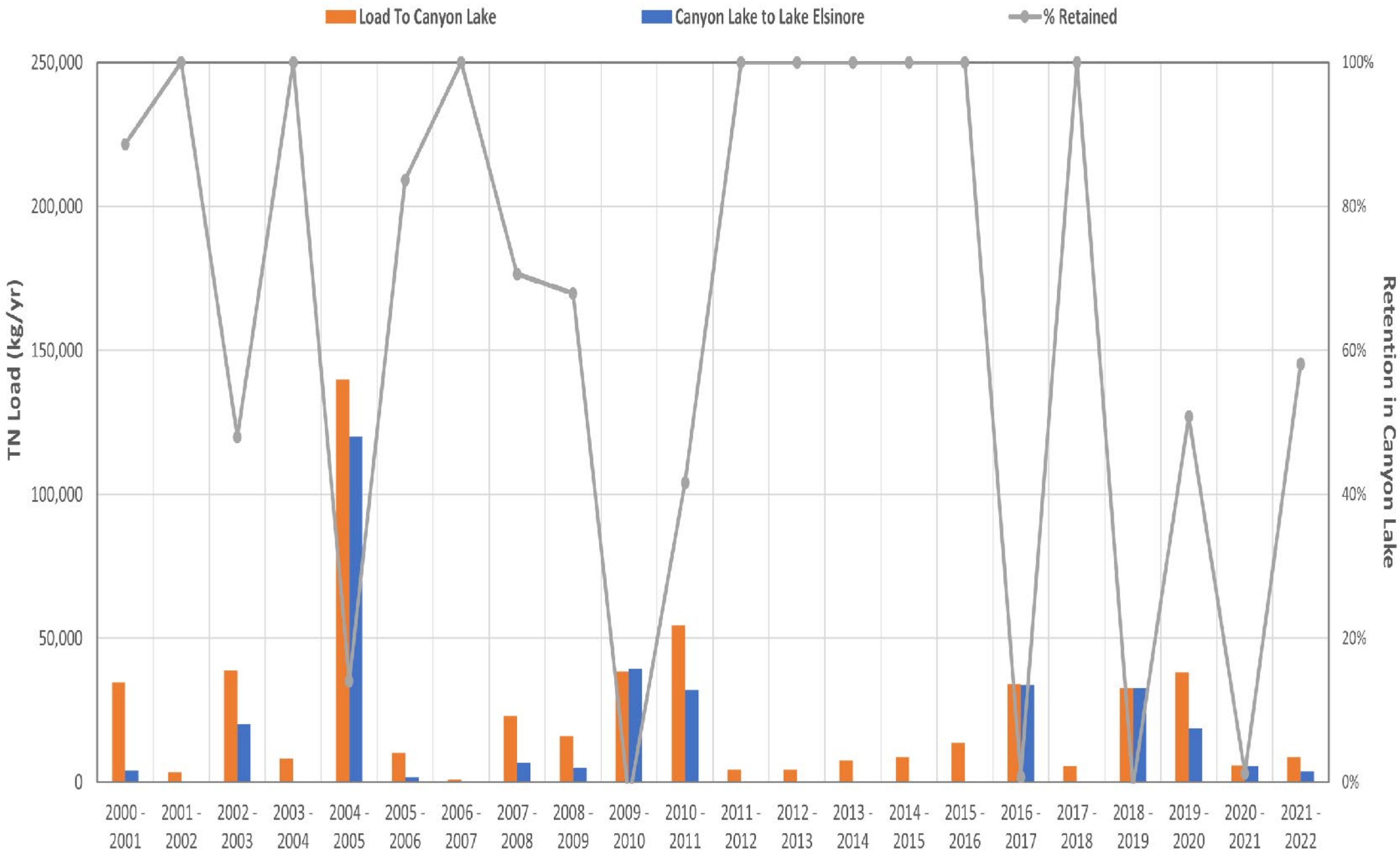

Figure 4-14. Annual Total Nitrogen Load into Canyon Lake and Overflow to Lake Elsinore

4.1.3.3 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 4-8 presents urban, dairy, other livestock, and open space land use-based nutrient washoff concentrations used to develop the source assessment. **Table 4-8** also documents the basis of estimation for each of these nutrient washoff concentrations using monitoring sites representative of general land use categories (**Figure 4-15**). 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.[18] 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. SJNF data and San Jacinto Basin Resource Conservation District (2009) provided information on open space/forested and dairy land uses, respectively. Assumed nutrient washoff concentrations for other livestock land use (e.g., chicken farms, horse ranches) were estimated to provide per acre loading rates at the median of a nationwide database used in the Measured Annual Nutrient Loads from Agricultural Environments (MANAGE) database (Harmel et al. 2006). Actual nutrient loads from specific properties characterized as "other livestock" in the San Jacinto River watershed are expected to be dependent upon types of operations, animal density and site conditions. Site specific assessment of nutrient loads will be important in the future to estimate loads for individual properties that may be subject to future non-dairy CAF orders.

[18] https://rcwatershed.org/programs/monitoring/

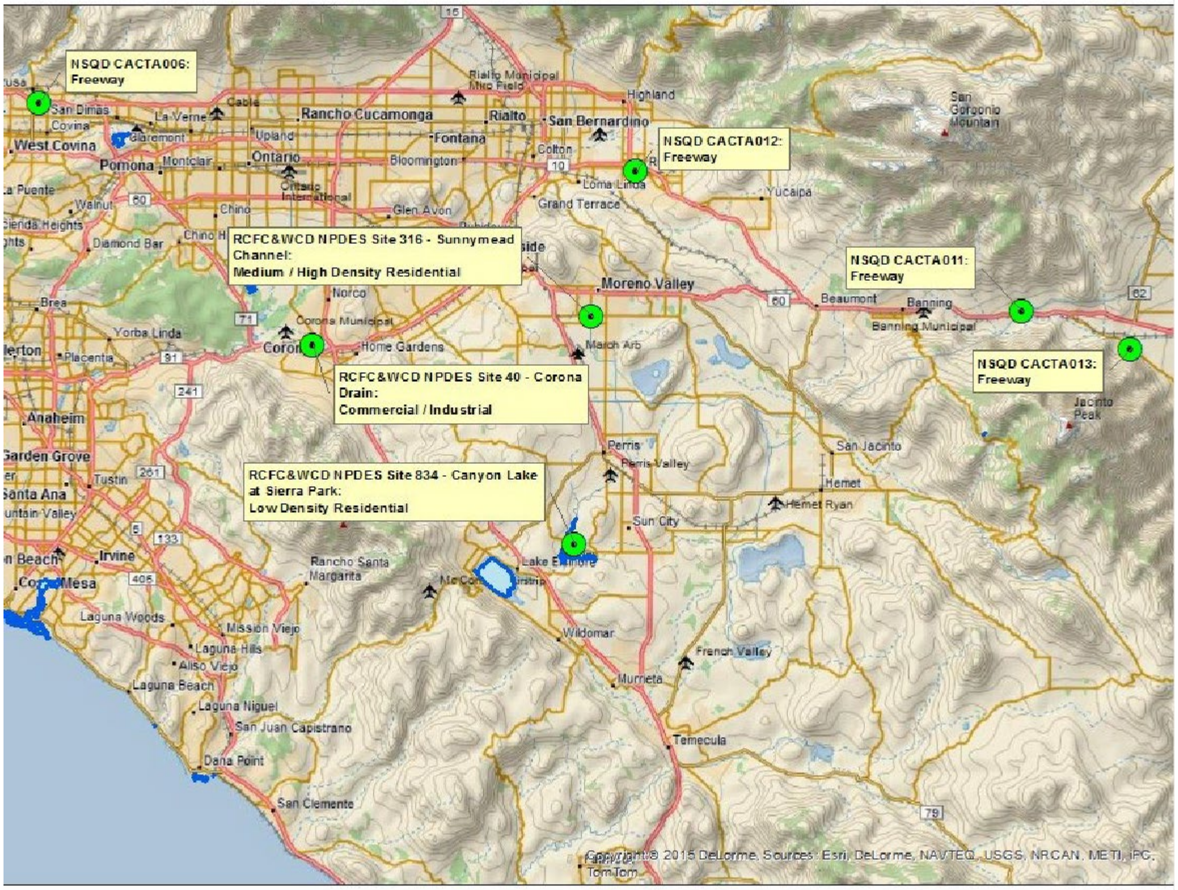

Figure 4-15. Map of Water Quality Monitoring Sites in the San Jacinto River Watershed and Vicinity Used to Estimate Land Use-based Washoff Concentrations for TP and TN

Table 4-8. Urban 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	0.56	2.76	Corona Storm Drain (Station 40)	RCFC&WCD (n=49; 2004–2022)
Residential – Sewer	0.48	1.80	Sunnymead Channel (Station 316)	RCFC&WCD (n=49; 2004–2022)
Residential – Septic	0.59	5.30	Canyon Lake at Sierra Park (Station 834)	RCFC&WCD (n=21; 2000-2004)
Roadway	0.38	3.41	Freeway (FW) CACTA006, 011, 012, 013	NSQD (n=14; 1997-1999)
Open Space / Forested	0.32	0.92	Cranston Guard Station	USFS (n=51; 2003–2010)
Other Livestock (e.g., chicken farm, horse ranch)	3.34	13.49	Median of nationwide studies included in the MANAGE model database (after Harmel et al. 2006)	
Dairy[1]	9.10	14.90	SJBRCD1	San Jacinto Resource Conservation District 2009 (n=1; May 2008)

[1] CAFO NPDES permit requirements are estimated to provide 99.7 percent retention of this land use's estimated washoff

For the Residential – Septic land use, land use-based monitoring was conducted from 2001-2004 to support the 2004 TMDLs. This monitoring included 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 wastewater treatment systems (OWTS), 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 septic systems watershed-wide.

Agricultural Land Uses

For agricultural land uses, the estimate for nutrient washoff concentration was developed using preliminary results from a soil health study conducted by WRCAC. The study, conducted in March 2018, is a key step in the implementation of a 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 4-9**).

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 4-9** to approximate soil erosion from irrigated and non-irrigated one-acre agricultural fields in the San Jacinto River watershed (NRCS 2006).

Table 4-9. 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	0.28	0.5	5%	1,400	0.03	1.09	1,300	0.03	1.01
Non-irrigated	0.28	2.1	5%	1,100	0.10	3.60	1,400	0.13	4.58
Orchards	0.28	0.5	5%	800	0.02	0.62	550	0.01	0.43
Pasture/ Hay	0.28	2.1	5%	1,400	0.03	1.09	1,300	0.03	1.01

[1] Pervious land runoff estimated from RC = 0.041 and average annual rainfall of 11.8 in/yr (RCFC&WCD Station 186 San Jacinto)

Kinnell (2008) notes that the USLE-M, 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 acre 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 agricultural fields and lake inflows in the San Jacinto River watershed, **Table 4-9** incorporates a 5 percent SDR in the estimation of nutrient washoff from agricultural lands to receiving waters in the San Jacinto River watershed. This value for SDR provided nutrient concentrations within range of edge of field experiments conducted by UCR (UCR 2011).

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 for TP (**Figure 4-16**) and TN (**Figure 4-17**). 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.

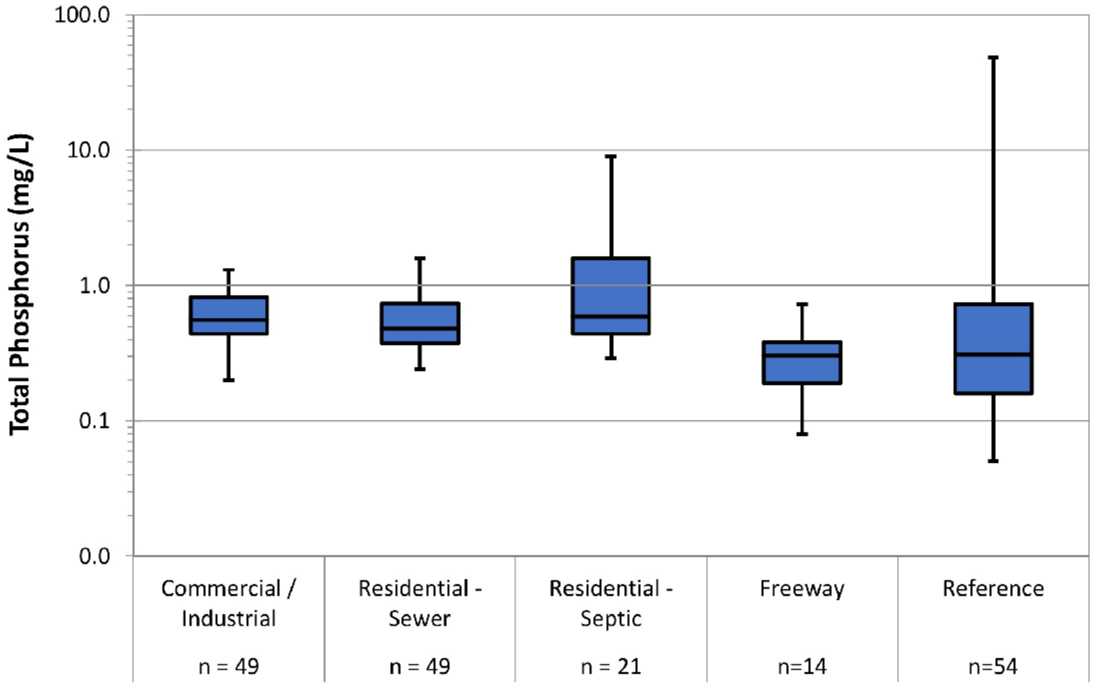

Figure 4-16. Box/Whisker Plots of Wet Weather Total Phosphorus from Land Use-specific Sites

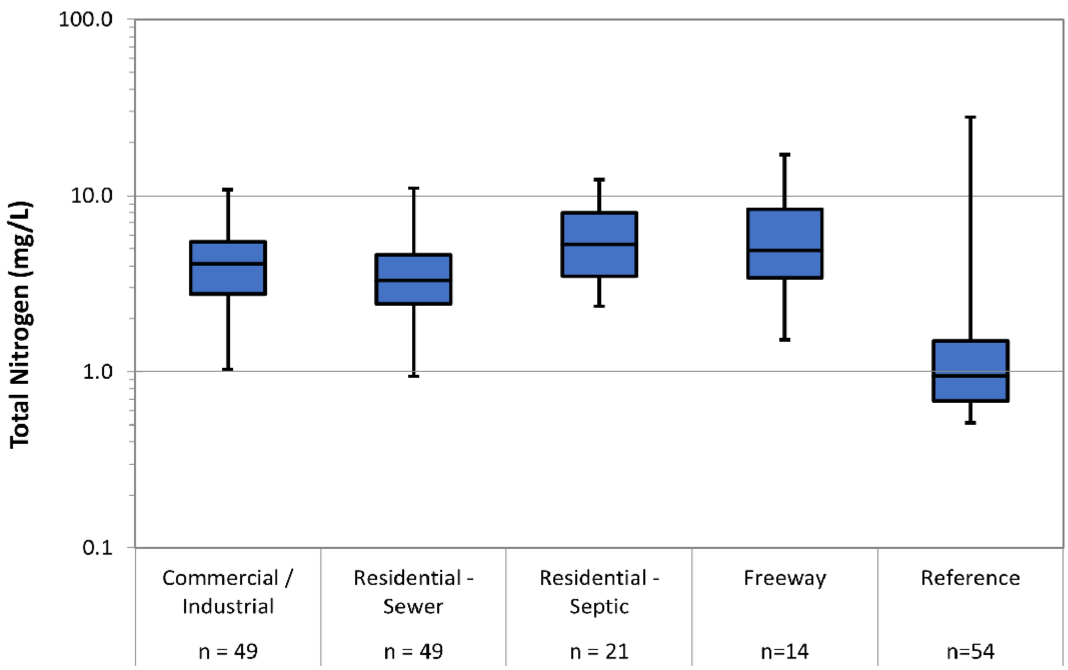

Figure 4-17. Box/Whisker Plots of Wet Weather Total Nitrogen from Land Use-specific Sites

Applying these land use specific washoff concentrations to average annual runoff (see Section 4.1.2 above) provides an estimate of nutrient washoff for all modeled HRUs (Appendix B). **Table 4-10** reports nutrient washoff for jurisdictions to provide a baseline for comparison with allocations (see Tables 6-1 and 6-2) to compute load reductions (Table 6-3) based on long-term average annual rainfall (see **Table 4-2** above), the current (2022) land use distribution (see Table 4-6 above) and jurisdictional boundaries.

Nutrient loads to Lake Elsinore come from watershed runoff in Subwatershed Zone 1 (i.e., local Lake Elsinore watershed) and overflows from Canyon Lake from runoff above or below Mystic Lake. Each of these areas is discussed briefly below:

- *Nutrient load from Subwatershed Zone 1* - This load is estimated using factors developed in the calibrated watershed model. No channel bottom recharge or other losses are simulated between the drainage areas and lake inflows.
- *Mystic Lake Overflow to Lake Elsinore* – About 96 percent of nutrient washoff from jurisdictions in Subwatershed Zones 7-9, upstream of Mystic Lake, is retained within Lake Hemet, spreading basins, or Mystic Lake. Infrequent overflows from Mystic Lake occur during extreme wet periods (most recently occurring in 1998) when runoff volumes flowing through Canyon Lake from the upper watershed exceed the storage capacity of Canyon Lake by 5-10 times. Thus, it may be assumed that nutrient loads from Mystic Lake overflows are delivered entirely to Lake Elsinore, passing through Canyon Lake with negligible retention.
- *Canyon Lake Overflow to Lake Elsinore When Mystic Lake is Not Overflowing* – Nutrient loads originating in Subwatershed Zones 2-6 that are ultimately transferred from Canyon Lake to Lake Elsinore in overflows are not shown in **Table 4-10** above. The linkage analysis for this TMDL revision did not explicitly simulate pass through from Canyon Lake to Lake Elsinore. Instead, flow gauge records and co-located watershed monitoring provides data to compute mass emission in the overflow for the past 20 years (see **Figure 4-1** for flow and **Figures 4-13** and **4-14** for TP and TN load, respectively). If, in the future, measured data show exceedances of the load allocation for overflows from Canyon Lake to Lake Elsinore, a formula for estimating offsets needed in Lake Elsinore by individual jurisdictions is provided in Section 7.2.5.4.

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 2000-2022 allows for comparison of modeled to measured loads (**Figure 4-18**). Ungauged subareas that are downstream of the monitoring sites and drain directly to the shoreline of Canyon Lake (see **Figure 4-11** above) as well as all model subareas upstream of Mystic Lake (no overflows occurred in 2006-2022 period) are excluded from these calibration outputs.

Table 4-10. Baseline Nutrient Watershed Runoff Loads at Jurisdictional Boundaries

Responsible Agency or Jurisdiction	Local Lake Elsinore Watershed (Zone 1)[1]		Canyon Lake Watershed (Zones 2 6)[1]		Mystic Lake Watershed (Zones 7 9)[1,2]	
	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)
Banning	0	0	0	0	20	89
Beaumont	0	0	0	0	184	739
CAF[3]	0	0	10	15	31	47
Caltrans	14	104	69	489	53	240
City of Canyon Lake	15	67	102	490	0	0
Federal – DOD	0	0	78	516	0	0
Hemet	0	0	720	2,590	307	1,222
City of Lake Elsinore	441	1,654	77	290	0	0
March Joint Powers Authority	0	0	76	329	0	0
Menifee	7	23	1,220	4,519	0	0
Moreno Valley	0	0	1,326	5,685	19	47
Murrieta	0	0	25	99	0	0
Perris	0	0	972	2,952	0	0
City of Riverside	0	0	38	143	0	0
Riverside County	151	551	3,037	8,134	2,404	6,641
San Jacinto	0	0	3	14	571	2,110
Wildomar	137	523	0	0	0	0
Agriculture: Irrigated	0	0	352	331	347	306
Agriculture: Non-irrigated	0	0	463	590	293	373
California DFW	0	0	48	138	197	559
Federal – BLM	0	0	44	114	193	554
Federal – National Forest	64	184	5	13	2,002	5,742
Federal – Native American Land	0	0	0	0	136	335
Federal – Wilderness	0	0	0	0	389	1,120
State Land	0	0	47	122	160	456
Western Riverside County Regional Conservation Authority	0	0	19	55	43	82
Baseline Watershed Load	**828**	**3,107**	**8,729**	**27,628**	**7,331**	**20,573**

[1] Washoff load for open space and forest lands estimated using 50th percentile of Cranston Guard Station shown in Table 4-7 above. For estimation of load reduction to meet final allocations at the 25th percentile of Cranston Guard Station, these baseline loads were necessarily adjusted for open space and forest to coincide with the 25th percentile washoff concentrations of 0.16 mg/L TP and 0.68 mg/L TN.

[2] Loads are total delivered to Mystic Lake from the Subwatershed Zones 7-9 that are assumed to entirely pass through Canyon Lake to Lake Elsinore during storm events that cause a Mystic Lake overflow

[3] If the Santa Ana Water Board determines at any time during Phase II or Phase III that any facilities regulated in Order R8-2018-0001 as CAFOs (as defined in 40 CFR 122.23(b)(2)) should instead be regulated as nonpoint sources, the wasteload allocation for such facilities shall be deemed a load allocation and shall continue to apply.

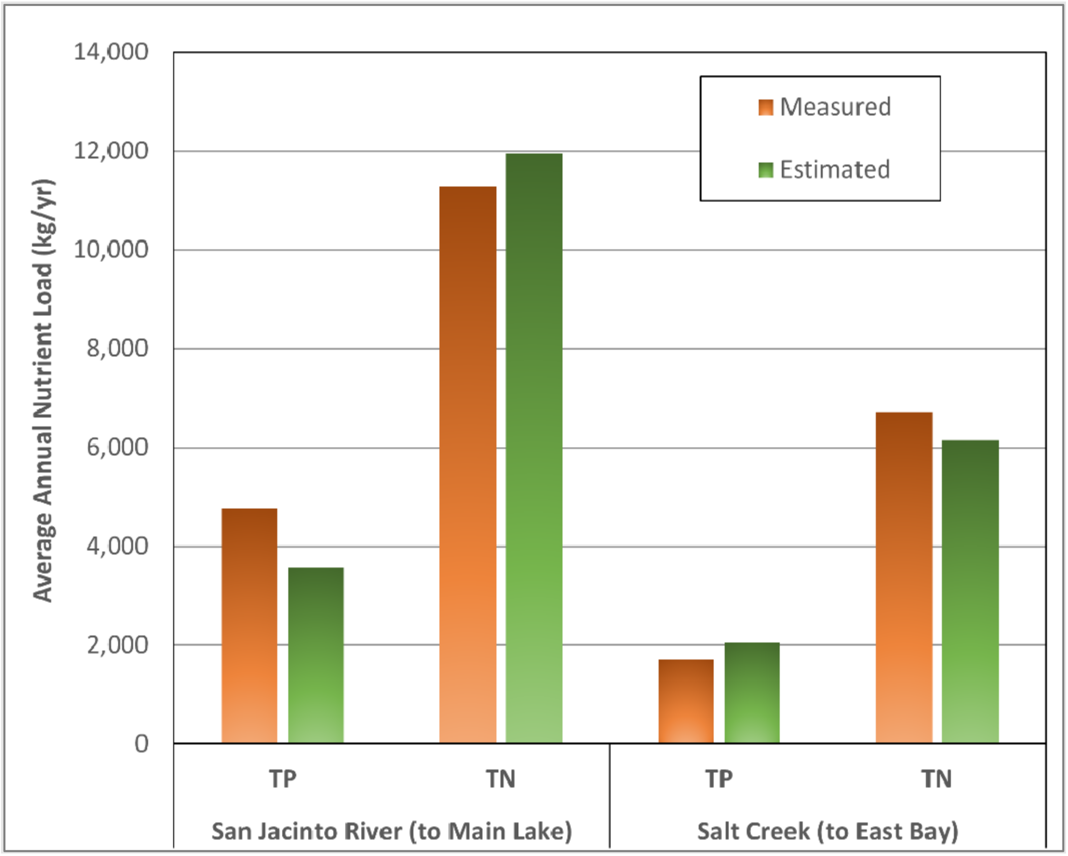

Figure 4-18. Comparison of Measured and Estimated Average Annual Nutrient Loads (2000-2022) to Monitoring Sites for San Jacinto River at Goetz Road and Salt Creek at Murrieta Road

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 (REs for TP and TN to San Jacinto River of -25 percent and +6 percent, respectively; TP and TN to Salt Creek of +19 percent and -9 percent, respectively).

Table 4-11 provides the results for nutrient loads delivered to the lakes based on long-term average annual rainfall (1948-2022) and accounting for all model HRUs. These results include runoff from ungauged subareas, offsite runoff from CAFs, 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.

Figures 4-19 and 4-20 summarize nutrient loading to the lakes from watershed runoff by subwatershed zone and by general land use category, 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.

Table 4-11. Model Results for Average 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)[1]	6,363	4,710	15,891
Canyon Lake East Bay (Zones 3, 4)[1]	3,273	2,650	7,974
Mystic Lake Overflow (Zones 7, 8, 9)[2]	237	289	811
Local Lake Elsinore (Zone 1)[1]	1,578	828	3,107
Canyon Lake Overflow to Lake Elsinore (Zones 2-6)[3]	6,259	3,620	14,701

[1] Basis of runoff volume from average annual rainfall over 1948-2022

[2] See Section 4.1.2.5 above for basis

[3] Not modeled results, basis is the period of record for mass emission sampling (2000-2022)

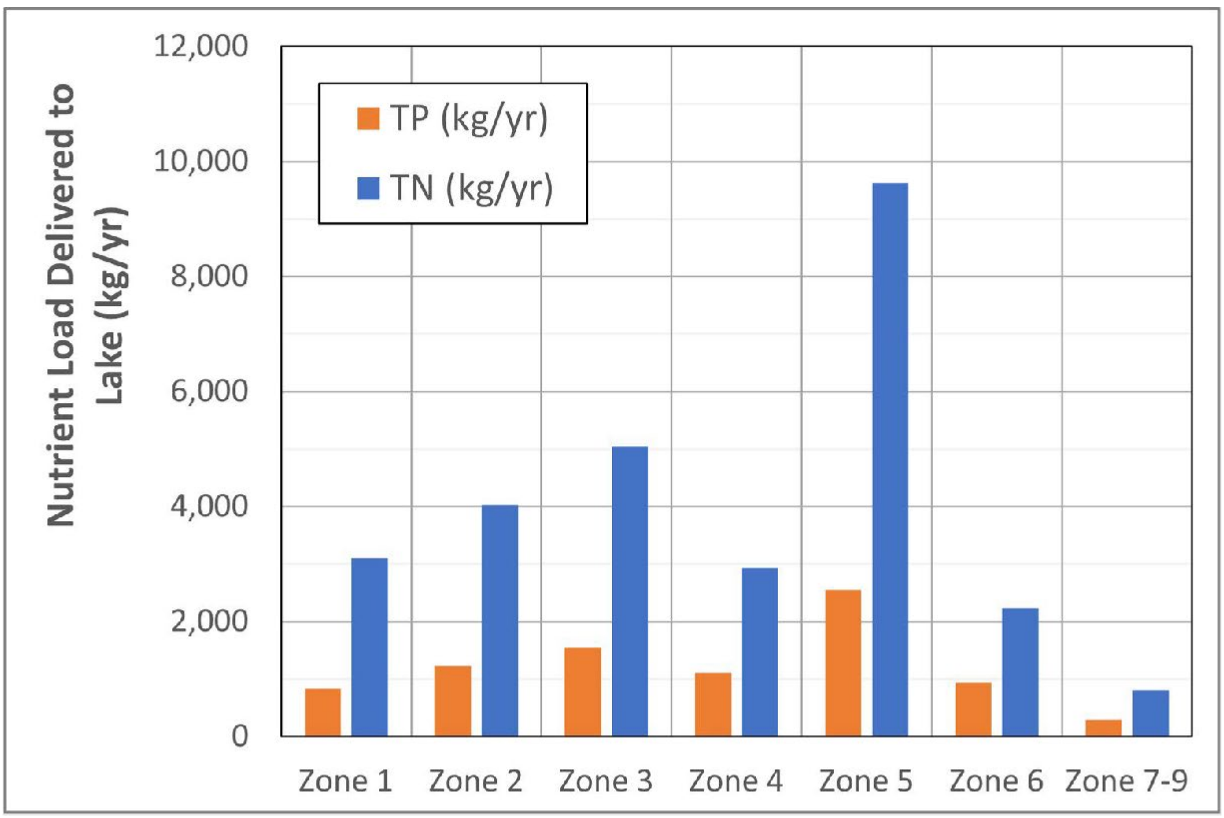

Figure 4-19. Annual Nutrient Loading to Lakes by Subwatershed Zone (Includes overflows from Subwatershed Zones 7-9; Zone 1 delivers load to Lake Elsinore; Zones 2, 5, and 6 deliver loads to Canyon Lake Main Lake; Zones 3 and 4 deliver loads to Canyon Lake East Bay

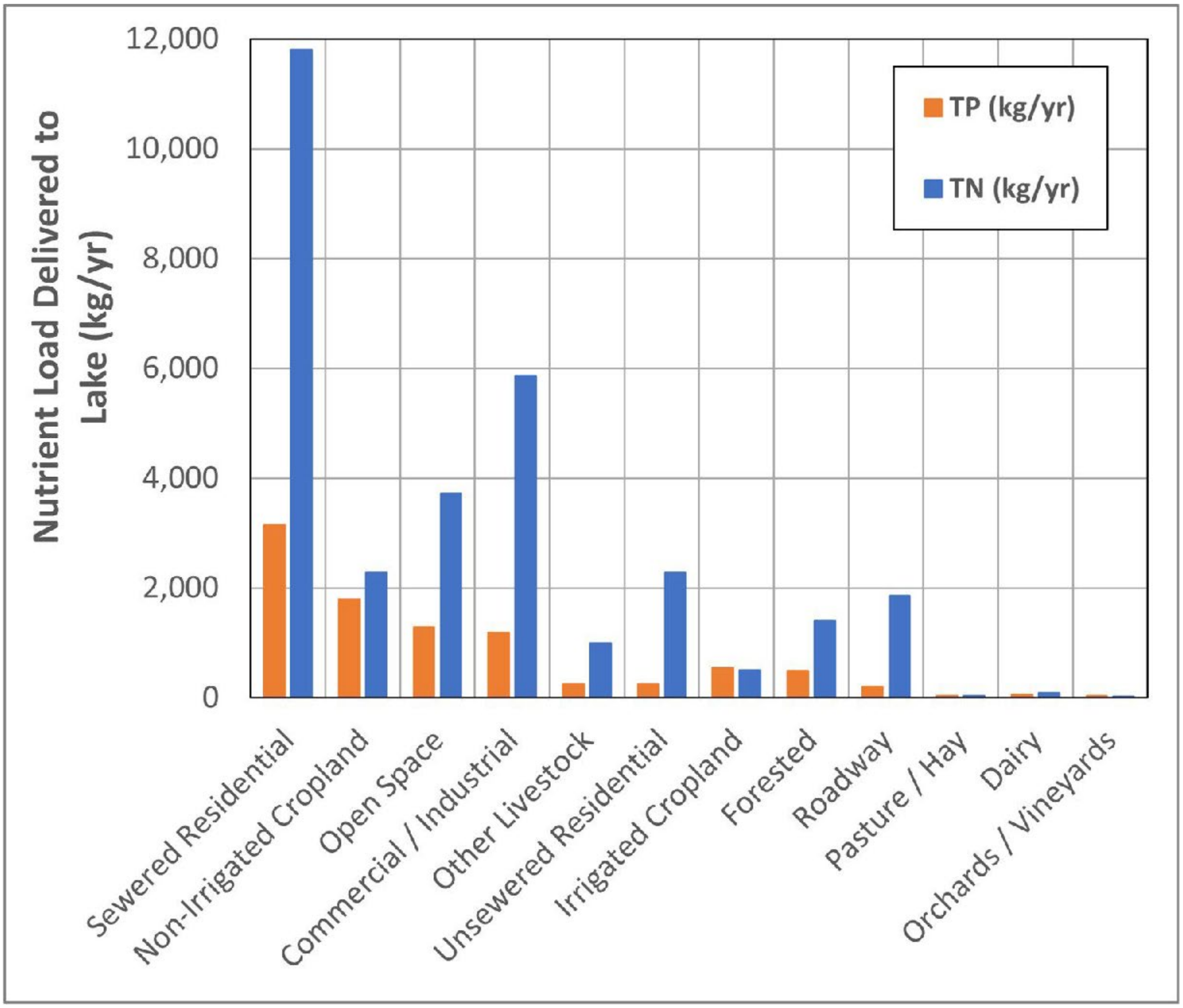

Figure 4-20. Annual Nutrient Loading to Canyon Lake (Main Lake and East Bay Segments) by General Land Use Category

Land use categories with the greatest acreage in the watershed were the largest source of nutrient loading to the lakes. This includes residential – sewered and commercial / industrial categories as well as forest and open space model subareas. Acreage of agricultural land uses in the San Jacinto River watershed have declined since the existing TMDLs were developed. The acreage of agricultural land use in the watershed is expected to continue to decline as land use in the watershed changes to more urban uses. 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 below allocations in the 2004 TMDLs.

4.2 Supplemental Water

An additional source of volume and nutrient load exists for Lake Elsinore in the form of recycled water from EVMWD's Regional Water Reclamation Facility (RWRF). Since 2008, EVMWD has added recycled wastewater to Lake Elsinore for lake level stabilization. A deeper lake provides multiple benefits including enhanced aesthetics, support for recreational uses and greater storage volume which results in more dilution and mixing of internal and external nutrient loads to the water column.

EVMWD's NPDES permit (Santa Ana Water Board 2013b) for the RWRF discharge to Lake Elsinore includes requirements for nutrient loads to the lake as follows:

- *Total Nitrogen* – Twelve-month running average TN concentration shall not exceed 1 mg/L, and the five-year running average mass of TN discharged to the lake shall not exceed 16,372 lbs/yr (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 five-year running average mass limit for TP discharged to the Lake shall not exceed 8,186 lbs/yr (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 TP limits.

Table 4-12 summarizes the annual volumes of recycled water discharged and estimated TP and TN loads. The estimated load is based on monthly measured nutrient concentrations and monthly metered volume added to the lake. EVMWD plans to increase discharged volume from current levels (~5.5 million gallons/day [mgd]) to 7.5 mgd with population growth in the service area prior to 2030. Thus, nutrient loads are anticipated to increase to about 5,500 k/yr TP and 49,900 kg/yr TN. Currently, EVMWD uses phosphorus and 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 recycled water to maintain lake levels is the largest source of new external nutrient loads to Lake Elsinore.

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 the lake water quality model used in the linkage analysis 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.

Table 4-12. Volume and Estimated Nutrient Load in Supplemental Water Additions to Lake Elsinore

Year[1]	Recycled Water (AFY)	Island Wells (AFY)	Total Supplemental Volume (AFY)	Estimated TP Load (kg/yr)	Estimated TN Load (kg/yr)
2007	2,361	0	2,361	1,732	14,027
2008	5,365	359	5,724	4,200	34,006
2009	5,470	404	5,874	4,310	34,898
2010	6,039	385	6,424	4,713	38,165
2011	1,920	6	1,926	1,413	11,442
2012	5,499	295	5,794	4,251	34,422
2013	5,843	264	6,107	1,761	20,024
2014	5,778	298	6,076	2,736	17,507
2015	5,380	50	5,430	2,465	25,573
2016	5,075	90	5,165	4,102	28,730
2017	5,677	175	5,852	4,800	32,778
2018	5,457	106	5,562	6,016	34,575
2019	6,247	148	6,394	3,566	41,360
2020	6,020	331	6,352	6,557	41,261
2021	5,911	264	6,175	5,211	25,360
2022	5,980	0	5,980	1,783	49,053
2013-2022 Average	**5,251**	**212**	**5,450**	**3,900**	**31,622**

[1] Population growth and expansion of the recycled water discharge to Lake Elsinore is anticipated to increase to 7.5 mgd or approximately 8,400 AFY within the Phase II Implementation Plan (effective date of the revised TMDLs plus 20 years)

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 forms, phosphate for P and ammonium for NH_4-N). 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 TMDLs, 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 TMDLs source assessment aggregated the results into lake-wide flux rates for winter (6.6 milligrams/square meter/day [mg/m^2/d] TP; 17.9 mg/m^2/d TN) and summer (8.4 mg/m^2/d TP; 71.0 mg/m^2/d 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 phosphate measured as phosphorus (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 4-13** provides the updated sediment nutrient flux data that provided the basis for revising the TMDLs.

Table 4-13. Average of Area-Weighted Summer Season Sediment Nutrient Flux from Core-Flux Studies in Lake Elsinore (2001, 2010) and Canyon Lake (2001, 2006, 2014)

Waterbody	SRP (mg/m^2/d)	NH_4 N (mg/m^2/d)
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 TMDLs Staff Report (Santa Ana Water Board 2004b); range from samples collected August 2001 and August 2010 (Anderson 2010)

[2] See Anderson 2016e

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 areas 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. 2022). A key variable in the linkage analysis models is the nutrient flux rate, which was set to coincide with the ranges reported above in **Table 4-13**.

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 $mg/m^2/d$ 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 (ha) 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 $mg/m^2/d$ was estimated.[19] 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 $mg/m^2/d$.[20] These rates were added to estimates from **Table 4-13** above to serve as the baseline nutrient flux rate parameters for GLM and AEM3D, inclusive of releases from physical resuspension as well as diffusive flux described in the Section 4.3.1 above.

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

[20] 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

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 4-21** shows the modeled annual internal nutrient load from lake bottom sediment in Lake Elsinore for current and reference watershed conditions over the period from 2001-2020. **Table 4-14** provides the long-term annual average internal sediment nutrient load for current and reference model scenarios for both TP and TN. The nutrient flux for the reference watershed conditions (based on interim and final milestones) may be expected to occur sometime into the future after external loads are reduced. For Canyon Lake, a shorter simulation period was evaluated (see 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 2007-2011 (**Figure 4-22**). These results are reported above as average annual loads in **Table 4-12**.

When employing a reference watershed approach for the TMDL revisions, 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 7.1.2), and these may partially address the legacy sediment enrichment.

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 of years ago prior to Railroad Canyon Dam construction and land development, when periodic lakebed desiccation facilitated export of bottom sediments in the form of dust. 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 nutrient 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:

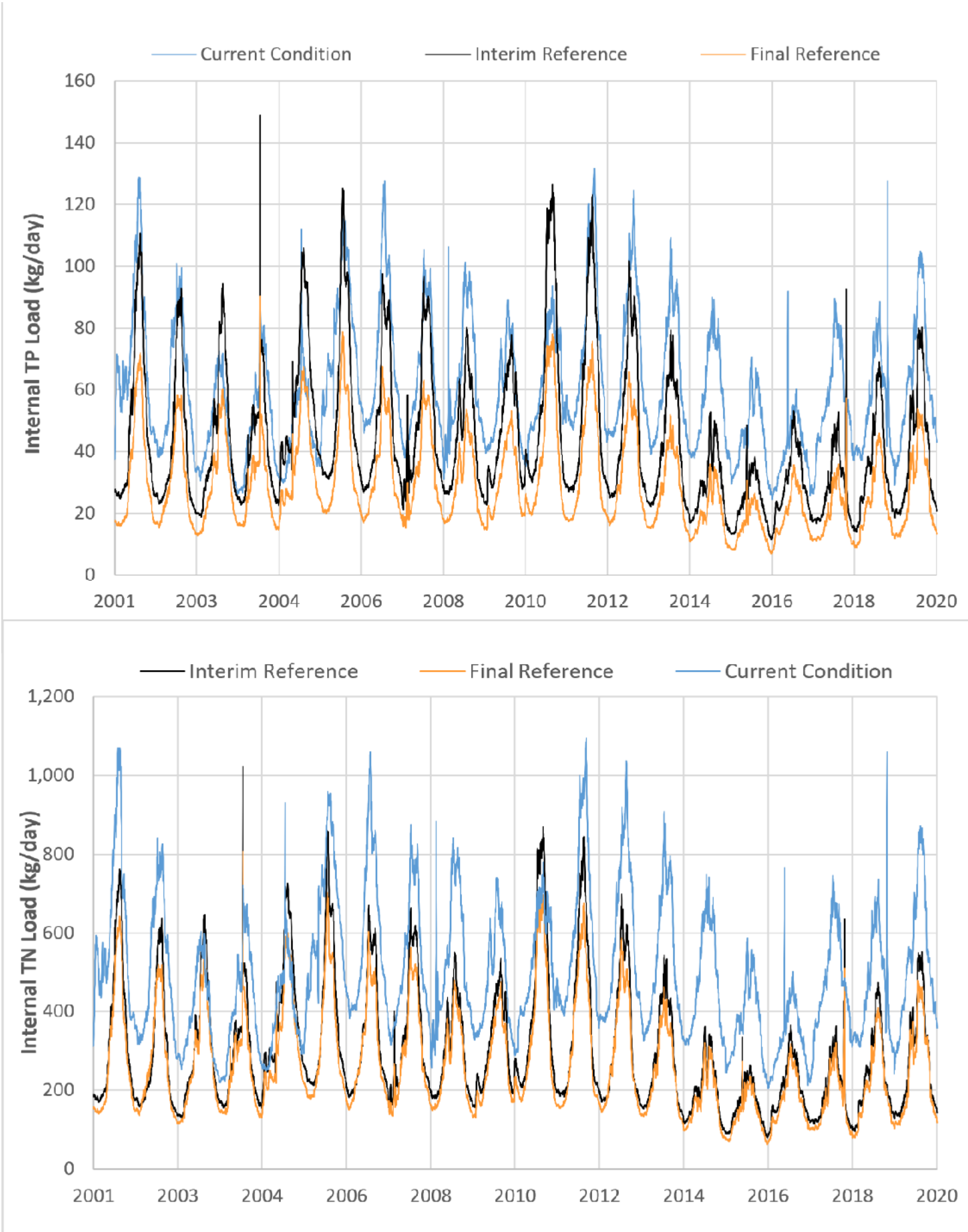

Figure 4-21. Modeled Flux (kg/day) of PO_4-P (upper) and NH_4-N (lower) from Lake Elsinore Bottom Sediment to Overlying Water Column for Current and Reference Scenarios

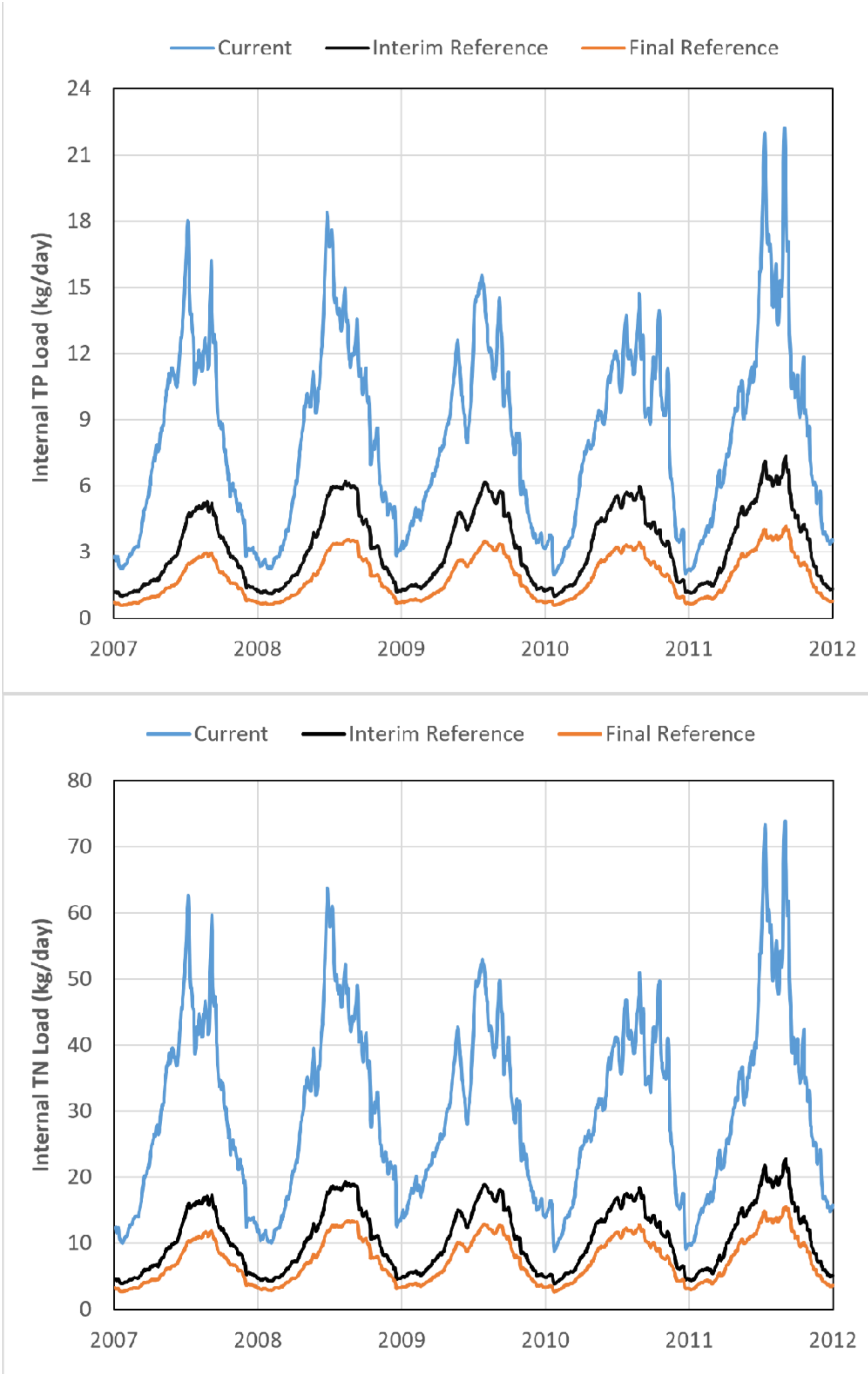

Figure 4-22. Modeled Flux (kg/day) of PO_4-P (Upper) and NH_4-N (Lower) from Canyon Lake Bottom Sediment to Overlying Water Column for Current and Reference Scenarios

Table 4-14. GLM and AEM3D Estimates of Average Annual Nutrient Loads from Lake Bottom Sediments in Lake Elsinore and Canyon Lake for Reference and Current Watershed Loading Scenarios

Lake	Current		Interim Reference		Final Reference	
	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)
Lake Elsinore (2001-2020)	22,103	183,777	15,227	104,559	10,221	91,232
Canyon Lake (2007-2011)	2,997	11,023	1,190	3,955	683	2,741

- Kirby et al. (2005) evaluated the paleolimnology of Lake Elsinore through the collection and dating of 10-m 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 years ago). Results showed an enrichment in organic phosphorus (OP) and a proxy for nitrogen of ~50 percent (**Figure 4-23**).
- 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.[21] Specifically, the linkage analysis model parameter for sediment nutrient flux rate was adjusted to half of current levels when developing TMDL numeric targets based on a reference watershed condition. Modeled annual load from lake bottom sediments under a reference watershed condition is reported in **Table 4-14** above.

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 TMDLs (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 TMDLs but ensures a consistent method for TP and TN is applied to each lake.

[21] This approach involving estimation of different sediment flux parameters for current and reference conditions is necessary because the version of GLM and AEM3D used in the TMDL revision does not allow for a dynamic simulation of sediment diagenesis.

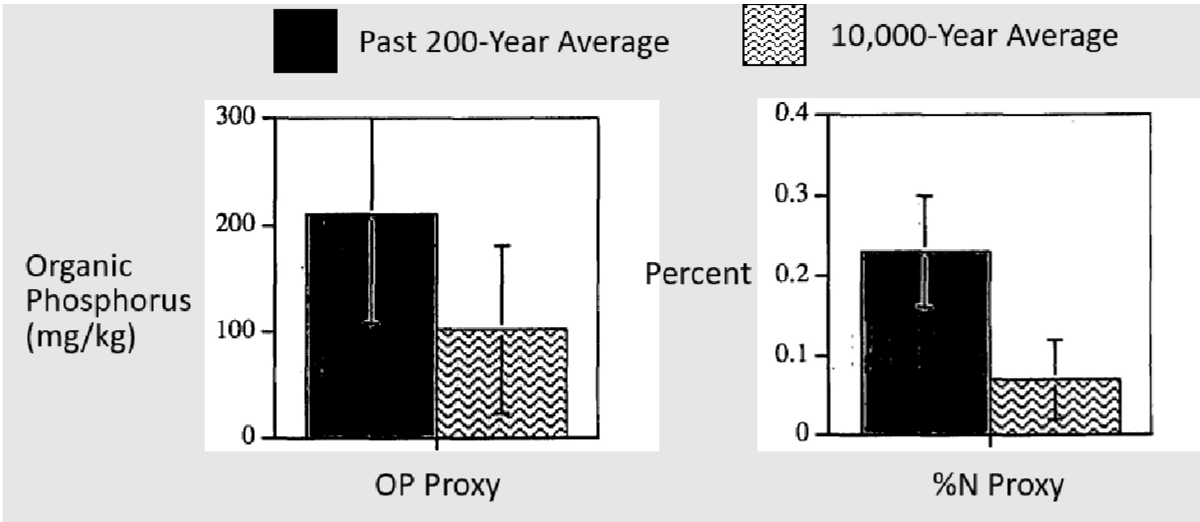

Figure 4-23. Paleolimnology Indicators of Nutrient Enrichment in Lake Elsinore Bottom Sediment Comparing Modern Era (dark grey) to Pre-Historic Era (hatch) Deposits (from Kirby et al. 2005)

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 4-15.**

Table 4-15. Estimated Nutrient Loads from Atmospheric Deposition onto the Surface of Lake Elsinore and Canyon Lake

Lake	Estimated TP Load (kg/yr)	Estimated TN Load (kg/yr)
Canyon Lake	22	1,406
Lake Elsinore	156	9,682

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 TMDLs used a value of 7.1 lbs/ac/yr (3.2 kg/ac/yr). No significant changes to atmospheric N deposition are expected nor are there any new regional data, therefore the same rates will be used in the revisions to the TMDLs. **Table 4-15** above shows the load allocation for TN in each lake.

4.4 Summary of Nutrient Sources

The above source assessment describes the key sources of nutrients to each of the lakes and quantifies long-term average loading. **Table 4-16** 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 (**Figure 4-24**) and Canyon Lake (**Figure 4-25**). 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 to meet allocations. These allocations are developed in Section 6.

Table 4-16. Summary of Nutrient Loads from All General Source Categories

General Source Category	Canyon Lake		Lake Elsinore	
	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)
Watershed Runoff[1]	7,360	23,864	828	3,107
Canyon Lake Overflows from Above Mystic Lake [2]	n/a	n/a	289	811
Canyon Lake Overflows from Below Mystic Lake [3]	- 2,532	-10,542	2,532	10,542
Sediment Nutrient Flux	2,997	11,023	22,103	183,777
Atmospheric Deposition	23	1,406	156	9,682
Supplemental Water	n/a	n/a	3,900	31,622
Total Average Annual Loading	**7,848**	**25,751**	**29,808**	**239,541**

[1] Estimated runoff from Subwatershed Zones 2-6 at Canyon Lake inflows, local Lake Elsinore Subwatershed Zone 1 direct inflow for average annual rainfall (1948-2022)

[2] Includes all modeled load from Subwatershed Zones 7-9 that is estimated to overflow from Mystic Lake and pass through Canyon Lake with negligible retention

[3] Measured nutrient loads in overflows from Canyon Lake to Lake Elsinore (2006-2022). Shown as reduction from Canyon Lake total net load and addition to Lake Elsinore

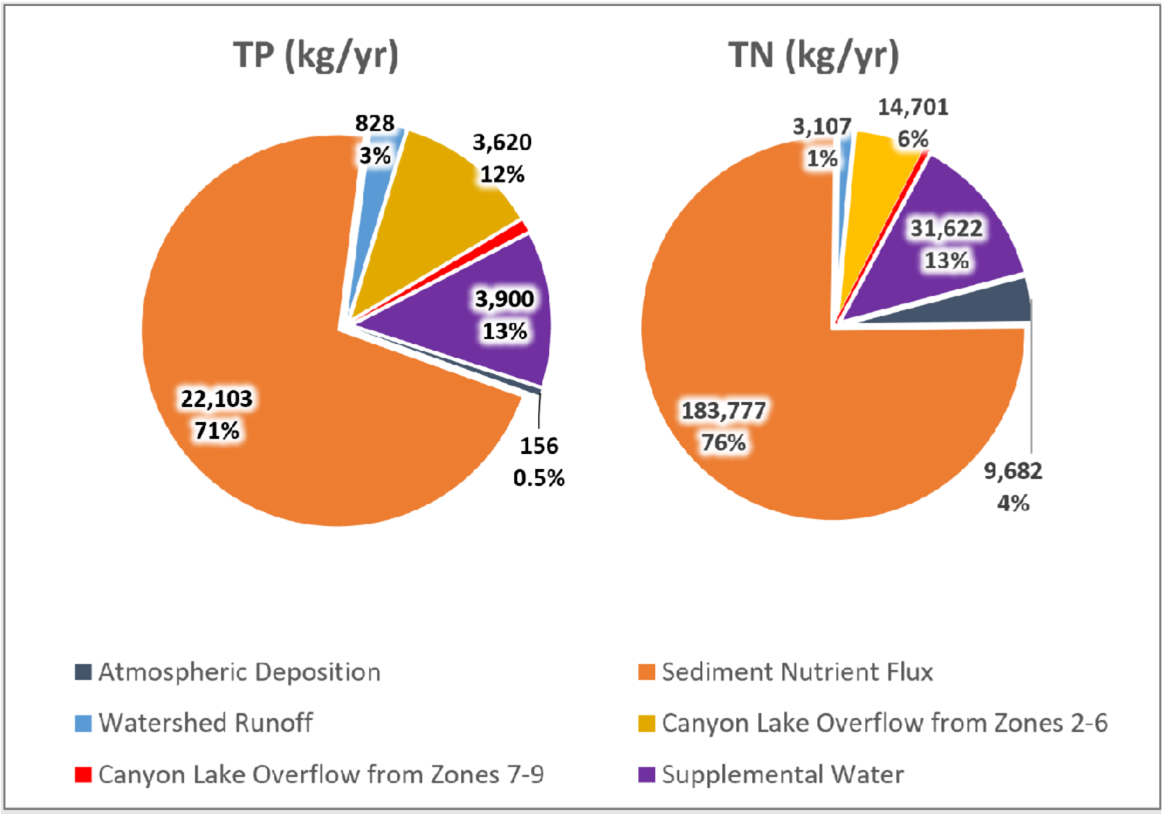

Figure 4-24. Relative Contribution of General Source Categories for Lake Elsinore Long-term Average Annual Nutrient Budget

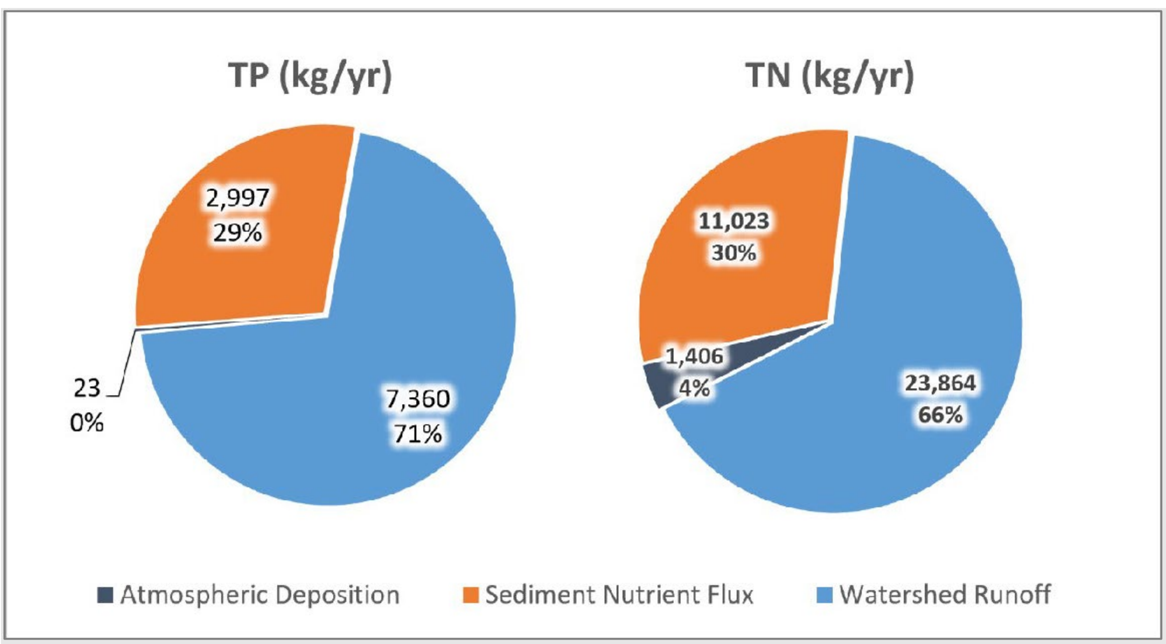

Figure 4-25. Relative Contribution of General Source Categories for Canyon Lake Long-term Average Annual Nutrient Budget

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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 AEM3D to simulate biogeochemical processes in Canyon Lake and GLM-AED2 to simulate biogeochemical processes in Lake Elsinore 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 recycled water has been added to maintain water levels (see Section 2.2.2.3). The smaller lake surface area is a baseline assumption in the creation of lake water quality models for the reference condition. Conversely, the addition of recycled water is not assumed as an element of the linkage analysis for 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 may also be used for implementation to test the water quality benefits that may be achieved with existing and potential supplemental watershed BMPs and lake management scenarios. The only physical structures included in the reference condition linkage analysis are (see Section 2.2.2.3): (1) Railroad Canyon Dam, because Canyon Lake would not exist without its presence; and (2) the levee and lower outfall elevation associated with the LEMP project. 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 may be used to support implementation by testing 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 the unique conditions associated with Lake Elsinore and Canyon Lake resulting from a highly variable climate regime characterized by long periods of extended drought punctuated by periodic extreme wet weather events. 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.

The physics-based 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.

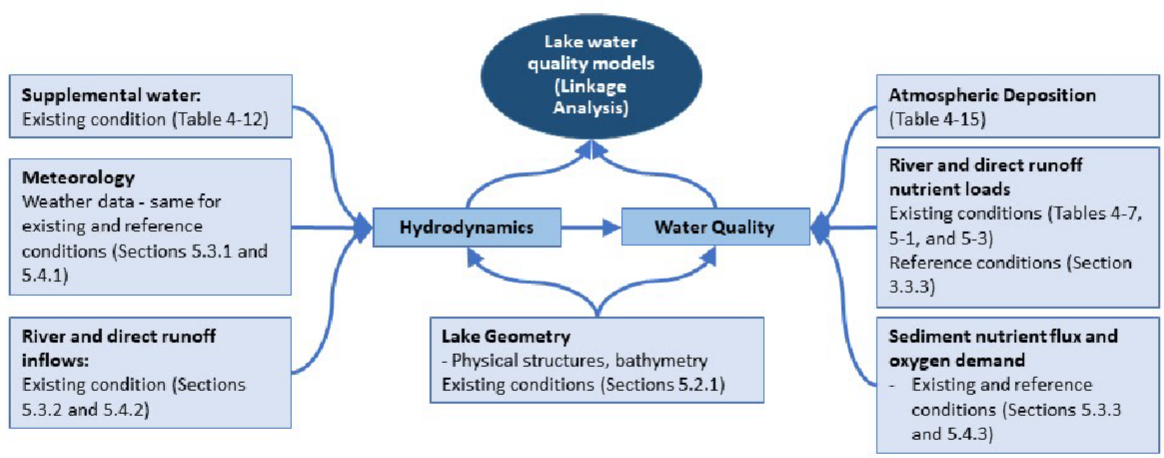

Figure 5-1. Document Location for Key Input Data and Boundary Conditions for Linkage Analysis

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), DELFT3D, DYRESM-CAEDYM, ELCOM-CAEDYM, GLM-AED2 and AEM3D. 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 zero dimensional (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 (e.g., photosynthesis by algae in the water column) 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 manganese (II) (Mn^{2+}), iron (II) (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 GLM 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, two dimensional (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. Given the horizontal and vertical complexity of Canyon Lake, a 3-D model was selected for use to capture key processes of physical transport and vertical nutrient fluxes and allow for outputs that quantify the spatial and temporal variability in water quality associated with a reference condition.

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 msl) that, including the channelized part of the lake linking it to the San Jacinto River, possesses a simple geometry (13.5 miles of shoreline, shoreline development number[22], D_L of 3.5, indicating the complexity of the shoreline - a high development number is representative of lakes with a more complex shoreline). The lake bottom is at ~1,218 ft above msl and overflow spillway is at 1,255 ft above msl. The relationship between depth and lake surface area is provided in **Figure 5-2**, where,

*Current and Reference Condition (with LEMP): Volume = (68.8 * LSE^2) – (167,152.51 * LSE) + 101,526,291*

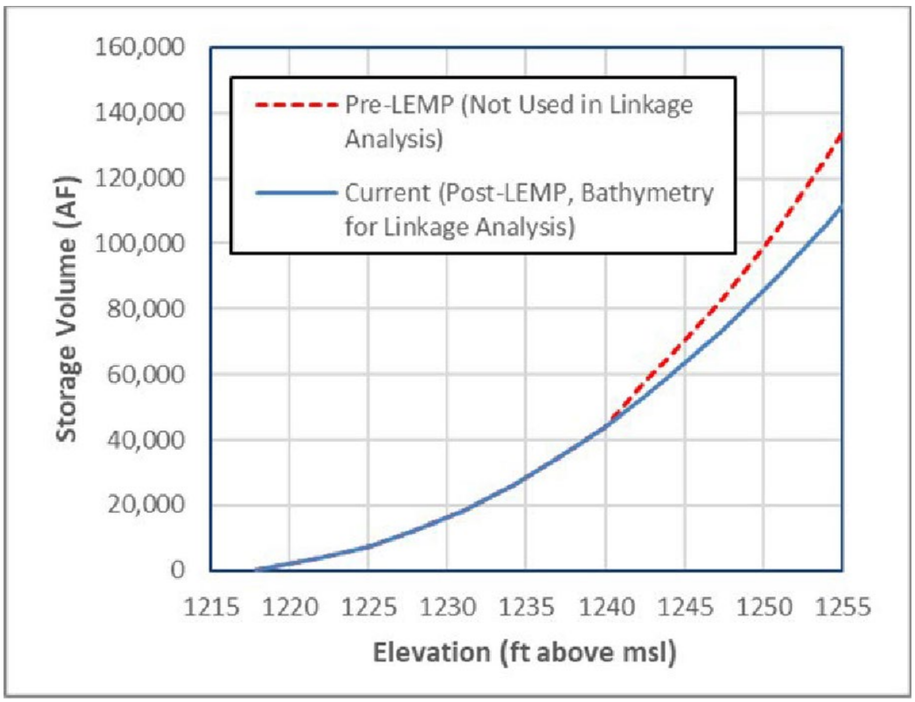

Figure 5-2. Lake Elsinore Elevation-Storage Volume Relationship for the Current Condition and Pre-LEMP Condition

The figure shows the impact that LEMP has on lake volume; at lake levels above 1,240 ft, storage volume increases significantly. LEMP is incorporated into both the calibration and reference scenario simulations.

As shown in lake monitoring reports (and summarized in Section 2.2.2.5),[23] variations in measurements of temperature, DO, and TDS generally demonstrate a vertical variation that

[22] Lakeshore length / circumference of a circle within the lakes area

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

dominates lateral variation. Satellite imagery sometimes demonstrates lateral gradients in chlorophyll-*a* concentrations that result from the development and wind movement of algal blooms; however, averaging over several days typically damps out short-term variability in chlorophyll-*a* concentrations.

Lake Elsinore 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 the lake is characterized by vertical gradients and extreme response to decade-scale forcings, the 1-D GLM model for Lake Elsinore was adopted. GLM uses a Lagrangian approach in which the thickness of the vertical layer is calculated dynamically in response to inflows, outflows, mixing and surface mass fluxes (Hipsey et al. 2019).

5.2.1.2 Canyon Lake

The model AEM3D was adopted for use in Canyon Lake because of the lake's complex, sinuous morphology (D_L=13.5). Strong gradients in lake 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, as this was the longest timestamp that also met conditions for evaluating periods of high runoff into the boundary cells. 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 five-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, ~8,800 AF of storage at full capacity, 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). The lake bottom is at ~1,323 ft above msl and overflow spillway is at 1,381.76 ft above msl. Lake bathymetry and geometry suggest that strong gradients in lake properties may exist in both vertical and lateral dimensions, thus a 3-D model was selected for the linkage analysis (**Figure 5-3**).

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**.

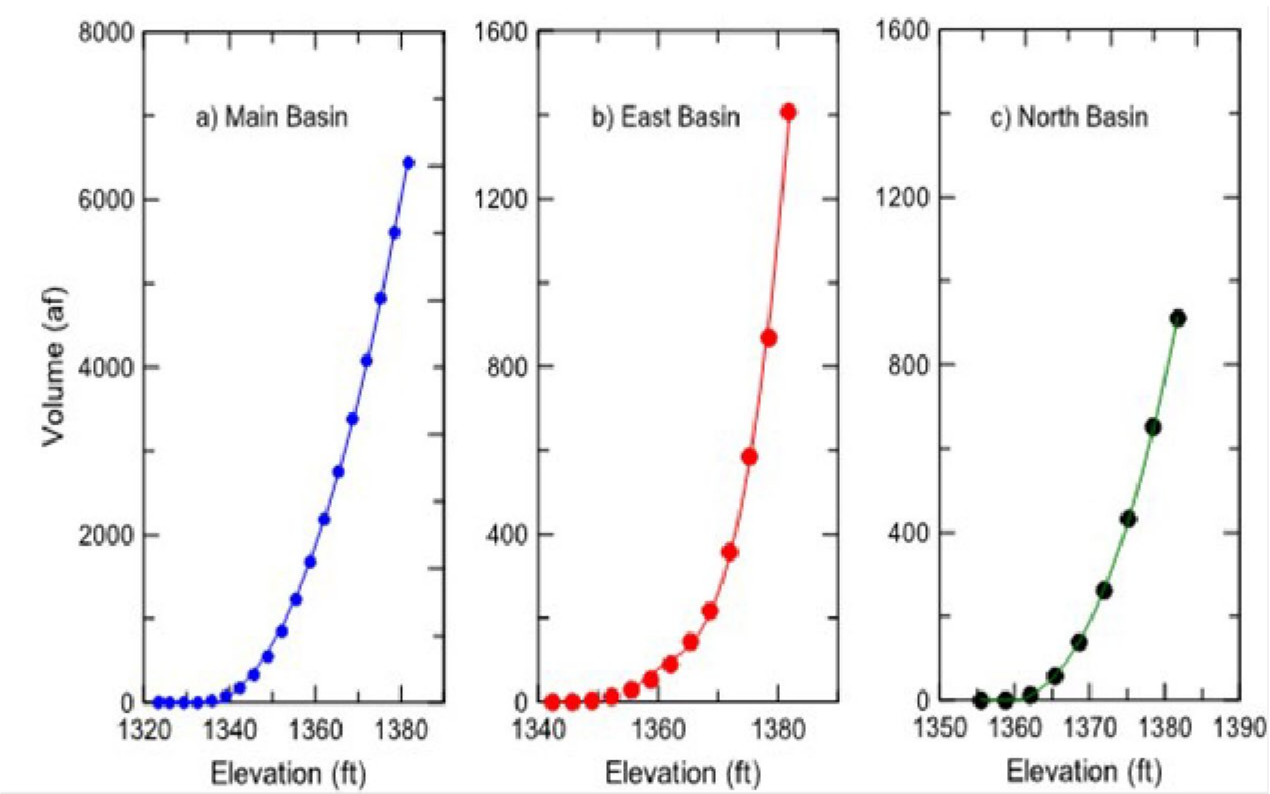

Figure 5-3. Canyon Lake Elevation-Volume Relationship for (a) Main Basin (Main Lake), (b) East Basin (East Bay), and (c) North Basin (North Ski Area) (Note different scale for Main Basin figure versus figures for East and North Basins)

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 Hodges and Dallimore (2021).

For a linkage analysis to support the development of numeric targets, 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.

AEM3D and GLM include full eutrophication kinetics and can adequately represent water column water quality dynamics. Water quality in Canyon Lake was simulated using AEM3D. AEM3D's water quality and hydrodynamic models are seamlessly linked to each other. Similarly, AED2, which also includes full eutrophication kinetics, is used to simulate water quality in Lake Elsinore. AED2 is seamlessly linked with GLM.

5.3 Lake Elsinore Model Configuration, Calibration and Scenario Simulations

This section describes the Lake Elsinore model configuration for calibration, calibration results, configuration for the reference simulation, and reference simulation results. The Lake Elsinore model was calibrated to current conditions between 2000 and 2014, with extension of model-data comparison through 2020. Data available between 2000 and 2014 is primarily used for calibration efforts, and depth-integrated data available through 2020 is used to supplement the calibration. This long-term model calibration effort is focused on capturing long-term trends in nutrient and water quality indicators, rather than in capturing short-term phenomena.

The following subsections describe the meteorological, hydrologic, and water quality input data used to parameterize the GLM-AED2 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 (2000-2014) simulations used in calibration were modified to represent a reference condition for numeric target setting that account for long-term (1916-2020) lake water quality dynamics.

5.3.1 Meteorological Input Data

Meteorological inputs include the shortwave solar radiation, air temperature, relative humidity, precipitation 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 nanometers) (**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 (millimeters, mm) that also showed annual variability (**Figure 5-4c, d**).

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 recycled water from EVMWD and water pumped from island wells (see Section 4.2).[24] Lake outflows include evaporation and a lake outlet channel to downstream Temescal Creek.

[24] Supplemental water from EVMWD recycled water discharge and island well pumping were collectively represented as recycled water in the model

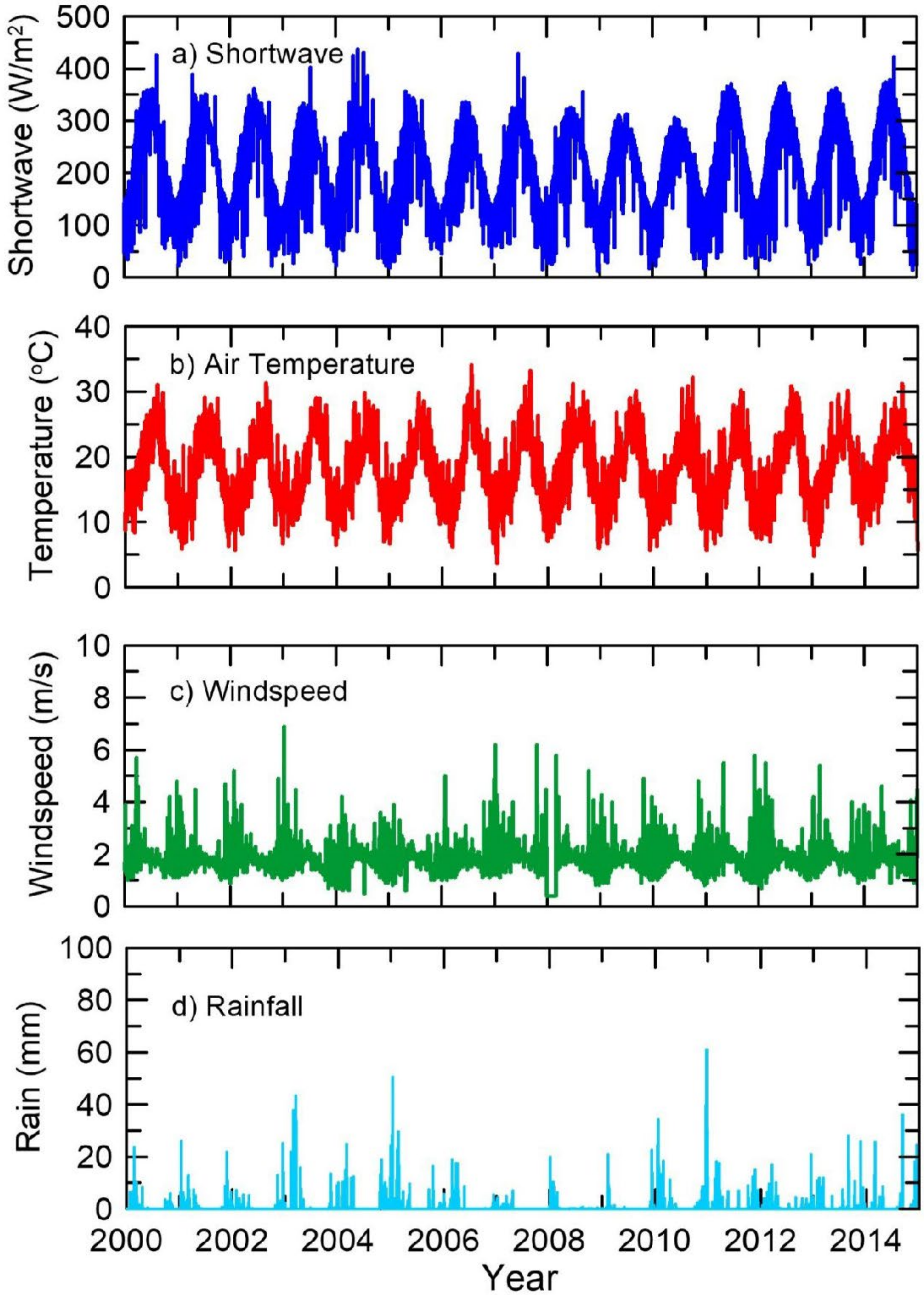

Figure 5-4. Daily Average (a) Shortwave Radiation, (b) Air Temperature, (c) Windspeed, and (d) Rainfall Used in Model Simulations for the Calibration Period 2000-2014

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 using water balance analysis (see Section 3.2.2.2). Recycled water discharge and island well pumping 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 AF. 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 recycled water inputs exceeded that of local runoff and contributed about 50,000 AF through 2014 (**Figure 5-6**), which has increased to 75,000 AF as of 2022. Based upon these values, a total of 187,926 AF of water was delivered to Lake Elsinore over the 2000-2014 calibration period, with approximately 53% derived from San Jacinto River flows, 20% from local runoff and 27% from recycled water.

For internal water quality processes, default water quality parameters were used in AED2 (Hipsey et al. 2022) except for key parameters for bioavailable nutrient (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 more than two thirds 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 parameterize sediment nutrient flux rates used by the model for standard temperature, DO, and pH conditions (see Section 4.3.1). The long-term average sediment nutrient flux rate is a constant input to GLM-AED2 for simulated nutrients for standard conditions. GLM-AED2 estimates a daily flux of dissolved nutrients relative to the constant flux parameter 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 grams/square meter/day ($g/m^2/d$) was used in the model calibration.

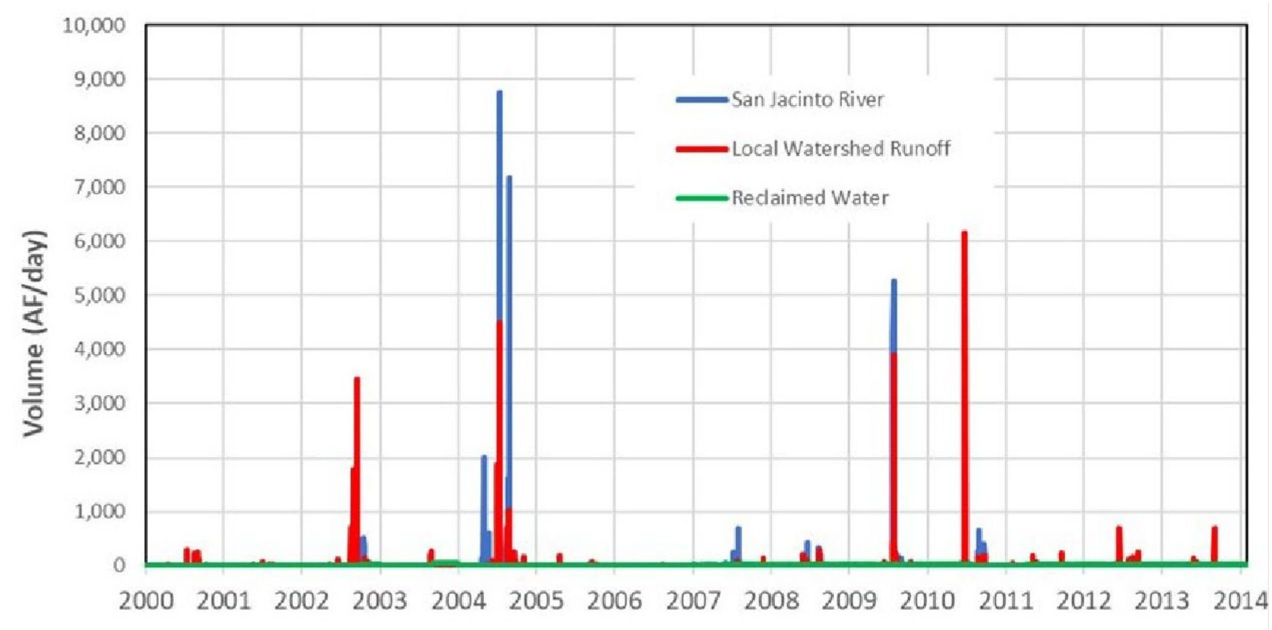

Figure 5-5. Inflows to Lake Elsinore for the Calibration Period 2000-2014

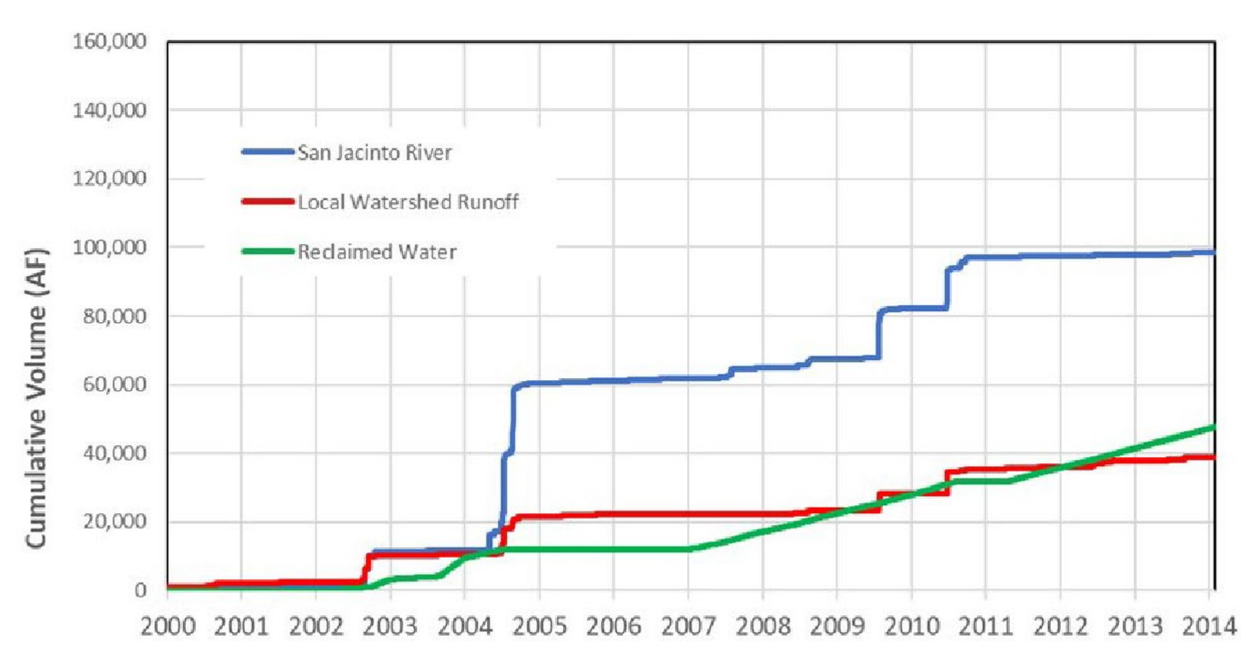

Figure 5-6. Cumulative Inflow to Lake Elsinore from the San Jacinto River, Local Runoff and Recycled Water for the Calibration Period 2000-2014

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 recycled 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 (see **Figure 5-5**) and nutrient concentrations (**Table 5-1**). A sharp drop in phosphorus concentrations in San Jacinto River inflows to Lake Elsinore from Canyon Lake was observed between 2000-2011 and 2017-2020 (no overflows from Canyon Lake occurred in four consecutive wet seasons 2011-12 through 2015-16). This drop may be largely attributable to alum additions within Canyon Lake that have reduced ambient TP levels in the lake throughout the year, including prior to storm events that cause overflows of Railroad Canyon Dam. These values are reflected in the table and were used in model parameterization during the respective time periods.

Table 5-1. Nutrient Concentrations (mg/L) of Inflows to Lake Elsinore Used in Model Simulations (based on data collected by the Annual Monitoring Program for runoff and EVMWD monitoring for recycled water discharge)

Source	PO_4 P	Total P	NH_4 N	NO_3 N	Total N
San Jacinto River	0.24 / 0.08 [3]	0.51 / 0.18 [3]	0.16 / 0.13 [3]	0.54 / 0.44 [3]	1.89 / 1.55 [3]
Local Runoff[1]	0.19	0.42	0.18	0.59	2.08
Recycled Water[2]	0.32	0.41	0.36	1.62	2.87

[1] Assumed concentration for local Lake Elsinore watershed inflows based on land use weighted average of EMCs (see Tables 4-8 and 4-9 above) for the land use distribution in Zone 1. Partitions in dissolved forms were assumed to be 46 percent for PO_4-P of TP and 29 percent NOx and 8 percent NH_4-N of TN based on fractionation in samples measured at the watershed mass emissions stations from 2001 through 2017.

[2] Recycled water concentrations for EVMWD 2007-present.

[3] Values for 2000-2013 and 2017-2020, respectively.

5.3.4 Model Calibration

The Lake Elsinore coupled GLM-AED2 model was calibrated primarily against available data at specific depths for 2000-2014 and was also validated using depth-integrated data collected between 2015 and 2020 for chlorophyll-*a*, TDS, TP and TN. This calibration period coincides with a period of routine flow gauging and watershed and lake water quality monitoring and predates significant deployment of watershed or in-lake nutrient controls. Model calibration was focused on assessing model-data agreement on a seasonal timescale for water quality parameters. The following sections provide a qualitative assessment of model performance and present results as graphical time series outputs. Quantitative performance metrics are reported in Section 5.3.5.

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 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 (see **Figure 5-5**). Simulated water surface elevations reflect all of these observed trends and also match closely in magnitude. Absolute model results generally match observations within approximately one foot over this extreme range for about 80 percent of the simulation days.

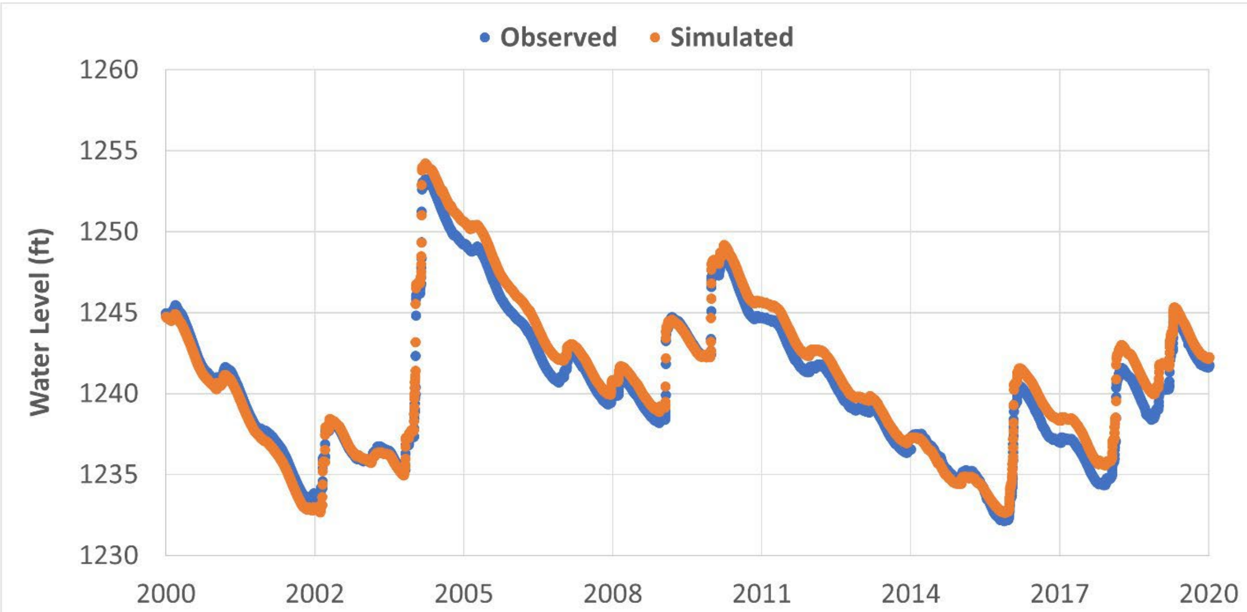

Figure 5-7. Simulated and Observed Lake Surface Elevation for Lake Elsinore for the Calibration Period 2000-2020

5.3.4.2 Salinity

Simulated salinity is calibrated using observed salinity measured at 2-m depth between 2000 and 2014, and also depth-integrated measurements between 2015 and 2020. Salinity in the lake varied from approximately 700 – 2,600 mg/L TDS between 2000 and 2014, with low concentrations following the very large runoff in winter 2005 (**Figure 5-8**). The model captures trends in TDS reasonably well, including the high TDS concentrations measured in late fall 2002 and the marked decline in TDS in 2005. Depth-integrated observations between 2015 and 2020 (**Figure 5-9**) indicate that the model also performed well in simulating the salt balance in the lake through 2020.

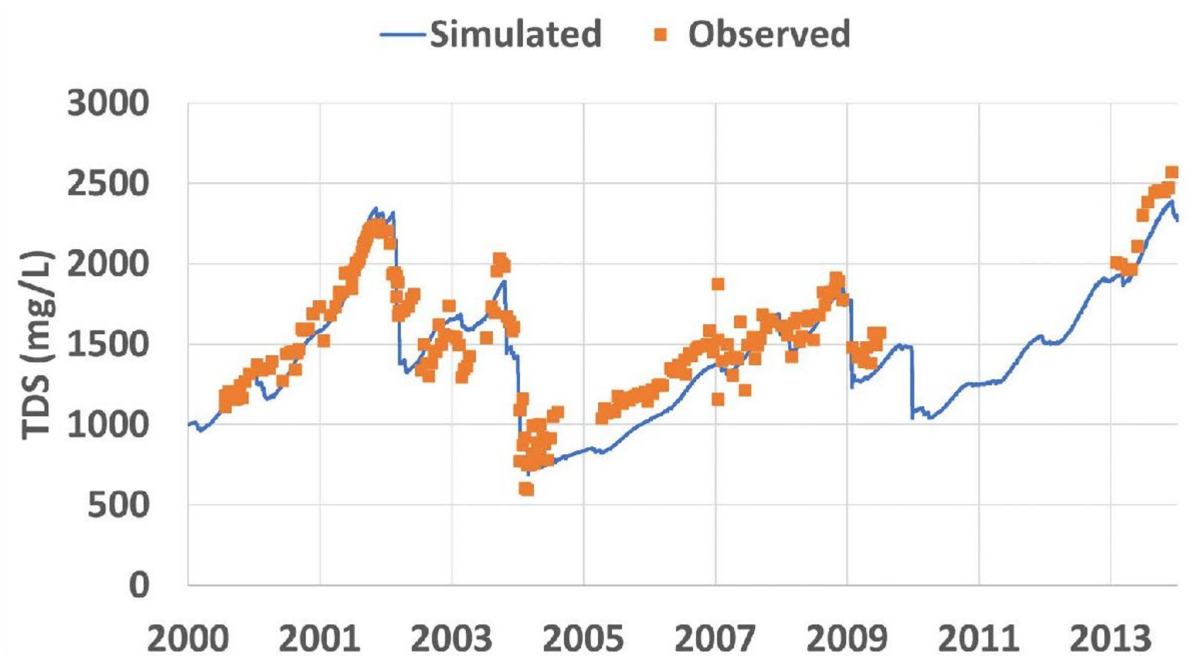

Figure 5-8. Simulated and Observed Near Surface TDS Concentrations for Lake Elsinore between 2000 and 2014

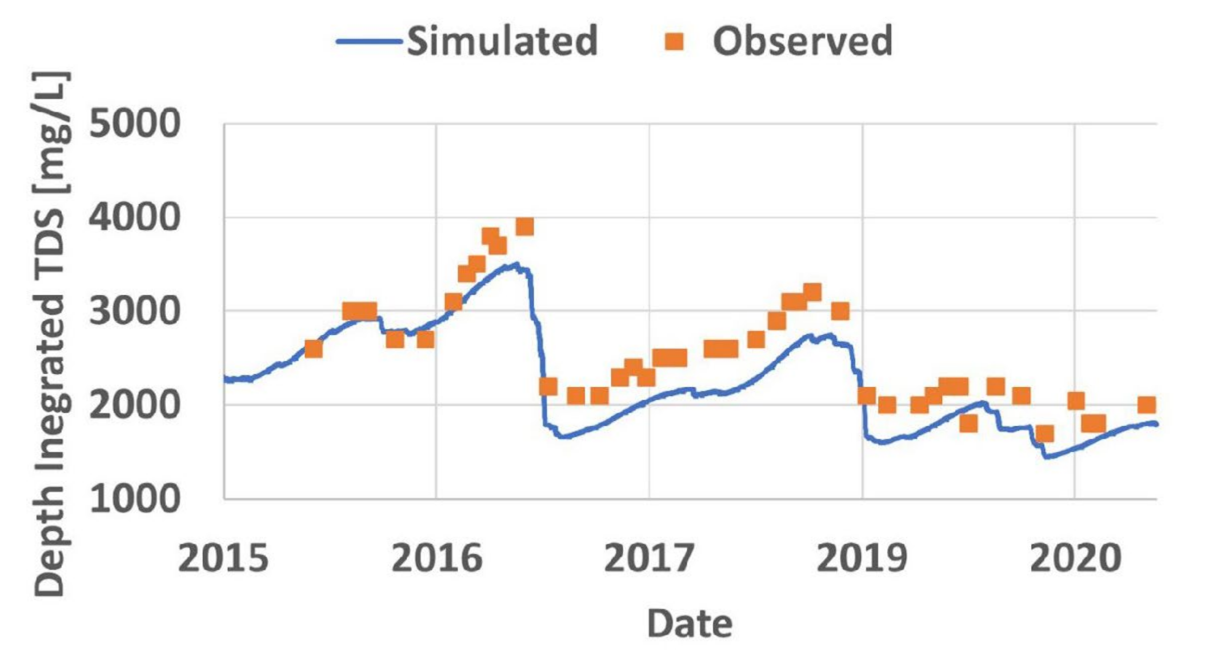

Figure 5-9. Simulated and Observed Depth Integrated TDS Concentrations for Lake Elsinore between 2015 and 2020

5.3.4.3 Temperature

The model reasonably captured measured temperature values in Lake Elsinore. **Figures 5-10 and 5-11** show model simulated-observation comparisons near the surface at 2-m depth and also at 6-m depth. 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.

5.3.4.4 Dissolved Oxygen

DO in the lake varied seasonally and with depth (**Figures 5-12** and **5-13**). The temperature effect on oxygen solubility was evident in model predictions for the 2-m depth, with DO values often above 10 mg/L in the winter and 6-7 mg/L in the summer. The model simulated 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.

5.3.4.5 Total Nitrogen

The model captures the large-scale trends in concentrations of TN in the lake between 2000 and 2014 (**Figure 5-14**), and also between 2015 and 2020 **(Figure 5-15**). Inherent variability in the observed TN concentrations show swings of 2-4 mg/L within a season – the GLM-AED2 model does not have the granularity to represent these short-term swings.

5.3.4.6 Total Phosphorus

TP 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 (**Figures 5-16** and **5-17**). The model captured average trends in TP.

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 (**Figures 5-18** and **5-19**). The model did a fair job overall in reproducing these complex trends and correctly predicted summer maximum chlorophyll-*a* concentrations in 2000-2004 (**Figure 5-18**, line). 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.

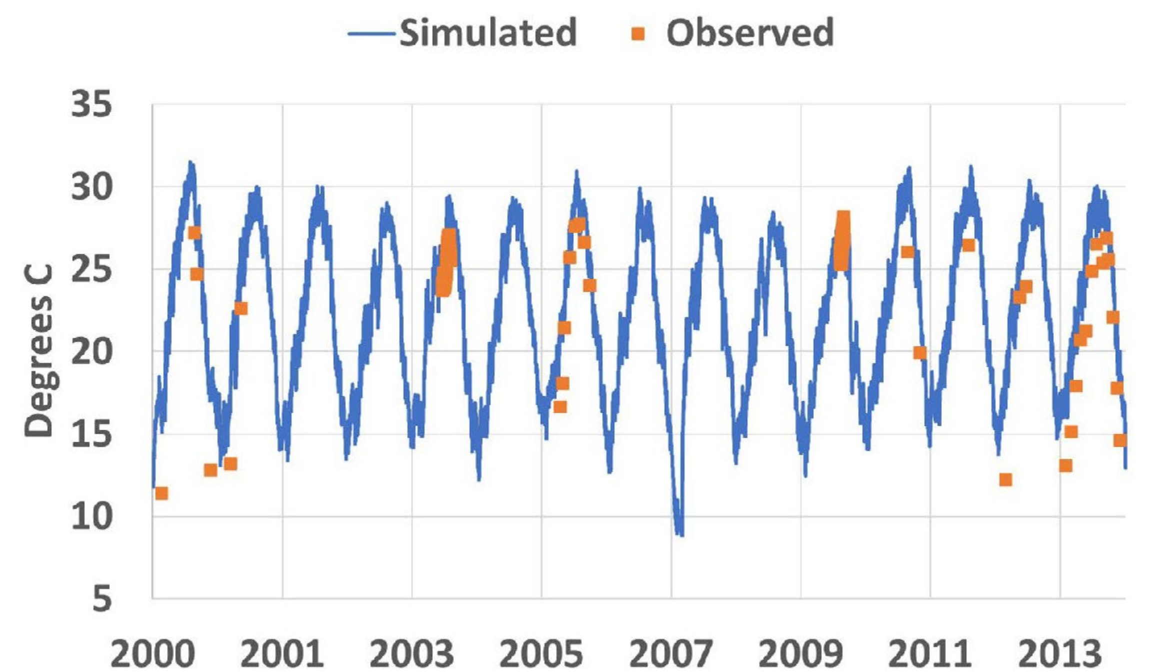

Figure 5-10. Near Surface at 2-m Depth Simulated and Observed Temperature for Lake Elsinore for the Calibration Period 2000-2014

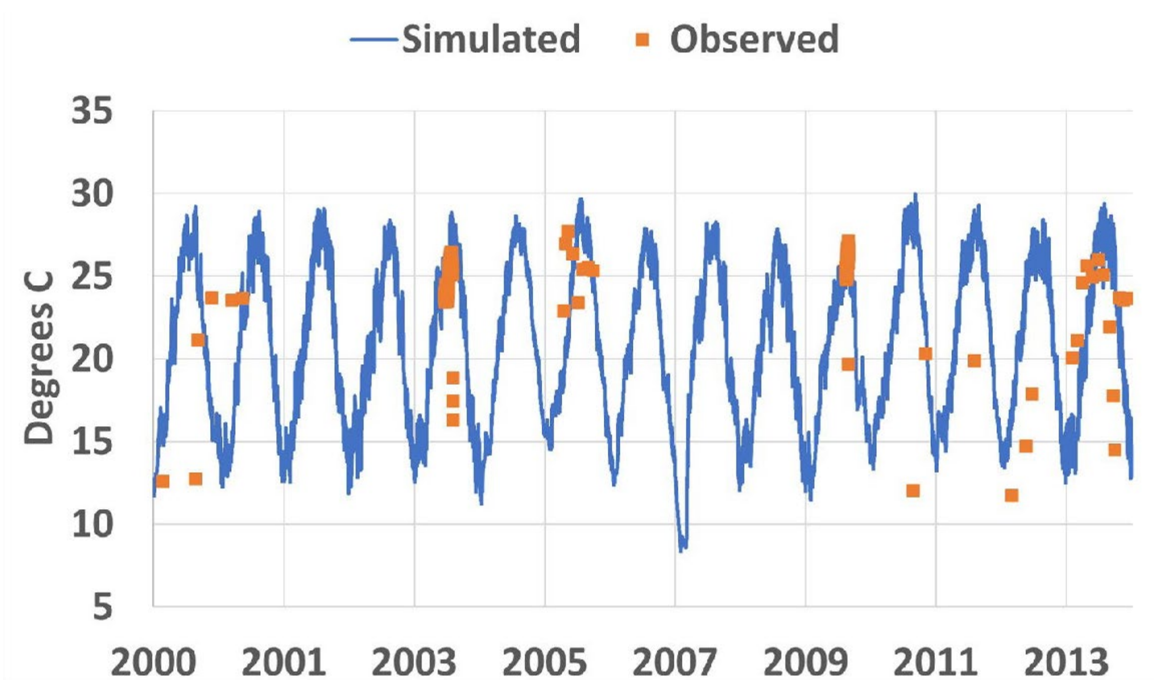

Figure 5-11. Simulated and Observed Temperature for Lake Elsinore at 6-m Depth for the Calibration Period 2000-2014

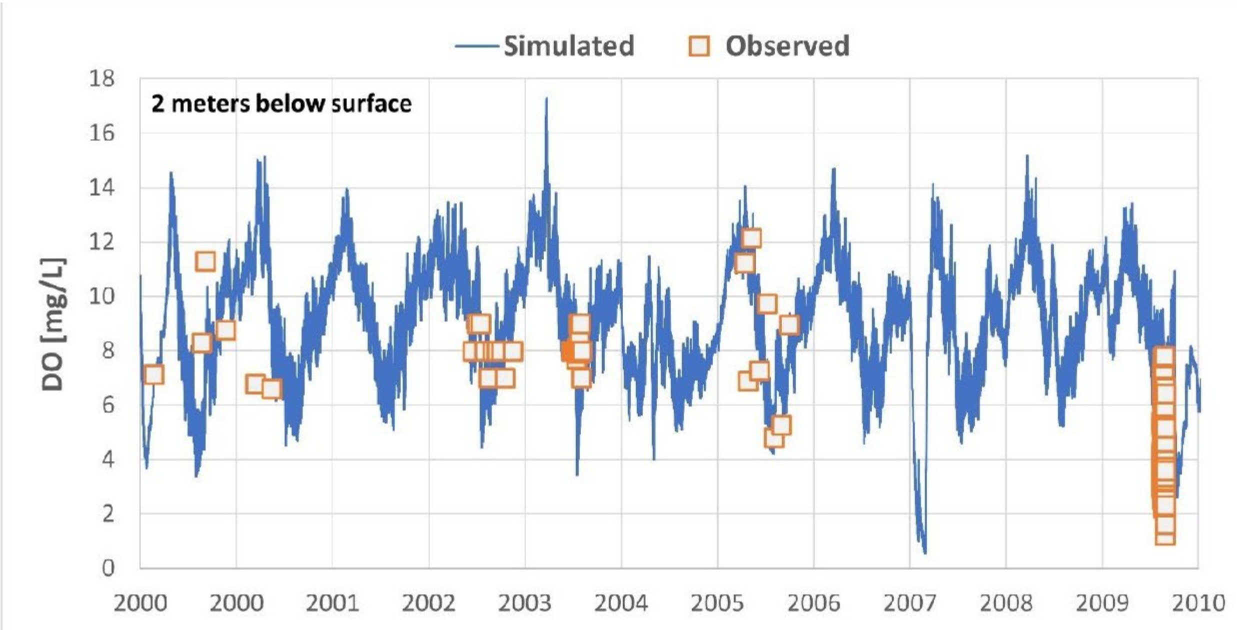

Figure 5-12. Simulated and Observed Near Surface Dissolved Oxygen for Lake Elsinore at 2-m Depth (2000-2010)

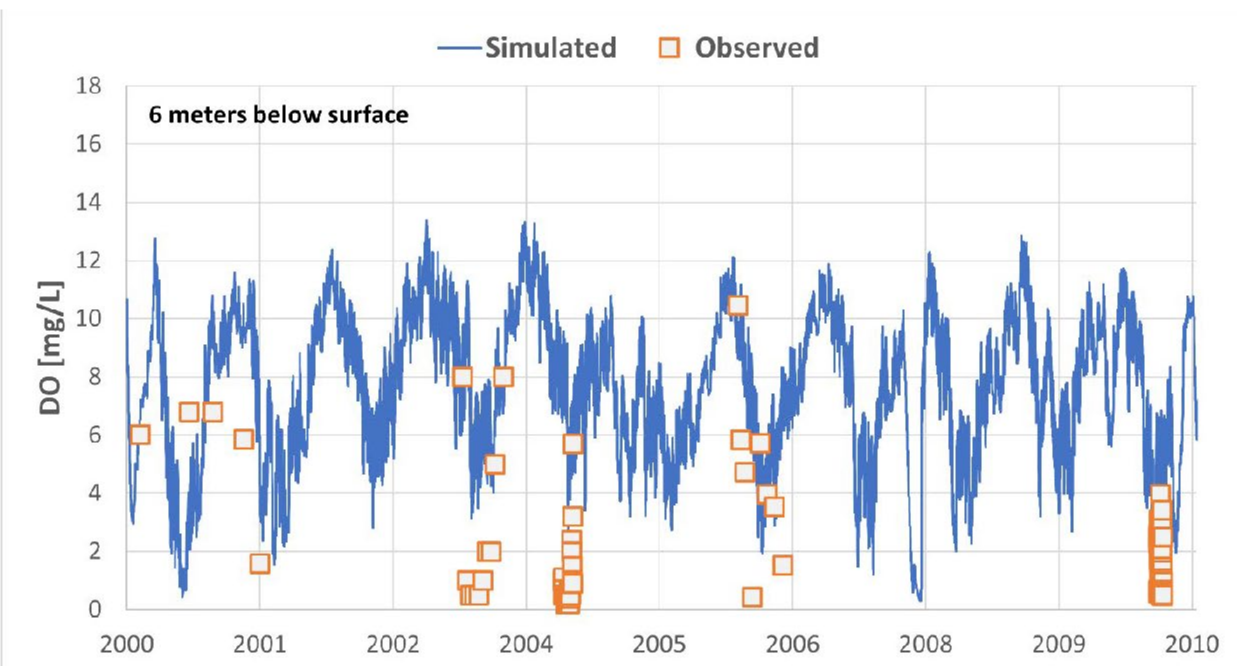

Figure 5-13. Simulated and Observed Dissolved Oxygen for Lake Elsinore at 6-m Depth (2000-2010)

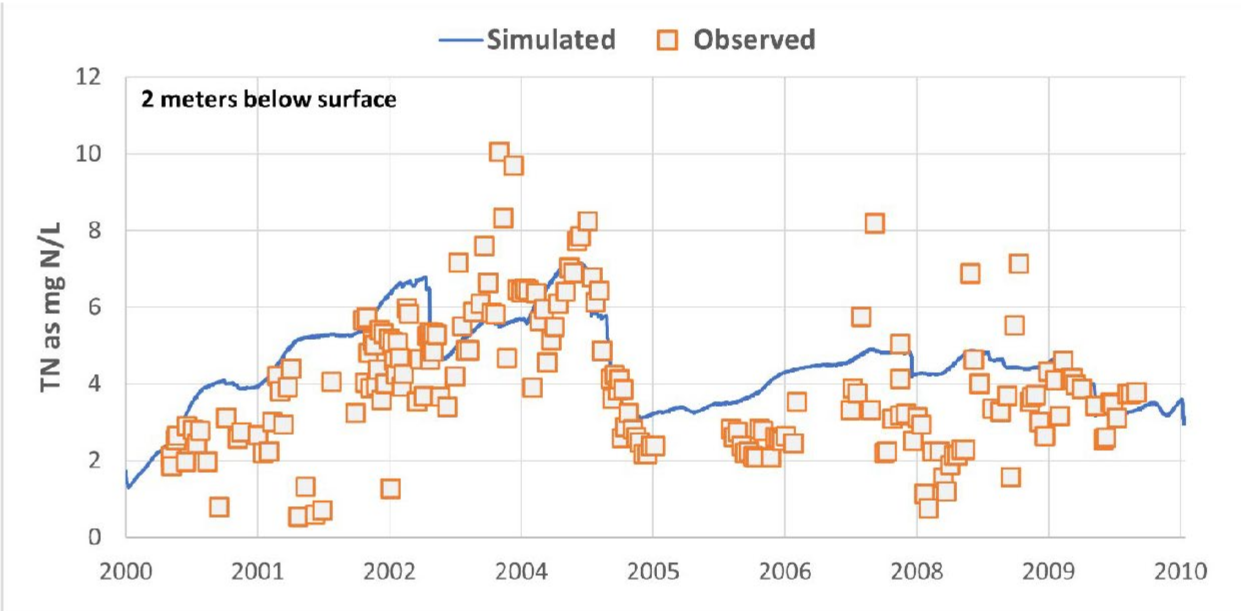

Figure 5-14. Simulated and Observed Near Surface Total Nitrogen Concentrations for Lake Elsinore at 2-m Depth for the Calibration Period 2000-2010

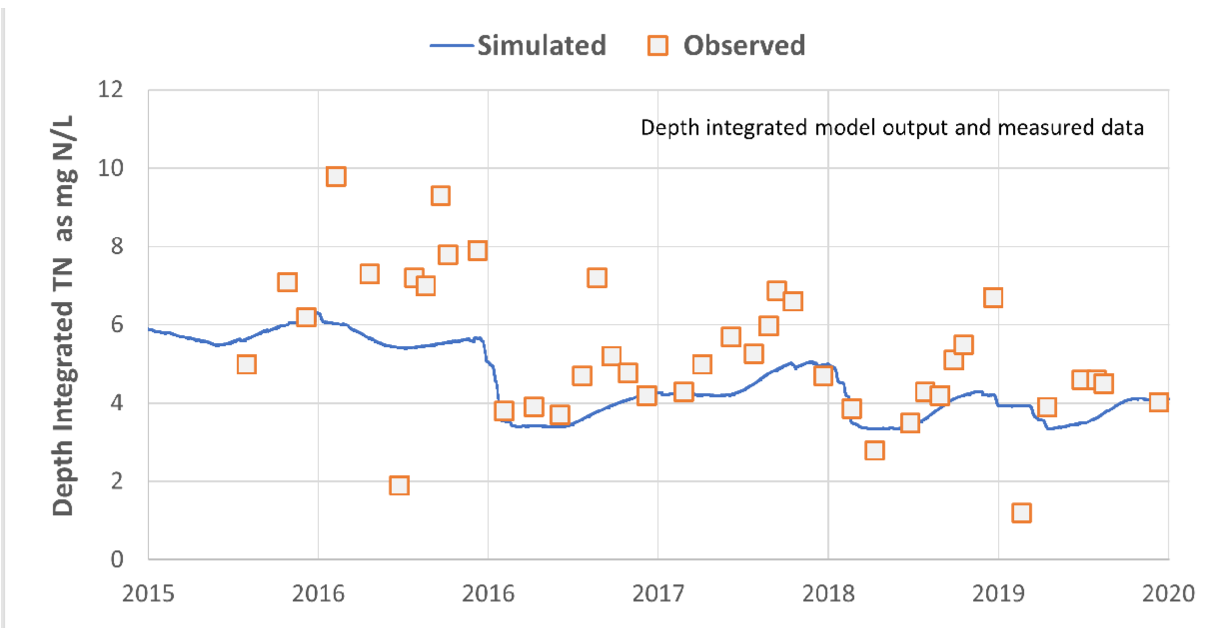

Figure 5-15. Simulated and Observed Depth Integrated Total Nitrogen Concentrations for Lake Elsinore for the Validation Period 2015-2020

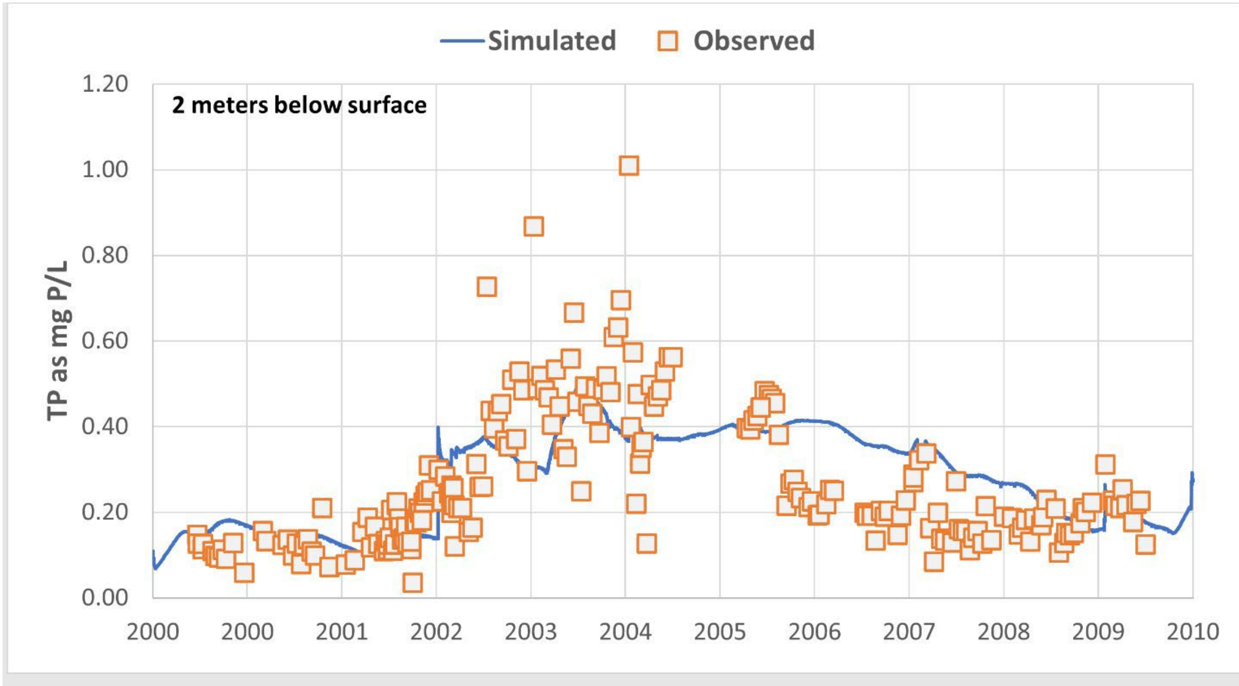

Figure 5-16. Simulated and Observed Near Surface Total Phosphorus Concentrations for Lake Elsinore at 2-m Depth for the Calibration Period 2000-2014

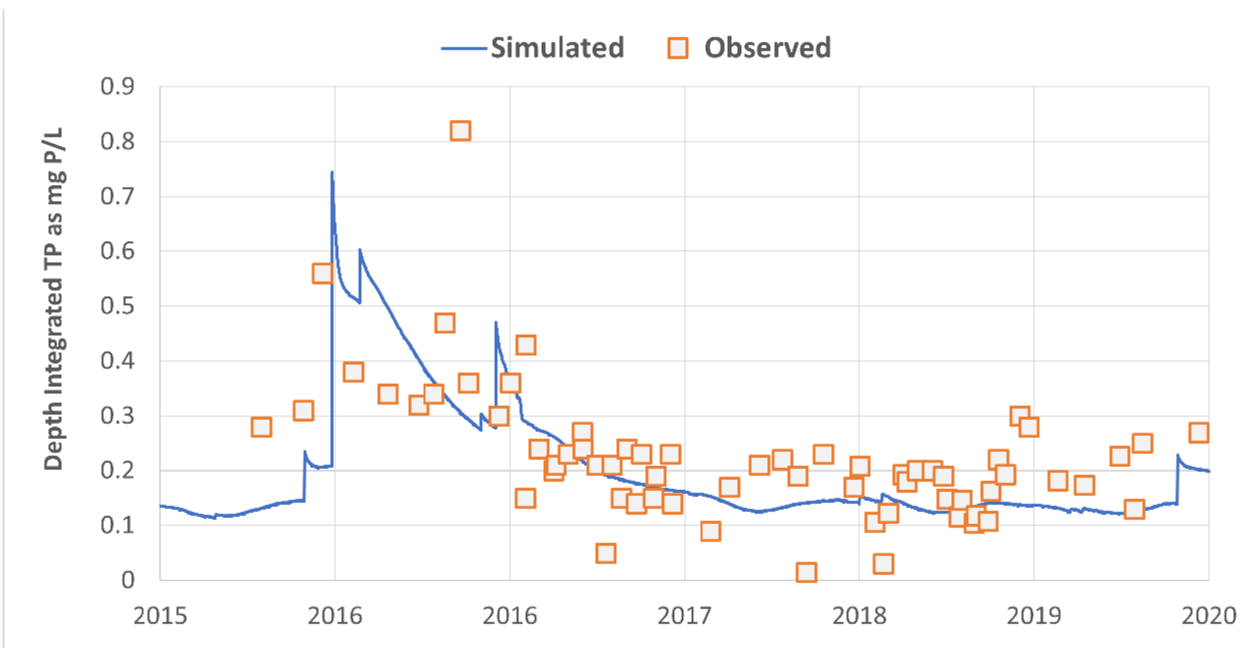

Figure 5-17. Simulated and Observed Depth Integrated Total Phosphorus Concentrations for Lake Elsinore for the Validation Period 2015-2020

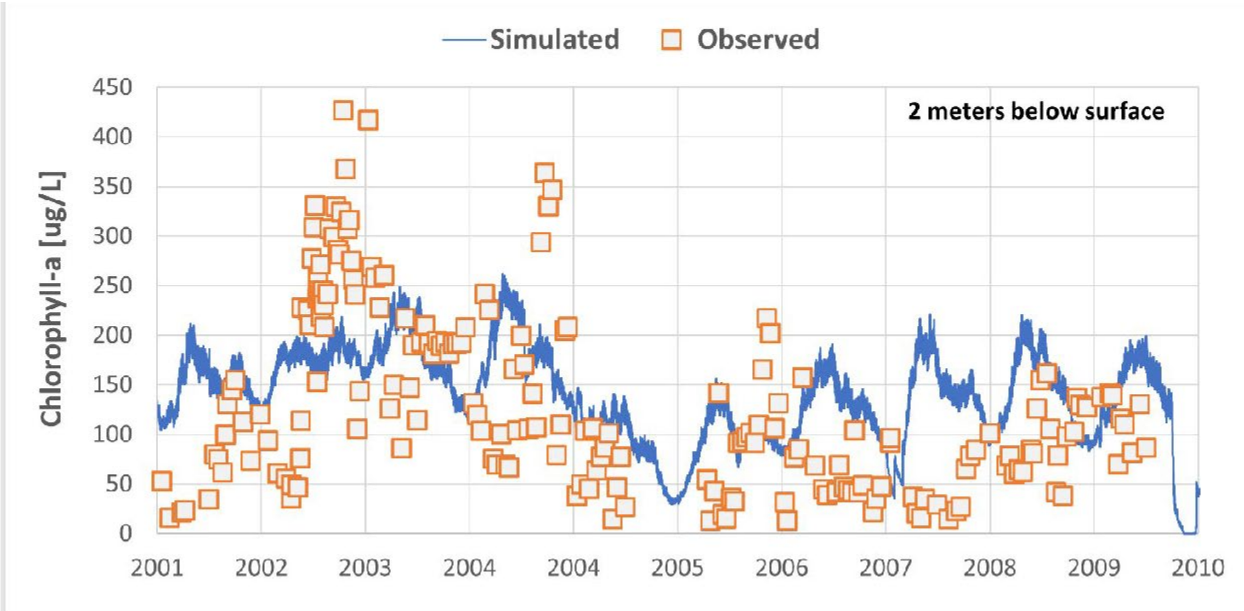

Figure 5-18. Simulated and Observed Near Surface Chlorophyll-a Concentrations for Lake Elsinore at 2-m Depth for the Calibration Period 2000-2014

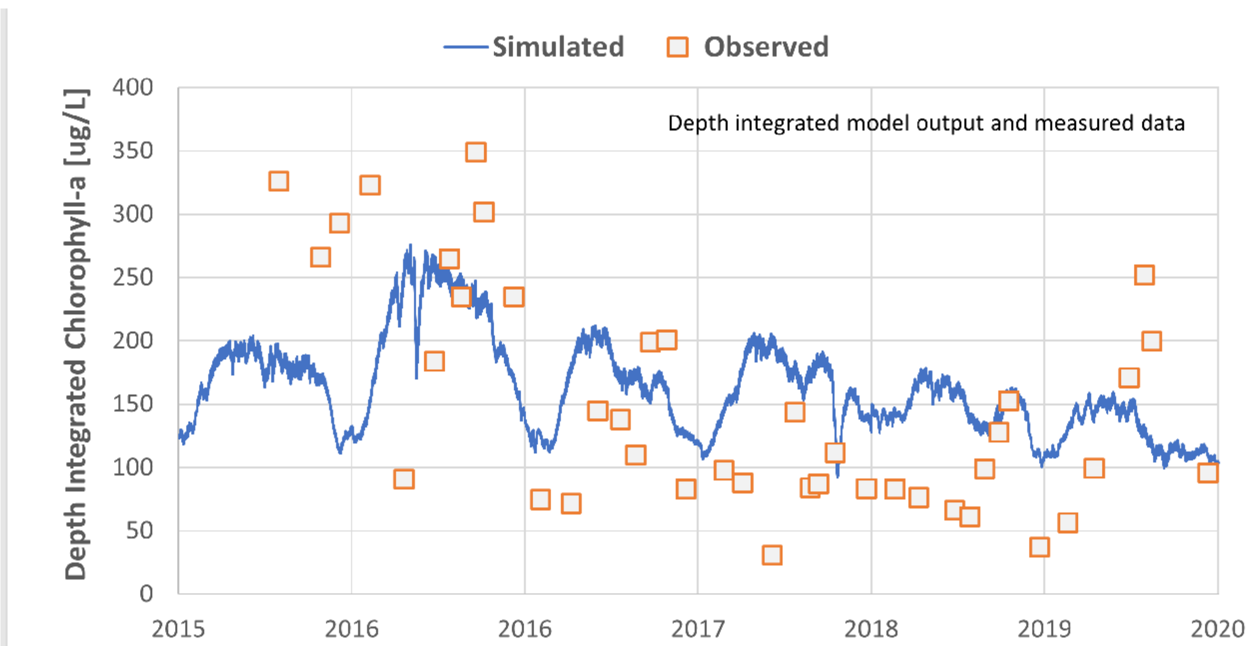

Figure 5-19. Simulated and Observed Depth Integrated Chlorophyll-a Concentrations for Lake Elsinore for the Validation Period 2015-2020

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 the percent bias

(PBIAS). Multiple objective functions including relative percent error (%RE), root mean square error (RMSE), Nash-Sutcliff efficiency (NSE), and root mean standard deviation ratio (RSR), were used to assess the fit between predicted and observed values (**Table 5-2**). The following equations were used to calculate these statistics:

$$\%RE = {|Modeled - Observed|}/{Observed}$$

$$RMSE = \sqrt{\frac{\sum(Modeled - Observed)^2}{n}}$$

$$NSE = 1 - \frac{\sum(Modeled_t - Observed_t)^2}{\sum(Observed_t - Observed_{mean})^2}$$

$$PBIAS = \frac{\sum(Modeled_t - Observed_t)}{Observed_{mean}}$$

$$RSR = \frac{\sqrt{(Modeled_t - Observed_t)^2}}{\sqrt{(Observed_t - Observed_{mean})^2}}$$

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	SD	% RE	RMSE	NSE	PBIAS	RSR
Lake Elevation (ft)	1,241.5	1,241.3	4.43	2.6%	0.86	0.96	0.04%	0.20
Temperature (°C)	25.8	25.5	2.42	6.9%	2.17	0.99	-0.4%	0.08
TDS (mg/L)	1,509	1,499	401	12.2%	200	0.75	-3.3%	0.50
DO (mg/L)	8.1	7.9	1.16	19.2%	2.02	-2.1	-0.7%	1.76
Seasonal Average TN (mg/L)	4.2	5.1	1.75	36.9%	1.65	0.83	33.8%	0.41
Seasonal Average TP (mg/L)	0.26	0.27	0.16	35.1%	0.10	0.45	13.5%	0.74
Seasonal Average Chlorophyll-*a* (µg/L)	141	151	98	50.7%	63	0.28	33.3%	0.43

SD = standard deviation; RE = relative error; RMSE = root mean square error; NSE = Nash-Sutcliff efficiency; PBIAS = percent bias; RSR = root means standard deviation ratio

Table 5-2 shows that the model performed well simulating long-term averages for water quality constituents (compare first two columns in table). A review of statistical performance measures (e.g., %RE) shows declining performance of model parameters as follows: lake elevation, temperature, TDS, and DO or seasonal averages for TP, TN, and chlorophyll-*a*. Several potential reasons for error in excess of 20 percent for nutrient and chlorophyll-*a* lake water quality parameters include:

- External inputs from recycled water and watershed runoff involved constant concentration assumptions for both nitrogen and phosphorus based on long-term averages of measured data. Temporal variability of the concentration of nutrients in these gauged inputs was thus neglected in the linkage analysis model.
- 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 within the lake bottom resulting in nutrient recycling and efflux from sediments.
- A very long (14-year) simulation period was used for model calibration which allows for the model to capture multidecadal climatic patterns but limits the ability to calibrate model parameters to potentially interannual conditions.

When comparing the RMSE with the standard deviation of observed values, it can be concluded that the model error falls within the total range of measured data. This finding shows that performance of the model produced a set of results that reasonably represents the range of water quality conditions experienced over the 14-year period from 2000-2014.

5.3.6 Reference Condition Scenario Evaluation

The GLM linkage analysis model was used to evaluate the water quality conditions in Lake Elsinore for a scenario involving external loads reduced to levels representative of a reference watershed condition for a 100-yr hydrologic period. Two sets of model scenarios were developed for a range of potential values to represent a reference nutrient concentration in the San Jacinto River watershed. Results of the 100-yr simulation provide the basis for 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 105-year (1916-2020) 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 RC model for this same period (see Section 3.2.2.2). 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 3.2.2.1, 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 included in the reference condition for Lake Elsinore. The elevation volume relationship for the current and assumed reference condition lake basin is included in **Figure 5-2** above.

Results at 2-m depth of the reference condition model for Lake Elsinore are plotted as time series in **Figures 5-20** through **5-27** for lake level, temperature, TDS, DO, chlorophyll-*a*, TP and TN. 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 3-10 through 3-12). 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. Figures showing DO, chlorophyll-*a,* and nutrients include both the interim and final reference conditions described in Section 3. Physical parameters including water level, temperature and TDS do not change between reference scenarios.

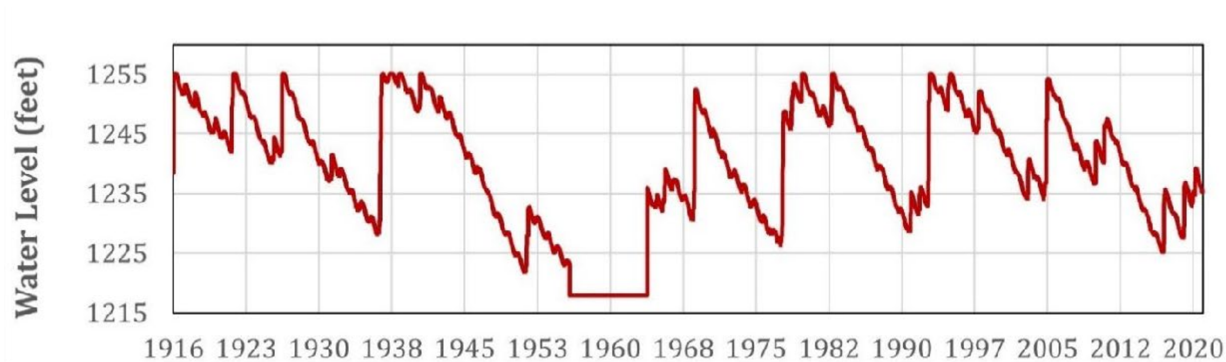

Figure 5-20. Simulated Lake Elsinore Water Level in Reference Scenario (period between June 1956 and May 1964 involved complete lakebed desiccation)

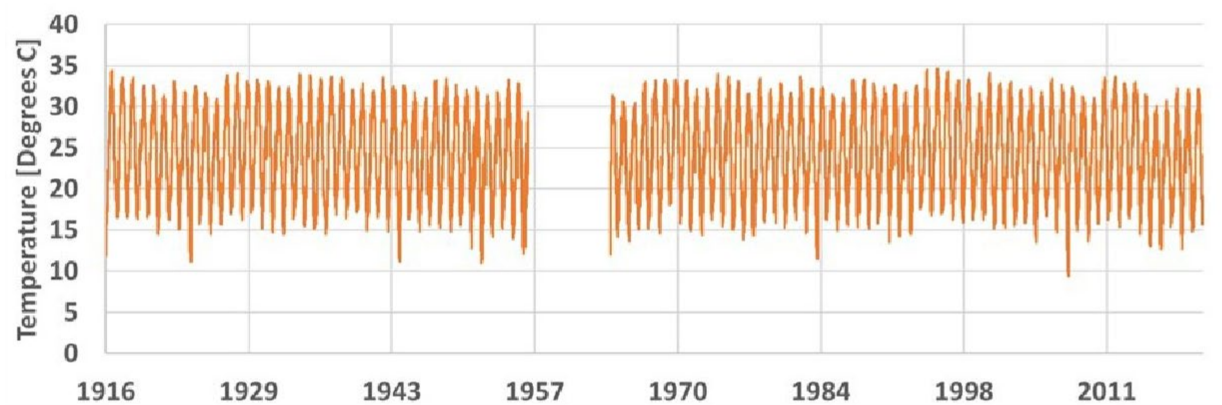

Figure 5-21. Simulated Lake Elsinore Water Temperature at 2-m Depth in Reference Scenario

Figure 5-22. Simulated Lake Elsinore Total Dissolved Solids at 2-m Depth in Reference Scenario

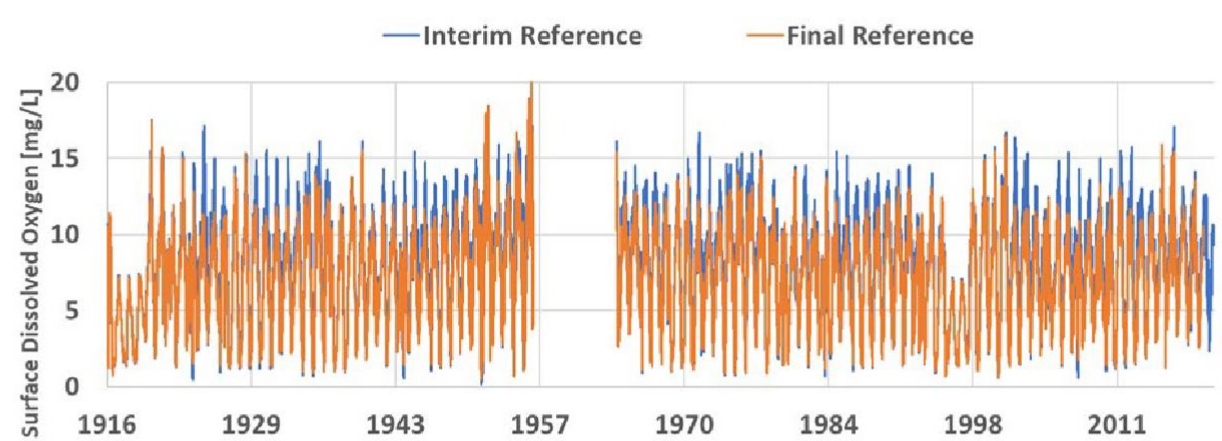

Figure 5-23. Simulated Lake Elsinore Dissolved Oxygen at 2-m Depth in Reference Scenario

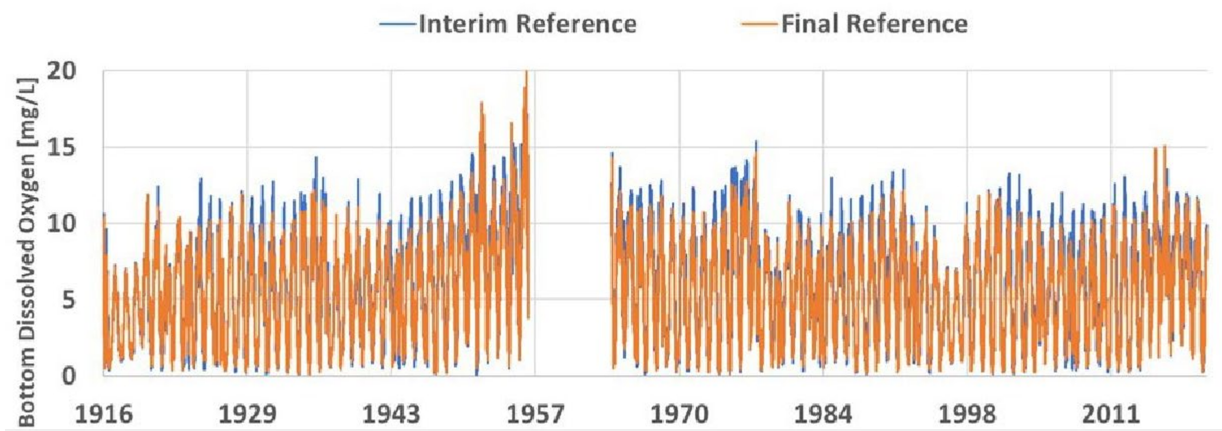

Figure 5-24. Simulated Lake Elsinore Dissolved Oxygen at 6-m Depth in Reference Scenario

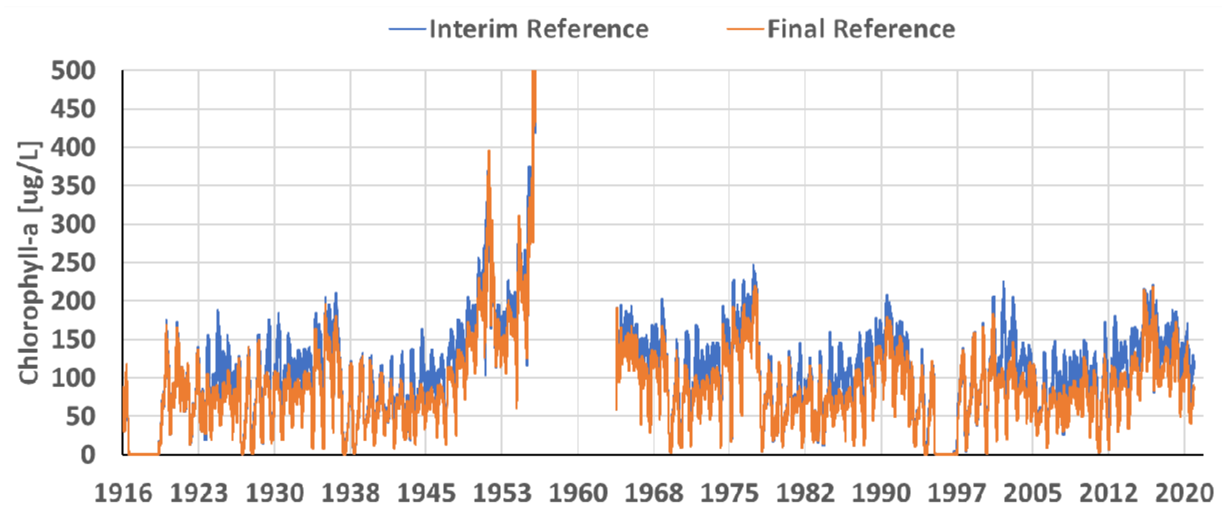

Figure 5-25. Simulated Lake Elsinore Chlorophyll-*a* at 2-m Depth in Reference Scenario

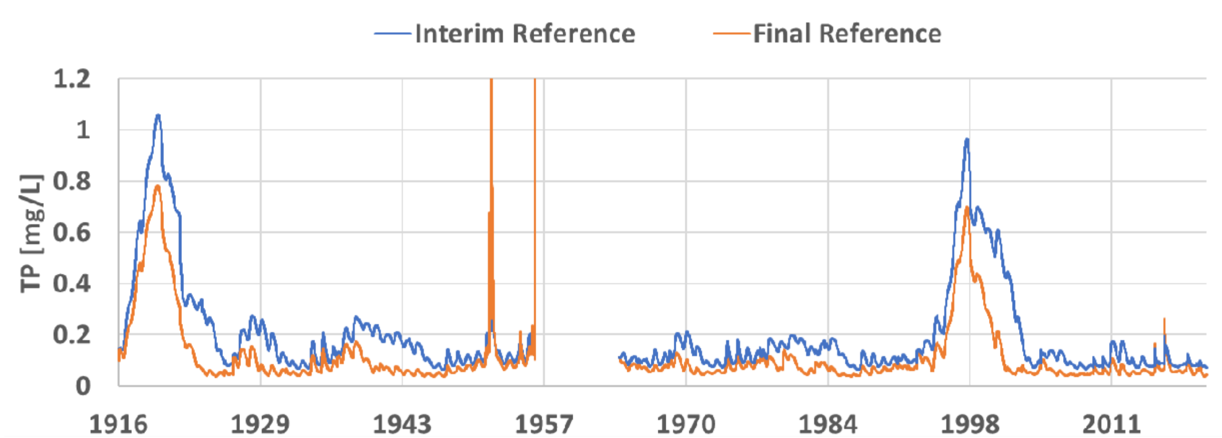

Figure 5-26. Simulated Lake Elsinore Total Phosphorus at 2-m depth in Reference Scenario

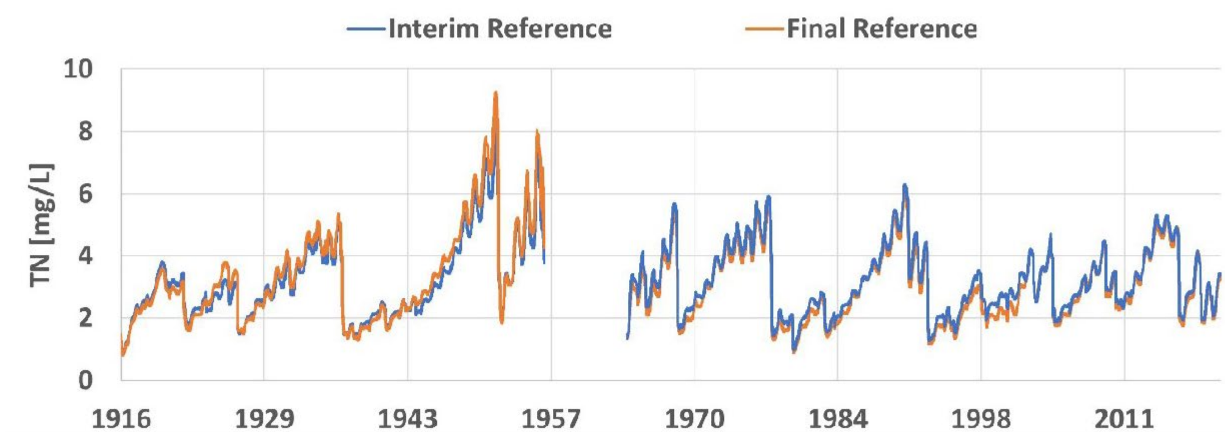

Figure 5-27. Simulated Lake Elsinore Total Nitrogen at 2-m Depth in Reference Scenario

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 AEM3D model for Canyon Lake. In addition, these subsections summarize the results after model calibration to yield 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 AEM3D hydrodynamic model restricted the simulation to a five-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. This calibration period coincides with a period of routine flow gauging and watershed and lake water quality monitoring and predates significant deployment of watershed or in-lake nutrient controls. The sections below also describe an AEM3D 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). Metered daily volumetric withdrawals from the lake over this period were provided by EVMWD.

Daily average meteorological data were calculated from hourly data and presented in **Figure 5-28**. As previously seen for Lake Elsinore, clear seasonal trends are evident in critical parameters. Daily solar shortwave radiation was low in winter, with cloud cover during winter storms lowering the daily average flux to < 50 W/m^2 on numerous occasions (**Figure 5-28a**). Daily shortwave flux reached maximum values of > 300 W/m^2 in early summer (**Figure 5-28a**), although we note that maximum daily air temperatures were reached later in the summer (**Figure 5-28b**). Daily average wind speeds, while variable, were generally stronger during the winter months (**Figure 5-28c**), which in many cases coincided with rainfall events (**Figure 5-28d**).

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 5-29**). Inflow data for the calibration period are taken from two USGS gauges; the San Jacinto River at Goetz Rd (Station #11070365) and Salt Creek at Murrieta Road (Station #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 events (**Figure 5-29**). 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 2012b).

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 (see **Table 5-3**). Total external nutrient loading over the calibration period was calculated from flow data (see **Figure 5-29**) and nutrient concentrations (**Table 5-3**).

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

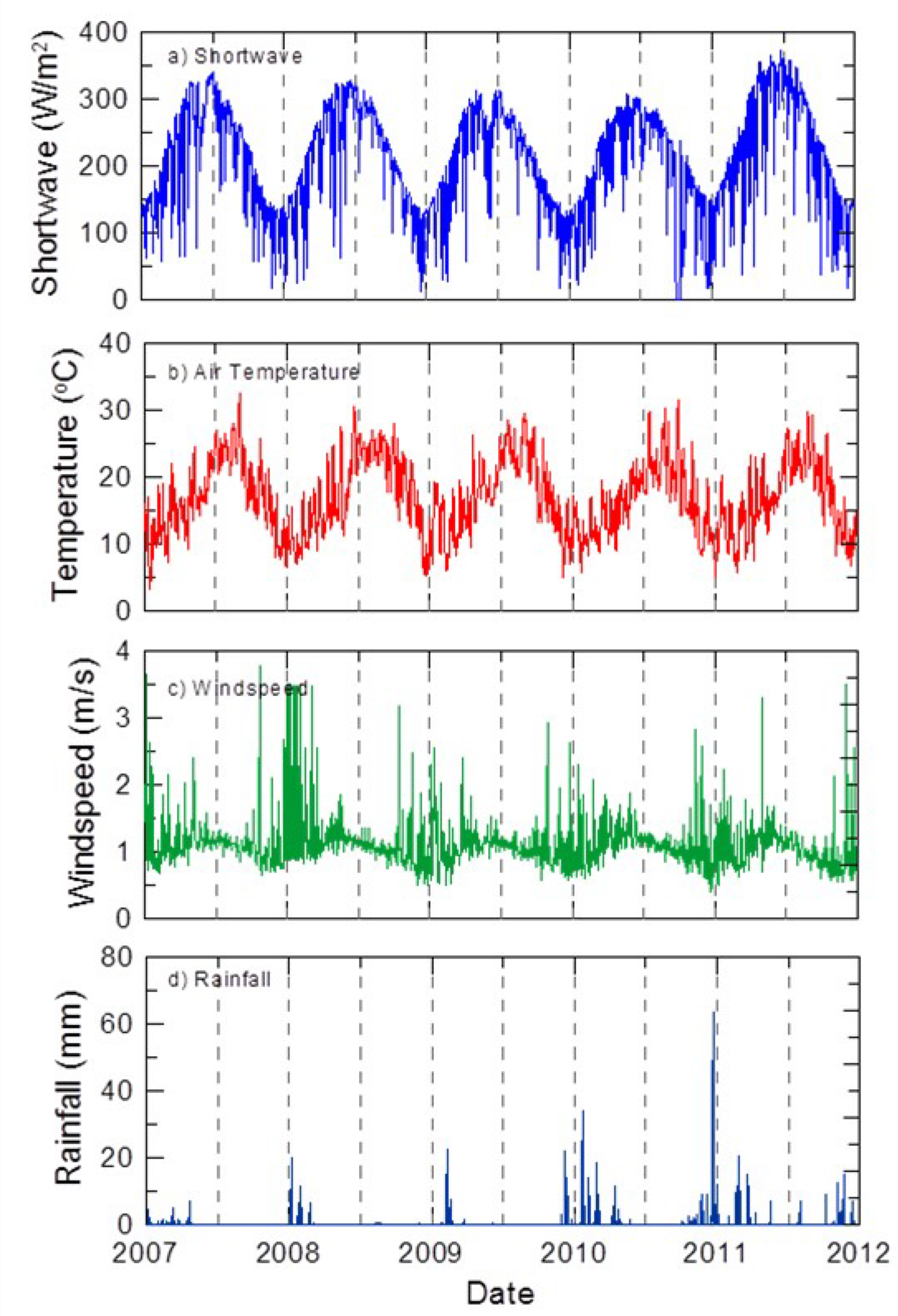

Figure 5-28. Daily Average (a) Shortwave Radiation, (b) Air Temperature, (c) Windspeed and (d) Rainfall Used in Model Simulations for Canyon Lake for the Calibration Period 2007-2011

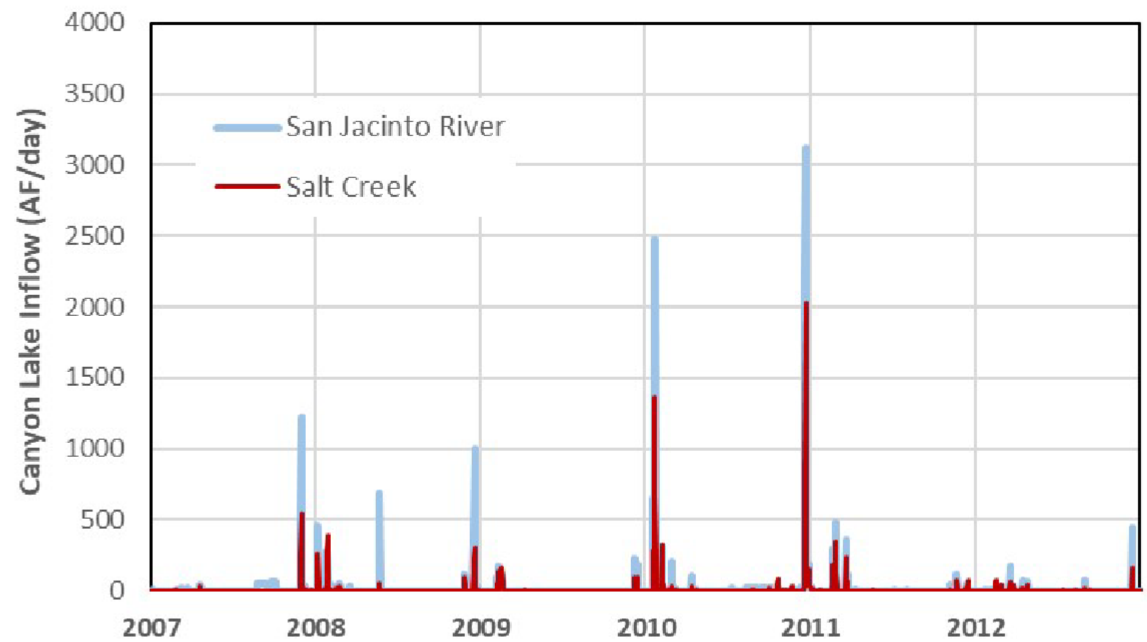

Figure 5-29. Daily Inflows to Canyon Lake for the Calibration Period 2007-2011

For internal water quality processes, default water quality parameters were used in AEM3D (Hodges and Dallimore 2021) except for key parameters for bioavailable nutrient (SRP and NH_4) fluxes and SOD, as follows:

- Rates of internal loading of nitrogen and phosphorus to the water column were separately measured in laboratory core-flux studies (Anderson 2001; 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). Measurements conducted in July 2006 found SOD values of about 0.3 g/m^2/d, with very little difference between sites (Anderson 2007). Additional measurements 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.

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/dissolved nutrients, and other constituents. Discrete samples were also collected at the thermocline, and composited discrete samples were collected from two to three depths within the hypolimnion (except during winter when the water column was well-mixed vertically and only a single depth-integrated sample was collected at each site). Section 2.2.3.3 summarizes monitoring results from Canyon Lake; key data from these results were used for calibration.

A large number of model simulations were conducted for January 1, 2007 – December 31, 2011; default model parameters were used in initial simulations and compared visually with observed data. Model parameters representing algae growth rates, nutrient uptake, and zooplankton predation 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 ft that occurred each summer as well as the generally very rapid increase in lake surface elevation each winter to the spillway elevation (see **Figure 5-30**). The model reproduced well the average elevation over this period (1,378.71 vs. 1,378.79 ft, respectively), with %RE of 0.03%.

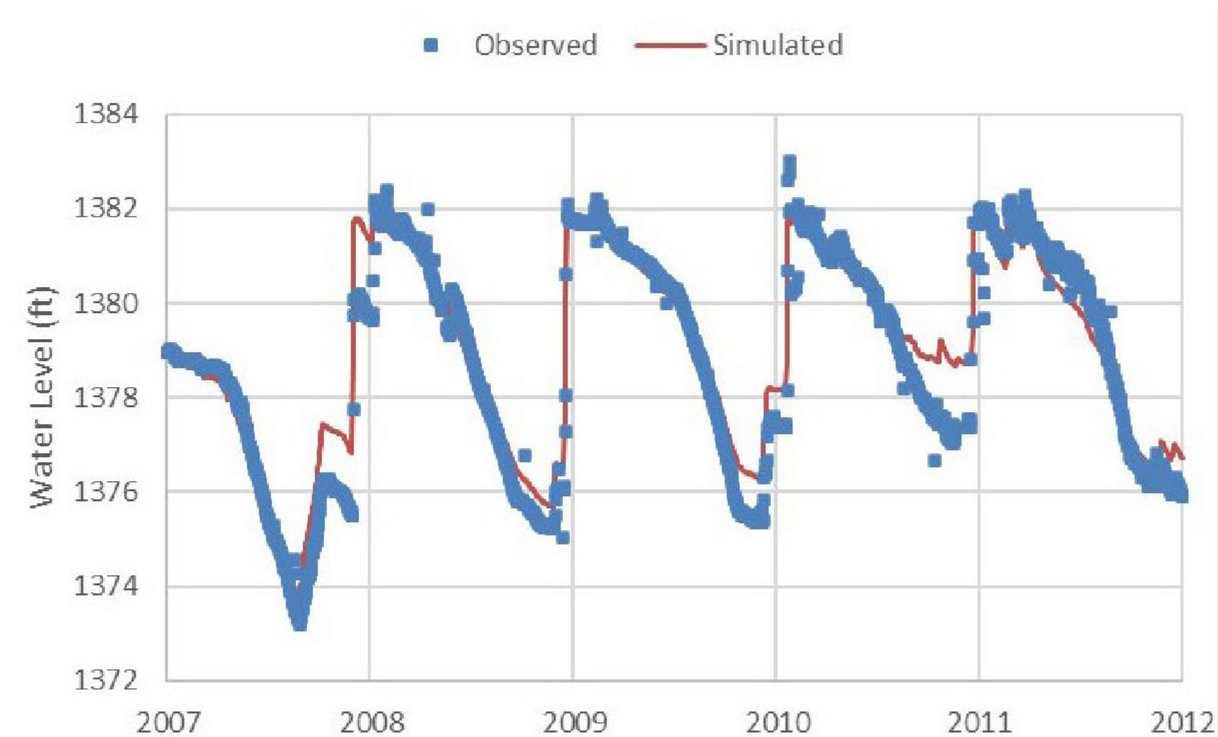

Figure 5-30. Observed and Simulated Lake Surface Elevations for Canyon Lake the Calibration Period 2007-2011

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 (blue circles) and 12-m (red circles) for Main Lake site M1 (and other sites) were reasonably reproduced in the simulation (**Figure 5-31**). 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 5-31**) due to reduced solar shortwave radiation inputs and lower air temperatures (see **Figure 5-28** 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 (salmon line) also reasonably reproduced temperatures at 12-m depth (red symbols) that increased slowly during much of the year before increasing more dramatically in the fall during lake turnover. 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 °C) slightly lower than the mean observed value (13.3 °C).

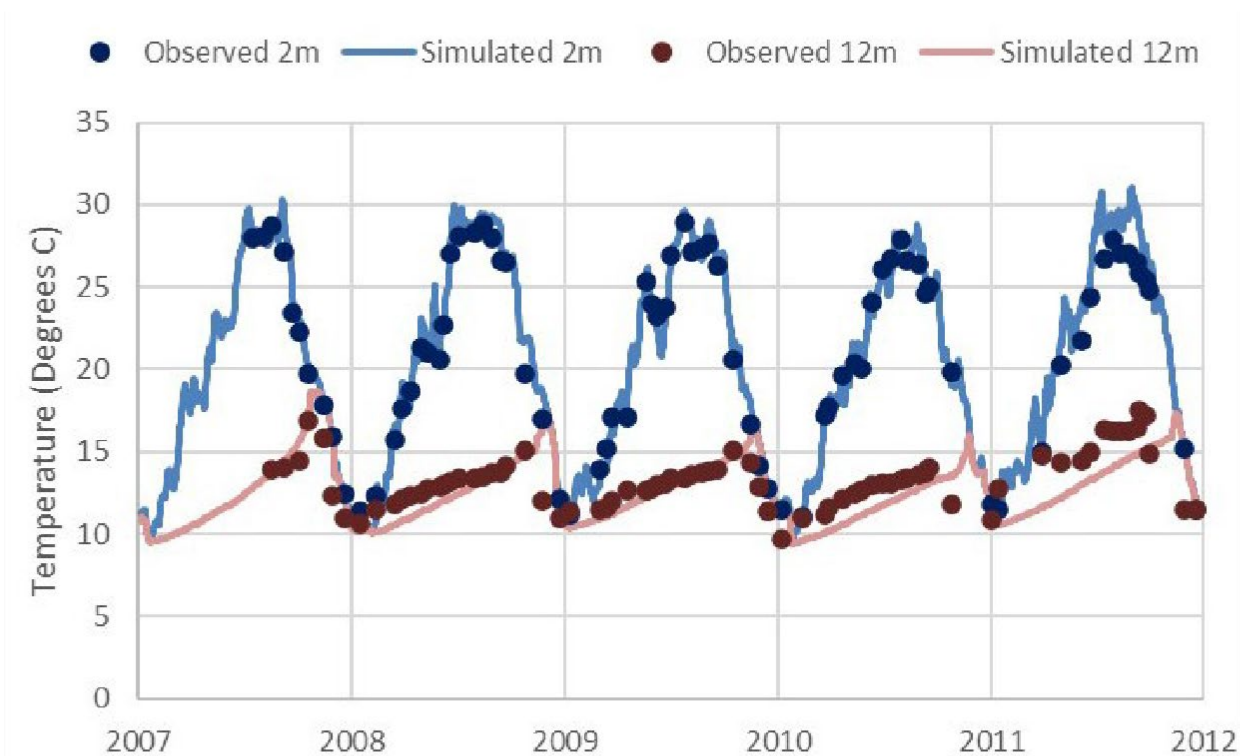

Figure 5-31. Observed and Simulated Temperatures at 2-m and 12-m Depths for Canyon Lake for the Calibration Period 2007-2011

5.4.4.3 Dissolved Oxygen

DO is specifically a function of photosynthetic production and respiratory loss by algae, SOD, microbial respiration in the water column, chemical demand by reduced substances, and other processes. DO in Canyon Lake is highly dynamic, with concentrations in the epilimnion often supersaturated in the spring and very low in the fall following turnover. The model (blue line) reproduced the trends reported for DO, with lower values in the late fall and maximum values generally seen in the spring. 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 7.43 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.

DO 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 5-32**). The model reproduced this trend quite well and yielded a mean DO concentration at 12-m depth of 1.27 mg/L, in good agreement with the observed mean value of 0.99 mg/L. Several performance metrics were poor because of numerous very low concentrations where even a modest difference yields high 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.

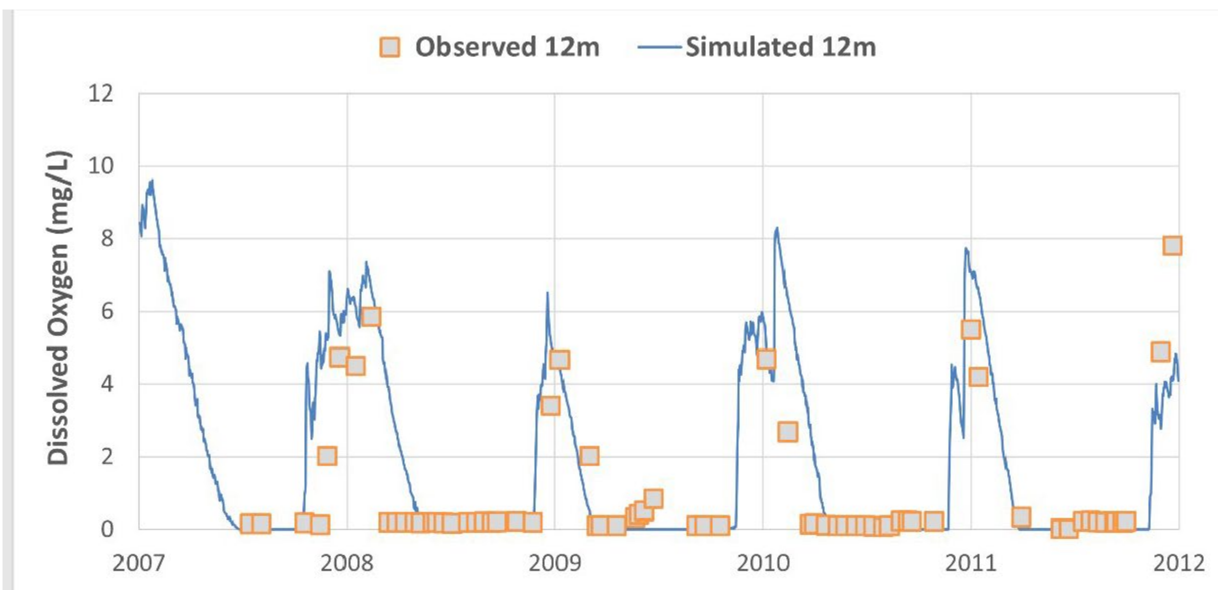

Figure 5-32. Observed and Simulated Dissolved Oxygen at 12-m Depth for Canyon Lake for the Calibration Period 2007-2011

5.4.4.4 Total Nitrogen

The observed concentrations over time of TN at 2-m depth are presented in **Figure 5-33**. 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 5-33**). 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.

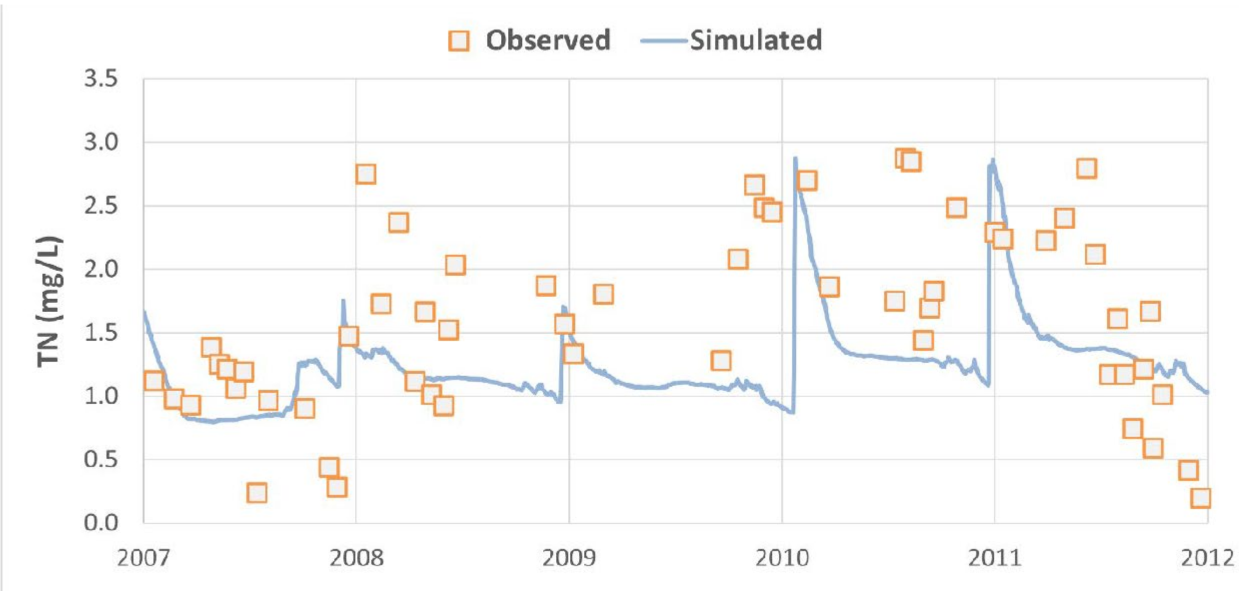

Figure 5-33. Observed and Simulated Total Nitrogen at 2-m Depth for Canyon Lake for the Calibration Period 2007-2011

The data showed seasonal trends in epilimnion 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 with a %RE of 33.3% and 35.2% in Main Lake and East Bay, respectively. In both Main Lake and East Bay, predicted mean concentration were lower than the mean of observed data for this period. Ammonium-N in the hypolimnion was negligible during the winter following overturn of the water column while NH4-N increased each spring and summer as a result of internal recycling and accumulation in the bottom waters.

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 5-34**). The model did an adequate job of reproducing the average concentration of TP; however, the model did not capture the variability present in the data (modeled range of 0.40 – 1.2 mg/L) (**Figure 5-34**), with a %RE of 33.3% and 71.8% in Main

Lake and East Bay, respectively. 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 falling sharply with mixing of the water column.

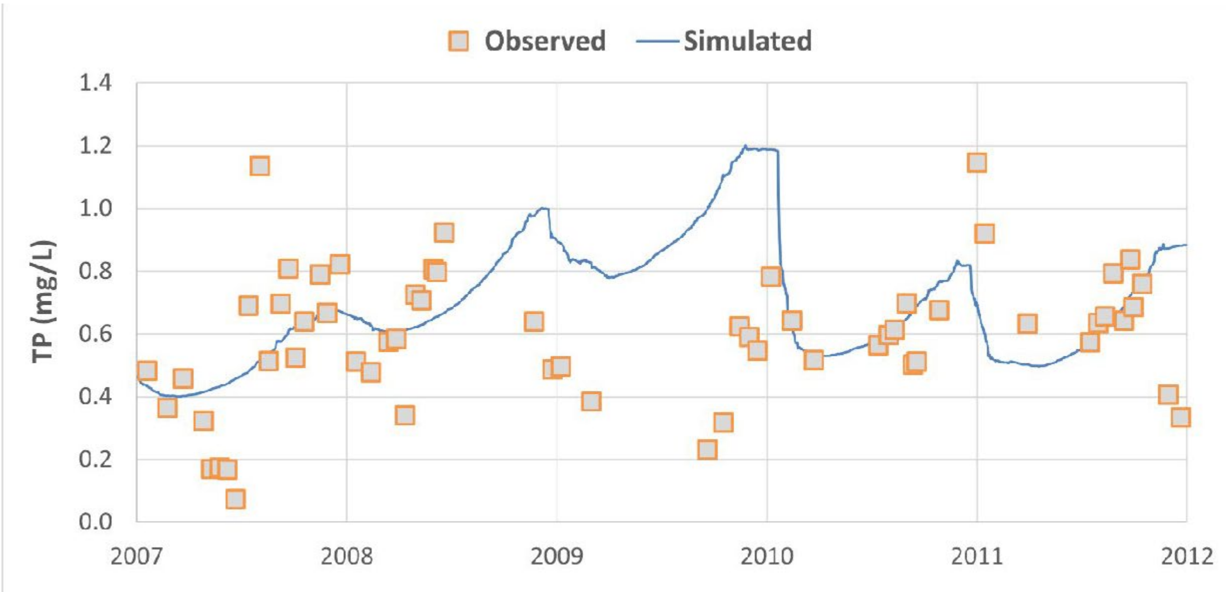

Figure 5-34. Observed and Simulated Total Phosphorus at 2-m Depth for Canyon Lake for the Calibration Period 2007-2011

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 5-35**). Model predictions reflected these seasonal trends in chlorophyll-*a*, with temporally averaged concentrations in relative agreement between observed and predicted values in the Main Lake (31.2 and 38.8 µg/L, respectively) and in East Bay (51.1 and 53.7 µg/L, respectively). Notwithstanding, the timing of the phytoplankton blooms varied in some years with overall poorer model performance metrics. 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.

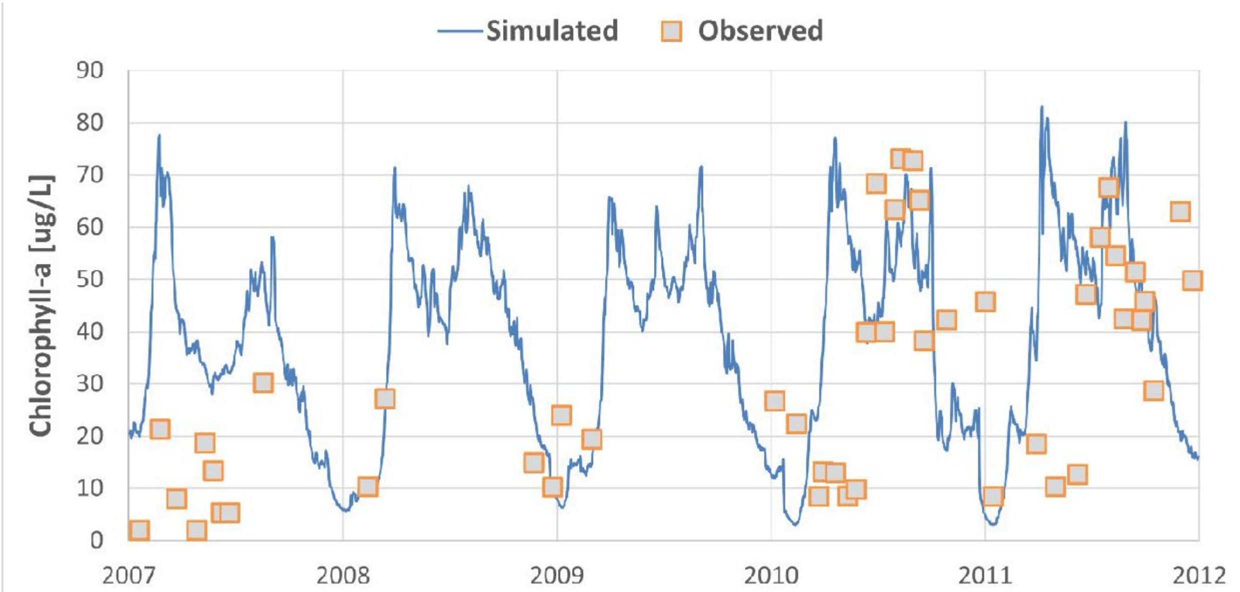

Figure 5-35. Observed and Simulated Chlorophyll-a at 2-m Depth for Canyon Lake for the Calibration Period 2007-2011

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 (five years) with markedly different hydrology created extra challenges in simulating water quality in the lake. However, five year means for water quality parameters matched well with observed data in both Canyon Lake Main Lake (M1) and Canyon Lake East Bay (E2) (**Table 5-4**).

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 (see **Table 5-4**). Discussion is provided above related to the goodness-of-fit for each parameter.

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. Reference watershed nutrient concentrations are assumed to occur in the total daily inflow volume to Canyon Lake.

Table 5-4. Model Calibration Summary Statistics for Water Quality Parameters in Canyon Lake

Site	Variable	Observed	Predicted	SD	RMSE	% RE	NSE	RSR	PBIAS
Lakewide	Lake Elevation (ft)	1378.8	1379.0	2.31	0.65	0.03%	0.92	0.28	0.02%
	Temperature (°C) at 2m	21.42	21.93	5.71	1.12	4.1%	1.00	0.00	2.1%
	Temperature (°C) at 12m	13.28	12.85	1.66	1.45	8.8%	1.00	0.02	-2.9%
	DO (mg/L) at 2m	8.14	7.43	2.85	2.30	28.2%	0.34	0.81	-1.1%
	DO (mg/L) at 12m	0.99	1.27	1.80	1.35	135%	0.43	0.76	117.8%
Main Lake (M1)	Seasonal Average TN (mg/L)	1.57	1.24	0.72	0.59	33.3%	-0.18	1.09	-8.8%
	Seasonal Average TP (mg/L)	0.59	0.66	0.22	0.25	32.6%	0.25	0.87	22.3%
	Seasonal Average Chl-*a* (µg/L)	31.19	38.76	21.81	23.36	58.9%	0.37	0.79	18.5%
East Bay (E2)	Seasonal Average TN (mg/L)	1.80	1.36	0.83	0.63	35.2%	-0.61	1.27	-19.9%
	Seasonal Average TP (mg/L)	0.48	0.66	0.22	0.35	71.8%	-1.22	1.49	83.8%
	Seasonal Average Chl-*a* (µg/L)	51.06	53.69	34.41	30.11	75.0%	-0.04	0.91	43.0%

SD = standard deviation; RE = relative error; RMSE = root mean square error; NSE = Nash-Sutcliff efficiency; PBIAS = percent bias; RSR = root means standard deviation ratio

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 **Figures 5-36** through **5-40** for Canyon Lake Main Lake and **Figures 5-41** through **5-45** for Canyon Lake East Bay. Results include TDS, TP, TN, ammonia-N, DO and chlorophyll-*a*. Figures showing DO, chlorophyll-*a* and nutrients include both the interim and final reference conditions described in Section 3. Physical parameters including water level, temperature and TDS do not change between reference scenarios.

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 trends 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).
- Naturally occurring oxygen demand in the Canyon Lake hypolimnion caused the DO at 12 meter depth to be reduced below 2mg/L during periods of stratification in 8 of the 15 years in the simulation period.

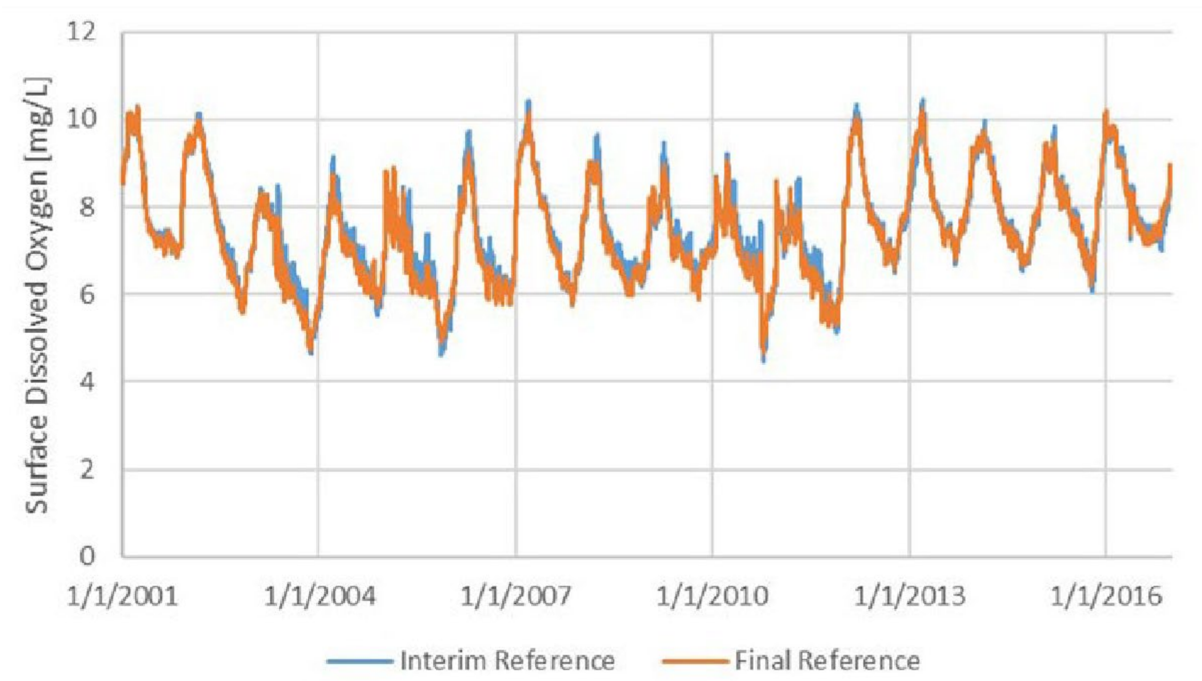

Figure 5-36. Simulated Dissolved Oxygen at 2-m depth in Canyon Lake Main Lake for Reference Scenario

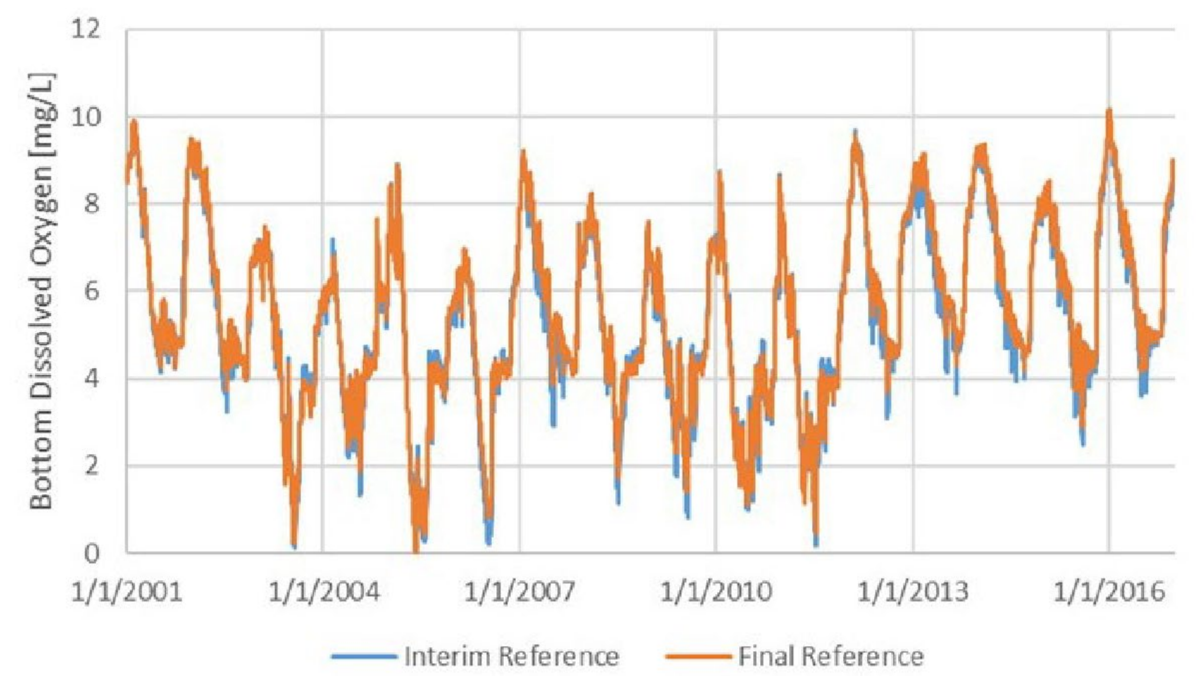

Figure 5-37. Simulated Dissolved Oxygen at 12-m Depth in Canyon Lake Main Lake for Reference Scenario

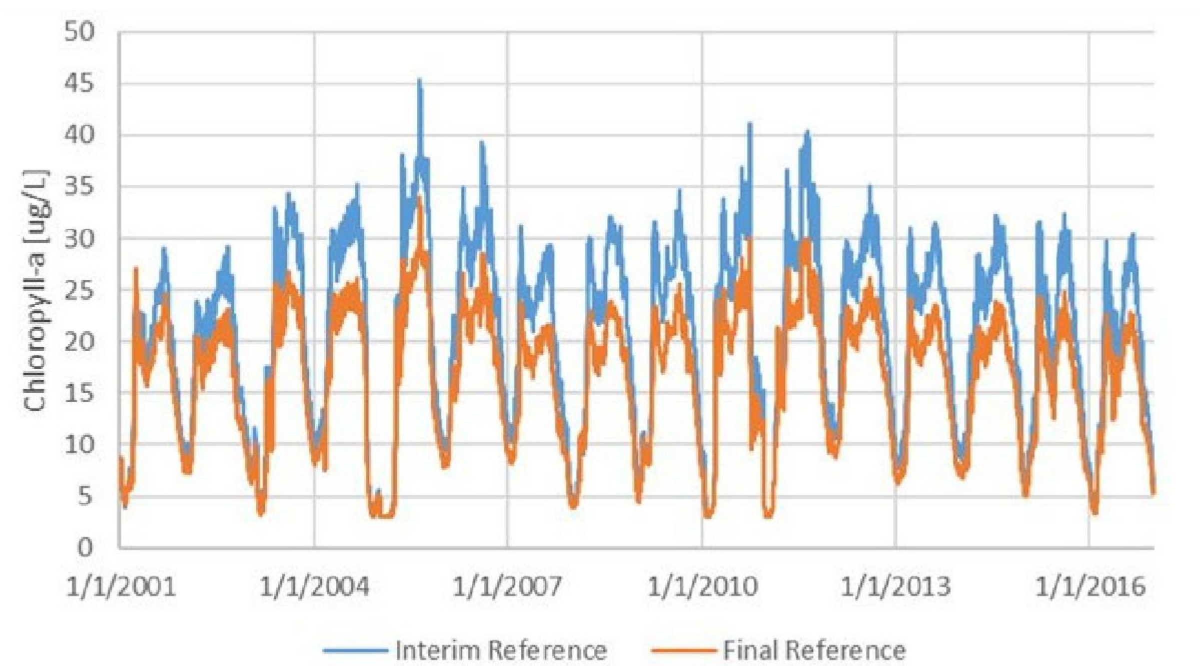

Figure 5-38. Simulated Chlorophyll-*a* at 2-m Depth in Canyon Lake Main Lake for Reference Scenario

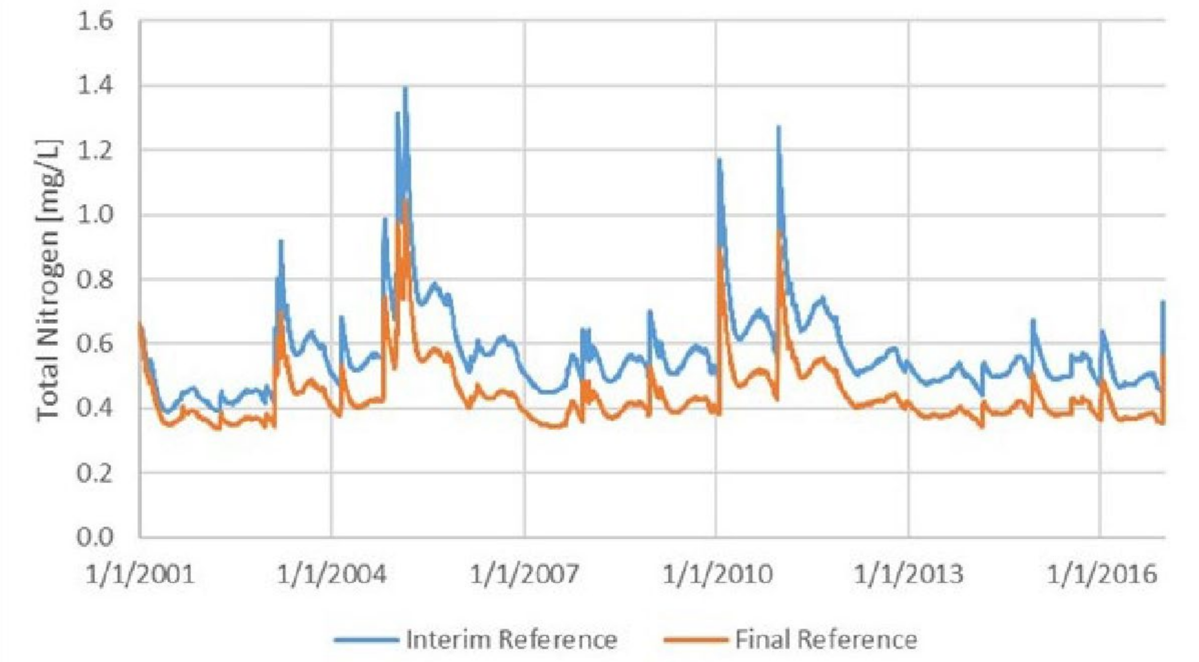

Figure 5-39. Simulated Depth-integrated Total Nitrogen in Canyon Lake Main Lake for Reference Scenario

Figure 5-40. Simulated Depth-integrated Total Phosphorus in Canyon Lake Main Lake for Reference Scenario

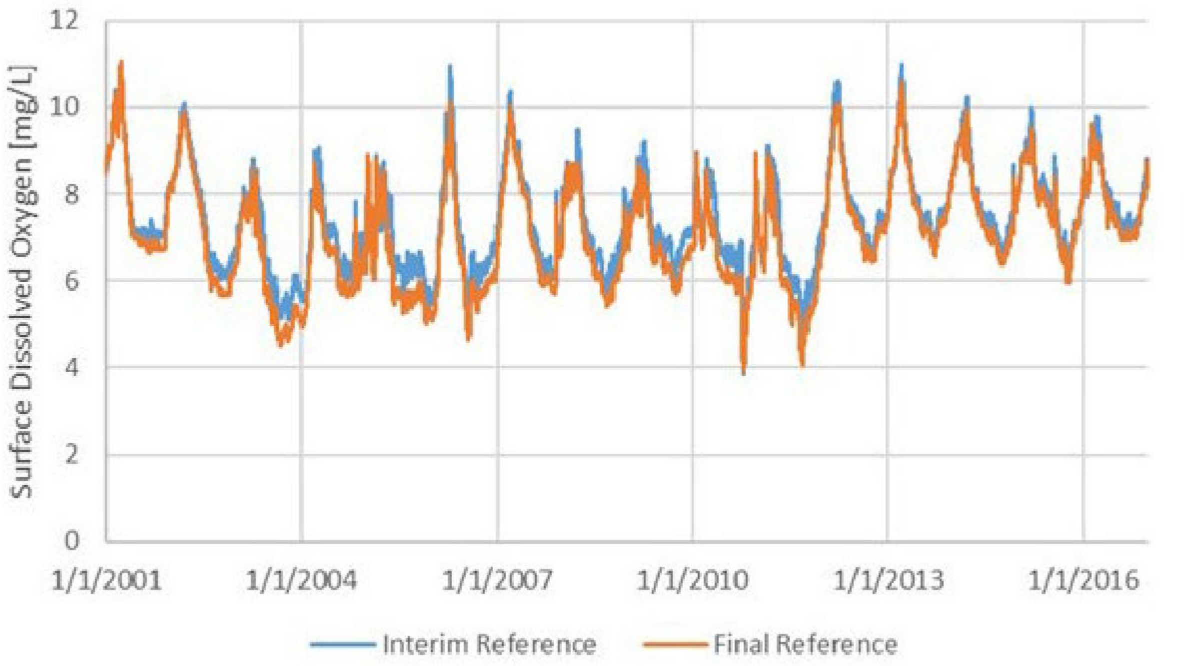

Figure 5-41. Simulated Dissolved Oxygen at 2-m Depth in Canyon Lake East Bay for Reference Scenario

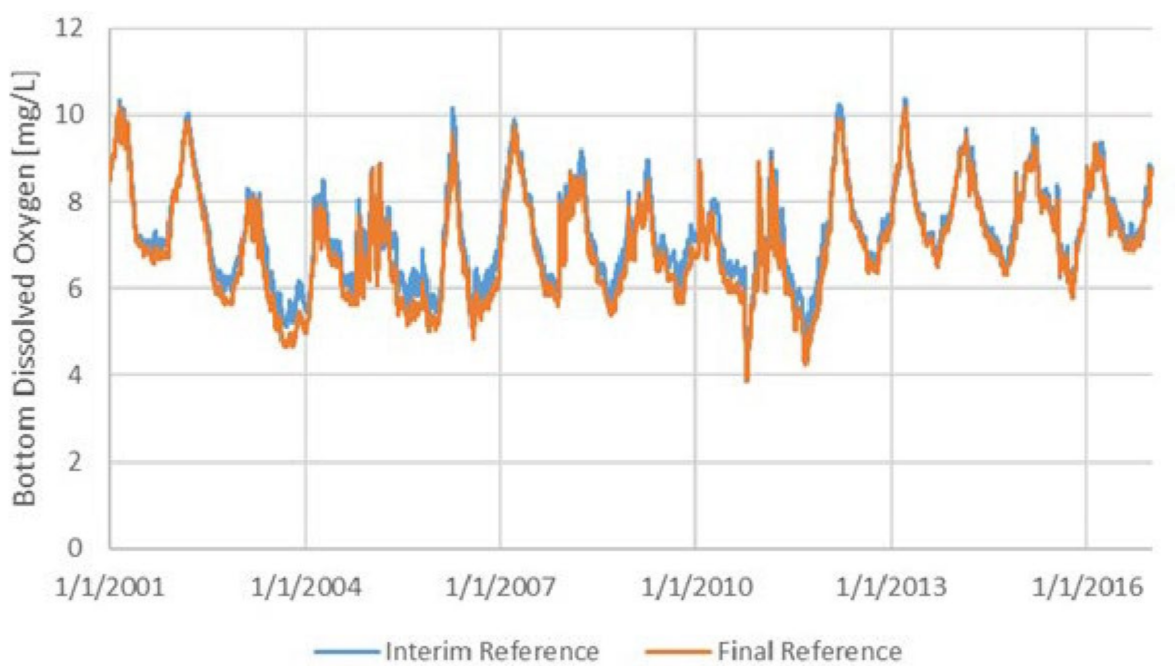

Figure 5-42. Simulated Dissolved Oxygen at 12-m Depth in Canyon Lake East Bay for Reference Scenario

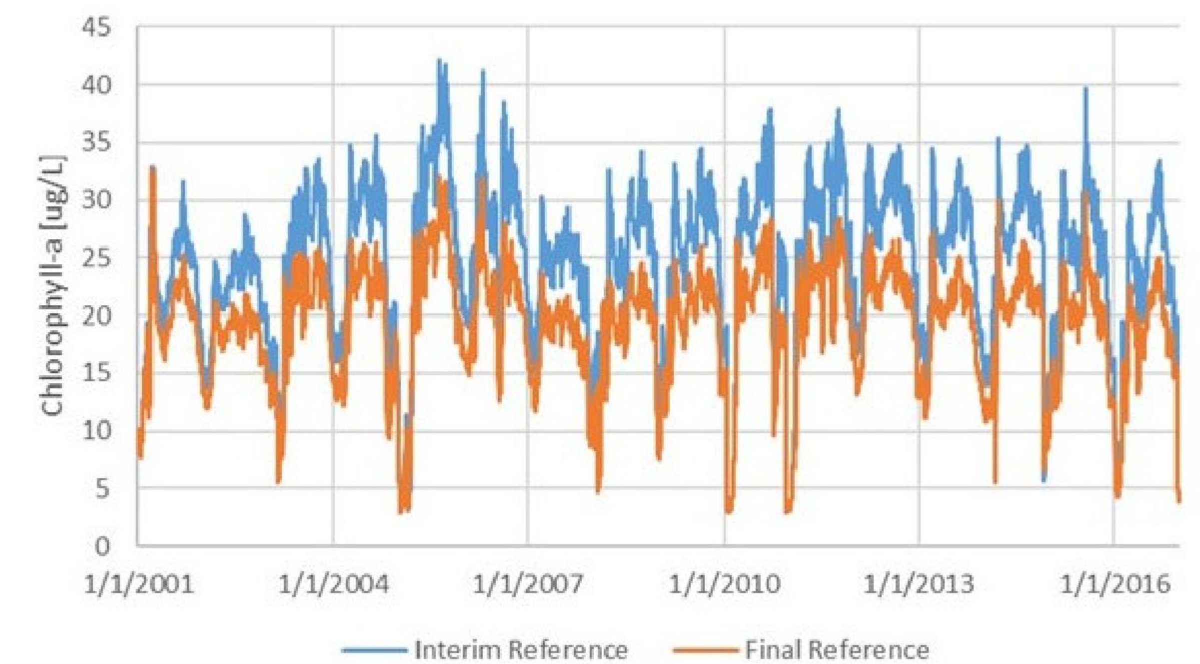

Figure 5-43. Simulated Chlorophyll-*a* at 2-m Depth in Canyon Lake East Bay for Reference Scenario

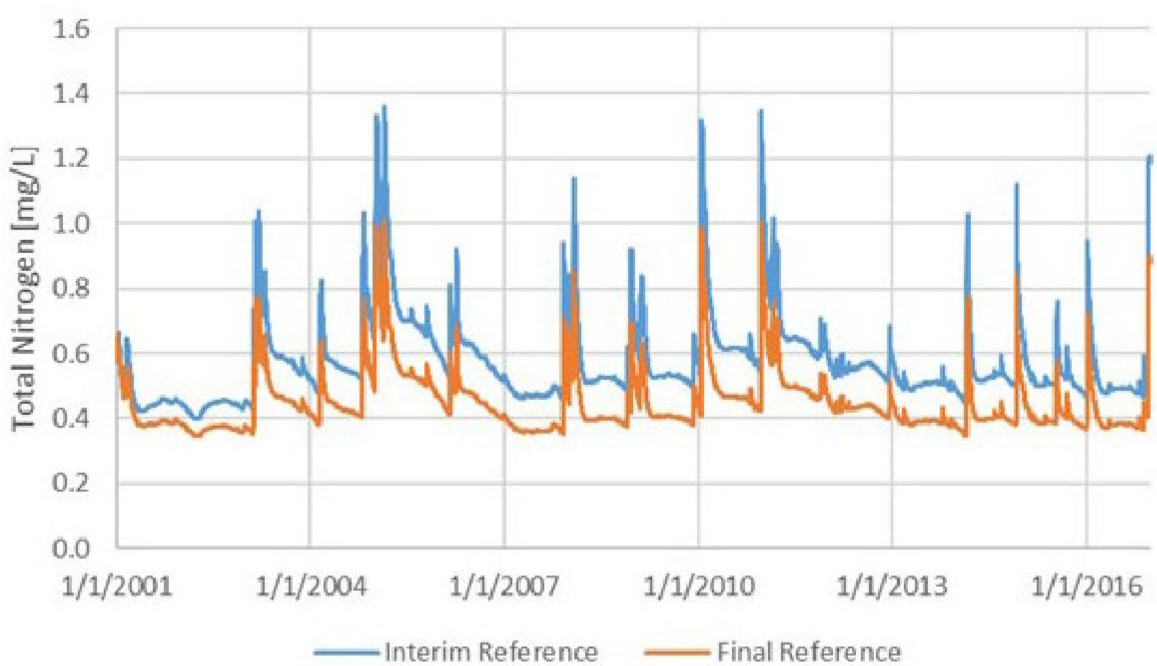

Figure 5-44. Simulated Depth-integrated Total Nitrogen in Canyon Lake East Bay for Reference Scenario

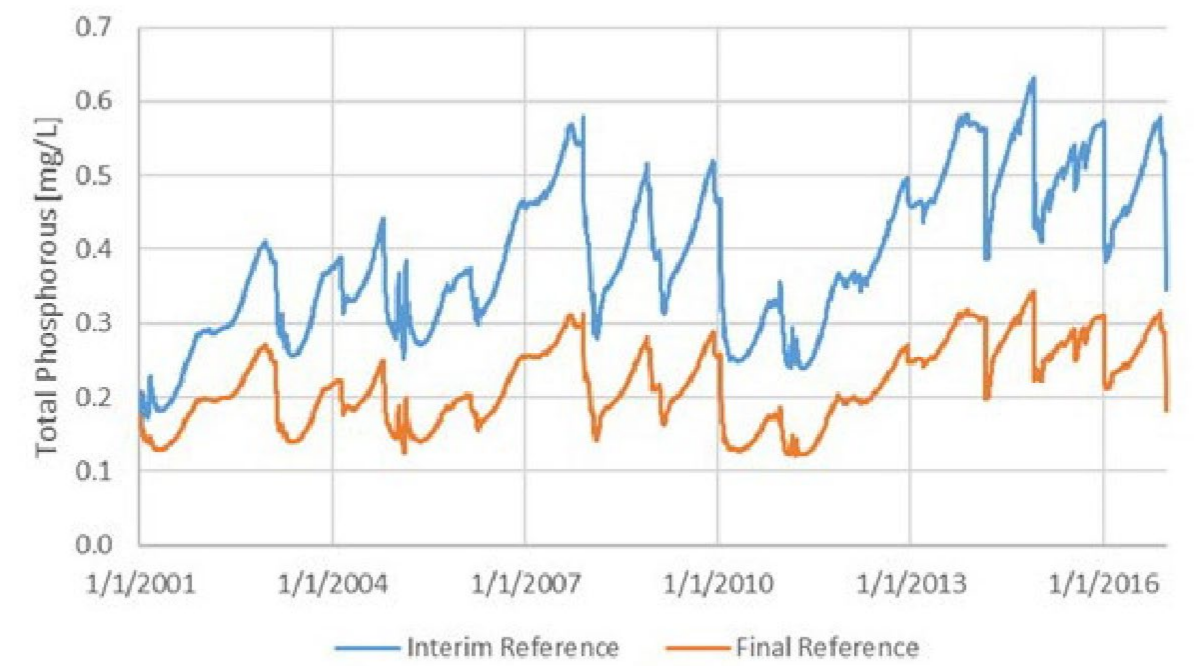

Figure 5-45. Simulated Depth-integrated Total Phosphorus in Canyon Lake East Bay for Reference Scenario

6. Total Maximum Daily Loads, Wasteload Allocations and Load Allocations

The allowable nutrient loading to Lake Elsinore and Canyon Lake is determined from analysis of the hydrology and water quality for the reference watershed condition (see Section 3.2 for description of the reference watershed condition). Specifically, this information was developed based on the following:

- Reference watershed conditions were approximated from modeling the watershed subareas by reducing external inflow nutrient concentrations levels estimated from wet weather samples collected at the San Jacinto River Cranston Guard Station (see Section 3, Numeric Targets).
- Loading of nutrients to the lakes under reference conditions was simulated based on the hydrologic responses in the watershed runoff model developed to assess existing sources of nutrients from the watershed (see Section 4, Source Assessment).
- Approximations of the internal loads associated with sediment nutrient flux (which comprises the single greatest source of TP and TN in Lake Elsinore) under reference watershed conditions (see Section 5, Linkage Analysis).

This section partitions the total allowable loads of TP and TN into WLAs (for point sources) and LAs (for non-point sources) for individual jurisdictions as follows:[25]

- *Section 6.1 – Total Maximum Daily Load:* The total allowable load of nutrients from external sources, plus a MOS, equals the TMDLs for Lake Elsinore and Canyon Lake. For these waterbodies, the TMDLs are based on estimated nutrient concentrations in washoff from a hypothetical reference condition over the entire watershed. Due to the benefits realized with increased lake volume (see Section 3.2.2.2), current volumes of runoff and supplemental water additions are accounted for in the estimation of WLAs and LAs.
- *Section 6.2 – Watershed Runoff:* Nutrient loads from watershed runoff are allocated to upstream jurisdictional areas in this section. 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 within the watershed.

[25] 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 non-point sources of pollution or to natural background sources.

- *Section 6.3 – Supplemental Water:* Allowable loads from the addition of supplemental water to Lake Elsinore are described in this section. While the addition of supplemental water represents a discharge of nutrients, it is important to recognize that the addition of supplemental water also represents a water quality management strategy. The WLA for supplemental water to Lake Elsinore is based on a reference watershed runoff nutrient concentration (See Section 3.2.2.3) and does not consider additional water quality benefits for response targets that may be achieved with a deeper lake.
- *Section 6.4 – Internal Loads:* Estimates of allocations for internal loads including atmospheric deposition and sediment nutrient flux are described in this section. Implementation of the TMDLs 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 averaging periods for allocations. 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 Loads

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:

$$TMDL = WLA + LA - Retention$$

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 decision to use a concentration basis for allocations is intended to support a water management goal of increasing the volume of water that reaches the lakes.

Since the TMDLs are expressed in terms of mass, there must be a term for volume in the calculation of the TMDLs and in-turn allocations for external sources. The following sections employ model estimates of long-term average runoff for existing watershed conditions (based on 2019 land use mapping) and near-term projections of long-term average supplemental water additions to convert reference concentrations into 10-year average load allocations for watershed loads. 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.

A TMDL requires a MOS that accounts for the uncertainty about the relationship between pollutant loads and the quality of the receiving water. As noted in Section 3, the MOS may be implicit, i.e., it is incorporated into the TMDLs through conservative assumptions in the analysis, or explicit, i.e., it is an explicit load set aside to provide a MOS. The MOS is incorporated into the LECL TMDLs implicitly through conservative assumptions; specifically, the use of the 25th percentile TP and TN concentrations (0.16 mg/L and 0.68 mg/L, respectively) of water quality observations from the San Jacinto River watershed Cranston Guard Station reference site as a MOS for the TMDLs.

6.2 Watershed Runoff

6.2.1 Allowable Runoff Loads

For all external nutrient sources, WLAs and LAs are determined from nutrient concentrations in wet weather runoff from a reference watershed ($C_{reference}$). Due to the benefits realized with increased lake volume, current volumes (V_{annual}) of runoff and supplemental recycled water additions are accounted for in the estimation of WLAs and LAs, as follows:

$$WLA \text{ or } LA = V_{annual} * C_{reference}$$

Allocations for external loads were developed based on assumptions of reference nutrient concentrations at the 25th percentile of all wet weather samples in the Cranston Guard Station dataset (TP: 0.16 mg/L and TN: 0.68 mg/L). The revised TMDLs include an interim milestone nutrient load (aligned with Phase II Implementation Plan – see Section 7 below) to demonstrate progress toward meeting the allocations. These milestones are calculated based on the median of all wet weather samples in the Cranston Guard Station dataset (TP: 0.32 mg/L and TN: 0.92 mg/L).

Section 3.2 describes how nutrient concentrations are estimated for a reference watershed condition. 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**).

Allocations of nutrient loads were parsed by jurisdiction using current city, county, state, federal, and agricultural land mapping (**Figure 6-2**). Runoff and nutrient loading from these areas were estimated by reducing nutrients to reference concentrations in the watershed model. The subwatershed zone for jurisdictional areas plays a role in reference loading due to variations in annual rainfall.

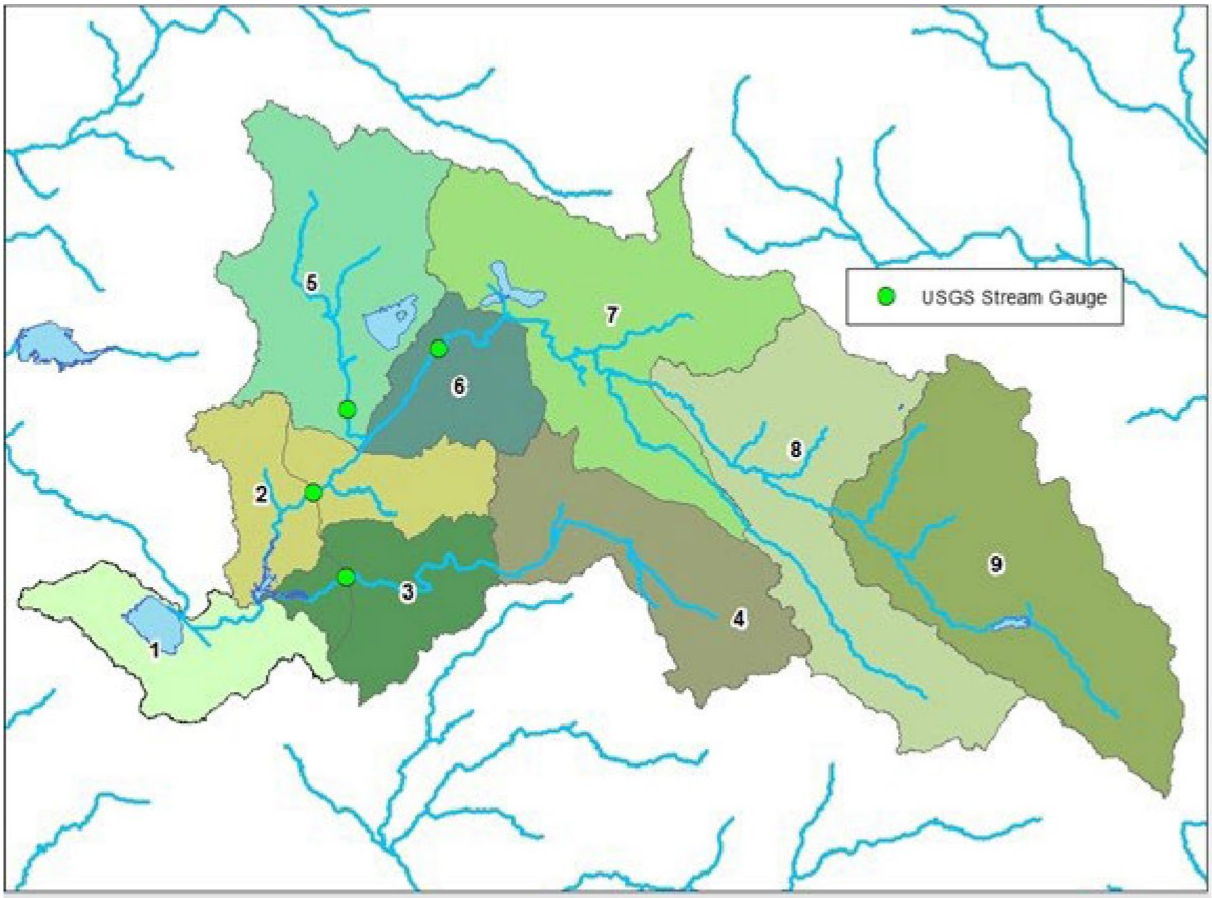

Figure 6-1. Location of Subwatershed Zones in the San Jacinto River Watershed (Zones 2, 5-9 drain to Canyon Lake – Main Lake [except note that Zones 7-9 are often intercepted by Mystic Lake]; Zones 3-4 drain to Canyon Lake – East Bay; and Zone 1 drains to Lake Elsinore)

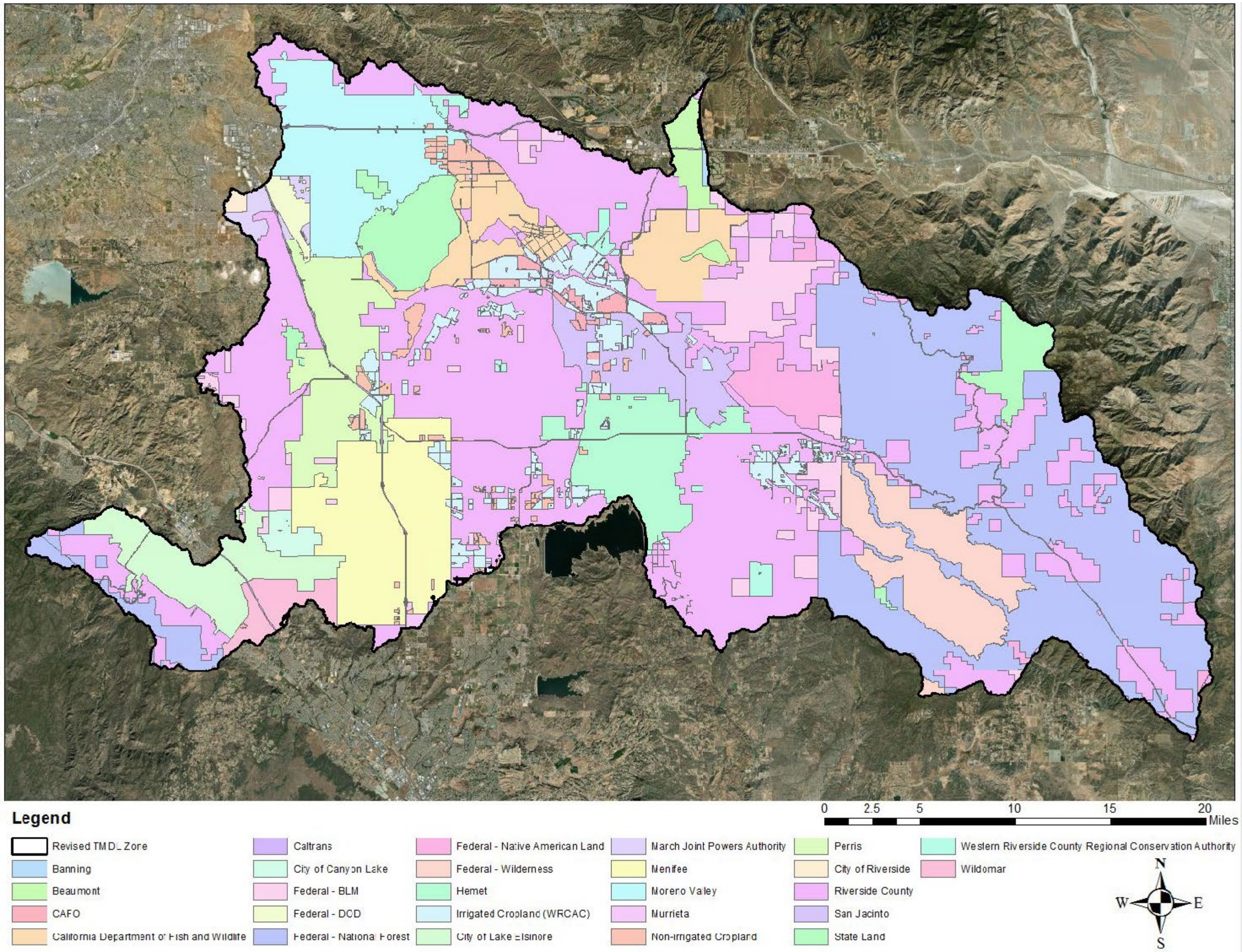

Figure 6-2. Jurisdictional Boundaries in the Lake Elsinore and Canyon Lake Watershed

TMDLs and allocations are presented for each of the following sources:

Canyon Lake

- Watershed runoff from jurisdictions in San Jacinto River downstream of Mystic Lake (i.e., Subwatershed Zones 2 - 6), including: (a) WLAs for urban runoff from urban MS4s, California Transportation Department (Caltrans), CAFs, March Joint Powers Authority (JPA), and March Air Reserve Base (ARB); (b) LAs for irrigated and non-irrigated agriculture (> 20 acre operators); and (c) state and federal lands.
- Losses from channel bottom recharge in Salt Creek, San Jacinto River, and Perris Valley Channel.
- Internal nutrient load from lake bottom sediment releases estimated (with AEM3D) to occur when external loads are reduced to reference watershed condition.
- Atmospheric deposition at existing estimated loading.

Lake Elsinore

- Watershed runoff from the local Lake Elsinore watershed downstream of Canyon Lake (i.e., Subwatershed Zone 1) including: (a) WLAs for urban runoff from urban MS4s and Caltrans; and (b) LAs for federal lands.
- Addition of supplemental recycled water to maintain lake levels.
- Overflows from Canyon Lake to Lake Elsinore.
- Watershed runoff from the Mystic Lake watershed (i.e., Subwatershed Zones 7 - 9) including: (a) WLAs for urban runoff from urban MS4s, Caltrans, and CAFs; and (b) LAs for irrigated and non-irrigated agriculture (> 20 acre operators) and state and federal lands.
- Losses from retention in Mystic Lake.
- Internal nutrient load from lake bottom sediment releases estimated (with GLM) to occur when external loads are reduced to reference watershed condition.
- Atmospheric deposition at existing estimated loading

The basis for how the WLAs/LAs were developed for the revised TMDLs is summarized in the following sections. Further, in accordance with the CWA and its implementing regulations, margins of safety have been included to account for uncertainty and a lack of knowledge.

Tables 6-1 and 6-2 provide the results of the allocation analysis for each jurisdiction or agency responsible for implementation of the TMDLs in Canyon Lake and Lake Elsinore, respectively. These results represent a snapshot of allocations at lake inflows based on 2022 updates to jurisdictional boundaries across the San Jacinto River watershed. As the characteristics of jurisdictional areas change, which is anticipated to be largely a conversion of undeveloped or agricultural land uses to urban land uses (see Section 2.2.1, Table 2-5 for changes to watershed land use since the 2004 TMDL), the allowable loads and need to reduce existing loads is transferred to the jurisdiction or entity that becomes responsible for the area where the land has been urbanized. For example, when an agricultural field in Hemet is converted to a commercial development, the City of Hemet would receive an increased allowable load to accommodate the new jurisdictional area that has been urbanized. Thus, allocations as well as existing loads may be reconsidered with future updates to land use mapping at the discretion of the Regional Board Executive Officer.

6.2.2 Watershed Runoff Load Reductions to Meet TMDL Allocations

The difference between existing nutrient load and allocation is the reduction needed for each watershed jurisdiction to meet the reference watershed condition and thereby meet the TMDLs (**Table 6-3**). This nutrient mass reduction would be needed if watershed BMPs were solely used to reduce excess load from an individual jurisdictional area. **Table 6-3** would not apply to jurisdictions that participate in regional in-lake offsets to meet a portion of WLA/LA. Section 7.2.5.4 provides formulas for estimating offset demands for regional in-lake project participation.

6.3 Supplemental Water

Supplemental water is added to Lake Elsinore to maintain lake levels (Santa Ana Water Board 2013b). The GLM model for Lake Elsinore showed that without supplemental water additions since 2002, the lake level would have fallen below 1,228 ft in 2016 (**Figure 6-3**). **Table 6-4** provides the WLA for supplemental water additions to Lake Elsinore based on projected effluent rates for EVMWD recycled water. Managing the lake level through addition of supplemental water is contrary to the natural condition, which results in a periodically dry lake (See Section 2.2.2.2). Increased lake levels resulting from supplemental water addition may provide water quality benefits by increasing habitat for littoral zone aquatic communities and reducing resuspension of bioavailable nutrient concentrations into the water column. Further, managing the lake to keep it "wet" not only changes the dynamics of the lake, but a wet lake management strategy also ensures support of existing recreational beneficial uses.

Table 6-1. Allocations for Watershed Runoff in Canyon Lake Nutrient TMDLs

Responsible Agency or Jurisdiction	Interim Milestone[1]		Final Allocation[1]	
	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)
Wasteload Allocations[2]				
CAF[4]	0.8	2	0.4	1.6
Caltrans	52	151	26	111
City of Canyon Lake	71	203	35	150
Federal – Department of Defense	55	158	28	117
Hemet	444	1,277	222	944
City of Lake Elsinore	55	160	28	118
March Joint Powers Authority	53	153	27	113
Menifee	758	2,179	379	1,611
Moreno Valley	862	2,478	431	1,832
Murrieta	16	45	8	33
Perris	500	1,438	250	1,063
City of Riverside	25	72	13	53
Riverside County	1,205	3,464	602	2,561
San Jacinto	3	9	1	6
Wildomar	0.1	0.3	0.1	0.3
Load Allocations[2]				
Agriculture: Irrigated	105	302	53	223
Agriculture: Non-irrigated	41	119	21	88
California Department Fish & Wildlife	48	138	24	102
Federal – Bureau of Land Management	37	106	18	78
Federal - National Forest	5	13	2	10
State Land	38	111	19	82
Western Riverside County Regional Conservation Authority	19	55	10	40
Minus Watershed Retention[3]	-590	-1695	-295	-1253
Total Allowable Watershed Load (WLAs and LAs)	**3,804**	**10,937**	**1,902**	**8,084**

[1] Interim milestones are to be achieved within 20 years of the effective date of the revised TMDL and coincide with the Phase II Implementation Plan (see Section 7.2 below), final allocations are to be achieved within 30 years of the effective date of the TMDL and coincide with the Phase III Implementation Plan (see Section 7.3 below).

[2] Allocations are for watershed runoff at the jurisdictional boundary and reflect current boundaries. Revision to the TMDL and these allocations may be needed in the future if substantial changes to jurisdictional areas occur in the future (such as with attrition of agricultural land)

[3] Retention is based on assumed reference nutrient concentration in retained runoff.

[4] If the Santa Ana Water Board determines at any time during Phase II or Phase III that any facilities regulated in Order R8- 2018-0001 as CAFOs (as defined in 40 CFR 122.23(b)(2)) should instead be regulated as nonpoint sources, the wasteload allocation for such facilities shall be deemed a load allocation and shall continue to apply.

Table 6-2. Allocations for Watershed Runoff in Lake Elsinore Nutrient TMDLs

Responsible Agency or Jurisdiction[4]	Interim Milestone[1]		Final Allocation[1]	
	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)
Local Lake Elsinore Watershed				
Wasteload Allocations[2]				
Caltrans	11	33	6	24
City of Canyon Lake	11	31	5	23
City of Lake Elsinore	323	930	162	687
Menifee	5	15	3	11
Riverside County	110	315	55	233
Wildomar	99	284	49	210
Load Allocations[2]				
Federal - National Forest	64	183	32	135
Subtotal Watershed Allocation (local watershed)	623	1,791	311	1,324
Watershed Above Mystic Lake				
Wasteload Allocations[2]				
Beaumont	134	385	67	284
CAF[5]	3	8	1	6
Caltrans	42	120	21	89
Hemet	192	552	96	408
Moreno Valley	10	29	5	21
Riverside County	1,187	3,414	594	2,523
San Jacinto	353	1,016	177	751
Load Allocations[2]				
Irrigated Cropland (WRCAC)	119	342	59	253
Non-irrigated Cropland	26	75	13	55
California Department of Fish and Wildlife	192	553	96	409
Federal - BLM	192	553	96	409
Federal - National Forest	1,987	5,712	993	4,222
Federal - Native American Land	113	325	57	240
Federal - Wilderness	389	1,120	195	828
State Land	157	452	79	334
Western Riverside County Regional Conservation Authority	19	53	9	39
Minus Watershed Retention[3]	-4,915	-14,131	-2,458	-10,444
Subtotal Watershed Allocation (above Mystic Lake)	201	577	100	427
Load Allocation for Canyon Lake Overflow to Lake Elsinore	2,471	7,104	1,235	5,251
Total Allowable Watershed Load (WLAs and LAs)	**3,295**	**9,472**	**1,647**	**7,001**

[1] Interim milestones are to be achieved within 20 years of the effective date of the revised TMDL and coincide with the Phase II Implementation Plan (see Section 7.2 below), final allocations are to be achieved within 30 years of the effective date of the TMDL and coincide with the Phase III Implementation Plan (see Section 7.3 below).

[2] Allocations are for watershed runoff at the jurisdictional boundary and reflect current boundaries. Revision to the TMDL and these allocations may be needed in the future if substantial changes to jurisdictional areas occur in the future (such as with attrition of agricultural land).

[3] Retention is based on assumed reference nutrient concentration in retained runoff

[4] The City of Banning discharges nutrients to the watershed but does not have a wasteload allocation, pending results from Task 9 to define and identify minor source contributors. The absence of assigned milestones or a wasteload allocation to the City should not be considered a WLA of zero. The TMDL assumes that the current loading from this area will continue with insignificant to no net increase.

[5] If the Santa Ana Water Board determines at any time during Phase II or Phase III that any facilities regulated in Order R8- 2018-

0001 as CAFOs (as defined in 40 CFR 122.23(b)(2)) should instead be regulated as nonpoint sources, the wasteload allocation for such facilities shall be deemed a load allocation and shall continue to apply.

Table 6-3. Nutrient Load Reduction Required for Watershed Jurisdictions Downstream of Mystic Lake to Lake Elsinore and Canyon Lake Nutrient TMDLs

Responsible Agency or Jurisdiction	Interim Milestone[1]		Final Milestone[2]	
	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)
Canyon Lake[3]				
CAF	9	13	9	13
Caltrans	17	338	40	374
City of Canyon Lake	31	287	65	337
Federal – Department of Defense	23	357	49	396
Hemet	276	1,313	462	1,592
City of Lake Elsinore	21	130	41	161
March Joint Powers Authority	22	176	38	199
Menifee	462	2,340	747	2,768
Moreno Valley	463	3,207	845	3,779
Murrieta	9	54	16	65
Perris	472	1,514	665	1,804
City of Riverside	13	71	25	89
Riverside County	1,832	4,669	2,123	5,106
San Jacinto	0.4	6	1	6
Irrigated Cropland (WRCAC)	247	29	298	107
Non-irrigated Cropland	422	471	443	502
Federal - BLM	7	8	8	9
State Land	8	12	9	13
Total (below Mystic Lake)	**4,335**	**14,996**	**5,884**	**17,320**
Lake Elsinore				
Caltrans	3	71	8	78
Canyon Lake	4	36	8	42
Lake Elsinore	117	725	221	881
Menifee	2	8	3	10
Riverside County	42	236	72	282
Wildomar	38	239	72	291
Federal - National Forest	0.3	1	1	1
Total (Local LE Watershed)	**206**	**1,316**	**385**	**1,585**

[1] Baseline load (Table 4-10) – Allocation (Table 6-1 or 6-2) = Watershed Load Reduction (Table 6-3)

[2] Baseline load adjusted to account for open space and forest at 25th percentile of Cranston Guard Station wet weather grab sample TP and TN concentrations (not shown in Table 4-10)

[3] Watershed load reductions not reported for subwatersheds 7-9 upstream of Mystic Lake. Typical runoff controls assumed to be ineffective in storms large enough to cause Mystic Lake overflow

Table 6-4. Milestones and WLAs for EVMWD Recycled Water Additions to Lake Elsinore

EVMWD Recycled Water Additions	Flow[1]	Concentration[2]		Nutrient Load[3]	
	mgd (AFY)	TP (mg/L)	TN (mg/L)	TP (kg/yr)	TN (kg/yr)
Current Permit	7.5 (8,402)	0.50	1.00	3,721	7,442
Milestones	7.5 (8,402)	0.32	0.92	3,317	9,535
WLA	7.5 (8,402)	0.16	0.68	1,658	7,048

[1] Recycled water discharges to Lake Elsinore as required to maintain water levels up to 7.5 mgd

[2] Concentration based on 12-month running average

[3] Mass load is a 5-year running average.

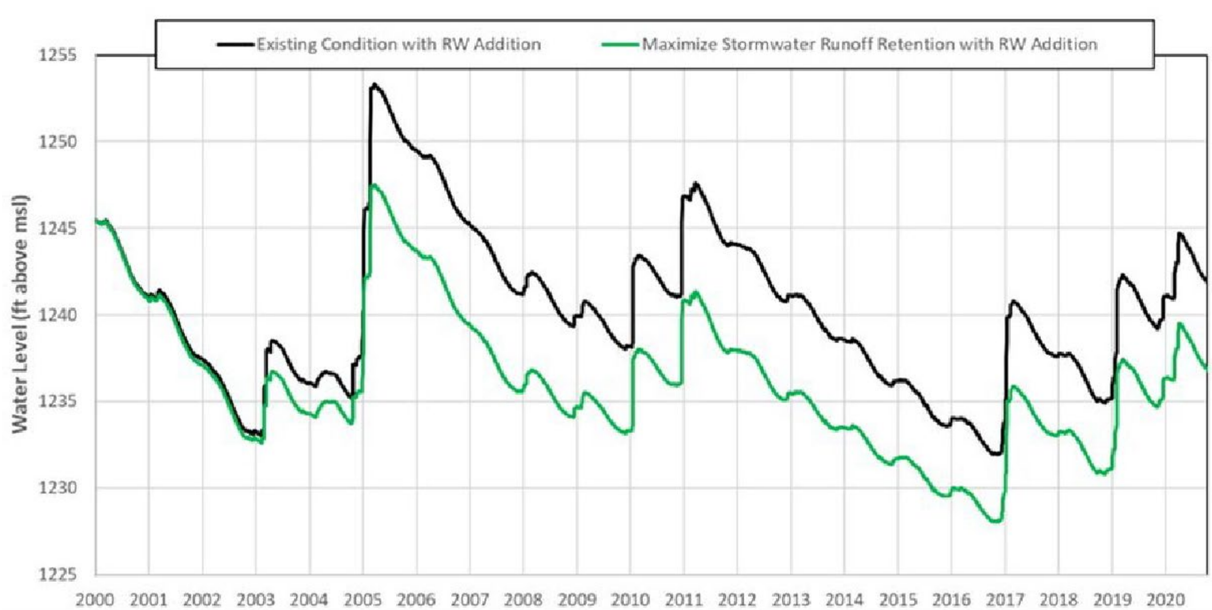

Figure 6-3. Actual Lake Level Compared to Reference Condition (without supplemental water and with LEMP basin)

6.4 Internal Loads

The information provided in the sections below was first presented in Section 4.3. It 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 the 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:

- To evaluate the paleolimnology of Lake Elsinore, Kirby et al. (2005) collected and dated 10-m sediment cores to represent the past 10,000 years. Results showed higher total organic matter, higher nitrogen levels, lower carbon to nitrogen (C:N) ratios (a measure of the relative contribution of terrestrial vs. aquatic organic matter with lower values indicating increased contributions from aquatic sources), and higher OP values in sediment from shallow depths (most recent 200 years) compared with sediment in the remainder of the core (200 – 10,000 years ago) (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.

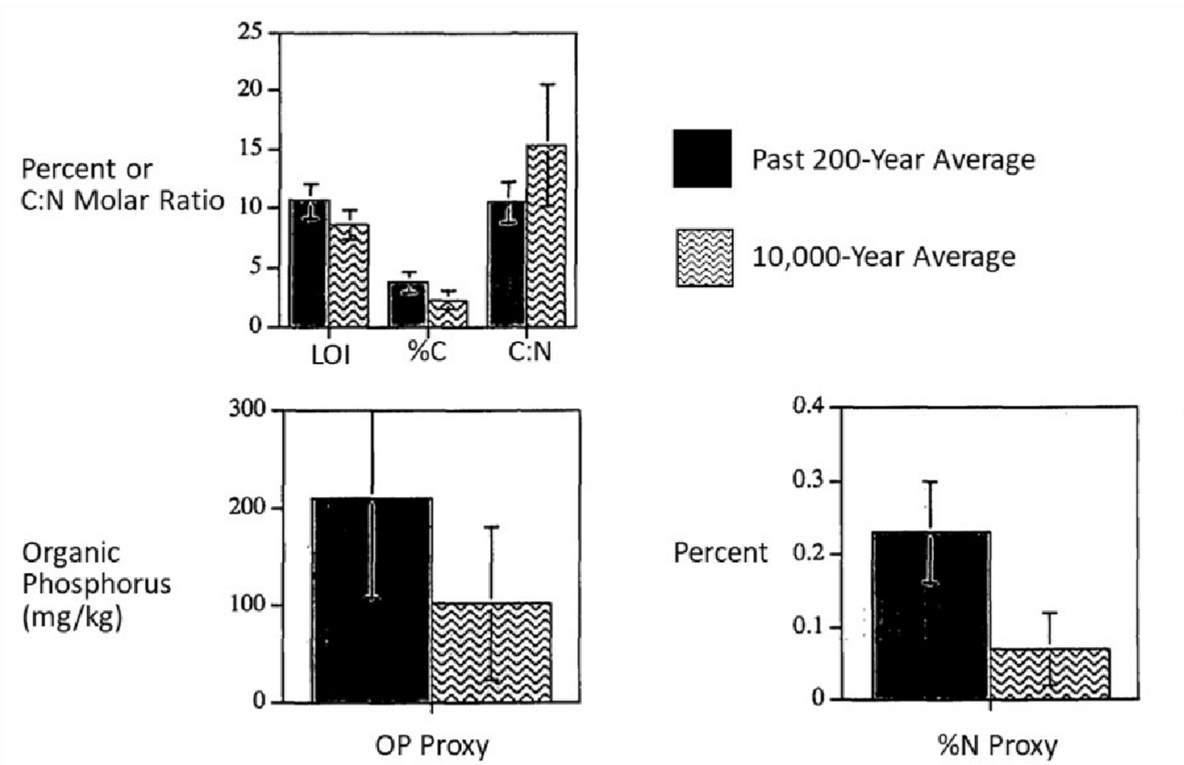

Figure 6-4. Comparison of Nutrient Levels and Lake Productivity Level Proxies (LOI = loss on ignition) for the Past 200 Years Versus the 10,000 Year Historic Record (Dark shaded area = past 200-year average; hatched area = 10,000-year average; bars represent 1 standard deviation from mean) (adapted from Figure 22 in Kirby et al. 2005)

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 (charts in **Figure 6-4** show that enrichment in most recent 200 years is about double that of the preceding 9,800 years). The dynamic simulation for this scenario approximates the naturally occurring sediment nutrient flux modulated by daily fluctuations in DO, 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 to or better than a reference watershed condition. Once reference watershed conditions are achieved, it may take several decades[26] for internal loads to return to the load allocation, depending mostly upon future hydrologic conditions.

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 - Interim[1]	437	1.6	5.4	1,190	3,955
Canyon Lake - Final[1]	437	0.9	3.7	683	2,741
Lake Elsinore - Interim	3,000	4.0	27.0	17,629	121,053
Lake Elsinore – Final	3,000	2.6	32.0	11,568	103,251

[1] Includes North Ski Area, the portion of Canyon Lake north of the causeway, but no sediment data has been collected to date to characterize flux rates from this zone.

6.4.2 Atmospheric Deposition

Load allocations were developed for direct deposition from the atmosphere to the lake surfaces. The approach presented below is based on similar data used for the 2004 TMDLs but ensures a consistent method for TP and TN is applied to each lake.

6.4.2.1 Total Phosphorus

Wet deposition of TP to each lake 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**.

[26] Estimated lag time supported by empirical analysis of Dr. Michael Anderson, slideshow presentation titled, “Task 1: Estimate Rate at Which Phosphorus is Rendered No Longer Bioavailable in Sediments”, January 23, 2012.

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[1]	437	0.05	3.23	22	1,408
Lake Elsinore	3,000	0.05	3.23	156	9,682

[1] Includes North Ski Area portion of Canyon Lake, north of the causeway

6.4.2.2 Total Nitrogen

Estimates for atmospheric deposition of TN are based on results of 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 TMDLs used a value of 7.1 lbs/ac/yr (3.2 kg/ac/yr) based on Meixner et al. (2004). No significant changes to atmospheric N deposition are expected nor is there any new regional data, therefore the same rates have been used in the revision of the TMDLs. Table 6-6 shows the load allocation for TN in each lake segment.

6.5 Summary of Allocated Loads

6.5.1 Total for Point and Non-point Source Allocations

Tables 6-7 and 6-8 present the total allocated load, considering both point and non-point sources of nutrients for Canyon Lake and Lake Elsinore, respectively. The watershed jurisdiction runoff loads are expressed at the jurisdictional boundary and do not account for losses within downstream retention areas (e.g., Mystic Lake,) or seepage within unlined channel bottoms. Losses are accounted for in computing the TMDL for each lake as reported in **Tables 6-7 and 6-8**. **Table 6-9** compares these allocations with the 2004 TMDLs, 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. 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 2004 TMDLs has been used in the revised TMDLs.

Table 6-7. Summary of Milestones, WLAs and LAs for Major Categories of Nutrient Sources to Canyon Lake from Subwatersheds below Mystic Lake

Source	Phase II Milestone (kg/yr as 10 yr running average)		Phase III Final Allocation (kg/yr as 10 yr running average)	
	TP	TN	TP	TN
MS4 Jurisdiction Runoff (WLA)	3,939	11,326	1,970	8,371
Caltrans Jurisdiction Runoff (WLA)	52	151	26	111
March JPA Jurisdiction Runoff (WLA)	53	153	27	113
March ARB Jurisdiction Runoff (WLA)	55	158	28	117
CAF (WLA)[1]	1	2	0.4	2
Irrigated Agriculture (LA)	105	302	53	223
Non-Irrigated Agriculture (LA)	41	119	21	88
Other State/Federal/Tribal Jurisdictions (LA)	147	421	73	311
Reference Watershed Retention[2]	- 590	- 1695	- 295	- 1253
Subtotal Watershed Allocation (below Mystic Lake)	3,804	10,937	1,902	8,084
Atmospheric Deposition (LA)	23	1,406	23	1,406
Sediment Nutrient Flux (LA)	1,190	3,955	683	2,741
Canyon Lake TMDL	**5,017**	**16,298**	**2,608**	**12,230**

[1] If the Santa Ana Water Board determines at any time during Phase II or Phase III that any facilities regulated in Order R8-2018-0001 as CAFOs (as defined in 40 CFR 122.23(b)(2)) should instead be regulated as nonpoint sources, the wasteload allocation for such facilities shall be deemed a load allocation and shall continue to apply

[2] Retention is based on assumed reference nutrient concentration in retained runoff.

Table 6-8. Summary of Milestones, WLAs and LAs for Major Categories of Nutrient Sources to Lake Elsinore

Source	Phase II Milestone (kg/yr as 10 yr running average)		Phase III Allocation (kg/yr as 10 yr running average)	
	TP	TN	TP	TN
Local Lake Elsinore Watershed				
MS4 Jurisdiction Runoff (WLA)	548	1,575	274	1,164
Caltrans Jurisdiction Runoff (WLA)	11	33	6	24
Other State/Federal/Tribal Jurisdictions (LA)	64	183	32	135
Subtotal Watershed Allocation (local watershed)	623	1,791	311	1,324
Watershed Above Mystic Lake				
MS4 Jurisdiction Runoff (WLA)	1,876	5,395	938	3,987
Caltrans Jurisdiction Runoff (WLA)	42	120	21	89
CAF (WLA) [1]	3	8	1	6
Irrigated Agriculture (LA)	119	342	59	253
Non-Irrigated Agriculture (LA)	26	75	13	55
Other State/Federal/Tribal Jurisdictions (LA)	3,050	8,769	1,525	6,481
Minus Reference Watershed Retention[2]	-4,915	-14,131	-2,458	-10,444
Subtotal Watershed Allocation (above Mystic Lake)	201	579	101	428
Canyon Lake to Lake Elsinore (LA)	2,471	7,104	1,235	5,251
Supplemental Water	3,317	9,535	1,658	7,048
Atmospheric Deposition	156	9,682	156	9,682
Sediment Nutrient Flux	15,227	104,559	10,221	91,232

Table 6-8. Summary of Milestones, WLAs and LAs for Major Categories of Nutrient Sources to Lake Elsinore

Source	Phase II Milestone (kg/yr as 10 yr running average)		Phase III Allocation (kg/yr as 10 yr running average)	
	TP	TN	TP	TN
Lake Elsinore TMDL	**21,994**	**133,248**	**13,683**	**114,963**

[1] If the Santa Ana Water Board determines at any time during Phase II or Phase III that any facilities regulated in Order R8-2018-0001 as CAFOs (as defined in 40 CFR 122.23(b)(2)) should instead be regulated as nonpoint sources, the wasteload allocation for such facilities shall be deemed a load allocation and shall continue to apply.
[2] Retention is based on assumed reference nutrient concentration in retained runoff.

Table 6-9. Comparison of Total WLAs and LAs for External Nutrient Sources Between the Proposed Revised TMDLs and Existing 2004 TMDLs

Total Allowable External Loads[1]	Total Phosphorus (kg/yr)			Total Nitrogen (kg/yr)		
	2004 TMDL	TMDL Revision Interim	TMDL Revision Final	2004 TMDL	TMDL Revision Interim	TMDL Revision Final
Total Canyon Lake	3,845	3,804	1,902	22,268	10,937	8,084
Canyon Lake to Lake Elsinore (LA)	2,770	2,471	1,235	20,774	7,104	5,251
Lake Elsinore[2]	6,922	6,612	3,306	29,953	19,009	14,050

[1] Total allowable external load for watershed and supplemental water is the TMDL minus allocations for internal sources, e.g., sediment nutrient flux and atmospheric deposition.
[2] TMDL includes the LA for Canyon Lake overflows.

7. Implementation

Revision of the LECL TMDLs includes implementation requirements designed to continue progress toward returning water quality to a reference condition for both Lake Elsinore and Canyon Lake. Through the TMDLs' Phase I Implementation Plan, a combination of watershed and in-lake controls have been implemented by individual entities or through collaboration by multiple agencies. This section describes the Implementation Plan for Phase II (interim milestones) and Phase III (final compliance) of the revised TMDLs. These water quality control activities include: (1) completing studies to support future management and policy decisions; (2) constructing watershed and in-lake water quality controls; and (3) conducting monitoring that collects data needed to support demonstrations of attainment either through collective watershed load reductions or participation in offset programs involving in-lake treatment. The following sections summarize Phase I activities and present the Phases II and III Implementation Plans and adaptative management approach:

- *Section 7.1 – Review of Past and Present Water Quality Control Efforts (Phase I Implementation Plan)*: Water quality control activities and studies have been ongoing in the San Jacinto River watershed for many years. The outcomes from these 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 TMDLs' 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 these analyses, this section presents the scientific basis for estimating future water quality benefits that will be accrued from continued implementation of existing water quality control efforts.
- *Section 7.2 – Phase II Implementation Plan:* This section presents the Phase II Implementation Plan designed to achieve, at a minimum, the interim targets and milestones established in the revised TMDLs. This section describes the specific tasks planned during Phase II, schedule for completion of each task, entities responsible for implementation and allowable approaches to demonstrate attainment with milestones. In general, Phase II tasks involve studies, updates to existing permits, implementation plans and programs, evaluation and assessment of existing in lake controls, enhancement of existing watershed and in-lake water quality control activities, potential design and construction of new, supplemental projects, and evaluation of the effectiveness of enhanced and supplemental projects. Phase II includes two milestones for comprehensive review of new data and understanding gained with completion of tasks to support assessment of the appropriateness of the revised TMDLs and potential for their reconsideration.

- *Section 7.3 – Phase III Implementation Plan:* This section presents the Phase III Implementation Plan designed to achieve the final targets and allocations in the revised TMDLs. This section describes the specific tasks planned during Phase III, schedule for completion of each task and entities responsible for implementation. Unless updated during Phase II, the approaches for demonstrating attainment during Phase III are expected to be the same as described for Phase II (see Section 7.2).

7.1 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 other key planning studies completed since implementation of LEMP, and a summary of completed or ongoing water quality control efforts in the lakes and/or the watershed during Phase I implementation (2004-2023).

7.1.1 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 3-6). This project demarcates when the decision was made 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 uses 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 several planning studies to evaluate options for implementation of additional water quality controls in the watershed or lakes. The findings from these studies and others are summarized below.

7.1.2 Pre-TMDL & Phase I Water Quality Planning/Management Efforts

7.1.2.1 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 both Lake Elsinore and Canyon Lake. Since the effective date of the 2004-adopted TMDLs, the TMDL responsible parties have implemented activities to meet the applicable WLAs and LAs and completed technical studies to better understand the water quality dynamics of Lake Elsinore and Canyon Lake. Efforts completed to date include, but may not be limited to:

- Key studies as summarized in **Table 7-1**;
- Lake modeling activities completed by Dr. Michael Anderson and UCR (e.g., see Section 5); and
- Implementation plans established by the MS4 Program (CNRP) and WRCAC (AgNMP).

Through the implementation of Phase I activities, there is now an increased understanding of the watershed reference condition, lake dynamics during wet and dry periods, and the attainability of existing causal and response targets established in the 2004 TMDLs. In 2020, the LECL Task Force demonstrated that collectively the allocations in the 2004 TMDL had been achieved (LESJWA 2021). There is remaining uncertainty regarding nutrient washoff from reference watersheds, HABs, the long-term effectiveness of in-lake controls, and climate change impacts that will be further studied through a series of studies as part of the Phase II and III programs of implementation. The following sections describe key watershed and in-lake projects and activities completed during Phase I of the program of implementation.

7.1.2.1 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 their MS4 permit and support implementation of the LECL TMDLs since 2004. The agricultural community has also been implementing BMPs through requirements established in the Conditional Waiver for Agricultural Discharge (CWAD) (Santa Ana Water Board 2017),[27] which included implementation of an AgNMP (WRCAC 2013a) and General Waste Discharge Requirements (WDRs) for dairy CAFOs (Santa Ana Water Board 2013c).

[27] Santa Ana Water Board adopted a new General Order R8-2023-0006 for irrigated lands in the San Jacinto River watershed on February 3, 2023 (Santa Ana Water Board 2023), which replaced the CWAD adopted in 2017.

Table 7-1. Summary of Key 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 recycled 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 were found to be an insignificant source of nutrients. – Plan recommends further consideration or piloting of a submerged macrophyte system in the 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 compressors; – Local wetland filtration; and – 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; and – 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 Key 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; and – 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 would create a balanced, self-sustaining, and valued sport fishery that would complement the LESJWA'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; and – 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 Key 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 algal blooms, increase water clarity, increase DO concentrations throughout the water column, and reduce or eliminate fish kills; and – 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 – proposed source of supplemental water to stabilize lake water elevations is recycled water from the EVMWD RWRF. – 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); and • 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 I: • Lake level stabilization with levee and recycled water additions; • Destratification with axial flow pumps; • Large scale in-lake aeration system; and • Fishery management including carp netting and stocking of sport fish to control shad population. – Phase II Supplemental projects – if needed: • Enhanced aeration system - more frequent operation or additional pipelines/aerators; • Enhanced treatment of recycled water to < 0.5 mg/L TP; • Direct application of alum or other chemical P treatment; • Targeted suction dredging; • Constructed wetlands in back basin; • Active aquatic plant management; • Enhanced fishery management; and • Enhanced lake stabilization (groundwater or recycled water). ▪ Key Findings: – Continued monitoring recommended to determine whether a supplemental Phase II project would be needed. – Additional 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 Key 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; and ▪ 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 different 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 strategies, 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" document 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; and – 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, and 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 dairy 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 Key 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 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 (2012c) 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 (LID); – Septic system management; – Public education and outreach; – Canyon Lake in-lake remediation projects: (a) Alum addition; (b) HOS; and – 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 2012c). • 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 Key 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,b)	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 subsidence; 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, 2021, 2022; San Jacinto River Watershed Council 2015, Southern California Area Governments, 2019)	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.

Table 7-1. Summary of Key Lake Elsinore and Canyon Lake Water Quality Planning and Management Studies Since the 1990s

Study	Objectives	Relevant Findings
Fishery Management Study, 2019-2020 (LESJWA 2020)	Assess the current status of the Lake Elsinore fishery, including the fish community (and in particular the carp population), zooplankton and phytoplankton, and identify potential management measures to further improve the fishery, supporting aquatic habitat and water quality.	▪ Established comprehensive sampling approach for assessing fish communities in Lake Elsinore that can serve as a template for future fishery studies. ▪ Provided first estimate of carp biomass density in more than 10 years; 2019-2020 density was similar to that observed in 2008, at approximately 55.3 lbs/acre. ▪ Provided recommendations for future fish stocking activities and potential fishery habitat improvement projects.
US Army Corps of Engineers Continuing Authorities Program (CAP)	Determine if there is federal interest in implementing an alternative to restore aquatic ecosystems in Lake Elsinore Study Area consistent with the CAP Section 206 authority. Project objectives include restoration of lakeshore and riparian habitats, reduction of non-native and invasive species, and improvement to recreational and educational opportunities.	▪ Characterization of habitats and lists of threatened and endangered species. ▪ California Rapid Assessment Method was used to evaluation multiple project options for ecosystem restoration projects at sites near the EVMWD effluent channel and San Jacinto River inflow to Lake Elsinore. ▪ Comprehensive multi-parameter benefit analysis for six alternatives, including one for no action.
Lake Elsinore and Canyon Lake Nutrient TMDL 2020 Final Compliance Assessment Report (LESJWA 2021)	Assess compliance with the final milestone allocations and targets in the 2004 TMDL.	▪ Measured load at lake inflows minus reductions achieved with offset programs (alum addition in Canyon Lake and LEAMS in Lake Elsinore) and determined that final allocations for TP and TN in both Canyon Lake and Lake Elsinore were met. ▪ In-lake numeric targets for TP and chlorophyll-*a* were achieved in Canyon Lake. ▪ In-lake numeric targets for DO, TN in Canyon Lake and TP, TN, DO, and chlorophyll-*a* in Lake Elsinore were not achieved.
Review of the Two Current Mixing Systems in Lake Elsinore with Recommendations for Improving Water Quality (Horne and Anderson 2021)	Assess long-term trend in performance of LEAMS through investigations into DO in the lake bottom; develop list of potential in-lake treatment options to provide increased water quality benefit if LEAMS is determined to be reaching end of useful life.	▪ LEAMS has caused an increase in DO in the lake bottom waters to levels that would reduce internal phosphorus load under some conditions. ▪ The increase in DO per hour of operation has declined over time. ▪ Oxygenation would provide more DO than aeration and mixing and should be considered for whole lake application to provide enhanced nutrient reduction. ▪ Lake elevation is the most important determinant of nutrient concentrations in the lake.

The subsections below describe existing water quality control activities being implemented by MS4 and agricultural management programs, or successor programs, and the estimated nutrient load reductions that have occurred (see Section 4.1.3 for discussion of load reduction analysis methods). The revised TMDLs do not account for additional reductions in loading from MS4 or agricultural BMPs since adoption of the existing CNRP and AgNMP. Anticipated updates to the CNRP in Phase II (see Section 7.2) will assess the effectiveness of existing watershed BMPs and the need for additional load reductions in the future.

MS4 Program

As part of its existing CNRP, the Riverside County MS4 program is currently implementing the following BMPs within the portions of the San Jacinto River watershed subject to the LECL TMDLs:

- *Street Sweeping and Debris Removal* - Street sweeping and MS4 facility debris removal activities reduce 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 resulting from street sweeping and debris removal program implementation (RCFC&WCD 2013). The model provides an estimate of 0.045 kg/yr TP and 0.051 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 such as may be implemented to meet full trash capture requirements. 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

	Sediment Removal (Metric Tons/yr)		Nutrient Load Reduction	
	Street Sweeping	Catch Basin Cleaning	TP (kg/yr)	TN (kg/yr)
Canyon Lake (Zones 2-6)	3,706	2,074	262	292
San Jacinto River above Mystic Lake (Zones 7-9)	943	649	72	80
Local Lake Elsinore (Zone 1)	423	350	35	39

- *Septic System Management*[28] - Properly functioning septic leachfields capture and treat phosphorus in residential sewage within the vadose zone prior to reaching saturated groundwater or lateral discharge to surface waters. 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).

Table 7-3. Estimate of Load Reduction Achieved by Elimination of Septic Systems

Variables	Phosphorus	Nitrogen
Unsewered Residential: RCFC&WCD Station 834 (mg/L)	0.59	5.30
Sewered Residential: RCFC&WCD Station 316 (mg/L))	0.48	2.43
Septic Signal: Unsewered – Sewered (mg/L)	0.11	2.87
Pervious Land Runoff (Liters/ac) [1]	49,400	49,400
Load Reduction (kg/ac/yr)	0.0054	0.142

[1] Estimated runoff from pervious land RC of 0.041 and average annual rainfall of 11.8 in/yr

- *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.

[28] Many septic systems in the San Jacinto River watershed are located in areas not served by an MS4. These septic systems are regulated under State Water Board OWTS regulations (State Water Board 2012) and subject to the requirements of the Local Agency Management Program for Onsite Wastewater Treatment Systems (County of Riverside 2022).

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 (to be completed as part of the Phase II TMDL Implementation Plan, see Section 7.2.2) 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.

Agricultural Lands

WRCAC has been implementing 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, 2021, 2022) and findings from watershed-related studies (e.g., Hamilton and Boldt 2015a,b; UCR 2011; and WRCAC 2013c). In addition, as noted in Table 7-1, WRCAC has overseen efforts to update agricultural land use data for the watershed (San Jacinto River Watershed Council 2015; WRCAC 2008, 2011, 2012, 2015a, 2018a, 2021 and 2022). The outcomes from these efforts provided input to the development of nutrient management practices in the watershed to support compliance with the nutrient TMDLs.

In 2023, the Santa Ana Water Board adopted Order R8-2023-0006 General WDRs for Irrigated Lands in the San Jacinto River Watershed (Agricultural General Order) (Santa Ana Water Board 2023). This Order, which supersedes the 2017 CWAD, requires agricultural operators in the San Jacinto River watershed to "implement reliable and effective management practices to control, minimize, or eliminate pollutants from their agricultural operations to surface water and groundwater" (Santa Ana Water Board 2023). WRCAC developed an AgNMP in 2013 to identify actions that may be taken pending development of the CWAD and revisions to the nutrient TMDLs (WRCAC 2013a). BMPs included in the 2013 AgNMP were consistent with the CWAD adopted in 2017 (Santa Ana Water Board 2017). Specifically, per the CWAD the AgNMP included proposed plans and schedules for the implementation of the following:

a. Implementation of nutrient controls, BMPs and reduction strategies designed to meet load allocations;
b. Evaluation of the effectiveness of BMPs;
c. Development and implementation of compliance monitoring; and
d. Development and implementation of focused studies that will provide the following data and information:
    i. Inventory of crops grown in the watershed;
    ii. Amount of manure and/or fertilizer applied to each crop with corresponding nitrogen and phosphorus amounts; and
    iii. Amount of nutrients discharged from croplands.

The 2023 Agricultural General Order includes the above requirements. For dischargers subject to the Order: (Santa Ana Water Board 2023, page 18), "This Order …____ *constitutes their approved AgNMP under the Nutrient TMDLs, as this Order addresses and implements all the required elements listed above*."

A study of alternative agricultural land BMPs by UCR (2011) provided a basis for AgNMP estimates of projected reductions in nutrient washoff from croplands (irrigated/non-irrigated), 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. To track BMP implementation, and incentivize their implementation, WRCAC developed a Water Quality Index for Agriculture (WQI_{ag}), using a modified version of the United States Department of Agriculture (USDA) NRCS's Water Quality Index for Agricultural Surface Runoff (NRCS 2017). Through use of the WQI_{ag} Tool, once each field's evaluation is submitted, collectively their data provides the reporting requirements for agricultural washoff at the watershed scale. The WQI_{ag} considers key farming factors like soil characteristics, and the nutrient, tillage, and pesticide management methods used to assess washoff impacts. In addition to these factors, the WQI_{ag} adjusts the field's score according to influences from implemented BMPs, irrigation systems and enhanced drainage systems. The WQI_{ag} scores range from one to ten and respond in a similar fashion to real world pollutant discharges, where ten is the cleanest possible discharge.

Dairy Operators

Dairy operators have a NPDES permit which requires strict adherence to manure management practices, including recordkeeping, annual reporting and compliance with the TMDLs (Santa Ana Water Board 2018). Nutrient Management Plans are also required for dairies growing forage crops for their farms. The dairy CAFO permit has provisions prohibiting discharge in all but a 24-hr, 25-year storm event. Importation of manure into the watershed from outside the San Jacinto River watershed is 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 to Canyon Lake or Lake Elsinore, except in rare winters when Mystic Lake overflows into the San Jacinto River (see Section 4.1.2.5 for discussion of influence of Mystic Lake).

In 2007, WRCAC completed a 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 several 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 and dairies report annually to the Santa Ana Water Board as part of the CAFO requirements. Lastly, the Santa Ana Water Board is developing a non-dairy order to address large confined animal facilities raising other livestock (e.g., poultry).

7.1.2.2 In-Lake Best Management Practices

Several in-lake BMPs have been working to improve water quality since adoption of the 2004 TMDLs. In-lake water quality data analyses have evaluated the effectiveness of these controls on water quality in Lake Elsinore (Horne 2015, 2018, 2020; LESJWA 2021; Risk Sciences 2016; Stillwater Sciences and Alex Horne Associates 2022) and Canyon Lake (LESJWA 2020, RCFC&WCD 2022). These analyses have demonstrated that WLA/LAs in the 2004 TMDLs were achieved through participation by dischargers through in-lake offset programs. The sections below summarize analyses used to demonstrate the effectiveness of practices that are currently serving as the in-lake nutrient reduction basis for offset programs for existing water quality control projects.

Canyon Lake Activities

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 typically twice per year in Canyon Lake since September 2013 (**Table 7-4**).

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 phosphorus 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 (Welch and Cooke 1999).

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 7-1** 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 pre-alum monitoring levels. Once settled to the bottom, most of the alum floc 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 7-2**).

Table 7-4. Dates of Alum Application and Kilograms of Dry Alum Applied by Lake Segment Since September 2013 in Canyon Lake

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
9/18/2018	145,900	38,700	9,000	193,600
3/25/2019	80,300	50,700	11,200	142,200
10/21/2019	121,000	22,500	5,600	149,100
4/14/2020	80,000	50,000	11,000	141,000
10/12/2020	145,900	38,700	9,000	193,600
10/11/2021	142,400	36,100	8,500	187,000
4/18/2022	78,300	47,300	10,600	136,200
10/10/2022	140,400	34,600	8,200	183,200
5/15/2023	80,600	51,400	11,300	143,300
Total Kilograms (through May 2023)	**2,041,500**	**816,455**	**131,100**	**2,989,055**

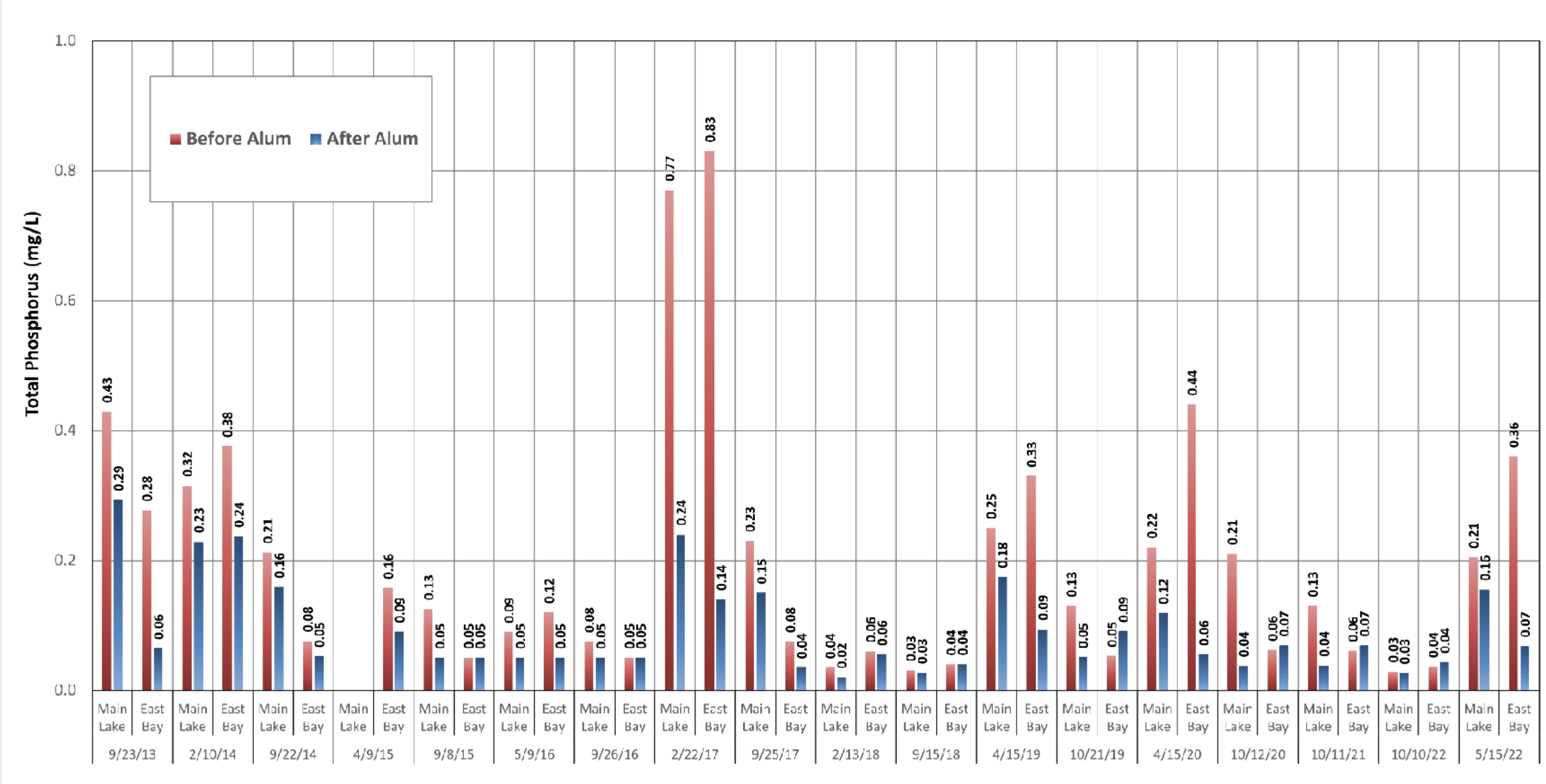

Figure 7-1. Depth-Integrated Total Phosphorus Concentration in Canyon Lake Before and After Alum Applications

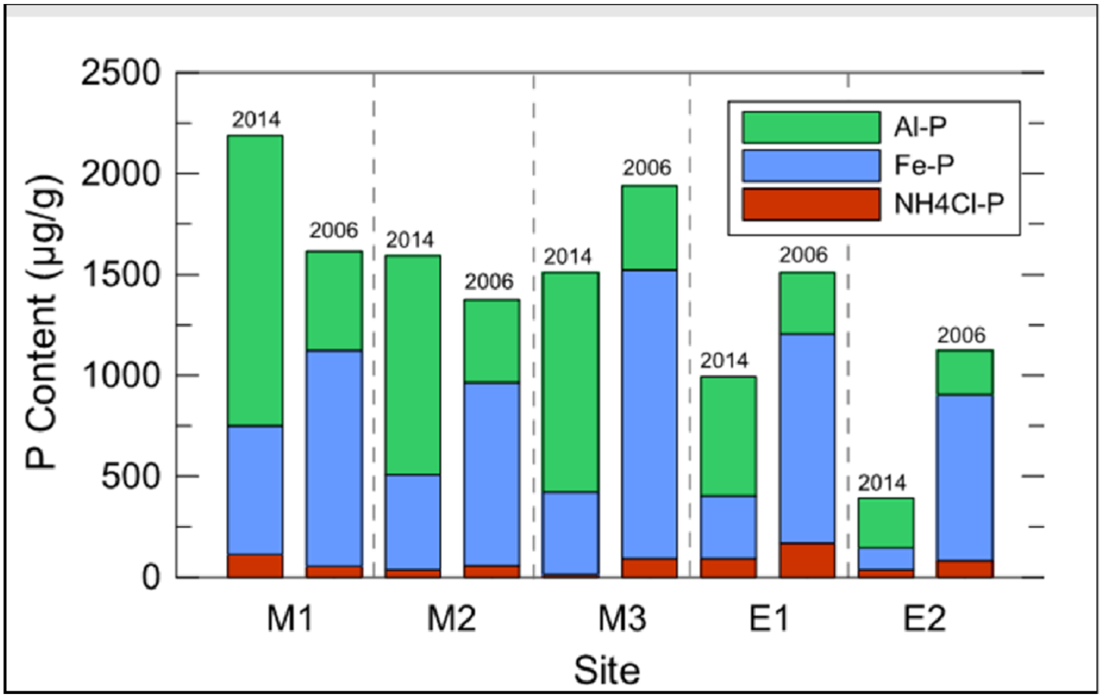

Figure 7-2. Comparison of Canyon Lake Bottom Sediment Samples Showing Changing Partitions of Phosphorus (Figure from Anderson 2016e) (M = Main Body; E = East Bay)

For waters with pH from 6 to 8, the binding capacity of alum floc was estimated based on a ratio of 150 parts alum for every one 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).

Lake Elsinore Activities

For more than 10 years multiple in-lake BMPs have been implemented in efforts to improve water quality in Lake Elsinore:

- Lake Elsinore Management Project (LEMP);
- Supplemental water addition;
- Lake Elsinore Aeration and Mixing System (LEAMS); and
- Fishery management.

Lake Elsinore Management Plan (LEMP)

According to the EA 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 2-9). 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). 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.

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 1928) 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[29] and Fill and Operate Agreement in 1991.[30] These agreements were superseded by the 2003 agreement between the City of Lake Elsinore and EVMWD, whereby EVMWD agreed reserve recycled water from its wastewater treatment facilities for maintain water levels in Lake Elsinore at 1,240 ft, subject to certain specified exceptions. [31]

Since 2002, EVMWD has provided supplemental makeup water to maintain lake levels in Lake Elsinore. Sources of supplemental water include EVMWD's treated recycled 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 4-12).

GLM results with the current lake bathymetry showed that Lake Elsinore would be dry about 9% of the time under reference conditions (see Figure 5-7). In 2015-2016, measured lake levels fell below 1,240 ft despite the addition of ~50,000 AF of supplemental water to Lake Elsinore from 2002-2016. Models estimated that the lake would have been completely dry in 2016 (CDM Smith 2022) without having these EVMWD supplemental water additions even with the levee. With population growth in the EVMWD service area, there will be sufficient volume in future years (at up to 7.5 mgd of recycled water discharged to the lake) to prevent lake levels from declining below 1,240 ft even during periods of extended drought (Anderson 2015).

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[29] Agreement entered on October 29, 1927, among George H. Tilley and Samantha Tilley, his wife, and other multiple parties. including the City of Lake Elsinore, a municipal corporation, and Temescal Water Company, a corporation. EVMWD is a successor-in-interest to the rights and obligations of the Temescal Water Company under the Tilley Agreement.

[30] 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.

[31] 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.

While the addition of EVMWD supplemental water to Lake Elsinore supports the stabilization of water levels in the lake, recycled water represents an additional external source of nutrient loads in excess of reference conditions. Currently, EVMWD is required to meet concentration and load requirements for both TP and TN per NPDES Order R8-2019-0054. These limitations are presented in Table 6-4. To meet these limits, EVMWD is allowed to offset the loads through operation of LEAMS.

Supplemental water will continue to be used to maintain minimum water levels in Lake Elsinore due to the existing agreements and understandings between the City of Lake Elsinore, EVMWD and others. This precludes any future lakebed desiccation events from occurring. Thus, the natural reset process of lakebed desiccation cannot be relied upon as a water quality improvement mechanism, nor would it be prudent to allow the lake to dry out as it results in a complete extinction of aquatic life before water quality improvement begins to occur.

Lake Elsinore Aeration and Mixing System

The 2004 TMDL set WLAs for EVMWD's recycled 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 7-3**).

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 photosynthesis, and 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 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. LEAMS provides DO at the lake bottom which can trigger the occurrence of the first step in the removal process known as nitrification, which is the conversion of ammonia released from the lake bottom into nitrate. Subsequently, the process of denitrification in zones/times of anoxia converts nitrate into nitrogen gas that is lost from the lake surface to the atmosphere (Horne 2015).

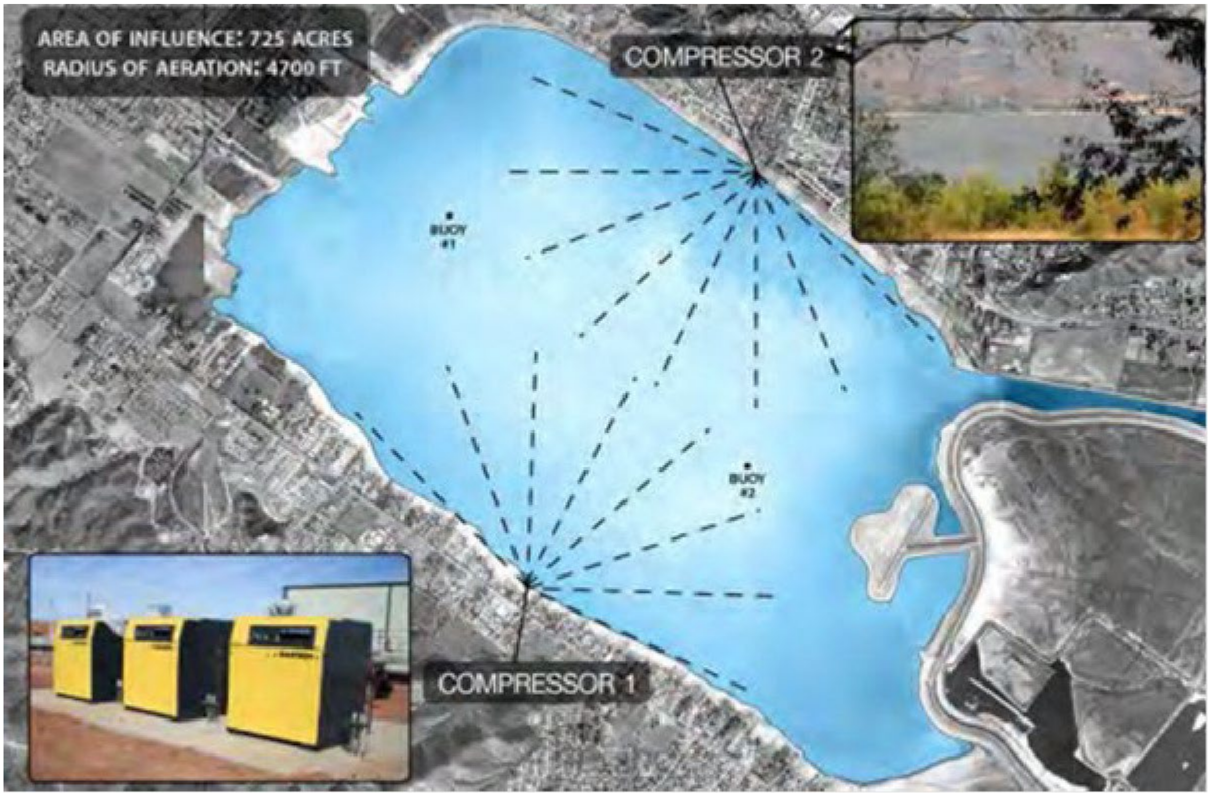


Figure 7-3. Diagram of the Lake Elsinore Aeration and Mixing System (aka LEAMS)

EVMWD has submitted technical analyses demonstrating the achievement of required offsets with LEAMS operation except for nitrogen in calendar years 2020 and 2022 (Horne 2015, 2018, 2020, 2021; Stillwater Sciences and Alex Horne Associates 2022). Review of the existing system by Horne and Anderson (2021) showed that rates of oxygen depletion from generally saturated levels in March into early summer have risen to over 0.1 mg/L/day even with extended hours and months of compressor operation, suggesting that LEAMS performance may be declining and rehabilitation or replacement with a different nutrient reduction option is now warranted. Task 5 of the Phase II Implementation Plan involves an evaluation of the current system and identification of potential enhancements or replacements for in-lake water quality control in Lake Elsinore (see Section 7.2.2.1). Task 5 is immediately followed by Task 6, the implementation of the preferred option(s) recommended through the Task 5 evaluation for in-lake water quality control in Lake Elsinore.

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 was carp removal given the impact carp, a benthivore fish community that disturbs bottom sediment by bioturbation, can have on the aquatic environment, including (1) increasing nutrient loadings to the water column through agitation of bottom sediments, 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 because 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).

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 lbs 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). Due to the success of the carp removal program, it was suspended in 2008 because the carp population was so low that the carp could no longer be captured efficiently. In 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 were resident when the carp removal program was suspended in 2008. A comprehensive fish survey was also conducted in 2019. The study found that carp density remained low at < 9 fish/acre; biomass density also remained low, i.e., it was similar to that observed in 2008 at approximately 55.3 lbs/acre (LESJWA 2020). 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 potentially restarting the carp removal program, fishery management as an existing supplemental project could also be enhanced to implement other fishery objectives previously identified (LESJWA 2005a), e.g., stocking of predator fish and improving fish habitat. The recently completed fish survey provided new recommendations (e.g., fish stocking and habitat improvements) that could be considered in conjunction with evaluations of additional supplemental projects during Phase II (see Section 7.2.2 below) (LESJWA 2020).

7.1.2.3 Watershed Monitoring Activities

Watershed monitoring data for inflows to the lakes were used to estimate current (2011-2022) nutrient loads. This approach facilitated current loading estimates that capture water quality improvements in the upstream drainage areas from implementation of watershed

BMPs deployed since 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 2011-2022 (**Table 7-5**). These changes likely 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) and CWAD that is now superseded by the Agricultural General Order (Santa Ana Water Board 2017, 2023). For the Canyon Lake overflow to Lake Elsinore, alum applications in Canyon Lake have contributed to the reduction in phosphorus in the overflow even though alum is never added during an active overflow (see **Table 7-5**).

Table 7-5. 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	2.87	0.62	2.68	0.46	1.89
Median (Post-2011)	0.58	2.10	0.43	2.29	0.15	1.50
Difference	-0.10	-0.77	-0.19	-0.39	-0.31	-0.39
Percent Change	-15%	-27%	-31%	-15%	-68%	-20%

Assessments based on downstream concentrations alone do not account for load reductions because of increased volume retention in stormwater BMPs and other factors such as episodic fires. 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 order of magnitude greater than measured in an experimental forest in Colorado (**Table 7-6**). Thus, forest land management by the US Forest Service and other entities to prevent and contain fires may be an important nutrient control measure in the San Jacinto River watershed.

Table 7-6. 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 Phase II Implementation Plan

As noted above, during the TMDLs' Phase I Implementation Plan, a combination of watershed and in-lake controls have been implemented by individual entities responsible for TMDL compliance or through collaboration by multiple agencies. This section describes the Phase II Implementation Plan under the revised TMDLs. Phase II, which begins with the effective date of the revised TMDLs, extends for a duration of 20 years. The Phase II Implementation Plan considers the existing water quality management strategies already being implemented to improve water quality in Lake Elsinore and Canyon Lake, in particular:

- *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. Considering the manmade alterations to Lake Elsinore and agreements between various entities, allowing the lake to go dry is not considered a reasonably foreseeable compliance alternative and thus is not included as a management option. Thus, the Phase II Implementation Plan under the revised TMDLs maintains a wet lake management approach.[32]
- *Canyon Lake* – Efforts to improve water quality are focused on managing nutrients within the watershed coupled with the implementation of in-lake controls, such as the application of alum to control TP. This approach will continue during TMDL implementation for the foreseeable future but must be re-evaluated as part of the Phase II Implementation Plan.

7.2.1 Key Elements of the Phase II Implementation Plan

The Phase II Implementation Plan includes a number of elements that are key to the implementation of the revised TMDLs. These elements, which are also applicable to the Phase III Implementation Plan (discussed further below in Section 7.3), include:

7.2.1.1 Implementation of TMDLs Through an Approved Coalition or Group

The responsible parties subject to these TMDLs may attains, WLAs, LAs, and the TMDLs' Implementation Plan either individually, or as part of a Santa Ana Water Board approved coalition or group. Where responsible parties are part of a Santa Ana Water Board approved

[32] EVWMD's permit to discharge recycled 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 State Water Board, Division of Water Rights approval for the change, and the State Water Board must find that the requirements of CEQA have been satisfied. Thus, any plans to change the point of the discharge in the future will require approval from the State Water Board. Further, the Phase II Implementation Plan of the revised TMDLs assumes that the discharge of recycled water will continue and may be expanded in the future up to 7.5 mgd.

coalition or group to meet all or part of the TMDL requirements, documentation demonstrating participation in the group shall be provided to the Santa Ana Water Board upon request. The Santa Ana Water Board encourages the approved coalition or group to consider subwatershed location and estimated loads of nutrients when determining cost share allocations for implementation of the tasks in this Implementation Plan. Since 2005, the LECL Task Force has operated as an approved stakeholder group that works collectively to implement certain tasks of the Lake Elsinore and Canyon Lake nutrient TMDLs.

7.2.1.2 Nutrient Offset Programs

These TMDLs establish milestones, WLAs and LAs for various sources of nutrients with the goal of returning the lakes to their reference watershed condition. The Santa Ana Water Board maintains the discretion to allow the use of pollution offsets among the different sources. Generally, pollution offsets can take place between point/point, point/non-point, and non-point/non-point pollutant sources. For these TMDLs, in-lake nutrient controls may be a cost-effective way to achieve in-lake water quality benefits and maintain beneficial uses. To encourage the implementation of in-lake nutrient controls (i.e., in-lake projects), the Santa Ana Water Board authorizes the use of nutrient offset programs through the reduction of in-lake sediment nutrient loads. Nutrient offset programs may be used to show attainment with these TMDLs, including milestones, WLAs and LAs, and may be used to demonstrate compliance with such provisions as incorporated into orders of the Santa Ana Water Board or State Water Board. Authorization for use of nutrient offset programs occurs after receiving approval from the Santa Ana Water Board, or the Santa Ana Water Board's Executive Officer as delegated by the Board.

The Implementation Plans for these TMDLs authorizes the use of offsets between internal nutrient loads in the lakes for external nutrient loads through implementation of in-lake projects because it helps to improve water quality in the lakes to meet in-lake numeric targets and protect beneficial uses. The Implementation Plan recognizes and maintains existing offset programs for a short period of time but requires that such programs be reviewed and renewed, or revised. The existing offset programs, and any new or revised offset programs, are subject to Santa Ana Water Board or Santa Ana Water Board Executive Officer review and approval.

If a TMDL responsible entity relies on nutrient offset credits for demonstrating attainment with the Phase II milestones or demonstrating compliance with the Phase III allocations (i.e., TMDLs, WLAs and LAs), as incorporated into relevant orders, documentation showing purchase of nutrient offset credits from an approved offset program shall be reported to the Santa Ana Water Board annually. Documentation of participation in an approved offset program may be provided by individual entities subject to the TMDLs or through submission of joint documents prepared by approved groups, such as LESJWA on behalf of the LECL Task Force. Although not required by these TMDLs, the Santa Ana Water Board encourages all TMDL stakeholders to work together as part of the TMDL Task Force to implement these TMDLs, and offset programs, in the most cost-effective manner.

7.2.1.3 TMDL Reconsideration

As part of the Implementation Plan, the Santa Ana Water Board will periodically review and reconsider these TMDLs. The revised TMDLs consist of two consecutive phases: Phase II applies to years 1 through 20 after the effective date of these TMDLs. Phase III applies to years 21 through 30 after the effective date of these TMDLs. Phase I was the original 2004 TMDL, which will be replaced in its entirety by these revised TMDLs.

Phasing these TMDLs is necessary because additional data and information will be obtained during Phase II that is necessary to evaluate and determine if the final numeric targets, TMDLs, WLAs and LAs that must be attained by the end of Phase III reflect the appropriate estimation of the reference watershed condition or if they should be modified to reflect a more appropriate estimate of the reference watershed condition.

As part of the Phase II Implementation Plan, the Santa Ana Water Board, in cooperation with the TMDL stakeholders, expects to reconsider these TMDLs no later than 10 years from the effective date of these TMDLs, and no later than 18 years from the effective date of these TMDLs. TMDL reconsideration is necessary because of the length of Phases II and III, the complexity of these TMDLs, evolving science related to nutrients, and the significant studies that are to be implemented over the term of these TMDLs. For Phase III (see Section 7.3 below), TMDL reconsideration will is expected to occur no later than 30 years after the effective date of these TMDLs, and every 10 years thereafter.

During reconsideration of a TMDL, the Santa Ana Water Board shall consider the following: (1) progress towards attainment of interim numeric targets and milestones; (2) effectiveness of in-lake projects and their ability to provide for offsets; (3) results of studies implemented and completed to date; and, (4) appropriateness of the final numeric targets, TMDLs, WLAs and LAs based on the 25th percentile of data from Cranston Guard Station from the San Jacinto River as compared to other estimations of the reference watershed condition. The Santa Ana Water Board shall also consider if other provisions of these TMDLs and this Implementation Plan should be amended based on new information available that was not available at the time of adoption of these TMDLs.

The TMDL reconsideration process in this Implementation Plan sets a minimum for Santa Ana Water Board reconsideration. Nothing in these provisions is intended to restrict Santa Ana Water Board discretion to update or revise these TMDLs, this Implementation Plan, or any portion thereof, as the Board determines appropriate throughout Phases II and III of these TMDLs.

7.2.1.4 Surveillance and Monitoring Program

On March 3, 2006, the Santa Ana Water Board approved a monitoring program for Lake Elsinore and Canyon Lake to support the 2004 TMDLs (Santa Ana Water Board 2006a). This program has been implemented since approval in 2006, by LESJWA and the TMDL Task Force, except for minor approved revisions over the years and during the period from June 2012 through April 2015 when the Santa Ana Water Board allowed the re-allocation of the in-lake monitoring program costs towards nutrient reduction projects in the Lakes and Watershed. In 2016, the Santa Ana Water Board approved further updates to the monitoring program (Haley & Aldrich, 2016). This existing monitoring program which will continue to be implemented until replaced by an approved TMDL SMP for these revised TMDLs. Per Phase II Task 18 below, the entities responsible for implementation of these TMDLs are required to submit an updated monitoring program Work Plan within one year after the effective date for these TMDLs. Section 8 below outlines elements that need to be considered for inclusion the TMDL SMP to support implementation of these revised TMDLs.

7.2.2 Phase II Schedule of Activities

7.2.2.1 Overview

This section provides detailed descriptions of the tasks included in the Phase II Implementation Plan and the schedule for execution. The proposed 20-year time frame for the completion of all tasks included in the Phase II Implementation Plan is based on consideration of the elements described in Section 7.2.1 above and the following key factors:

- Once the revised TMDLs have been adopted and approved by the State Water Board, Office of Administrative Law, and USEPA, they are not self-executing. That is, the Santa Ana Water Board and State Water Board will need to update several existing permits (see below) to incorporate the applicable requirements of the revised TMDLs. The process to update a discharge permit entails completion of all required public notice and review processes. Completing these processes for all permits in the watershed is expected to require significant time; therefore, until the permits of the entities responsible for TMDL implementation are updated, the provisions of the revised TMDLs are not in effect.
- Many of the entities responsible for TMDL implementation are MS4 permittees. Once the TMDLs become effective, then these entities are required to update their existing watershed management plans, i.e., the CNRP. Once an updated CNRP is submitted to the Santa Ana Water Board, it will undergo a public notice and review process. Thus, implementation of BMPs or other water quality control requirements included in the revised CNRP will not occur immediately and, thus, the benefits expected to be incurred from implementation of a revised CNRP will take time to be observed.
- Phase II implementation schedule includes requirements to evaluate the need for replacement and/or additional water quality controls in both Lake Elsinore and Canyon Lake. Where additional water quality controls or projects are identified and selected for

implementation, the process to implement such findings through a Work Plan requires (a) Santa Ana Water Board approval; (b) securing the funding for project(s) planned for implementation; and (c) completion of the design, permit (including CEQA) and construction phases of the project(s). The process from conception to full operation of any new water quality controls is expected to be a multi-year process.

- Given the dynamic hydrology of the watershed, in particular, the extremes between dry and wet hydrologic cycles, a multi-decadal assessment process that considers water quality data averaged over 10-year periods is required to evaluate progress towards attainment of WQOs. Thus, the full benefits from operation of new water quality controls may take many years to be observed.
- A multi-decadal assessment process is necessary to allow time for expected changes in the watershed that could affect nutrient loads to the downstream lakes to occur, including: (a) ongoing conversion of agricultural lands to an urban landscape; (b) expected increase in addition of supplemental recycled water discharged to Lake Elsinore; and (c) continued reduction of nutrients in the lake sediments.
- Phase II Implementation Plan includes five studies planned for completion during the first five years after the TMDLs become effective. The findings from these studies will provide critical understanding regarding status of compliance with the TMDLs in both lakes, long-term performance of watershed controls and potential need to consider revising the Lake Elsinore water quality criteria. If it is determined that revisions to these water quality criteria may be warranted, then the implementation schedule needs to allow enough time to complete the revisions and have them adopted into the Basin Plan and approved by state and federal agencies.
- Finally, the goal of the Phase II Implementation Plan is to achieve the interim targets and milestones of the TMDLs. The Phase II schedule must not only allow enough time to evaluate status of attainment with the TMDLs (allowing for the benefits of implemented water quality controls to be realized) but also enough time to consider revisions to the final TMDLs, which provide the basis for the Phase III Implementation Plan.

Implementation during Phase II will involve completion of specific tasks with measurable outcomes. Some tasks involve continued implementation over the full period such as operation of in-lake nutrient control offset programs, stakeholder coordination and monitoring and reporting. Other tasks involve focused studies or planning efforts designed to occur over a few specific years and scheduled to provide the LECL Task Force with the information it will need to support informed decision making in future years. Lastly, several key tasks involve implementation of new or enhanced watershed and in-lake water quality management projects. **Figures 7-4 and 7-5** provide a brief illustration of the overall Phase II program with the planned tasks and 20-year schedule of implementation. **Table 7-7** summarizes the requirements associated with each of the Phase II implementation tasks. The follow sections provide a description of each of the Phase II Implementation Plan tasks.

Task	Phase II Implementation - Year After Effective Date																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Task 1 – Stakeholder Coordination										Ongoing throughout Phase II										
Task 2 – Revise Permits and Other Regulatory Actions	Task duration depends on regulatory agencies																			
Task 3 – Revise Existing Watershed Implementation Plan(s)		Submit revised CNRP; implement upon approval																		
Task 4 – Review and Re-authorize Existing In-Lake Project(s) for Canyon Lake and/or Approve New In-lake Project(s)		Task Report & Work Plan (if needed); implement Work Plan upon approval																		
Task 5 – Evaluate In-Lake Project Options to Improve Water Quality in Lake Elsinore		Task Report; Identify Preferred Option(s) or Set of Options																		
Task 6 – Implementation of Preferred Project Option or Options for Lake Elsinore		Submit implementation schedule for Preferred Option(s); implement upon approval																		
Task 7 – Revise Lake Elsinore Water Quality Criteria Based on In-Lake Treatment Controls, if necessary						Submit Work Plan as necessary; implement upon approval														
Task 8 – Study to Evaluate Cyanobacteria in Lake Elsinore						Study Report														
Task 9 - Study to Define and Identify Minor Sources and Identify Responsibility Levels for TMDL Implementation for Such Sources				Study Report																
Task 10 – Study of Performance of Watershed Controls						Study Report														

Figure 7-4. Schedule for Phase II Implementation Plan: Task 1 through Task 10 (blue shading indicates general timing of preparation of task deliverable; ○ indicates deliverable associated with the task; blue arrows indicate tasks with continued implementation activity)

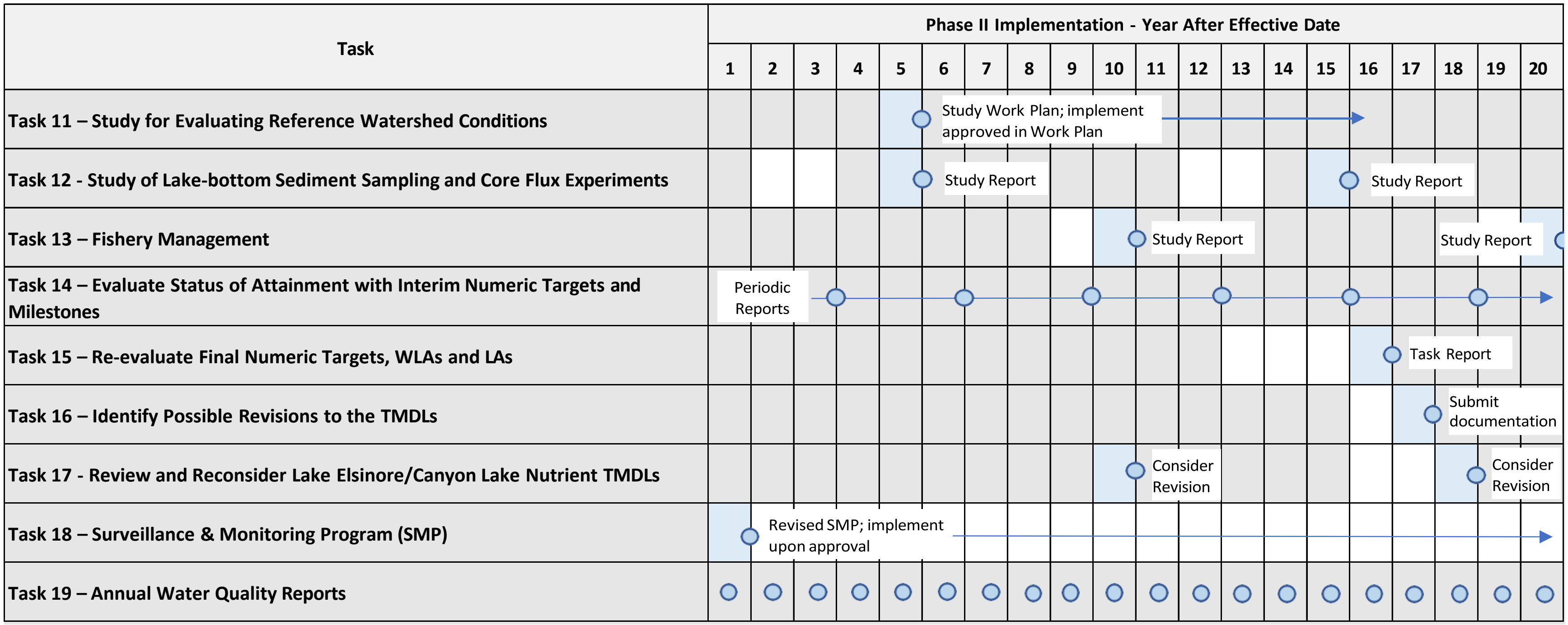


Figure 7-5. Schedule for Phase II Implementation Plan: Task 11 through Task 19 (blue shading indicates general timing of preparation of task deliverable; ○ indicates deliverable associated with the task; blue arrows indicate tasks with continued implementation activity)

Table 7-7. Phase II (Years 1 – 20) Implementation Plan Activities

Task	Description	Schedule	Responsible Entity(ies)[1]
1. Stakeholder Coordination	Maintain TMDL Task Force collaboration at a frequency determined appropriate by the TMDL Task Force	Ongoing throughout Phase II	TMDL Task Force Members
2. Revise Permits and Other Regulatory Actions	Update permits, adopt new permits and take other actions for TMDL implementation	In a timely manner, and as needed, at the discretion of the regulatory agency.	Santa Ana Water Board or State Water Board
3. Revise Existing Watershed Implementation Plan(s)	Revise existing CNRP (or prepare equivalent watershed management plan)	• Submit revised CNRP (or equivalent watershed management plan) to the Regional Board within one (1) year of TMDLs being incorporated into MS4 permit. • Continue to implement existing CNRP, until revised CNRP (or equivalent watershed management plan) is approved by the Santa Ana Water Board or the Executive Officer to the Santa Ana Water Board.	MS4 Permittees
4. Review and re-authorize existing In-lake Project(s) for Canyon Lake, and/or approve new In-Lake Project(s)	Evaluate effectiveness of the Canyon Lake Alum Project and potential feasibility of implementation of other in-lake projects	• Continue existing Canyon Lake Alum Project during implementation of Task 4. • Within one (1) year of TMDLs effective date, submit a report to the Santa Ana Water Board's Executive Officer that evaluates the effectiveness, and offsets provided by the existing alum project, and the feasibility of other in-lake projects to manage nutrients. Report shall include recommendations to revise the existing alum offset program, if determined necessary. • Upon receipt of Report, the Santa Ana Water Board's Executive Officer will review to determine if the existing alum program should be re-authorized, and will evaluate any proposed new in-lake projects for authorization. • If in-lake projects other than alum are recommended for implementation, include a Work Plan with a schedule for implementation in the report. Implement the Work Plan schedule, as approved by the Executive Officer.	Entities responsible for implementation of Canyon Lake TMDLs

Table 7-7. Phase II (Years 1 – 20) Implementation Plan Activities

Task	Description	Schedule	Responsible Entity(ies)[1]
5. Evaluate In-Lake Project Options to Improve Water Quality in Lake Elsinore	Identify and evaluate feasible water quality control options that may be implemented to improve and maintain water quality in Lake Elsinore; identify preferred option or set of options	Within one (1) year from the effective date of these TMDLs, submit a report to the Santa Ana Water Board's Executive Officer that assesses in-lake project options for Lake Elsinore, identifies a preferred option or set of options and potential funding sources that may be available to support implementation.	Lake Elsinore Aeration & Mixing System (LEAMS) Operators
6. Implementation of Preferred Project Option or Options for Lake Elsinore	Prepare schedule to implement findings from Task 5	• Within 18 months from the effective date of these TMDLs, submit an implementation schedule for proposed project(s) to the Santa Ana Water Board's Executive Officer. • Implement the schedule as approved by the Santa Ana Water Board's Executive Officer. • The implementation schedule should include a task to develop a proposed Offset Program that is associated with implementation of the preferred option, or options, once they are operational.	LEAMS Operators
7. Revise Lake Elsinore Water Quality Criteria Based on In-Lake Treatment Controls, if necessary	Develop Work Plan to revise water quality criteria applicable to Lake Elsinore	• Within five (5) years after new or enhanced in-lake controls are fully operational, as a result of work completed in Task 6, if deemed necessary, submit a Work Plan with implementation schedule to the Santa Ana Water Board's Executive Officer for review and approval. • Implement the Work Plan, as approved.	Entities responsible for implementation of Lake Elsinore TMDLs
8. Study to Evaluate Cyanobacteria in Lake Elsinore	Evaluate HAB conditions in Lake Elsinore and options to manage cyanobacteria and toxicity	• Within five (5) years from the effective date of these TMDLs, submit a report to the Santa Ana Water Board that provides the findings from this Study. • Depending on the results of this Study, it may be appropriate to conduct a follow up study after completion of task 6 to further evaluate HAB conditions in Lake Elsinore after implementation of a preferred in-lake project(s) for Lake Elsinore. The need for a follow up study should be evaluated with each triennial review report under task 14, starting with the first triennial review report after completion of task 6.	Entities responsible for implementation of Lake Elsinore TMDLs

Table 7-7. Phase II (Years 1 – 20) Implementation Plan Activities

Task	Description	Schedule	Responsible Entity(ies)[1]
9. Study to Define and Identify Minor Sources and Identify Responsibility Levels for TMDL Implementation for Such Sources	Evaluate contributions of TP and TN from minor sources and determine if there is a level of discharge that should be defined as minor; identify appropriate level of TMDL implementation for minor sources	Within three (3) years from effective date of these TMDLs, submit a report to the Santa Ana Water Board that provides findings from this Study, and recommendations to the Regional Board to revise the TMDLs as determined appropriate and necessary based on the results of the study.	Entities responsible for implementation of Canyon Lake and Lake Elsinore TMDLs
10. Study of Performance of Watershed Controls	Evaluate performance of updated watershed controls included in the revised and approved CNRP (or equivalent watershed management plan) and Agricultural General Order	• Within five (5) years from the effective date of the 2024 TMDLs, submit a Work Plan for conducting the Study to the Santa Ana Water Board's Executive Officer for review and approval. • Complete the Study per the schedule in the approved Work Plan.	MS4 Permittees & Agricultural Operators
11. Study for Evaluating Reference Watershed Conditions	Conduct Study to validate basis for estimation of an appropriate reference watershed conditions	• Within five (5) years from the effective date of the revised TMDLs, submit a Work Plan for conducting the Study to the Santa Ana Water Board's Executive Officer for review and approval. • Complete the Study per the schedule in the approved Work Plan.	Entities responsible for implementation of Lake Elsinore and Canyon Lake TMDLs
12. Study of Lake-bottom Sediment Sampling and Core Flux Experiments	Evaluate status of nutrient enrichment in lake sediments	• Round 1: Within five (5) years after the effective date of these TMDLs, submit a Sediment Study Report to the Santa Ana Water Board that provides study results and updated estimates of internal nutrient loads. • Round 2: Within 15 years after the effective date of the these TMDLs, submit a Sediment Study Report to the Santa Ana Water Board's Executive Officer that provides study results and updated estimates of internal nutrient loads.	Entities responsible for implementation of Lake Elsinore and Canyon Lake TMDLs, as applicable
13. Fishery Management	Evaluate status of Common Carp population in Lake Elsinore fishery	By August 15 of every 10th year from the effective date of these TMDLs, conduct a study of the fishery in Lake Elsinore to evaluate the Common Carp population to determine need for additional carp management activities to support attainment of the TMDLs.	Entities responsible for implementation of Lake Elsinore TMDLs

Table 7-7. Phase II (Years 1 – 20) Implementation Plan Activities

Task	Description	Schedule	Responsible Entity(ies)[1]
14. Evaluate Status of Attainment with Interim Numeric Targets and Milestones	Evaluate status of TMDL attainment	By August 15 of every 3rd year from the effective date of these TMDLs, submit a report on the status of attainment of the Phase II interim numeric targets and milestones	Entities responsible for implementation of Lake Elsinore and Canyon Lake TMDLs
15. Re-evaluate Final Numeric Targets, WLAs and LAs	Re-evaluate final numeric targets, WLAs, LA, and approaches to demonstrate TMDL attainment	• No later than 16 years from the effective date of these TMDLs, submit a report to the Santa Ana Water Board that re-evaluates (a) final numeric targets, WLAs and LAs; and (b) Phase II TMDL attainment demonstration approaches. • Report shall include recommendations for revising Phase III, including Phase III Final Numeric Targets, WLAs, LAs, and implementation provisions	Entities responsible for implementation of Lake Elsinore and Canyon Lake TMDLs
16. Identify Possible Revisions to the TMDLs	As appropriate, prepare necessary documentation to support revisions to the TMDLs	At least three (3) years before the end of Phase II (or no later than 17 years after the effective date of these TMDLs), submit to the Santa Ana Water Board the necessary documentation to support a revision to the Lake Elsinore and/or Canyon Lake TMDLs.	Entities responsible for implementation of Lake Elsinore and Canyon Lake TMDLs
17. Review and Reconsider Lake Elsinore/Canyon Lake Nutrient TMDLs	Santa Ana Water Board will review and reconsider the provisions of these TMDLs, as they determine appropriate and necessary	• (1) No later than 10 years from the effective date, and • (2) no later than at least two years before the end of Phase II (i.e., no later than 18 years after the effective date of the revised TMDLs), the Santa Ana Water Board will review and reconsider the TMDLs in their entirety, including the responsible entities identified in the TMDLs, milestones, interim numeric targets, Final Targets, WLAs and LAs, taking into consideration the data and information collected during Phase II. • As part of TMDL review and reconsideration, the Santa Ana Water Board will update the TMDLs, including Final Targets, WLAs and LAs and the Phase III Implementation Plan, as determined appropriate.	Santa Ana Water Board

Table 7-7. Phase II (Years 1 – 20) Implementation Plan Activities

Task	Description	Schedule	Responsible Entity(ies)[1]
18. Surveillance & Monitoring Program (SMP)	Update existing SMP for these TMDLs	• Starting with the effective date of these TMDLs, continue to implement the existing LECL monitoring program until an updated SMP has been approved. • Within one (1) year of the effective date of these TMDLs, submit an updated monitoring program for Santa Ana Water Board Executive Officer approval.	Entities responsible implementation of with Lake Elsinore and Canyon Lake TMDLs
19. Annual Water Quality Reports	Prepare annual water quality reports	By August 15 each year, after the effective date of these TMDLs, submit an Annual Water Quality Report to the Santa Ana Water Board based on the currently approved monitoring program	Entities responsible for implementation of Lake Elsinore and Canyon Lake TMDLs

[1] Tasks involving multiple responsible entities may be implemented collectively through the TMDL Task Force

7.2.2.2 Description of Phase II Tasks

Task 1. Stakeholder Coordination

In 2005, soon after approval of the 2004 TMDLs, the TMDL Task Force was formed to implement certain monitoring and watershed-based management tasks identified in Phase I of the TMDL and to collectively work towards meeting numeric targets, WLAs and LAs. LESJWA serves as the administrator for the TMDL Task Force (**Table 7-8**). Santa Ana Water Board staff attend and participate in Task Force meetings.

Since its inception, the TMDL Task Force and its members have made progress in improving water quality in both Lake Elsinore and Canyon Lake and furthering our scientific understanding of the San Jacinto River watershed and the lakes. Recognizing the success of the TMDL Task Force and its efforts to date, the Santa Ana Water Board supports continuation of the Task Force and its collaborative efforts for implementation of Phase II of the TMDLs. Accordingly, the Santa Ana Water Board encourages continued stakeholder coordination through the TMDL Task Force and recommends that the Task Force routinely meet throughout Phase II of TMDL implementation.

The frequency of such TMDL Task Force meetings may be adjusted by the participating stakeholders as determined appropriate. Further, where identified, certain Phase II TMDL tasks may be implemented by the TMDL Task Force on behalf of its members. However, ultimate responsibility for various tasks fall on the individual agencies and/or entities identified and as tasks are incorporated into permits or other orders.

Table 7-8. Current Members of the LECL Task Force

Category	Entity	
Cities and Counties	• 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 • Riverside County
Agriculture	• San Jacinto Agricultural Operators • San Jacinto Dairy and CAFO Operators	
Water Agencies	• Eastern Municipal Water District • Elsinore Valley Municipal Water District	
State Agencies	• California Department of Transportation • California Department of Fish & Wildlife	
Federal Entities	• March Air Force Reserve Joint Powers Authority • United States Air Force March Air Force Base	

Task 2. Revise Existing Permits and Other Regulatory Actions

TMDL provisions, as adopted into the Basin Plan, are not self-executing and must be directly incorporated into various discharge permits or other orders to be directly applicable to the named responsible entities. Accordingly, the Santa Ana Water Board and State Water Board, as applicable, will need to (a) update existing permits to incorporate Phase II provisions for these TMDLs; and (b) incorporate Phase II provisions, as needed, into new permits adopted within the Lake Elsinore and Canyon Lake watershed. Key permits, existing orders and other regulatory actions that may require updates include:

- Santa Ana Water Board Order R8-2010-0033, NPDES and WDRs for Riverside County Flood Control & Water Conservation District, County of Riverside and Incorporated Cities of Riverside County within the Santa Ana Region, Riverside County;
- Santa Ana Water Board Order R8-2010-0005, NPDES and Waste Discharge Requirements for United States Air Force, March Air Reserve Base, Storm Water Runoff;
- Santa Ana Water Board Order R8-2023-0006, General Waste Discharge Requirements for Discharges of Waste from Irrigated Lands in the San Jacinto River Watershed, Riverside County;
- Santa Ana Water Board Order R8-2013-0017 as amended, Waste Discharge and Water Reclamation Requirements for Elsinore Valley Municipal Water District, Regional Water Reclamation Facility, Riverside County;
- Santa Ana Water Board Order R8-2018-0001, NPDES and General Waste Discharge Requirements for Concentrated Animal Feeding Operations (Dairies and Related Facilities) within the Santa Ana Region;
- State Water Board Order 2022-0033-DWQ, Statewide Stormwater Permit and Time Schedule Order for the California Department of Transportation (Caltrans);
- State Water Board Order 2013-0001-DWQ as amended, NPDES General Permit for Waste Discharge Requirements for Storm Water Dischargers from Small MS4s;
- United States Forest Service Nutrient Management Plans; and,
- Santa Ana Water Board Water Code 13267 Orders for non-irrigated agricultural operations that are 20 acres or more.

Permit revisions, orders or other regulatory actions require sufficient time to develop, provide opportunity to receive public comment, and hold a formal adoption hearing, if applicable. Given the revisions that are potentially necessary to incorporate TMDL provisions into permits, orders or other regulatory action and due to limited staff resources, it is expected that the Santa Ana Water Board or State Water Board efforts required to revise or adopt new permits or take other regulatory actions under Task 2 may take time and effort over several years.

Task 3. Revise Existing Watershed Implementation Plan(s)

Watershed implementation plans, developed in Phase I to reduce nutrient loads to Lake Elsinore and Canyon Lake, included the 2013 CNRP for Riverside County MS4 permittees and 2013 Agricultural Nutrient Management Plan (AgNMP) for agricultural operators. These plans included a combination of watershed controls (non-structural and structural) and participation in downstream in-lake projects. Implementation of these plans, and other efforts, resulted in the TMDL Task Force being able to demonstrate compliance with the 2004 TMDLs based on measured mass emissions (accounting for watershed nutrient reductions) and internal load reductions realized by operation of in-lake projects; alum addition in Canyon Lake and LEAMS operation in Lake Elsinore (LESJWA 2021).

These TMDLs change the allocations and numeric targets that were the basis of the 2013 CNRP and AgNMP. They include new milestones and interim numeric targets that apply to Phase II. Updates to existing watershed programs are a key step to ensure that projects are designed and implemented to achieve the milestones and interim numeric targets.

The following must be considered with regards to updating the existing MS4 watershed program, which is expressed in the Comprehensive Nutrient Reduction Plan (or equivalent watershed management plan):

- Reasonable assurance analysis that demonstrates implementation of planned projects, including participation in proposed offset projects by appropriately identified responsible parties, will collectively result in the lakes meeting the new interim numeric targets, or alternatively demonstrate that the identified MS4 responsible parties individually or collectively meet milestones, accounting for offset credits.
- For the CNRP (or an equivalent watershed management plan), the update should include quantification of the extent to which LID and structural treatment BMPs have been implemented with urban development and the change to watershed nutrient loads. In general, retention-based BMPs are typically known for being effective at removing nutrients. However, such BMPs may also remove or divert runoff that would otherwise enter the lakes and be a critical resource in maintaining water elevations in the downstream lakes. The CNRP update should consider evaluating the advantages and disadvantages of implementing pollutant load reduction BMPs that retain runoff in the watershed versus potential impacts on lake water quality. The updated CNRP should also consider evaluating BMPs that treat and release runoff as an alternative to retention-based BMPs.

Per this task, Riverside County MS4 permittees will need to submit a revised CNRP (or equivalent watershed management plan) to the Santa Ana Water Board within one (1) year of the effective date of these TMDLs being incorporated into the MS4 permit that applies to the Riverside County permittees. Once the revised CNRP (or equivalent watershed management plan) is approved by the Santa Ana Water Board or the Santa Ana Water Board’s Executive

Officer, it must be implemented according to the approved schedule in the CNRP. Implementation of the existing CNRP, approved in 2013, would continue, as applicable, until the revised CNRP is approved by the Santa Ana Water Board or the Santa Ana Water Board's Executive Officer.

With respect to irrigated agricultural subject to Order R8-2023-0006, the order states, *"[t]his Order serves as WDRs for all enrollees and constitutes their approved AgNMP under the Nutrient TMDLs, as this Order addresses and implements all the required elements listed above.*" Order R8-2023-0006 constitutes an approved AgNMP because it includes multiple provisions that require dischargers subject to the order to implement appropriate management practices for the control of nutrients. Specifically, compliance with the agricultural load allocations assigned in the 2004 TMDLs may be achieved by demonstrating that the TP and TN loads from Irrigated Lands discharges meet the allocations specified for "Agriculture" in the Basin Plan, using representative surface water monitoring data and Santa Ana Water Board-approved modeling procedures. Alternatively, compliance may be achieved by demonstrating that the total combined waste load allocations and load allocations (i.e., collective watershed compliance) meet the total allocations as specified in the Basin Plan. Where TP and TN loads exceed the TMDL load allocations specified for agriculture or the total combined waste load allocations and load allocations for the TMDLs, Dischargers may offset excess loading through an offset program approved by the Santa Ana Water Board's Executive Officer.

The efficacy of Order R8-2023-0006 as the AgNMP is being measured through representative surface water quality monitoring. In Order R8-2023-0006, the Santa Ana Water Board finds that the WQI_{ag} Tool developed by the Western Riverside County Agricultural Coalition meets this surface water monitoring requirement for certain dischargers subject to Order R8-2023-0006. The WQI_{ag} Tool allows dischargers to input nutrient management practice information into a workbook that is part of their operating system data entry process to receive a water quality protection score. If the discharger's score meets a compliance threshold score, as approved by Santa Ana Water Board staff, then the discharger will be considered to be attaining milestones through implementation of an approved AgNMP. In other words, meeting or exceeding the compliance threshold score reflects implementation of effective management practices for the control of nutrients. For agricultural operators that are not eligible to use the WQI_{ag} Tool, compliance with the TMDL provisions in Order R8-2023-0006 must be fulfilled through individual monitoring and reporting.

With respect to these TMDLs, Order R8-2023-0006 will need to be updated since it constitutes the AgNMP associated with the 2004 TMDLs. As an updated AgNMP, dischargers enrolled under Order R8-2023-0006 (as updated) will meet the requirements of this task. Further, it is anticipated that future updates to Order R8-2023-0006 may incorporate use of the WQI_{ag} Tool for demonstrating attainment of the milestones for those that are considered eligible.

Task 4. Review and Re-Authorize Existing In-Lake Project(s) for Canyon Lake, and/or Approve New In-Lake Project(s)

For Canyon Lake, implementation measures taken to meet the 2004 TMDLs include watershed BMP deployments by MS4s and agricultural operators and the regional, multi-partner, alum addition program (Alum Project). The Alum Project, which began in September 2013, typically involves two applications of low dose alum (10-30 mg/L dry alum) each year across the lake surface to remove bioavailable phosphorus from the water column and sequester it at the surface of the sediment at key times of the year (prior to historical algae blooms at turnover in October/ November and following influx of watershed loads during the wet season in March/April). The application of alum to Canyon Lake helps to offsets watershed-based loads of TP that reach Canyon Lake.

Continued implementation of the Canyon Lake Alum Project existing at the time of TMDL adoption is currently planned under Phase II until such time that it can be reviewed and reauthorized by the Santa Ana Water Board's Executive Officer. As such, within one (1) year of the effective date of these TMDLs, entities responsible for the Canyon Lake Alum Project must submit a Canyon Lake Water Quality Control Report that evaluates the effectiveness of the existing alum program. As part of the effectiveness evaluation, the Report must evaluate the use of alum as an offset for TP and revisit the existing crediting basis. In addition, the Report will evaluate the potential feasibility of implementing alternative water quality controls to manage nutrients in Canyon Lake – either to supplement the Alum Project, or as a new project(s) to replace the Alum Project. If alternative controls are recommended for implementation, the Water Quality Control Report will include a proposed Work Plan with schedule for implementation of the alternative controls. The continuation of the existing Alum Project, or any proposed changes to the existing program, including the offset credit basis or implementation of a new water quality control project(s), is subject to review and approval by the Santa Ana Water Board's Executive Officer.

Task 5. Evaluate In-Lake Project Options to Improve Water Quality in Lake Elsinore

Water quality in Lake Elsinore involves a wide range of conditions from mesotrophic to hypereutrophic that are naturally occurring and not necessarily related to contributions from waste discharges or controllable sources. Waste discharges can exacerbate these naturally occurring conditions. Further, although naturally occurring, hypereutrophic conditions may cause HABs that may pose a health risk to recreational users and their pets, as well as fish and wildlife.

For Lake Elsinore, the designated beneficial uses include: REC1, REC2, WARM, and WILD. Two applicable WQOs for maintaining the designated beneficial uses in the Basin Plan include (1) algae and (2) DO. The algae WQO is a narrative statement that states as follows: "*Waste discharges shall not contribute to excessive algal growth in inland surface receiving waters*." For DO, the WQO relevant portion states: "*The dissolved oxygen content of surface waters shall not be depressed below 5 mg/L for waters designated **WARM**, …, as* *a result of controllable water quality factors.*" The Basin Plan defines controllable sources and controllable factors as follows: "Some of these water quality objectives refer to 'controllable sources' or controllable water quality factors.' Controllable sources include both point and nonpoint source discharges, such as conventional discharges from pipes and discharges from land areas or other diffuse sources. Controllable sources are predominantly anthropogenic in nature. Controllable water quality factors are those characteristics of the discharge and/or the receiving water that can be controlled by treatment or management methods. Examples of other activities that may not involve waste discharges, but which also constitute controllable water quality factors, include the percolation of storm water, transport/delivery of water via natural stream channels, and stream diversions. Uncontrollable sources of pollutants can occur naturally or as the result of anthropogenic activities. These sources are not readily managed through technological or natural mechanisms." (Ch. 4, pp. 4-2 – 4-3.)

These two WQOs, combined with the knowledge that Lake Elsinore is impaired for excessive nutrients, suggests that WQOs for nutrients are met as long as waste discharges are not contributing to excessive algal growth and that controllable sources are addressed through treatment or known management methods. In other words, excessive algal growth and DO levels depressed from uncontrollable sources may still occur in Lake Elsinore and not cause an exceedance of the existing WQOs. Ultimately, the goal of the TMDL is for the lakes to meet WQOs, which are designed to protect and maintain beneficial uses.

To help Lake Elsinore meet applicable WQOs (i.e., address excessive algal growth from waste discharges and controllable water quality factors), Task 5 will evaluate multiple supplemental in-lake project options to identify what option (or options) may provide the highest level of improved water quality that is both technically and economically feasible. This may include assessing the condition of the existing LEAMS facility and evaluating other potential in-lake treatment options. The assessment of in-lake project options should consider and evaluate the cost of implementing, operating and maintaining the control option as compared to the anticipated environmental benefits, including water quality improvements. A key outcome of the assessment will be to quantify the spatial and temporal extent for the highest level of improved water quality that Lake Elsinore could achieve with implementation of feasible in-lake treatment options. The effectiveness, scalability, cost, and long-term operation and maintenance (O&M) requirements of controls may be considerations in selecting the preferred option or options for implementation. At a minimum, controls used to demonstrate compliance with TMDL-based requirements in waste discharge requirements or other regulatory mechanisms must ensure that water quality will meet applicable water quality objectives and sustain beneficial uses.

No later than one (1) year from the effective date of these TMDLs, the entities responsible for assessing in-lake project options for Lake Elsinore must submit a report that documents their assessment of options and identifies a preferred option or set of options. As part of the report, the entities should identify potential funding that may be available to assist with the implementation of the preferred option or set of options. Assessments conducted and reports submitted prior to the due date for this Report may satisfy this task as long as it meets the descriptions herein.

Task 6. Implementation of Preferred Project Option or Options for Lake Elsinore

Based on the findings of Task 5, the responsible agencies will seek to implement the preferred option (or options) based on an approved schedule. Within 18 months from the effective date of the revised TMDLs, an implementation schedule for proposed project(s) will be submitted to the Santa Ana Water Board's Executive Officer. Further, the project implementation schedule should include a proposed Offset Program that would support ongoing operation and maintenance of the preferred option or options and allow other parties to purchase offsets from the project operators.

Task 7. Revise Lake Elsinore Water Quality Criteria Based on In-Lake Treatment Controls, if necessary

Attainment of these TMDLs means that external nutrient loads, considering offsets, will be at levels associated with the reference watershed condition. Under these conditions, algal growth and low DO levels may still occur in Lake Elsinore. At that time, it may be necessary to develop site specific water quality criteria that better reflect what is reasonably achievable for maintaining the lake's beneficial uses. Alternative water quality criteria may be developed that would consider the unique characteristics of Lake Elsinore and what is reasonably attainable. If deemed necessary, within five (5) years after new or enhanced in-lake projects are fully operational as a result of work completed in Task 6, a Work Plan to revise water quality criteria in Lake Elsinore may be prepared and submitted to the Santa Ana Water Board's Executive Officer for review and approval. If submitted, the Work Plan must include a proposed schedule for implementation. Task 7 is an optional task that may be implemented at the discretion of the entities responsible for achieving the TMDLs for Lake Elsinore.

Task 8. Study to Evaluate Cyanobacteria in Lake Elsinore

Recreational use in Lake Elsinore has been negatively impacted by persistent and toxic HABs. Swimming advisories and beach closures have frequently occurred in recent years. In 2021-2022, Santa Ana Water Board staff collected data at two sites on Lake Elsinore during more than 30 events to assess cyanotoxin conditions in Lake Elsinore.

Within five (5) years from the effective date of these TMDLs, a Study will be implemented to evaluate these data, other available HAB-related data from Lake Elsinore, and water quality data obtained since the implementation of new in lake projects pursuant to Task 6, if available. As part of the study, available data will be reviewed to evaluate the types and associated toxicity of cyanobacteria that may occur in Lake Elsinore. The evaluation should employ approaches provided in the State Water Board's Framework and Strategy for Freshwater Harmful Algal Bloom Monitoring. The findings from this data evaluation will be submitted as a report to the Santa Ana Water Board.

Depending on the results of this Study and the time for completion of a new in-lake project for Lake Elsinore, it may be appropriate to conduct a follow up study after completion of Task 6 to further evaluate HAB conditions in Lake Elsinore. The need for a follow up study should be evaluated with each triennial review report under Task 14, starting with the first triennial review report after completion of Task 6.

Task 9. Study to Define and Identify Minor Sources and Identify Responsibility Levels for TMDL Implementation for Such Sources

Some sources of nutrients in the San Jacinto River watershed are minor and likely have minimal impact on water quality in the downstream lakes. Under Task 9, contributions of TP and TN from potential minor sources in the watershed will be evaluated to determine if there is a level of discharge or minimum threshold that should be defined as being a minor source. Factors to be considered in defining what constitutes a minor source should include, but not be limited to, the following: Subwatershed location, potential for future expansions or restrictions in loads from source (i.e., reasonably foreseeable changes in acreage from one source to another), and determination of minor source for each lake individually. For sources determined to meet the definition of minor source, this study will identify potential obligations or requirements for these sources under the TMDLs. Within three (3) years from effective date of the revised TMDLs, a report shall be submitted to the Santa Ana Water Board that provides the findings from this Study, including recommendations for revisions to the TMDLs as determined appropriate and necessary based on the results of the study.

Task 10. Study of Performance of Watershed Controls

Pollution controls and BMPs have been deployed throughout the San Jacinto River watershed for urban and agricultural lands. Pollution controls and BMPs have been implemented to meet MS4 permit requirements such as Water Quality Management Plans for new and re-development, public education and outreach, and good housekeeping activities such as street sweeping and catch basin cleaning. Nutrient load reductions achieved by these controls within MS4 drainage areas should be evaluated as part of updates to the CNRP (or equivalent watershed management plan) under Task 2. This may require additional mass emission monitoring at MS4 locations in the watershed upstream from the inflows to Canyon Lake.

For agricultural lands, nutrient load reductions from different management practices such as conservation tillage, winter cover crop use, timing of fertilizer application, and irrigation practices should be considered by the Santa Ana Water Board when it updates orders applicable to agricultural operators.

This Study is intended to evaluate performance of the updated watershed controls to validate key assumptions employed in the updates of the CNRP and Order R8-2023-0006. The Study may include collection of data from constructed projects within the watershed or involve updating scientific assumptions based on newer information from other publicly available sources.

Within five (5) years from the effective date of Phase II, the responsible entities (or the TMDL Task Force on behalf of the responsible entities) must submit a Work Plan for conducting the Study to evaluate performance of watershed controls being implemented by permittees. The Work Plan needs to include a schedule for implementation and must be submitted to the Santa Ana Water Board's Executive Officer for review and approval. Once the Work Plan and schedule are approved by the Santa Ana Water Board's Executive Officer, the Study needs to be completed according to the approved schedule.

Upon completion of the Study, and after the Study's findings have been conveyed to the Santa Ana Water Board, such findings should be used during the next triennial review as required under Task 14 to evaluate attainment of these TMDLs and considered recommendations to revise these TMDLs.

Task 11. Study for Evaluating Reference Watershed Conditions

The milestones, interim numeric targets, WLAs and LAs are based on an estimated reference watershed condition and external load allocations (milestones, WLAs and LAs) are intended to be equivalent to the nutrient runoff associated with an undeveloped condition in the watershed. Data for estimating the reference watershed condition comes from the San Jacinto River at Cranston Guard Station. This location has been used as a reference site because the upstream watershed land use is comprised of 97 percent open space / forest. Laboratory analyses for nutrients were conducted on 51 samples collected from this location over the course of 10 wet weather events from 2003-2010.

The Phase III numeric targets, WLAs and LAs are more conservative than the interim numeric targets and milestones because of questions related to the degree that the Cranston Guard Station data are representative of the reference watershed condition and the appropriate percentile to use for estimating the condition. Prior to the start of Phase III, additional evaluation is necessary to support the use of the San Jacinto River at Cranston Guard Station as being representative of the reference watershed condition, or to determine if a different location is more representative. Further, this evaluation is necessary to determine what percentage or statistical calculation of data should be used to estimate the reference watershed condition.

Accordingly, a Study must be conducted to collect additional samples from this station and other undeveloped canyons in the San Jacinto River watershed to assess (a) the validity of the basis for Phase II milestones and interim numeric targets as being representative of the reference watershed condition, (b) if the Phase II milestones and interim numeric targets should be the final numeric targets, WLAs and LAs, or (c) if some other estimation of the reference watershed condition from the newly collected data should be used for calculation of numeric targets, WLAs and LAs. The results of this study will help to determine whether further revisions of these TMDLs are needed to better represent the reference watershed condition. The Study design will generate a dataset that is at least as robust as the historical sampling in the San Jacinto River at Cranston Guard Station (i.e., n = 51 samples).

Within five (5) years from the effective date of Phase II, the responsible entities (or the Task Force on behalf of the responsible entities) must submit a Work Plan for conducting the Study to study/evaluate nutrient loads from proposed reference watershed sites. The Work Plan needs to include a schedule for implementation and must be submitted to the Santa Ana Water Board's Executive Officer for review and approval. Once the Work Plan and schedule are approved by the Santa Ana Water Board's Executive Officer, the Study needs to be completed according to the approved schedule.

Task 12. Study of Lake-bottom Sediment Sampling and Core Flux Experiments

During the implementation of Phase II, two studies will be implemented to assess changes to nutrient enrichment in sediments following implementation of TMDL-related implementation projects. For this study, a minimum of two rounds of collection and analysis of lake bottom sediment cores will be collected from historically sampled locations in both Canyon Lake and Lake Elsinore. These two rounds of sample collection will be implemented within 5 years and 15 years after the effective date of these TMDLs. A Sediment Study Report with sample results and updated estimates of internal nutrient loads will be submitted to the Santa Ana Water Board's Executive Officer within six months after collection of the final sample collected during each round of sample collection.

Task 13. Fishery Management

By August 15 of every tenth year from the effective date of these TMDLs, the Lake Elsinore responsible entities need to conduct a study of the fishery in Lake Elsinore to evaluate the Common Carp population to determine the need for additional carp management activities. Carp are benthivores that disturb lake bottom sediments while foraging, which causes physical resuspension of nutrients from the lake bottom. A fish survey was completed in 2019 and found low carp populations; thus no removal action was recommended. In addition to carp population management, periodic fishery studies will help to evaluate the success of ongoing fish stocking activities, assess the potential to modify the species stocked and evaluate populations of other species. Any such surveys should rely on the use of consistent sampling and data analysis methods which will allow for more accurate comparisons of the characteristics of the fish community between years. A Fisheries Management Study Report with sample results and description of the existing fish community diversity and health as compared to the previous fishery study will be submitted to the Santa Ana Water Board's Executive Officer for review within six months of the completion of the sampling and data analysis.

Task 14. Evaluate Status of Attainment with Interim Numeric Targets and Milestones

By August 15 of every third year from the effective date of these TMDLs, responsible entities must submit a report on status of TMDL attainment (i.e., progress towards achieving milestones and interim numeric targets). Evaluations of attainment may be made in a manner consistent with the options for demonstrating attainment of the milestones. The TMDL Technical Report provides further guidance on how monitoring data or lake model outputs for all key parameters (watershed TP and TN mass emissions, lake chlorophyll-*a*, DO, and ammonia concentrations) may be used to assess attainment status.

As part of the triennial review report, the entities responsible for implementing these TMDLs may evaluate data and information collected from Studies completed during the preceding time-period and recommend to the Santa Ana Water Board if these TMDLs should be reopened and be revised at that point in time.

Task 15. Re-evaluate Final Numeric Targets, WLAs and LAs

Findings from Tasks 7 through 13 are expected to provide the additional information needed to support a decision-making process regarding the appropriateness of the final numeric targets, WLAs and LAs. The additional information may also be helpful in evaluating the appropriateness of the Phase III implementation tasks.

Based on the results of the studies and information gathered from implementation of the Phase II tasks, the final numeric targets, WLAs and LAs will be reevaluated. In addition, the options for demonstrating compliance for WLAs and LAs as they are incorporated into permits and other regulatory actions that are part of the allocations should also be reevaluated to determine if they should continue to be used during Phase III or if they should be revised. The results of these evaluations must be submitted to the Santa Ana Water Board no later than 16 years from the effective date of Phase II so that the Santa Ana Water Board can timely implement the second reopener identified in Task 17.

Task 16. Identify Possible Revisions to the TMDLs

Based on the outcome of Task 15, revision to these TMDLs may be warranted (e.g., to adjust assumptions regarding reference watershed conditions or update models used to develop the TMDLs). Under this task, necessary documentation will be prepared to support the Basin Plan amendment as needed to revise these TMDLs. Accordingly, at least three years before the end of Phase II (or no later than 17 years after the effective date of these TMDLs), the required documentation to support revision to the Lake Elsinore and/or Canyon Lake Nutrient TMDLs will be submitted to the Santa Ana Water Board.

Task 17. Review and Reconsider Lake Elsinore/Canyon Lake Nutrient TMDLs

Because of the complexity of these TMDLs and length of time required for each implementation Phase, the Santa Ana Water Board will reconsider these TMDLs twice during Phase II. Reconsideration is expected to occur (1) no later than 10 years after the effective date of these TMDLs, and (2) no later than 18 years after the effective date of these TMDLs. The second reconsideration is set at year 18 due to the process and time associated with potentially amending these TMDLs and relevant provisions in the Basin Plan in consideration of 18 years of data and information collected over Phase II. The scope of TMDL reconsideration is discussed above.

Task 18. Surveillance & Monitoring Program

Review the existing TMDL Surveillance and Monitoring Program (SMP) and Quality Assurance Project Plan (QAPP), and update such programs as determined necessary to provide data needed to support assessment of progress towards attaining interim numeric targets and milestones. The updated SMP should include a program to conduct watershed aerial surveys of land use every five years. This information will be used to support: (a) refinement of participation levels for regional project implementation at equitable levels relative to the distribution of land use; and (b) if needed, development of recommendations to the Santa Ana Water Board to revise these TMDLs, if significant changes have occurred in land use in the watershed. The updated SMP should consider including HAB and cyanotoxin monitoring for both lakes that can be used as a baseline for other studies. Until an updated SMP is approved by the Santa Ana Water Board's Executive Officer, the monitoring program existing when these TMDLs become effective will continue to be implemented.

Task 19. Annual Water Quality Reports

Annual water quality monitoring reports will continue to be developed that summarize conditions in accordance with the approved SMP. When necessary, proposed changes to the SMP will be included in a recommendations section of the Annual Water Quality Report to better address the needs of the TMDL Task Force or to align with studies described above. Prior to implementing any substantial changes, the proposed change(s) must be submitted to Santa Ana Water Board's Executive Officer in writing at least 45 days in advance; the Santa Ana Water Board's Executive Officer shall have 45 days to convey its agreement or disagreement with the proposed change, which must be made in writing. A substantial change is defined to include any decrease in monitoring frequency or locations, any substantial change in monitoring station locations, or any other departure from the approved SMP that could be considered significant. If the Santa Ana Water Board staff fails to convey in writing its agreement or disagreement with the proposed change(s) within the 45-day period, then the proposed change(s) in the monitoring program may be implemented, unless the Executive Officer has requested additional time for their review in writing prior to the end of the 45 days.

7.2.3 Adaptive Management

7.2.3.1 Overview

The process of "adaptive management" 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 consideration 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 that may need to periodically be assessed.

Adaptive management will allow opportunity for findings from Phase II implementation tasks as well as compliance assessments conducted by dischargers, e.g., through implementation of the CNRP or Agricultural General Order, to be considered and, where appropriate, provide the basis for revising the TMDLs again in the future, if needed. For example, Task 14 requires that a compliance evaluation must be completed every three years after the effective date of the revised TMDLs. Information from these evaluations may not only affect final TMDL targets and allocations (e.g., see Task 15), but also may be used to evaluate water quality criteria applicable to Lake Elsinore (Task 7). In addition, findings from compliance evaluations and special studies could result in future modifications to watershed implementation plans or identification of the need for supplemental projects to provide additional water quality improvements. **Table 7-9** provides some examples of the types of projects that could be considered as supplemental projects in the future based on findings from Phase II tasks.

7.2.3.2 Consideration of Climate Change Impacts

A challenging aspect of TMDL implementation over a long-time frame is the need to monitor potential impacts of climate change on the watershed. The most recent California Climate Change Assessment Report provided the following key relevant future projections for the area of California that includes the San Jacinto River watershed (Hall et al. 2018): (a) Continued warming of average temperatures with increases in extreme hot temperatures expected over the region; (b) small changes in average precipitation but extremes of dry and wet conditions are expected to increase; increased frequency and severity of atmospheric river events; and (d) potential for increased wildfires.

If realized, predicted climate change impacts in the watershed have the potential to influence water quality in Lake Elsinore and Canyon Lake in various ways, including:

- Increased temperatures and dry conditions may increase evaporative losses from the lake surface, impacting water levels and increasing risk of associated stressors to water quality, e.g., increased concentration of TDS.
- Increased water temperatures could result in more rapid phytoplankton growth rates, a greater fraction of total ammonia that is present in un-ionized form, and extended periods of thermal stratification.
- Potential for increased frequency of HABs and associated impacts to recreational uses, impacts which have been observed during the most recent extended drought in the region.
- Occurrence of more extreme wet weather events which may results in increased erosion of soil from the watershed and flooding of lakeshore and downstream waters.

Table 7-9. Potential Supplemental Projects that May Be Considered during the Phase II Implementation Plan (Potential costs for most of these projects are discussed in more detail in Section 10) (greater the number of “$” in the Cost column, the more costly)

Project	Action	Source	Waterbody	Cost	Description	Water Quality Benefits	Potential Constraints & Limitations
Mystic Lake Drawdown or other Source of Low TDS Water for Dilution	Hydrologic flushing	Internal	Lake Elsinore, Canyon Lake (Main/ East Bay)	$$$	Mystic Lake is a sump that captures all runoff from the upper San Jacinto River 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 in Mystic Lake. • Subsidence in the lake could impact facilities, e.g., pumping facilities) over time. • Mystic Lake is a water of the state listed in the Basin Plan. Pumping of water to the San Jacinto River would impact the beneficial uses within Mystic Lake (intermittent uses: MUN, REC1, REC2, WARM; existing or potential beneficial use: BIOL, WILD, RARE
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.
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 offsite.

Table 7-9. Potential Supplemental Projects that May Be Considered during the Phase II Implementation Plan (Potential costs for most of these projects are discussed in more detail in Section 10) (greater the number of "$" in the Cost column, the more costly)

Project	Action	Source	Waterbody	Cost	Description	Water Quality	Potential Constraints &
Enhanced Fishery Management	Algae control	Internal	Lake Elsinore	$$	Carp removal program already active (though currently suspended). LESJWA (2005a) noted that with carp managed, additional fishery management activities could be implemented that would improve water quality and health of the biological community, e.g., zooplankton enhancement; aquatic and emergent vegetation restoration; fish habitat improvement; and fish community structure improvement.	Improved aquatic community to enhance zooplankton that graze on algae	• Carp control is fundamental to the successful implementation of these fishery management activities. • Other potential limiting factors for zooplankton such as salinity may require controls.
Vegetation Management	Algae control	Internal	Lake Elsinore, Canyon Lake (Main/East Bay)	$$	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 in the Main Lake hypolimnion could cause an increase in nutrient concentrations within East Bay.

Table 7-9. Potential Supplemental Projects that May Be Considered during the Phase II Implementation Plan (Potential costs for most of these projects are discussed in more detail in Section 10) (greater the number of "$" in the Cost column, the more costly)

Project	Action	Source	Waterbody	Cost	Description	Water Quality Benefits	Potential Constraints & Limitations
Ultrasonic Algae Control	Algae control	Internal	Canyon Lake (East Bay, North Ski Area)	$	Devices can be deployed that will kill algae within a 50-ft 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.
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)	$$	Skimmers and other tools can be used to physically remove algae from the surface of the lake.	Control of algae growth	• Labor intensive • Management of algal slurry • Disposal of biosolids locally
Watershed BMPs in Urban Drainage Areas	Phosphorus & nitrogen reduction	External	Lake Elsinore, Canyon Lake (Main/East Bay)	$$$	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.

State Water Board Resolution 2017-0012 requires consideration of potential climate change impacts in Water Board actions (State Water Board 2017). The adopted resolution includes 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. The key elements of this resolution which have been considered as part of the planned action to revise the TMDLs include:

- *Reduction of greenhouse gas emissions, which is supported through increased water conservation and water recycling:* Revised TMDLs encourage continued delivery of EVMWD recycled water which supports local efforts to maintain a minimum lake level in Lake Elsinore. As is noted in Section 7.1.2.2 above (and Section 2.4.1), during the most recent extended drought period, Lake Elsinore would have dried up completely in 2016. The regular addition of recycled water, which prevents the lake from drying, reduces the need for imported water or transporting water over a long distance (thus reducing energy needs). The addition of recycled water has not only facilitated efforts to protect recreational uses, but the additional water also has increased ecosystem resilience by supporting efforts to maintain the Lake Elsinore fishery.
- *Improved ecosystem resilience through updates to plans, permits and policies:* The Phase II Implementation Plan includes tasks where implementation of this element of the state policy can appropriately consider climate change concerns, including:
  - *Revise Permits and Other Regulatory Actions (Task 2)* – Several regional and statewide permits have been identified that may need to be revised by the State Water Board or Santa Ana Water Board to incorporate provisions of the revised TMDLs.
  - *Revise Existing Watershed Implementation Plans (Task 3)* – Early in the implementation of the Phase II program, entities with existing watershed management plans are required to update those plans. Potential impacts from climate change can be considered during the development and review of those revised plans.
- *Improved ecosystem resilience through coordination with USEPA, external experts and interested stakeholders on how to meet water quality standards given potential climate change impacts*: Phase II includes studies to collect data and information that are relevant to meeting water quality standards, including studies to (a) evaluate cyanobacteria in Lake Elsinore (Task 8); (b) assess performance of watershed controls (Task 10); (c) improve estimate of nutrient loads from reference watersheds (Task 11); (d) evaluate status of internal nutrient loading from lake sediments (Task 12); and (e) evaluate status of Common Carp population in the Lake Elsinore fishery (Task 13). In addition, to these special studies, the Phase II program includes an evaluation of existing Lake Elsinore water quality criteria (Task 7), if needed.
- *Respond to climate change impacts associated with the potential for increased wildfires through collaboration between state and regional water agencies (e.g., State Water Board, Santa Ana Water Board and California Department of Forestry and Fire Protection) and federal land management agencies:* Under Task 2 of the Phase II

Implementation Plan, the Santa Ana Water Board will update existing permits/plans where needed to facilitate implementation of the revised TMDLs, including those implemented on USFS lands in the watershed. This effort could include working with the USFS on updating plans to facilitate wildfire management.

In addition to the above, Tasks 4 and 5 of the Phase II Implementation Plan include requirements to evaluate existing or alternative water quality control options in Canyon Lake and Lake Elsinore, respectively, and identify a preferred option or set of options for implementation to support attainment with the revised TMDLs. While benefits involving adaption to climate change from any of these potential projects cannot be determined at this time, it will be necessary for any projects selected under these tasks to consider impacts of climate change as part of efforts to plan, design and permit the project(s).

Many of the existing water quality controls that are being implemented in the San Jacinto River watershed already support efforts to mitigate potential climate change impacts in the region (e.g., addition of recycled water to Lake Elsinore). Water agencies in the San Jacinto River watershed are implementing projects that support state climate change policy, including extensive water recycling for non-potable use (EMWD 2021) and for indirect potable reuse (IPR) (EVMWD 2017), capture of stormwater for groundwater basin recharge or direct delivery (e.g., within areas under the jurisdiction of an MS4), and deployment of water conservation BMPs to levels that are achieving state conservation requirements (EMWD 2021; EVMWD 2021).

Collectively, there is very little freshwater lost to the ocean from the San Jacinto River watershed (which only occurs on those rare occasions when the lake overflows to Temescal Creek and then into the Santa Ana River), which serves to (a) sustain the lakes and water agencies during recent extended droughts, and (b) increases resiliency by reducing reliance on imported water supplies that are anticipated to be less reliable in the future as a result of climate change. Finally, the Back Bay and Summerly Development wetlands store excess runoff that may pose a flooding risk along Lake Elsinore's shoreline or in downstream Temescal Creek (EVMWD and City of Lake Elsinore 2015).

7.2.4 Attainment of Phase II Milestones

In general, the Phase II milestones in these TMDLs are numeric values designed to ensure that dischargers make progress in reducing watershed runoff loads. The milestones are set at levels that are intended to result in the lakes meeting the interim numeric targets, which are designed to protect and maintain beneficial uses in the lakes as associated with a reference watershed condition based on a median of existing data.

The milestones are not WLAs and therefore Title 40, section 122.44 of the CFR does not require them to be implemented as final water quality-based effluent limitations (WQBELs). However, Title 40, sections 122.44 and 122.47 of the CFR, permit requirements must be consistent with the assumptions and requirements of the TMDLs, including the Phase II milestones. Therefore, the Phase II milestones and interim numeric targets will be implemented as milestones or interim WQBELs in compliance schedules, as applicable. Further, although the milestones are not LAs as applied to non-point sources of nutrients to the lakes, non-point source waste discharge requirements must be consistent with schedules in the Basin Plan. Due to the length of the implementation schedule for these TMDLs, milestones are necessary to ensure that progress is made towards improving water quality conditions in the lakes to meet reference watershed conditions. Given the need to include milestones to measure progress, this Implementation Plan describes the options applicable to the entities responsible for these TMDLs to demonstrate attainment of the milestones. Entity-specific options are presented in the following sections and the technical methods for demonstrating attainment with these options are provided in Section 7.2.5 below. The Santa Ana Water Board, of course, has discretion to exclude or modify these options and approaches in permitting actions as necessary to ensure compliance with applicable law, including State Water Board precedential orders, or to the extent the Santa Ana Water Board finds an option would be infeasible or ineffective or as necessary to account for unanticipated watershed conditions.

7.2.4.1 Milestones for MS4 Permittees

The milestones for MS4s combine watershed runoff loads for MS4 permittees subject to specific milestones (i.e., MS4 permittees that discharge runoff in the applicable subwatersheds) (see Section 6.5). For MS4 permittees, attainment of the Phase II milestones may be demonstrated through any one of the following means:

- *Option 1*: Implement a program of pollution controls and BMPs according to an approved CNRP (or an equivalent Watershed Management Plan) that meets the requirements set forth in Phase II, Task 3, as applicable, of the Implementation Plan. This includes participating in pollution offset strategies and reducing external nutrient loads as set forth in the approved CNRP (or equivalent Watershed Management Plan), or
- *Option 2*: Demonstrate attainment of the interim numeric targets using in-lake water quality data collected over a minimum of a 10-year period, or
- *Option 3*: Demonstrate attainment of the Phase II watershed runoff milestones in Tables 6-7 and 6-8 through the use of monitoring data that shows nutrients in watershed loads from MS4s (individually or collectively) are at or below the applicable milestones for TP and TN, or
- *Option 4*: Demonstrate attainment of the Phase II watershed runoff milestones assigned to MS4 permittees (individually or collectively; see Tables 6-7 and 6-8) by offsetting nutrient watershed runoff loads in excess of the milestones using in lake nutrient controls. Excess watershed runoff loads arriving at the lakes may be offset through participation in regional in-lake projects, as applicable, that meet the requirements of the Implementation

Plan and reduce internal nutrient load. Use of offsets under Option 4 is not mutually exclusive from the other options and may be combined with the options as determined appropriate, or

- *Option 5*: Demonstrate attainment of the Phase II total milestones for TP and TN loads for the lakes through collective watershed compliance by offsetting watershed loads in excess of allocations using controls on nutrient loads in the lakes. Excess watershed runoff loads arriving at the lakes may be offset through participation in regional in-lake projects, as applicable, that meet the requirements of the Implementation Plan and reduces internal nutrient load, or
- *Option 6:* Demonstrate attainment of the Phase II watershed runoff milestones assigned to MS4 permittees in Tables 6-7 and 6-8 through implementation of volume retention pollution controls or BMPs that retain sufficient runoff volume such that the downstream load from a given drainage area is equal to or less than would occur in the reference watershed condition.

7.2.4.2 Milestones for Other NPDES Permittees (except EVMWD)

For Other NPDES Permittees (except EVWMD, which is addressed in Section 7.2.4.3 below), attainment of the Phase II milestones may be demonstrated through any one of the following means:

- *Option 1*: Implement an approved CNRP (or equivalent watershed management plan) that meets the requirements set forth in Phase II, Task 3, as applicable, of the Implementation Plan. This includes participating in pollution offset strategies and reducing external nutrient loads from the watershed as set forth in the approved CNRP, or
- *Option 2*: Demonstrate attainment of the interim numeric targets using in-lake water quality data collected over a minimum of a 10-year period, or
- *Option 3*: Demonstrate attainment of the Phase II watershed runoff milestones in Tables 6-7 and 6-8 through the use of monitoring data that shows nutrients in watershed loads are at or below the applicable milestones for TP and TN, or
- *Option 4*: Demonstrate attainment of the Phase II watershed runoff milestones in Tables 6-7 and 6-8 as an individual source by offsetting nutrient watershed runoff loads in excess of the Phase II milestones using in lake nutrient controls. Excess watershed runoff loads arriving at the lakes may be offset through participation in a regional in-lake projects that meet the requirements of the Implementation Plan and reduce internal nutrient load, as applicable to each lake, or
- *Option 5*: Demonstrate attainment of the Phase II total milestones for TP and TN for the lakes through collective watershed compliance by offsetting watershed loads in excess of allocations using controls on nutrient loads in the lakes. Excess watershed runoff loads arriving at the lakes may be offset through participation in regional in-lake projects, as

applicable, that meet the requirements of the Implementation Plan and reduce internal nutrient load, or

- *Option 6:* Demonstrate attainment of the Phase II watershed runoff milestones in Tables 6-7 and 6-8 through implementation of volume retention pollution controls or BMPs that retain sufficient runoff volume such that the downstream load from a given drainage area is equal to or less than would occur in the reference watershed condition.

7.2.4.3 Milestones for EVMWD

Attainment of Phase II milestones for EVMWD may be demonstrated through any one of the following means:

- *Option 1*: Demonstrate attainment of the interim numeric targets for Lake Elsinore using in-lake water quality data collected over a minimum of a 10-year period, or
- *Option 2:* Demonstrate attainment of the concentration-based and mass-based milestones in Table 6-4 as incorporated into EVMWD's NPDES permit as 12-month and 60-month running averages, respectively, unless EVMWD implements a plan, with the approval of the Santa Ana Water Board or its Executive Officer, to offset TP and TN discharges to Lake Elsinore in excess of the TP and TN milestones.

7.2.4.4 Milestones for Non-NPDES Permittees

Attainment of the Phase II milestones for non-NPDES permittees may be demonstrated through any one of the following means:

- *Option 1*: Implement individual or general waste discharge requirements order that explicitly states or serves as a watershed management plan such as the Agricultural General Order that has been revised by the Santa Ana Water Board per Phase II, Task 2 of the Implementation Plan, or
- *Option 2*: Demonstrate attainment of the interim numeric targets using in-lake water quality data collected over a minimum of a 10-year period, or
- *Option 3*: Demonstrate attainment of the Phase II watershed runoff milestones in Tables 6-7 and 6-8 through the use of monitoring data that shows nutrients in watershed loads from the applicable category of dischargers are at or below the applicable milestones for TP and TN, or
- *Option 4*: Demonstrate attainment of the Phase II watershed runoff milestones in Tables 6-7 and 6-8 by offsetting nutrient watershed runoff loads in excess of the milestones using in lake nutrient controls. Excess watershed runoff loads arriving at the lakes may be offset through participation in regional in-lake projects that meet the requirements of the Implementation Plan and reduces internal nutrient load. Use of offsets under Option 4 is

not mutually exclusive from the other options and may be combined with the options as determined appropriate, or

- *Option 5*: Demonstrate attainment of the Phase II total milestones for TP and TN loads for the lakes through collective watershed compliance by offsetting watershed loads in excess of Phase II milestones using controls on nutrient loads in the lakes. Excess watershed runoff loads arriving at the lakes may be offset through participation in regional in-lake projects, as applicable, that meet the requirements of the Implementation Plan and reduce internal nutrient load, or
- *Option 6:* Demonstrate attainment of the Phase II watershed runoff milestones in Tables 6-7 and 6-8 through implementation of volume retention pollution controls or BMPs that retain sufficient runoff volume such that it may be demonstrated that the downstream load from a given drainage area is equal to or less than would occur in the reference watershed condition.

7.2.5 Methods to Demonstrate Attainment of Phase II Milestones

Demonstrations of progress towards TMDL attainment must be submitted every three (3) years by all entities assigned an allocation (see Phase II, Task 14). The previous section described the various options available to entities responsible for implementation of the TMDLs. This section contains a detailed set of alternative methods for how data collected through implementation of the SMP may be used to assess attainment with the options described above. **Table 7-10** provides a summary of the relationship between a specified option number and the method to demonstrate attainment.

Multiple pathways exist to improve future lake water quality; however, two general strategies are being employed: (1) implement in-lake water quality controls that directly affect the response targets in the lakes, and/or (2) reduce external nutrient loads from the watershed to achieve WLAs and LAs and in turn lake response targets. For each of these two strategies, there are two approaches to demonstrate attainment, thus four total attainment demonstration approaches are provided in this TMDL revision. **Figure 7-6** illustrates the multiple pathways that may be employed to use monitoring or modeling results to demonstrate water quality has been improved to meet all TMDL requirements (both interim and final targets). These pathways include:

- If controls are implemented collectively, then the water quality benefit may be realized within the lakes by meeting interim numeric targets for chlorophyll-*a*, DO, and ammonia. Through Approach 1 (*Monitoring Data Compared to Numeric Targets*), in-lake water quality data collected over a 10-year period may be plotted as a CDF and compared to the interim numeric targets in the CDFs (see Section 3.3) to assess whether the range of measured data is equal to or better than water quality for a reference condition.

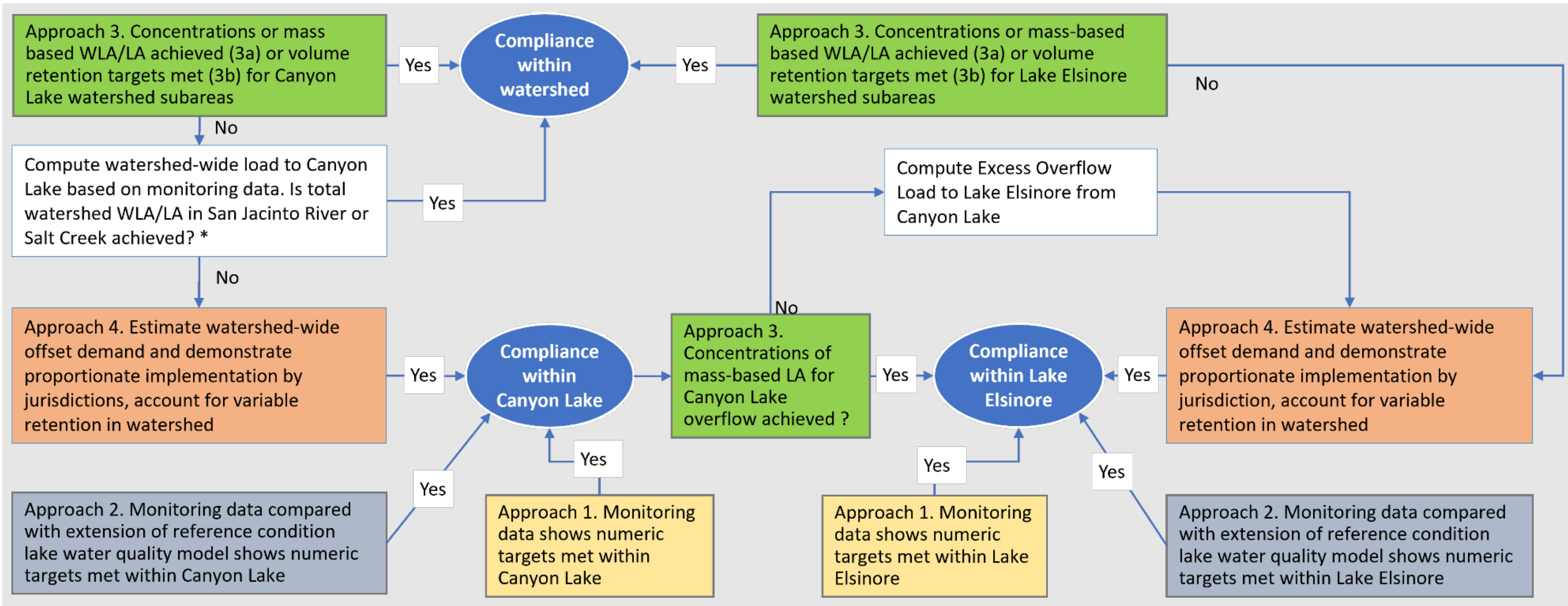


Figure 7-6. Flowchart Showing How Multiple Pathways May Be Used to Demonstrate Attainment with the Revised Nutrient TMDLs (*Partial attainment within the watershed can be achieved if San Jacinto River or Salt Creek meet the milestones. The non-compliant watershed would then follow the path to participate in an offset program involving regional in-lake controls)

Table 7-10. Relationship Between Options to Demonstrate Attainment with Phase II Milestones and Technical Methods to Demonstrate Attainment

Responsible Entity	Option No.	Methods to Demonstrate Attainment (see Section 7.2.5)				
		Approach 1	Approach 2	Approach 3A	Approach 3B	Approach 4
MS4 Permittees	1	X	X	X	X	X
	2	X	X	--	--	--
	3	--	--	X	--	--
	4	--	--	--	--	X
	5	--	--	--	--	X
	6	--	--	--	X	--
Other NPDES Permittees (except EVMWD)	1	X	X	X	X	X
	2	X	X	--	--	--
	3	--	--	X	--	--
	4	--	--	--	--	X
	5	--	--	--	--	X
	6	--	--	--	X	--
EVMWD	1	X	X	--	--	--
	2	--	--	X	--	X
Non-NPDES Permittees	1	X	X	X	X	X
	2	X	X	--	--	--
	3	--	--	X	--	--
	4	--	--	--	--	X
	5	--	--	--	--	X
	6	--	--	--	X	--

- If the preceding 10-year period of measured data is not representative of the long-term simulation period used to create the interim numeric target CDFs, Approach 2 (*Reference Condition Model*) provides an attainment demonstration method involving an extension of the reference condition lake water quality models into the assessment period. Model results for a reference watershed could be compared with measured data to allow for comparison of the same hydrology. This approach is most suitable in Lake Elsinore where the numeric targets were developed from a 105-year simulation period to account for multi-decadal climate variability.
- Through Approach 3 (*External Load Reduction*), attainment of the Phase II milestones can be achieved within the watershed through BMP deployments. Two options for use of this approach are provided: (1) Option 3A (10-year Average Nutrient Concentration), which relies on demonstrating attainment by showing nutrients in external sources have been reduced such that they are equal to or below the Phase II milestones; and (2) Option

3B (Volume Retention), which relies on retaining sufficient runoff volume such that it may be demonstrated that the return load from a given drainage area is equal to or less than what would occur in a zero impervious reference watershed.

- For some jurisdictions, it may be infeasible to collect water quality samples to characterize all runoff discharged to downstream receiving waters. However, Task Force collected monitoring data can be used to determine excess nutrient loads at the watershed scale which may then be reduced via in-lake offsets (*Approach 4: In-Lake Offsets*).
- Attainment with the TMDLs may also be achieved when in-lake numeric targets for chlorophyll-*a*, DO, and ammonia are achieved through collective watershed and in-lake project implementation.

The sections below describe each of the four methods for demonstrating attainment. All of these approaches are available for use during any specific reporting period. **Table 7-11** provides a tabular summary of the types of data needed to support each approach. Even if an area is determined to be in attainment during a reporting period, data collection needed to support attainment demonstrations must continue for future reporting periods.

7.2.5.1 Approach 1: Monitoring Data Compared to Numeric Targets

Attainment may be demonstrated if the CDFs of in-lake water quality monitoring data are equal to or better than numeric target CDFs for chlorophyll-*a*, DO, and ammonia-N. **Figure 7-7** provides an example attainment demonstration approach using hypothetical data. This example compares the preceding 10 years of bimonthly sampling data against the numeric target CDF for chlorophyll-*a*, DO, and ammonia-N (see constituent curves for each lake in Section 3). The type of monitoring data plotted as CDFs for comparison to the numeric targets differ depending upon the response variable, as follows:

- *Chlorophyll-a*: Surface concentration (integrated sample from top 2-m) from routine in-lake monitoring. Separate averages are computed for Canyon Lake for the Main Lake (average of monitoring locations CL07 and CL08) and East Bay (average of monitoring locations CL09 and CL10).
- *Dissolved Oxygen*: Bi-monthly depth profiles of DO at 1-m intervals from monitoring location LE02 in Lake Elsinore, monitoring locations CL07 and CL08 in Canyon Lake Main Lake, and monitoring locations CL09 and CL10 in Canyon Lake East Bay. 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 measurement 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 (see Figure 7-7).

Table 7-11. Summary of Minimum Watershed and In-Lake Data Needs to Apply Attainment Demonstration Approaches (see text)

Compliance Approach	Description	Metric	Waterbody			Recycled Water
			Canyon Lake East Bay	Canyon Lake Main Lake	Lake Elsinore	Lake Elsinore
Approach 1 – Monitoring Data Compared to Numeric Targets (Section 7.2.5.1)	Attainment demonstrated if in-lake monitoring data are equal to or better than numeric target CDFs (see Section 3)	10-year CDF	1. Average of bi-monthly samples collected at monitoring locations CL07 and CL08 (n = 60)	1. Average of bi-monthly samples collected at monitoring locations CL09 and CL10 (n = 60)	1. Single monitoring location LE2 sampled 8 times per year (n = 80)	N/A
Approach 2 – Reference Condition Model (Section 7.2.5.2)	Evaluates the current monitoring data against modeled water quality for a reference condition over the same hydrologic period	10-year CDF	1. Average of bi-monthly samples collected at monitoring locations CL07 and CL08 (n = 60) *AND* 2. 10-year AEM3D model simulation of reference condition over the same attainment assessment period	1. Average of bi-monthly samples collected at monitoring locations CL09 and CL10 (n = 60) *AND* 2. 10-year AEM3D model simulation of reference condition over the same attainment assessment period	1. Single monitoring location LE2 sampled 8 times per year (n = 80) *AND* 2. 10-year GLM model simulation of reference condition over the same attainment assessment period	
Approach 3, Option 3A – External Load Reduction (Section 7.2.5.3)	Demonstrating attainment with allowable concentrations that show nutrients in external sources have been reduced to be equal to or below the allocations	10-year average concentration at end of pipe (~1 per year)	At least 10 wet weather grab samples (~1 per year)			Monthly TP/TN concentration
Approach 3, Option 3B - External Load Reduction (Section 7.2.5.3)	Watershed runoff volume retained to return downstream loading to less than the reference load for a zero impervious drainage area	Watershed retention BMP sized to meet required capture volume (Section 7.3.3)	Annual inspection of facilities validate retention controls are functioning as intended and documentation of maintenance activities. As needed, refinement of information to support attainment demonstration based on outcome of watershed control effectiveness special study (see Section 7.2.2.1 for Phase II Task 10)			N/A
Approach 4 – In-Lake Offsets (Section 7.2.5.4)	Meeting milestones or WLAs/LAs by reducing internal loads by the amount of external load in excess of reference conditions	10-year average excess load, in-lake control effectiveness demonstration	Salt Creek USGS Gauge #11070465 runoff volume; flow-weighted samples at Murrieta Road (n = ~30)	San Jacinto River USGS Gauge #11070365 runoff volume; flow-weighted samples at Goetz Road (n = ~30)	San Jacinto River USGS Gauge #11070500 runoff volume; Canyon Lake Overflow flow-weighted samples (n = ~15)	Metered discharge; monthly TP/TN concentrations

Step 1. Calculate fraction of Main Lake volume with DO > 5mg/L

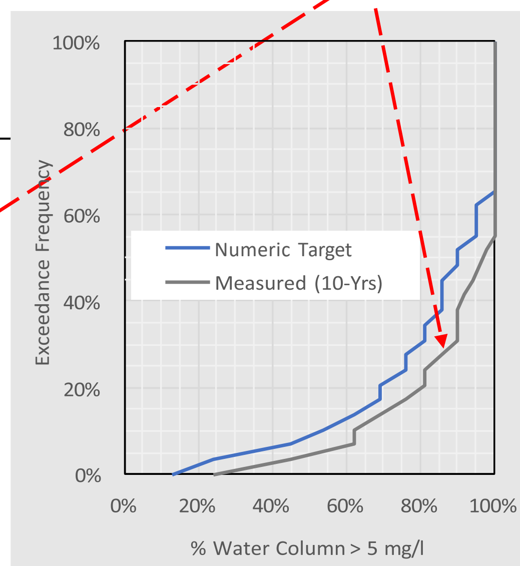
Example for Profile 1 of 60

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%	

Step 2. Repeat step 1 for all 60 profiles

Step 3. Plot as CDF

Exceedence Frequency	Fraction of Lake Volume with DO > 5 mg/L	Reference CDF (Numeric Target)
0%	24%	13%
3%	45%	24%
7%	62%	45%
10%	62%	54%
14%	69%	62%
17%	76%	69%
21%	81%	69%
24%	81%	76%
28%	86%	76%
31%	90%	81%
34%	90%	81%
38%	90%	86%
41%	92%	86%
45%	94%	86%
48%	96%	90%
52%	98%	90%
55%	100%	95%
59%	100%	95%
62%	100%	95%
66%	100%	100%
69%	100%	100%



Compliance √

Figure 7-7. Hypothetical Example for Attainment Demonstration Approach 1 – Use of Dissolved Oxygen Profile Data to Evaluate Compliance with Numeric Target for Dissolved Oxygen

- *Total Ammonia-N*: Depth integrated total ammonia-N concentration from bimonthly samples from monitoring location LE02 in Lake Elsinore, average of monitoring locations CL07 and CL08 in Canyon Lake Main Lake, and average of monitoring locations CL09 and CL10 in Canyon Lake East Bay. The set of 60 depth integrated averages are plotted as a CDF and compared with numeric target CDFs.

CDFs based on the SMP monitoring data must be equal to or better than the numeric target CDF over the full range of frequencies to demonstrate attainment. **Figure 7-7** provides an example involving the use of this method for a hypothetical (2020-2030) set of DO profiles from monitoring locations CL07 and CL08 in Canyon Lake Main Lake. To demonstrate attainment with the TMDL, the CDF for full lake volume estimated from depth profile measurements should remain above the reference condition CDF.

7.2.5.2 Approach 2: Reference Condition Model

Approach 2 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-year period. This approach is the most appropriate method to use when the preceding 10-year 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.

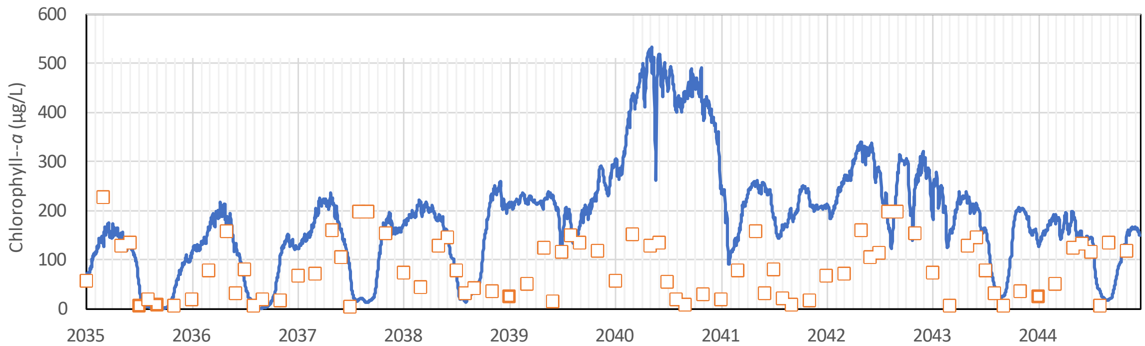
CDFs based on the SMP monitoring data must be equal to or better than a CDF of model results for reference conditions over the same 10-year period to demonstrate compliance. **Figure 7-8** provides an example demonstrating attainment using this method for chlorophyll-*a* in Lake Elsinore. The example is based on hypothetical (2035-2045) results from extension of the GLM model past the numeric target setting period and a hypothetical set of chlorophyll-*a* concentrations from the lake surface (integrated sample from top 2-m). To demonstrate attainment with the TMDL, the CDF from surface monitoring data should remain above the reference condition CDF.

7.2.5.3 Approach 3: External Load Reduction

Allocations are developed for nutrients in external sources with an allowable concentration of nutrients, TP and TN, representative of a reference watershed. Demonstrating attainment with these allowable concentrations involves collection of monitoring data that show nutrients in external sources have been reduced to be equal to or below the allocations. Two options may be used to show that external nutrients loads have been reduced to meet the TMDLs: Either (1) Option 3A, if the 10-year average TP and/or TN concentration in grab samples from a jurisdiction's runoff is equal to or less than the reference watershed (interim allocation of 0.32 mg/L for TP and 0.92 mg/L for TN; final allocation of 0.16 mg/L TP and 0.68 mg/L TN); or (2) Option 3B, if watershed runoff volume capture is sufficient to reduce downstream loads to be less than a reference watershed with zero impervious area. Detailed descriptions of each of these options including a hypothetical example are provided below.

Step 1. Run lake water quality model for preceding five-year period, output daily lakewide average surface chlorophyll-*a* concentration

Step 2. Compile chlorophyll-*a* from monitoring program dataset



Step 3. Plot measured and modeled chlorophyll-*a* (µg/L) as CDF

%ile	Observed Data	Reference Model	%ile	Observed Data	Reference Model
3%	4	3	51%	131	146
5%	5	14	54%	134	149
8%	5	21	56%	134	152
10%	7	27	59%	144	154
13%	11	40	62%	147	157
15%	16	63	64%	150	159
18%	18	86	67%	151	162
20%	18	103	69%	152	165
23%	20	118	72%	155	169
25%	24	126	74%	157	172
28%	28	133	77%	158	175
30%	30	140	79%	179	181
33%	33	145	82%	179	188
35%	38	150	85%	186	194
38%	46	155	87%	188	200
40%	51	159	90%	196	203
43%	55	163	92%	197	206
45%	65	168	95%	200	210
48%	70	175	97%	204	213
50%	72	182	100%	216	222

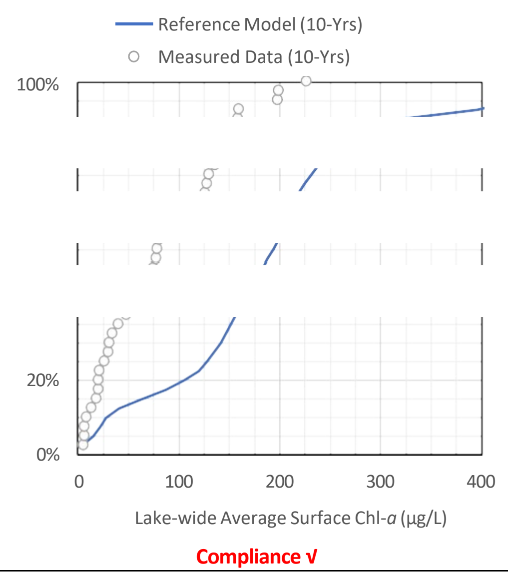


Figure 7-8. Hypothetical Example for Attainment Demonstration Approach 2 - Use of Chlorophyll-*a* Data to Evaluate Attainment Using the Reference Condition Model Approach

7.2.5.3.1 Option 3A – 10-Year Average Nutrient Concentration

This approach may be used based on data collected by the TMDL's SMP or from any additional upstream monitoring locations for an individual jurisdiction or groups of jurisdictions. However, the following must be considered:

- When using this approach, samples collected at a downstream monitoring station that is influenced by recently (within one year) burned hillsides, or other catastrophic hydrologic events, may be excluded from the calculation of 10-year average nutrient concentrations.[33]

[33] A period of one year is considered conservative given that even longer periods for recovery are likely in mountainous regions or Southern California (Rulli and Rosso 2007)

- For a single jurisdiction, at least 10 grab samples during wet weather (approximately one sample per year) are needed to support an attainment demonstration. For collective watershed attainment demonstrations at downstream lake inflows, data collected from the TMDL's SMP must be included in the 10-year average.

Figure 7-9 provides an example for demonstrating attainment using this method for TP in a MS4 outfall. The example is based on hypothetical (2035-2045) results from potential data collected at the MS4 outfall. To demonstrate attainment with the TMDLs, the 10-year average nutrient concentrations must be below the reference watershed nutrient concentration.

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	0.27			2.00		
Year 2	0.20	0.43		2.40	2.30	
Year 3	0.18	0.32		4.20	2.10	
Year 4	0.16			4.30		
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	16.02 *
Year 8	0.29	0.37		0.80	2.36	
Year 9	0.42			0.96		
Year 10	0.68	0.32		3.40	0.91	

* 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 7-9. Hypothetical Example for Attainment Demonstration Approach 3 (Option 3A) - Use of Nutrient Data to Evaluate Attainment with External Loads from the Reference Watershed for the Interim Milestone

7.2.5.3.2 Option 3B – Volume Retention

Retention of precipitation runoff from developed drainage areas in existing or planned retention BMPs can be an effective way to prevent nutrient loads from reaching the downstream lakes. But, despite the potential benefits from the reduction of nutrient load, a program of widespread deployment of retention BMPs is projected to have a net negative impact to lake water quality due to the potential cumulative impacts that retention can have on lake water levels in Lake Elsinore (CDM Smith 2022). Regardless, in certain circumstances, retention BMPs could be used to demonstrate attainment with the TMDLs, e.g., in small jurisdictional areas that drain to a single downstream retention BMP. Cities or individual agricultural operators with small (< 1,000 acre) drainage areas may consider this approach to demonstrating attainment with the TMDLs. In addition, when determining participation levels in a downstream offset program (using Attainment Demonstration Approach 4), entities could use the volume retention formulas below to remove portions of their respective larger jurisdictional area from estimates of the total jurisdictional load. This approach would be consistent with current nutrient reduction credit estimation and cost share accounting used to apportion costs for the alum addition and LEAMS operation offset programs in Canyon Lake and Lake Elsinore, respectively.

Under Option 3B, runoff volume is prevented from reaching the downstream lakes, therefore no allowance for increased runoff volume associated with watershed imperviousness is appropriate in the estimation of volume capture needed to demonstrate attainment. Volume retention provided by the BMP must first retain the full amount of increased runoff volume associated with imperviousness in the upstream drainage area. In addition, volume retention must mitigate the excess load associated with nutrient washoff from developed lands relative to the reference watershed, as estimated in Section 4.1.3 of the Source Assessment. A formula to estimate the annual volume of watershed runoff that must be retained is presented below:

$V_{CAPTURE} = (V_{DA} - V_{REF}) + (V_{REF} * (1 - C_{REF} / C_{DA}))$, where:

- $V_{CAPTURE}$ = Annual runoff capture to be demonstrated (AFY)
- V_{DA} = Annual runoff from developed drainage area = DA (acres) * RC * P/12; where:
    - RC = Runoff Coefficient = $0.041 * e \wedge ^{(3.1*IMP\%)}$, where IMP% = percent imperviousness; P = annual precipitation (in/yr)
- V_{REF} = Annual runoff from a zero impervious reference drainage area = DA (acres) * RC * P/12, where RC = 0.041
- C_{REF} = Reference nutrient concentration (Interim: 0.32 mg/L TP, 0.92 mg/L TN; Final: 0.16 mg/L TP, 0.68 mg/L TN)
- C_{DA} = Nutrient concentration of upstream drainage area (see Tables 4-8 and 4-9)

Figure 7-10 provides two hypothetical examples for use of Option 3B: (1) 10-acre sewered residential drainage area with 33% imperviousness and 11 inches of average annual precipitation (left side of figure); and (2) 10-acre irrigated cropland with no imperviousness and 11 inches of average annual precipitation (right side of figure).

Under Option 3B, the demonstration of attainment involves (1) construction of retention BMPs of the minimum size needed to return downstream loads to be less than a zero imperviousness under the reference watershed condition; and (2) effective operation and maintenance of retention BMPs to demonstrate in future years that the BMPs are functioning as intended. Demonstrations may be supported by collection of gauge data (with a maximum recording interval of 15 minutes) for flow at inflows/outflows or water level measurements from within the BMP. Attainment demonstrations based on Option 3B that involve an entire jurisdiction's allocation will be reviewed on a case-by-case basis. Lastly, attainment demonstration methods using this approach should be re-evaluated based on the findings from the special study that evaluates the performance of watershed controls (see Section 7.2.2.2, Task 10 of the Phase II Implementation Plan).

Step 1. Compute Excess Volume from Impervious Areas			
Drainage Area	Annual Rainfall (in/yr)	Impervious %	Drainage Area Volume (AF)
10	11	33%	1.05
10	11	0%	0.38
			0.67
Step 2. Compute Ratio of Reference / Developed Nutrient Washoff			
	TP (mg/L)	TN (mg/L)	
Reference Condition	0.32	0.92	
Sewered Residential	0.48	1.60	
Ratio	0.67	0.58	
Step 3. Compute Volume Capture to Achieve Reference Condition Nutrient Load (Pervious Volume * (1-Ratio in Step 2)			
Pervious Land Volume (AF)	To Meet Reference TP	To Meet Reference TN	
0.38	**0.13**	**0.16**	
Step 4. Compute Total Volume to be Captured: Step 1 + Step 3 (max of TP or TN)	AFY of Retention	% of Drainage Area Volume	
	0.83	**79%**	

Step 1. Compute Excess Volume from Impervious Areas			
Drainage Area	Annual Rainfall (in/yr)	Impervious %	Drainage Area Volume (AF)
10	11	0%	0.38
10	11	0%	0.38
			0.00
Step 2. Compute Ratio of Reference / Developed Nutrient Washoff			
	TP (mg/L)	TN (mg/L)	
Reference Condition	0.32	0.92	
Irrigated Cropland	1.28	1.19	
Ratio	0.25	0.77	
Step 3. Compute Volume Capture to Achieve Reference Condition Nutrient Load (Pervious Volume * (1-Ratio in Step 2)			
Pervious Land Volume (AF)	To Meet Reference TP	To Meet Reference TN	
0.38	**0.28**	**0.09**	
Step 4. Compute Total Volume to be Captured: Step 1 + Step 3 (max of TP or TN)	AFY of Retention	% of Drainage Area Volume	
	0.28	**75%**	

Figure 7-10. Hypothetical Example for Attainment Demonstration Approach 3 (Option 3B) - Use of PLOAD Watershed Model to Compute Retention Volume Needed to Demonstrate Attainment with External Loads for the Interim Milestone (Left – Example 1 involving sewered residential area; Right – Example 2 involving irrigated cropland)

7.2.5.4 Approach 4: In-Lake Offsets

This approach allows a responsible entity to meet WLA/LAs by reducing internal lake loads to offset the amount of external watershed loads in excess of reference conditions. Allocations are developed for nutrients in external sources with an allowable concentration of nutrients, TP and TN, representative of a reference watershed (C_{REF}). For runoff sources, long-term USGS gauge measured volume that reaches Canyon Lake from the San Jacinto River (V_{SJR}) and Salt Creek (V_{SC}), and Canyon Lake overflows to Lake Elsinore (V_{OVER}) is used to compute allowable loads based on the preceding 10-year hydrologic period. For recycled water addition to Lake Elsinore, metered data on volume (V_{RW}) is used to compute allowable load at reference nutrient concentrations.

Actual load to the lakes is estimated from measured flow volumes for watershed runoff or recycled water and sampled concentrations. For watershed runoff, three storms per year are sampled and 10-year running average loads are reported annually (LESJWA 2023). Routine monitoring is also conducted for recycled water and reported annually (Stillwater Sciences and Alex Horne Associates 2022).

If the external load arriving at the lakes exceeds the collective WLA/LAs for watershed runoff sources, then the excess loads can be offset with participation in a regional in-lake water quality control project that reduces the internal nutrient loads. Demonstrating attainment involves first computing the excess nutrient loads from external sources. This determines the collective demand for nutrient reduction credits through participation in an offset program involving implementation of in-lake BMPs. The amount of loads to be offset, or offset demand (OD), is calculated as follows:

- Canyon Lake, $OD_{CL} = (L_{SJR} – V_{SJR}*C_{REF}) + (L_{SC} – V_{SC}*C_{REF})$, where
  - OD_{CL} = Offset demand in Canyon Lake
  - L_{SJR} = Measured loads to Canyon Lake from San Jacinto River
  - V_{SJR} = Measured volume to Canyon Lake from San Jacinto River
  - C_{REF} = Reference nutrient concentrations
  - L_{SC} = Measured loads to Canyon Lake from Salt Creek
  - V_{SC} = Measured volume to Canyon Lake from Salt Creek
- Canyon Lake Overflow to Lake Elsinore, $OD_{OVER} = (L_{OVER} – V_{OVER}*C_{REF})$, where
  - OD_{OVER} = Offset demand for Canyon Lake overflows to Lake Elsinore
  - L_{OVER} = Measured overflow loads from Canyon Lake to Lake Elsinore
  - V_{OVER} = Measured overflow volume from Canyon Lake to Lake Elsinore
  - C_{REF} = Reference nutrient concentrations
- Local Lake Elsinore Watershed, $OD_{zone1} = (L_{Zone1} – V_{Zone1}*C_{REF})$, where
  - OD_{zone1} = Offset demand for local Lake Elsinore watershed
  - L_{Zone1} = Estimated load from local Lake Elsinore watershed
  - V_{Zone1} = Estimated volume from local Lake Elsinore watershed
  - C_{REF} = Reference nutrient concentration
- Recycled Water Addition, $OD_{RW} = V_{RW} * (C_{RW} - C_{REF})$, where
  - OD_{RW} = Offset demand for recycled water addition to Lake Elsinore
  - V_{RW} = Measured volume of recycled water addition to Lake Elsinore
  - C_{RW} = Measured nutrient concentration of recycled water addition to Lake Elsinore
  - C_{REF} = Reference nutrient concentration

Estimation of excess nutrients should consider the following:

- Nutrient loads from San Jacinto River to Canyon Lake Main Lake, Salt Creek to Canyon Lake East Bay, and Canyon Lake overflows to Lake Elsinore (respectively as L_{SJR}, L_{SC}, L_{OVER}) are computed from the 10-year average of estimated mass emissions, collected through the SMP and reported in Annual Monitoring Program reports.
- Nutrient loads from the local Lake Elsinore watershed (L_{Zone1}) is estimated using the pollutant loading model supported by land use based nutrient event mean concentrations (EMCs) described in Section 4.1.3 in the Source Assessment chapter.

- Determinations of proportional participation levels for upstream jurisdictions that have not met allocations within the watershed will be proportional to the estimated load reaching the downstream lakes, which is a function of land use based nutrient EMCs described in Section 4.1.3, subwatershed specific rainfall, imperviousness, and retention losses between jurisdictions and lake inflows from either channel bottom recharge (see Section 4.1.2.4) or captured in Mystic Lake (see Section 4.1.2.5). Moreover, jurisdictional area is continually evolving in the San Jacinto River watershed (i.e., because of agricultural land conversion to urban land use). Relative contributions to excess downstream nutrient loadings, 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 Agricultural General Order should include a method for reporting and tracking watershed BMP deployments by subwatershed to support a scientifically defensible distribution of excess nutrient loads measured at downstream lake inflows to apportion offset demands in the future to upstream jurisdictions.
- Natural uncontrollable events can potentially add excess nutrients to the lakes. Possible sources include: (1) legacy loading in riverbeds and lake beds (Horne 2002) when scoured from riverbeds during high flow events; (2) resuspension from lake beds during high wind events or fish disturbances; (3) increased organic content from ash and particles associated with forest fires; and (4) river channel levee breaches during extreme flow events.
- A project-specific effectiveness analysis must be developed that computes internal nutrient load reductions achieved with in-lake BMPs. The methodology used to estimate nutrient reductions achieved with in-lake BMPs shall be included within reasonable assurance analyses prepared for updated TMDL implementation plans and submitted to the Santa Ana Water Board for review and approval as specified in Phase II tasks. The in-lake BMP nutrient reduction credit should provide sufficient reductions to watershed-wide nutrient load to offset excess external loads arriving at each lake.

Figure 7-11 provides an example demonstrating attainment using this method to offset excess phosphorus in watershed runoff to Canyon Lake. The example is based on hypothetical (2035-2045) results from continued implementation of the watershed monitoring program.

7.3 Phase III Implementation Plan

At a minimum, the goal of the Phase II Implementation Plan is to achieve attainment of the interim numeric targets and milestones no later than 20 years after the effective date of the revised TMDLs. Task 14 in Phase II requires an assessment of the status of attainment with these interim numeric targets and milestones every three years. Following Phase II, the goal of the revised TMDLs is to achieve attainment with the revised TMDLs' final targets and allocations no later than 30 years after the effective date of the revised TMDLs (or within 10 years from the beginning of Phase III). These final targets and allocations will be re-

Step 1. Identify Reference Concentration for Target Nutrient(s) based on Milestone	Nutrient	Milestone	Concentration (mg/L)
	Phosphorus	Final	0.16
Step 2. Extract 10-Year Average Volume for Canyon Lake Runoff Inflows from USGS Gauge Data (Station 11070365 for San Jacinto River and 11070465 for Salt Creek)	Salt Creek (AFY)	San Jacinto River (AFY)	Total (AFY)
	3,000	5,000	8,000
Step 3. Compute Allowable External Loads as Volume * Reference Concentration (Values in Step 1 * Step 2 * 3.785 CF)	TP (kg/yr)	TP (kg/yr)	Total (kg/yr)
	592	987	1,579
Step 4. Extract Measured 10-Year Average Nutrient Load from Annual SMP Report	TP (kg/yr)	TP (kg/yr)	Total (kg/yr)
	1,100	2,200	3,300
Step 5. Compute Nutrient Offset Demand to be demonstrated with in-lake BMPs (Step 4 - Step 3)	TP (kg/yr)	TP (kg/yr)	TP (kg/yr)
	508	1,213	1,721
Step 6. Independent In-lake BMP Offset Effectiveness Demonstration: Offset in Step 6 Must Exceed Offset Demand in Step 5	520	1,220	1,740
	Compliance √	Compliance √	Compliance √

Figure 7-11. Hypothetical Example for Attainment Demonstration Approach 4 - Use of Nutrient Data to Evaluate Use of In-Lake Offsets as an Approach to Demonstrating Attainment

evaluated prior to the beginning of Phase III to verify they continue to be appropriate given outcome of Phase II implementation activities (see Tasks 15 through 17 in the Phase II Implementation Plan), knowledge gained during Phase II and other factors that could affect the attainability of the final targets and allocations, e.g., outcome of anticipated climate change impacts or changes in regional water management strategies or watershed characteristics.

7.3.1 Phase III Schedule of Activities

Table 7-12 provides the Phase III tasks to achieve the final TMDL numeric targets and allocations. The 10-year timeline to complete Phase III includes time to update and approve watershed implementation plans and General Orders. It also provides sufficient time to evaluate the water quality controls being implemented in each lake and very importantly complete an implementation gap analysis to determine if any additional water quality controls may be necessary to achieve the final TMDL targets. If any implementation gaps are identified in either Lake Elsinore or Canyon Lake, then Phase III provides time to either refine existing water quality controls or implement new controls. Finally, as noted above in Section 7.2.1, the key elements established to support implementation of the revised TMDLs (e.g., implementation of the TMDLs through an approved coalition or group and the applicability of a nutrient offset program) also apply to the Phase III Implementation Plan.

Table 7-12. Phase III (Years 21 – 30) Implementation Plan Activities

Task	Description	Schedule	Responsible Entity
1. Stakeholder Coordination	TMDL Task Force collaboration at a frequency as determined by the stakeholders	Ongoing throughout Phase III	Task Force Members
2. Revise Existing Watershed Implementation Plans	Review existing CNRP (or equivalent watershed management plan) Revise existing Irrigated Lands General Order Revise other existing Watershed Implementation Plans, as needed	CNRP: Within one (1) year past the end of Phase II, review the existing CNRP (or equivalent watershed management plan) and submit revisions to the Santa Ana Water Board, if revisions are necessary; continue implementation of the existing CNRP or watershed management plan until revised CNRP or watershed management plan is approved by the Santa Ana Water Board. Within two (2) years past the end of Phase II, revise any General Orders or other Watershed Implementation Plans where needed to support implementation of the TMDLs.	MS4 Permittees; Agricultural Operators; (Others, as needed); Santa Ana Water Board
3. Evaluation of In Lake Project(s) for Canyon Lake	Evaluation and implementation of existing in-lake projects	• Continue to implement existing Canyon Lake in-lake projects • Within two (2) years after the end of Phase II, submit an evaluation of the effectiveness of the existing/ongoing in-lake project(s) for Canyon Lake and any approved offsets that may be associated with the in-lake project(s) to the Santa Ana Water Board's Executive Officer for review. 1. Upon review of the evaluation, the Santa Ana Water Board's Executive Officer may reauthorize the project(s) and any associated offsets should be reauthorize, or deny reauthorization. • If the Santa Ana Water Board's Executive Officer reauthorizes the Project and the Project continues, then within five (5) years from the Executive Officer's determination, and once every five (5) years thereafter, an evaluation of the effectiveness of the Project and use of any offsets associated must be submitted to the Santa Ana Water Board's Executive Officer for review and consideration of continuation of reauthorization. • Any significant changes to the offset program must be requested in advance of implementation of the change and such change must be approved by the Santa Ana Water Board's Executive Officer prior to implementation.	Entities responsible for implementation of Canyon Lake TMDLs

Table 7-12. Phase III (Years 21 – 30) Implementation Plan Activities

Task	Description	Schedule	Responsible Entity
4. Implement New or Revised In-Lake Projects for Lake Elsinore	Implement new or revised in-lake projects for Lake Elsinore as determined appropriate	• Continue to operate new/refined in-lake projects in Lake Elsinore that were implemented in Phase II • Within two (2) years after the end of Phase II, submit an evaluation of any approved offsets associated with the implementation of in-lake projects for Lake Elsinore to the Santa Ana Water Board's Executive Officer for review. Upon review of the evaluation, the Santa Ana Water Board's Executive Officer has the right to determine if the existing approved offsets should be reauthorized, or if reauthorization should be denied.	Entities responsible for implementation of Lake Elsinore TMDLs
5. Fishery Management	Evaluate status of fishery populations in Lake Elsinore using consistent sampling and data analysis methods used in previous studies	• Within five (5) years after the end of Phase II (but no later than 10 years from year that the last fishery survey was conducted during Phase II), and every 10th year thereafter, submit a report that includes the results of a Study conducted to evaluate the status of fishery populations in Lake Elsinore and compare to previous studies. Submit the report to the Santa Ana Water Board's Executive Officer for review.	Entities responsible for implementation with Lake Elsinore TMDLs
6. Evaluate Status of TMDL Attainment of Numeric Targets, WLAs and LAs	Evaluate status of attainment with the final numeric targets and allocations	Starting two (2) years after the end of Phase II, and every 3rd year thereafter, submit a report that evaluates progress towards meeting the final numeric targets, WLAs and LAs in these TMDLs.	Entities responsible for implementation of the Lake Elsinore and Canyon Lake TMDLs
7. Implementation Gap Analysis	Based on results of Task 6, determine the load reductions remaining to be achieved to meet the WLAs, LAs and numeric targets	Within three (3) years after the end of Phase II, submit a report to the Santa Ana Water Board's Executive Officer that provides an evaluation of the implementation gaps, i.e., that determines the load reductions that must still be achieved to meet WLAs, LAs, and/or targets and allocations in the TMDLs.	Entities responsible for implementation of Lake Elsinore and Canyon Lake TMDLs

Table 7-12. Phase III (Years 21 – 30) Implementation Plan Activities

Task	Description	Schedule	Responsible Entity
8. Study for Lake-bottom Sediment Sampling and Core Flux Experiments	Based on the results of sediment sampling in Phase II, task 12, at least one round of collection and analysis of lake bottom sediment cores needs to occur during Phase III. If there is significant variability, it may be necessary to conduct additional rounds periodically during the life of Phase III. Sediment will be collected from historically sampled locations in both Canyon Lake and Lake Elsinore to assess changes to nutrient enrichment after implementation of watershed implementation plans and other TMDL-related projects in the watershed.	• Round 1: No later than five (5) years after the end of Phase II, submit a Sediment Study Report to the Santa Ana Water Board that provides study results and updated estimates of internal nutrient loads. • Subsequent studies: Depending on the results of previous sediment sampling studies, the studies should be repeated periodically during the Phase III if there are significant variations in the results. • Submit study results and any recommendations for future sampling to the Santa Ana Water Board's Executive Officer for review and approval.	Entities responsible for implementation of Lake Elsinore and Canyon Lake TMDLs, as applicable
9. Evaluate in-lake project options for Canyon Lake to Maintain Intended Aquatic Life, Recreational and Municipal Uses, if necessary	Evaluation of reasonably feasible lake management activities in Canyon Lake that may be implemented to improve and maintain water quality for intended uses, including reduction of HABs in frequently used swimming beaches and impacts to water supply.	• Within three (3) years after the end of Phase II, submit a proposed Work Plan for an evaluation of Canyon Lake's ability to maintain intended beneficial uses for approval by the Santa Ana Water Board's Executive Officer. • Complete the tasks in the Work Plan according to the schedule as approved by the Santa Ana Water Board's Executive Officer	Entities responsible for implementation of Canyon Lake TMDLs
10. Evaluate Supplemental in-lake project options for Lake Elsinore to Maintain Intended Aquatic Life and Recreational Uses, if necessary	Evaluate supplemental and reasonably feasible water quality control options for Lake Elsinore to maintain intended aquatic life and recreational uses, including reduction of HABs in frequently used swimming beaches.	• Within four (4) years past the interim compliance milestone, submit a proposed Work Plan for an evaluation of Lake Elsinore's ability to maintain intended beneficial uses for approval by the Santa Ana Water Board's Executive Officer. • Complete the tasks in the Work Plan according to the schedule as approved by the Santa Ana Water Board's Executive Officer.	LEAMS Operators

Table 7-12. Phase III (Years 21 – 30) Implementation Plan Activities

Task	Description	Schedule	Responsible Entity
11. Surveillance & Monitoring Program	Update TMDL SMP (and QAPP) as needed; updates should include a program to conduct watershed aerial surveys of land use every 5 years, and HAB and cyanotoxin monitoring for both lakes.	Continue to implement the existing SMP as approved under Phase II, unless or until an updated SMP is approved by the Santa Ana Water Board's Executive Officer.	Entities responsible for implementation of Lake Elsinore and Canyon Lake TMDLs
12. Annual Water Quality Reports	Prepare annual water quality reports	• By August 15 each year, submit an Annual Water Quality Report that reports the results of SMP implementation to the Santa Ana Water Board; reports must identify any changes or proposed changes to the SMP. • Prior to implementing any significant changes to the approved SMP, the proposed change must be submitted to Santa Ana Water Board's Executive Officer in writing at least 45 days in advance; Santa Ana Water Board's Executive Officer shall have 45 days to convey its agreement or disagreement with the proposed change; if Santa Ana Water Board's Executive Officer fails to convey in writing its agreement or disagreement with the proposed change within the 45 day period, then the change in the SMP may be implemented unless the Executive Officer requests an extension of the deadline prior to the end of the 45 days. • A substantial change is defined to include any decrease in monitoring frequency or locations, any substantial change in monitoring station locations, or any other departure from the approved SMP that could be considered significant.	Entities responsible for implementation with Lake Elsinore and Canyon Lake TMDLs
13. Adaptive Management	Throughout the implementation of Phase III, taking into consideration results of studies conducted during Phases II and III, adaptive management needs to be employed to coordinate project refinements or enhancements with operators and other stakeholders.	Ongoing activity.	Entities responsible for implementation with Lake Elsinore and Canyon Lake TMDLs

Table 7-12. Phase III (Years 21 – 30) Implementation Plan Activities

Task	Description	Schedule	Responsible Entity
14. Review and Reconsider Lake Elsinore/Canyon Lake Nutrient TMDL	Santa Ana Water Board will review and reconsider the provisions of these TMDLs, as they determine appropriate and necessary	• (1) No later than 10 years after the end of Phase III, and every 10 years thereafter, 2. The Santa Ana Water Board will review and reconsider the TMDLs in their entirety, including the responsible entities identified in the TMDLs, numeric targets, WLAs and LAs, taking into consideration the data and information collected during Phase II and the previous Phase III 10 years as applicable. • As part of TMDL review and reconsideration, the Santa Ana Water Board will update the TMDLs, including Final Targets, WLAs, LAs, and the Phase III Implementation Plan, as determined appropriate.	Santa Ana Water Board

7.3.2 Attainment of Phase III WLAs and LAs

Options to attain the Phase III WLAs and LAs vary depending on the entity responsible for compliance with these WLAs/LAs. The following sections describe the options applicable to these entities to clearly indicate how compliance with the WLAs and LAs will be determined in future Santa Ana Water Board regulatory actions to implement these TMDLs. Unless revised in the future, Section 7.2.5 above describes the methods or approaches that may be used to assess compliance with Phase III WLAs and LAs. **Figure 7-6** above also illustrates the various means that may be employed to use monitoring or modeling results to demonstrate water quality has been improved to meet TMDL requirements. As in Phase II, the Santa Ana Water Board has discretion to exclude or modify these options and approaches in permitting actions as necessary to ensure compliance with applicable law, including State Water Board precedential orders, or to the extent the Santa Ana Water Board finds an option would be infeasible or ineffective or as necessary to account for unanticipated watershed conditions. At a minimum, all permitted entities must meet applicable wasteload or load allocations by the final compliance date.

7.3.2.1 WLAs for MS4 Permittees

The WLAs will be incorporated into applicable NPDES permits for MS4 permittees subject to these TMDLs as effluent limits in a manner that is consistent with Title 40, sections 122.44 and 122.47 of the CFR. The time to attain the WLAs shall be included in applicable NPDES permits for MS4 permittees subject to these TMDLs. Compliance with the WLAs as incorporated into NPDES permits must occur as soon as possible but no later than 30 years from the effective date of these TMDLs. The WLAs for MS4s in Tables 6-7 and 6-8 combine watershed runoff loads for MS4 permittees subject to specific WLAs (i.e., MS4 permittees that discharge runoff in the applicable subwatersheds). Compliance with the Phase III WLAs as incorporated into MS4 NPDES permits may be demonstrated through any one of the following means:

- *Option 1*: Implement a program of pollution controls and best management practices according to an approved CNRP (or an equivalent Watershed Management Plan) that meets the requirements set forth in Phase III, Task 2, as applicable, of the Implementation Plan. This includes participating in pollution offset strategies and reducing external nutrient loads as set forth in the approved CNRP (or equivalent Watershed Management Plan), or
- *Option 2*: Demonstrate attainment of the final numeric targets using in-lake water quality data collected over a minimum of a 10-year period, or
- *Option 3*: Demonstrate attainment of the Phase III watershed runoff WLAs in Tables 6-7 and 6-8 through use of monitoring data that shows nutrients in watershed loads from MS4s (individually or collectively) are at or below applicable WLAs for TP and TN, or
- *Option 4*: Demonstrate attainment of the Phase III watershed runoff WLAs assigned to MS4 permittees (individually or collectively; see Tables 6-7 and 6-8) by offsetting nutrient watershed runoff loads in excess of the WLAs using in lake nutrient controls. Excess watershed runoff loads arriving at the lakes may be offset through participation in regional

in-lake projects, as applicable, that meet the requirements of the Implementation Plan and reduce internal nutrient load. Use of offsets under Option 4 is not mutually exclusive from the other options and may be combined with the options as determined appropriate, or

- *Option 5*: Demonstrate attainment of the Phase III total allocations for TP and TN loads for the lakes through collective watershed compliance by offsetting watershed loads in excess of allocations using controls on nutrient loads in the lakes. Excess watershed runoff loads arriving at the lakes may be offset through participation in regional in-lake projects, as applicable, that meet the requirements of the Implementation Plan and reduces internal nutrient load, or
- *Option 6*: Demonstrate attainment of the Phase III watershed runoff WLAs assigned to MS4 permittees in Tables 6-7 and 6-8 through implementation of volume retention pollution controls or BMPs that retain sufficient runoff volume such that the downstream load from a given drainage area is equal to or less than would occur in the reference watershed condition.

7.3.2.2 WLAs for Other NPDES Permittees (except EVMWD)

The WLAs will be incorporated into applicable NPDES permits for permittees subject to these TMDLs as effluent limits in a manner that is consistent with Title 40, sections 122.44 and 122.47 of the CFR. The time to attain the WLAs shall be included in applicable NPDES permits for permittees subject to these TMDLs. Compliance with the WLAs as incorporated into NPDES permits must occur as soon as possible but no later than 30 years from the effective date of these TMDLs. Compliance with the Phase III WLAs as incorporated into NPDES permits may be demonstrated through any one of the following means:

- *Option 1*: Implement an approved CNRP (or an equivalent watershed management plan) that meets the requirements set forth in Phase III, Task 2, as applicable, of the Implementation Plan. This includes participating in pollution offset strategies and reducing external nutrient loads from the watershed as set forth in the approved CNRP, or
- *Option 2*: Demonstrate attainment of the final numeric targets using in-lake water quality data collected over a minimum of a 10-year period, or
- *Option 3*: Demonstrate attainment of the Phase III watershed runoff WLAs in Tables 6-7 and 6-8 through the use of monitoring data that shows nutrients in watershed loads are at or below the applicable WLAs for TP and TN, or
- *Option 4*: Demonstrate attainment of the Phase III watershed runoff WLAs in Tables 6-7 and 6-8 by offsetting nutrient watershed runoff loads in excess of the Phase III WLAs using in lake nutrient controls. Excess watershed runoff loads arriving at the lakes may be offset through participation in a regional in-lake projects that meet the requirements of the Implementation Plan and reduce internal nutrient load, as applicable to each lake, or
- *Option 5*: Demonstrate attainment of the Phase III total allocations for TP and TN for the lakes through collective watershed compliance by offsetting watershed loads in excess of

allocations using controls on nutrient loads in the lakes. Excess watershed runoff loads arriving at the lakes may be offset through participation in regional in-lake projects, as applicable, that meet the requirements of the Implementation Plan and reduce internal nutrient load, or

- *Option 6:* Demonstrate attainment of the Phase III watershed runoff WLAs in Tables 6-7 and 6-8 through implementation of volume retention pollution controls or BMPs that retain sufficient runoff volume such that the downstream load from a given drainage area is equal to or less than would occur in the reference watershed condition.

7.3.2.3 WLAs for EVMWD

WLAs will be incorporated into EVMWD's NPDES permit as effluent limits in a manner that is consistent with Title 40, section 122.44 and 122.47 of the CFR. The time to attain them shall be included in EVMWD's NPDES permit for discharges to Lake Elsinore. Compliance with the Phase III WLAs as incorporated into EVMWD's NPDES permit must occur as soon as possible but no later than 30 years from the effective date of the Lake Elsinore TMDLs. Compliance with the Phase III WLAs as incorporated into EVMWD's NPDES permits may be demonstrated through any one of the following means:

- *Option 1*: Demonstrate attainment of the numeric targets for Lake Elsinore using in-lake water quality data collected over a minimum of a 10-year period, or
- *Option 2*: Demonstrate attainment of the concentration-based and mass-based WLAs in Table 6-4 as incorporated into EVMWD's NPDES permit as 12-month and 60-month running averages, respectively, unless EVMWD implements a plan, with the approval of the Santa Ana Water Board or its Executive Officer, to offset TP and TN discharges to Lake Elsinore in excess of the TP and TN WLAs.

7.3.2.4 LAs for Non-NPDES Permittees

LAs and the time to attain them shall be included in applicable WDRs, conditional waivers from WDRs, or other orders as the Santa Ana Water Board determines appropriate for non-point source dischargers subject to these TMDLs. Compliance with the LAs as incorporated into WDRs, conditional waivers from WDRs or other orders must occur as soon as possible but no later than 30 years from the effective date of these TMDLs. Compliance with the Phase III LAs as incorporated into WDRs, conditional waivers of WDRs or other orders may be demonstrated through any one of the following means:

- *Option 1*: Implement individual or general WDRs order that explicitly states or serves as a watershed management plan, e.g., the Agricultural General Order, that has been revised by the Santa Ana Water Board per Phase III, Task 2 of the Implementation Plan, or
- *Option 2*: Demonstrate attainment of the numeric targets using in-lake water quality data collected over a minimum of a 10-year period, or

- *Option 3*: Demonstrate attainment of the Phase III watershed runoff LAs in Tables 6-7 and 6-8 through use of monitoring data that show nutrients in watershed loads from the applicable category of dischargers are at or below applicable LAs for TP and TN, or
- *Option 4*: Demonstrate attainment of the Phase III watershed runoff LAs in Tables 6-7 and 6-8 by offsetting nutrient watershed runoff loads in excess of the LAs using in lake nutrient controls. Excess watershed runoff loads arriving at the lakes may be offset through participation in a regional in-lake projects that meet the requirements of the Implementation Plan and reduces internal nutrient load. Use of offsets under Option 4 is not mutually exclusive from the other options and may be combined with the options as determined appropriate, or
- *Option 5*: Demonstrate attainment of the Phase III total allocations for TP and TN loads for the lakes through collective watershed compliance by offsetting watershed loads in excess of Phase III allocations using controls on nutrient loads in the lakes. Excess watershed runoff loads arriving at the lakes may be offset through participation in a regional in-lake projects, as applicable, that meet the requirements of the Implementation Plan and reduce internal nutrient load, or
- *Option 6:* Demonstrate attainment of the Phase III watershed runoff LAs in Tables 6-7 and 6-8 through implementation of volume retention pollution controls or BMPs that retain sufficient runoff volume such that it may be demonstrated that the downstream load from a given drainage area is equal to or less than would occur in the reference watershed condition.

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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 status of attainment with TMDLs.

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 Total Suspended Solids (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 (Haley & Aldrich 2016). This plan re-evaluated water quality parameters to be monitored, 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:

- 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:

- An update to the QAPP for the program that was based on guidance from the California Surface Water Ambient Monitoring Program (SWAMP). The QAPP was submitted to the Regional Board in November 2016 (LESJWA 2016).
- 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 CCHAB Network, Santa Ana Water Board in a grant funded study, and by the City Lake Elsinore on an as needed basis to protect public health at swimming beaches. A combination of image analysis and point samples are collected.

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 7-7, Phase II TMDL Implementation Activities, see Task 16). A more detailed description of these elements is provided below.

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. Historical 10-year rolling average mass emissions will be computed and compared with the interim and final WLAs to assess progress. A special study (see Task 11 in Section 7.2.2) will be designed and implemented to better understand loading from natural background sources within the San Jacinto River watershed, including at a minimum one historical reference site (i.e., San Jacinto River at Cranston Guard Station with less than one percent impervious cover in the upstream drainage area) and two new monitoring stations below reference subwatersheds with little to no anthropogenic development.[34]

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 San Jacinto River at Cranston Guard Station #792 (see text) • Add a minimum of two new monitoring stations below reference subwatersheds (selected from candidate sites included in Table 8-2, or others with less than 3 percent watershed imperviousness) • 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-hrs. The January 1 through April 30 mobilization criteria remain the same.
Lake Elsinore	• Continue sample collection per the existing SMP and QAPP at a minimum. Consider enhancements to the SMP and QAPP to generate data needed to support future attainment demonstrations. • 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. • In the annual report, characterize data from 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. • Consider incorporating 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	• Continue sample collection per the existing SMP and QAPP at a minimum. Consider enhancements to the SMP and QAPP to generate data needed to support future attainment demonstrations. • 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. • Install 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. • Consider incorporating 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)

[34] Coleman et al. (2005) determined that the percent imperviousness threshold to discern hydromodification impacts to Southern California stream channels from urban development is 2-3 percent. Accordingly, the drainage area to a site selected as a reference site in a watershed should have imperviousness of less than 2-3 percent. The estimated imperviousness of the watershed that drains to the Cranston Guard Station reference site is 0.4 percent.

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 may be revised to be a 0.5-inch forecast within 24-hrs through the entire wet season of October 1 through May 31st. Samples will not be collected during dry weather due to the general lack of flow at inflows to the lakes.

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.

San Jacinto River at Ramona Expressway sampling location is down gradient 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, at least two additional reference locations will be selected for inclusion in the watershed monitoring program (see Table 7-7, Phase II Implementation Activities, Task 11 Special Study). A program of rotating stations could also be considered for the special study into reference watershed nutrients.

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 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.

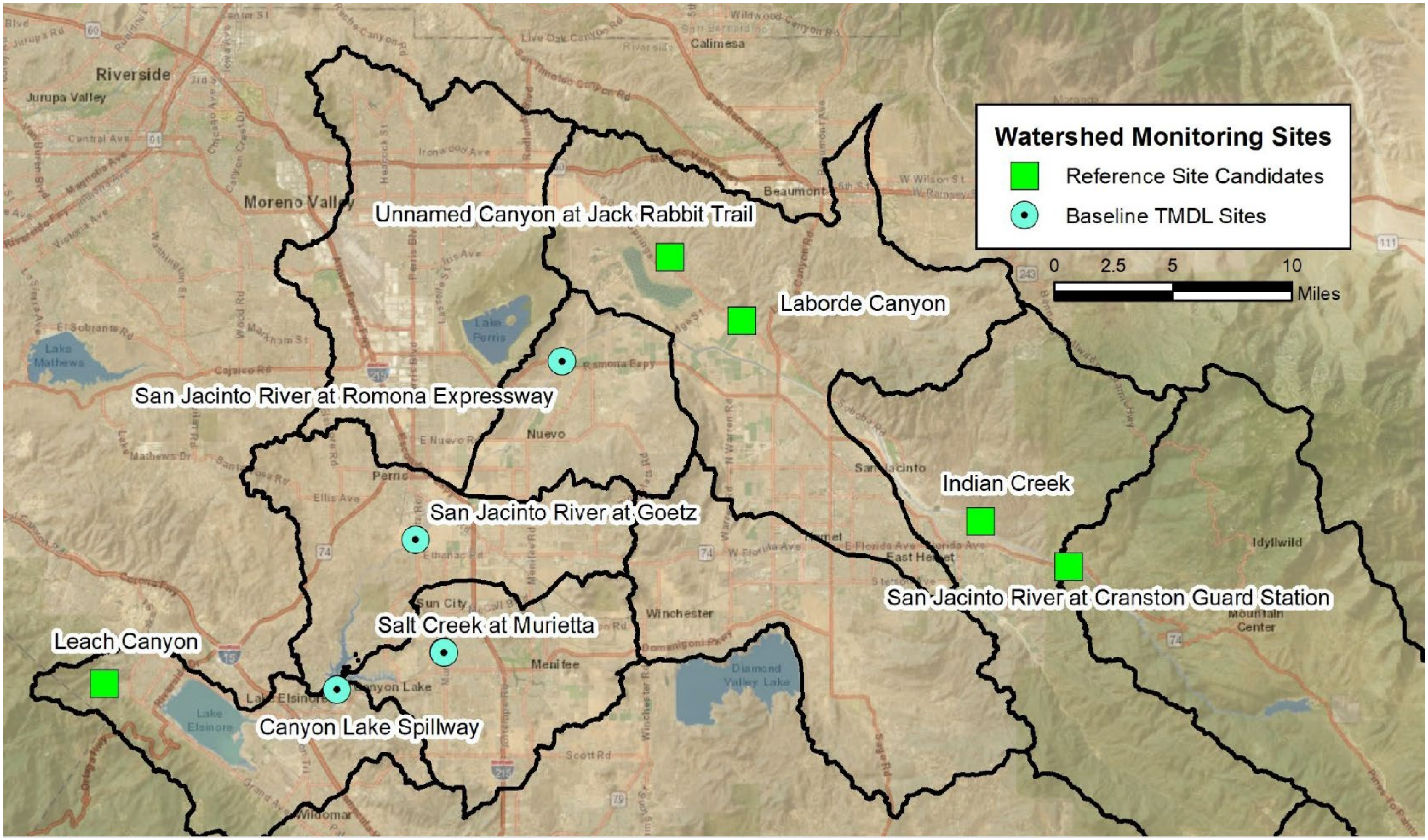

Figure 8-1. San Jacinto River Watershed Monitoring Locations (Note: The San Jacinto River at Cranston Guard Station is not currently monitored but is recommended for monitoring in the future under the revised TMDLs, see text)

Table 8-2. Watershed-wide Historical and Potential Future Monitoring Stations (also see Figure 8-1)

Site Type	Location Number and Description	Historical Database Station Number	Latitude/Longitude
Historically Sampled Watershed Sites	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
Historical Reference Site	San Jacinto Rivers at Cranston Guard Station	Reference Station 792	33.736812, -116.826491
Candidate Future Reference Sites	Leach Canyon	Reference Station 11	33.677998, -117.414117
	Unnamed Canyon at Jack Rabbit Trail	Reference Station 13	33.890439, -117.070250
	Indian Creek above San Jacinto River	Reference Station 15	33.761685, -116.882620
	Laborde Canyon	Reference Station 16	33.862848, -117.025500

Sample Analytes

Table 8-3 summarizes sample analytes and their associated laboratory methods. *In-situ* water quality measurements (pH, DO, EC, 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**).
- 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).

Figure 8-2. Lake Elsinore Monitoring Locations

Table 8-3. Watershed Analytical Constituents and Methods

Parameter	Analysis (SM Standard Method, RL Reporting Limit)
Turbidity	Field Meter
Water Temperature	Field Meter
DO	Field Meter
Conductivity (EC)	Field Meter
pH	Field Meter
Total Organic Nitrogen (Org-N)	Calculated
Nitrite Nitrogen (NO_2-N)	SM4500-NO2 B; RL ≤ 0.1 mg/L
Nitrate Nitrogen (NO_3-N)	USEPA 300.0; RL ≤ 0.2 mg/L
Ammonia Nitrogen (NH_4-N)	SM4500-NH3 H; RL ≤ 0.1 mg/L
Total Kjeldahl Nitrogen (TKN)	USEPA 351.3; RL ≤ 0.4 mg/L

Table 8-3. Watershed Analytical Constituents and Methods

Parameter	Analysis (SM Standard Method, RL Reporting Limit)
Total Phosphorus (TP)	SM4500-P E; RL ≤ 0.01 mg/L
Soluble Reactive Phosphorus (SRP / Ortho-P)	SM4500-P E; RL ≤ 0.01 mg/L
Total Suspended Solids (TSS)	SM2540C
Chemical Oxygen Demand (COD)	SM5220D; RL ≤ 10 mg/L
Biochemical Oxygen Demand (BOD)	SM5210B; RL ≤ 10 mg/L
Total Dissolved Solids (TDS)	USEPA 160.1; RL ≤ 10 mg/L
Total Hardness as Calcium Carbonate ($CaCO_3$)	SM 2340C

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 EC; 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, EC, pH, and temperature at 1-m intervals using permanently installed *in-situ* YSI™ data sondes that record at less than 5-minute frequency

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 (DO)	Field	Portable Meter
Turbidity	Field	Secchi disk
Total Hardness as $CaCO_3$	SM 2340 C; RL ≤ 0.1 mg/L	Depth Integrated[1]
Total Alkalinity as $CaCO_3$	SM 2320 B	Depth Integrated[1]
Nitrite Nitrogen (NO_2-N)	SM4500-NO2 B	Depth Integrated[1]
Nitrate Nitrogen (NO_3-N)	USEPA 300.0	Depth Integrated[1]
Total Kjeldahl Nitrogen (TKN)	USEPA 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 & USEPA 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[3]	USEPA 200.7	Depth Integrated[1]
Dissolved Aluminum	USEPA 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

[3] Samples for aluminum in Canyon Lake only

- 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.
- *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.

- 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 compliance with DO targets. 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. Other parameters measured by the sondes include water depth, temperature, specific conductivity, TDS, pH, turbidity, DO saturation, oxidation-reduction potential, and fluorometers for blue-green algae and chlorophyll.
- 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 (these data are currently lacking from EVMWD sondes). Data from these two sources supplement the manual water column profile measurements taken during each field sampling event.
- 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.
- Implement a Special Study to further Evaluate HAB conditions in Lake Elsinore and options to manage cyanobacteria and toxicity (see Table 7-7, Phase II TMDL Implementation Activities, Task 8). This evaluation will also consider the status of promulgation of USEPA 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**).

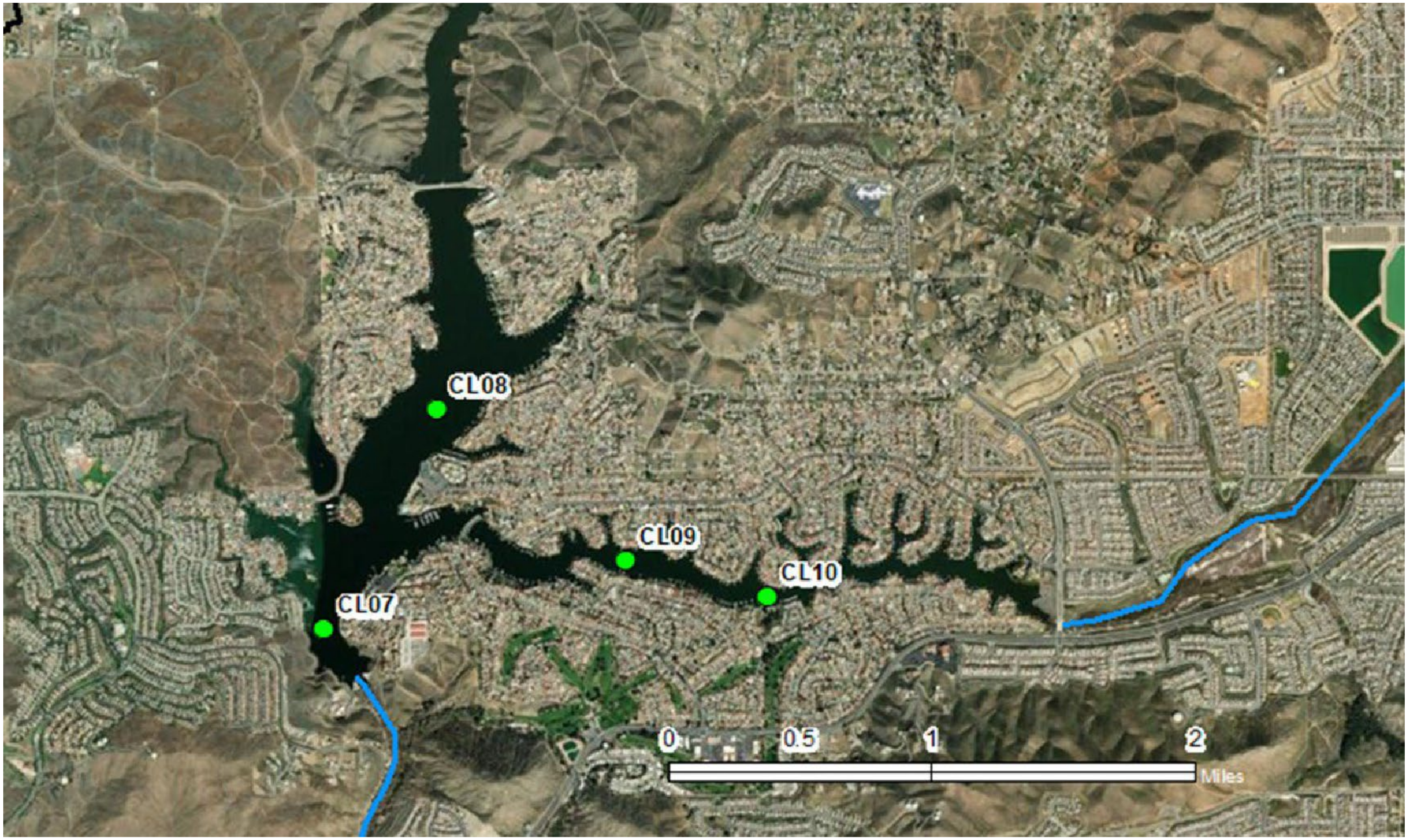

Figure 8-3. Canyon Lake Monitoring Locations

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

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 EC; 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

- 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.
- *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.[35] 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 less than 5-minute intervals. Data from these sondes will supplement the bi-monthly water column profiles, and will provide a higher resolution, continuous dataset 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 compliance with DO targets. 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 promulgation of USEPA 304(a) criteria (USEPA 2019) and status of State Water Board or Santa Ana Water Board adoption of water quality standards for cyanotoxins.

8.2.5 Satellite Imagery

Satellite imagery was added to the existing TMDLs 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. These data are intended to supplement collection of water samples for laboratory analysis, which will at a minimum continue to be implemented at current levels in the SMP and QAPP. 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.

[35] 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.

9. California Environmental Quality Act Analysis

As the 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 Project). This Section includes the following elements:

- *Section 9.1 – Regulatory Setting*: Summarizes the requirements for completing a CEQA analysis to support a Basin Plan amendment.
- *Section 9.2 – Proposed Project*: Describes the proposed revisions to the Basin Plan that comprise the Proposed Project to be evaluated.
- *Section 9.3 – Environmental Setting*: This section provides a description of the environmental characteristics of the area that may be affected by the Proposed Project.
- *Section 9.4 – Environmental Issues*: This section presents the Environmental Checklist that serves as the basis for a systematic evaluation of the potential for the Proposed Project to result in a significant impact relative to a variety of environmental factors such as biological resources, recreation, and water quality.
- *Section 9.5* – Describes alternatives to the Proposed Project.

9.1 Regulatory Setting

Pursuant to Public Resources Code section 21080.5, and section 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. (CEQA Guideline 15250.) This analysis is 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 Project may have on the environment; or (2) a statement that the Proposed Project would not have any significant or potentially significant effects on the environmental as supported by a checklist or other documentation. (Guideline 15252; 23 Cal. Code of Regs. § 3777, 3779.5.) Additionally, the environmental analysis must include an analysis of reasonably foreseeable methods of compliance with the basin plan amendment, which must consider reasonably foreseeable significant adverse impacts of those methods, an analysis of reasonably foreseeable alternative methods of compliance that would have less significant impacts, and reasonably foreseeable mitigation measures to minimize those impacts. The analysis of methods of compliance may utilize numerical ranges and averages where specific data are not available, but is not required to, nor should it, engage in speculation or conjecture. (CEQA Guideline 15187; Cal. Code of Regs, tit. 23, §3777(c); *see,* Pub. Res. Code §21159.) The environmental analysis must take into account a reasonable range of environmental, economic, and technical factors, population and geographic areas, and specific sites. (*Ibid; see also,* Pub. Res. Code §21159, subd. (c).) A project-level analysis is not required. (Pub. Res. Code §21159, subd. (d).)

The State Water Board has adopted regulations to implement the CEQA requirements applicable to basin planning. (*See,* Cal. Code of Regs., tit. 23, §§ 3720-3721, 3775-3782). Sections 3775-3782 provide the exclusive procedural requirements for basin plan amendments. (Cal. Code of Regs, tit. 23, § 3720(c)(2).)

Pursuant to California Water Code (Water Code) section13360, the Santa Ana Water Board is prohibited from specifying the design, location, type of construction, or particular manner of compliance with WDRs 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, as a practical matter, conduct project-level CEQA analyses of strategies that would be implemented by others, nor is it required to do so.

Consistent with the requirements identified above, the environmental analysis contained herein includes a written analysis that identifies a reasonable range of reasonably foreseeable compliance strategies (Section 9.2.3), presents an Environmental Checklist (Section 9.4) that evaluates reasonably foreseeable environmental effects and mitigation measures if applicable, discusses alternatives to the Proposed Project (Section 9.5), and identifies and discusses reasonably foreseeable methods of compliance (Section 9.2.3). 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 TMDLs were deficient or defective. They were not; they were based on the best data available at the time. Today, however, a great deal more is known about how Lake Elsinore and Canyon Lake function (physically, chemically and biologically) than was known at the time of adoption of the original TMDLs in 2004; almost twenty years 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 TMDLs were first approved.

According to USEPA, updating the TMDLs to reflect this new information will "facilitate better watershed planning and adaptive implementation" (USEPA 2012). In fact, because regular review and revision was successful, the Santa Ana Water Board 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). Re-evaluation in this TMDL revision and in the future following results of new special studies that will be conducted in Phase II, provides reasonable assurance of continued progress toward attainment of water quality standards and protection of beneficial uses in Lake Elsinore and Canyon Lake.

9.2 Proposed Project Description

9.2.1 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 USEPA 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 USEPA’s approval, stakeholders throughout the watershed, working together through the LECL Task Force, initiated several programs and projects to meet the requirements set forth in the TMDLs’ Implementation Plan.

Concurrent to the implementation actions, the LECL Task Force also supported several 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 revising water quality targets and allocations that reflect current land use conditions and account for the large nutrient load reductions that have resulted from BMP implementation, LID requirements, restrictions on agricultural-related discharges, changes in certain water quality standards, and the in-lake remediation projects that have occurred over the last 15 years.

9.2.2 Proposed Project

The Proposed Project 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 point sources and non-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), estimation 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 9-1**). 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.

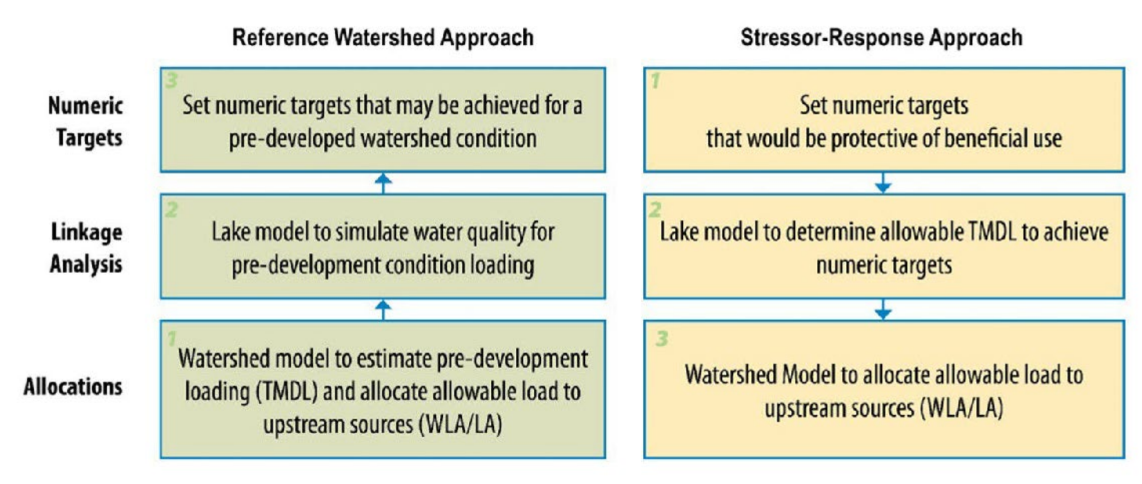

Figure 9-1. Alternative Approaches to TMDL Development

9.2.2.1 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 beneficial uses. A TMDL establishes numeric targets at levels that are expected to result in the waterbody of concern no longer being impaired. Where the WQO is narrative, the TMDL translates the narrative WQO into appropriate response targets to assure attainment of the objective.

Table 5-9n in the 2004 TMDLs (or Table 6-1n in Santa Ana Water Board 2019) 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 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 USEPA 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 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 TMDLs 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 targets for DO allow for a portion of the lake volume to have DO concentrations less than 5 mg/L (numeric WQO in the Basin Plan), as would occur naturally.

9.2.2.2 Milestones and Allocations

Milestones and allocations in the TMDLs distribute the allowable nutrient loads to each lake segment that would result in achieving the interim and final numeric targets (see Section 6), respectively. 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 interim and final 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 milestones (50th percentile of wet weather samples) and final (25th percentile of wet weather samples) 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 relative to the 2004 TMDL (see Table 6-7).

9.2.2.3 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 attain 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 2007, 2010, 2014, 2016, 2018, 2021-2022; San Jacinto River Watershed Council 2015). Many developments also included implementation of LID BMPs. The proposed revision to the TMDLs relies on a watershed model that accounts for land use mapping updated in 2022 for agricultural lands and 2019 for all other land uses.

Mass Emission Data

The 2004 TMDLs had limited nutrient mass emission data at the inflows to Lake Elsinore and Canyon Lake. USGS operates 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. New USGS 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 collect 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 55 storm events between 2007 and 2022. 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 (2012-2022) 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 and Mystic Lake (see following section). 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 and increasing annually because of land subsidence, 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) (see Section 4.1.2.5 for more details). 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-hr return period and to not allow spreading of manure within the watershed. 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. Moreover, the number of dairies and head count of cattle is significantly reduced relative to the early 2000s. As a result, the portion of downstream nutrient loads attributed to runoff leaving CAFO land areas is dramatically reduced in the proposed revised TMDLs relative to the 2004 TMDL.

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-unsewered. 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.

9.2.3 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 (see Sections 6.3 and 7.2.1). The Implementation Plan 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. Ongoing and past 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. Given these circumstances, the revised TMDLs include a two-phased Implementation Plan (i.e., Phases II and III, given that the Implementation Plan in the existing TMDLs is considered Phase I) to achieve interim and final compliance milestones. These phased implementation plans include continued implementation of existing water quality controls, where they are providing water quality benefits, evaluation and potential implementation of new water quality controls to further improve water quality, special studies to inform the long-term implementation process and continued implementation of watershed and lake surveillance and monitoring programs.

Many of the possible reasonably foreseeable methods of compliance are already being implemented under the existing TMDLs (see Section 7.1 and Section 9.2.3.1 below). However, the potential need for changes to existing water quality controls or the need for the addition of new supplemental controls will be evaluated during the execution of the proposed Phase II TMDL Implementation Plan, in particular under Tasks 4 and 5. As described below, multiple options will be evaluated to identify reasonably foreseeable methods of compliance that can be employed in an adaptive implementation framework. It is anticipated that the types of supplemental projects that may be considered are the same, or similar to, projects that could be implemented under the existing TMDLs. **Table 9-1**, below (see Section 9.2.3.2), identifies a number of potential supplemental water quality controls that may be evaluated during Phase II implementation. As noted in this table, this list of potential projects is not intended to be an exhaustive list of potential supplemental projects. Instead, it is intended to illustrate the types of projects that may provide the water quality benefits necessary to attain the TMDLs, while also noting potential constraints and limitations that would need to be evaluated if a project is further considered for implementation. Without the additional studies that will occur during Phase II, the Santa Ana Water Board cannot identify the particular combination of projects that will be implemented to meet applicable requirements; the scope of any particular project, which will vary based on other selected projects that may provide similar water quality benefits or controls; or project-specific issues such as siting, timing or volume of such things as alum or algaecide application or conveyance of stored stormwater from Mystic Lake, volume or location of upstream stormwater retention, etc. At this time, implementation of any of the potential supplemental projects as well as the potential constraints or limitations associated with a potential supplemental project are therefore speculative. If and when an actual project and its location are being considered for approval, the environmental benefits or impacts associated with the project will be evaluated, as required by CEQA. Conducting such evaluations at this time would necessarily involve speculation or conjecture, even at a programmatic level.

9.2.3.1 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 Water Code section13360, subdivision (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 implementation will need to determine the best method, such as selection of different or enhanced BMPs, implementation of supplemental projects, or participation in offset programs to meet the revised TMDLs, as applicable.

The variety of methods that are being implemented to achieve compliance with the existing TMDLs include both external nutrient load controls and in-lake projects 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 (Order No. R8-2010-0033) 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. To date, CNRP implementation has also involved implementation of significant in-lake controls described below. As noted in Section 9.2.3.2 below, the Implementation Plan for the revised TMDLs requires updates for the CNRP which may include supplemental projects.
- 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 required 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 also involved implementation of significant in-lake controls described below. In 2023, the Santa Ana Water Board adopted General WDRs for Irrigated Lands in the San Jacinto River Watershed (Order No. R8-2023-0006) (Santa Ana Water Board 2023). This Agricultural General Order, which requires agricultural operators in the San Jacinto River watershed to "implement reliable and effective management practices to control, minimize, or eliminate pollutants from their agricultural operations to surface water and groundwater," constitutes the approved AgNMP under the existing 2004 nutrient TMDLs (Santa Ana Water Board 2023).

In-lake Water Quality Projects

Prior to implementation of the Phase I TMDLs' Implementation Plans, stakeholders in the region implemented the LEMP project (see Section 2.2.2.3). This project entailed the construction of a levee to reduce the surface area of Lake Elsinore and thereby decrease evaporative losses to improve water quality as well as provide sustained recreation opportunities. Since adoption of the TMDLs in 2004, the LECL Task Force (or some of its members) have implemented, or have supported through agreements, in-lake projects within Lake Elsinore and Canyon Lake. These are described in detail within Section 7.1.2.2 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 semi-annually since 2013. Alum binds with phosphorus thereby preventing excess algae growth in the lake. As of May 2023 almost three million kg of dry alum have been applied in Canyon Lake and additional alum additions have occurred into 2024. Currently, the Task Force plans to continue semi-annual applications of alum.
- *Supplemental Water Addition* -EVMWD continues to discharge tertiary treated effluent to Lake Elsinore to maintain lake levels. Since 2007 EVWMD's recycled water discharges to Lake Elsinore have averaged about 5,250 AFY. While the addition of recycled water stabilizes lake water levels and generally improves water quality, variations in the lake level and water quality can still be substantial. In fact, without the addition of recycled water hydrologic models for Lake Elsinore suggest complete lakebed desiccation would likely have occurred in 2016.
- *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. Constructed in 2007, this project continues to operate. Review of the existing system by Horne and Anderson (2021) showed that rates of oxygen depletion from generally saturated levels in March into early summer have risen to over 0.1 mg/L/day even with extended hours and months of compressor operation, suggesting that LEAMS performance may be declining and rehab or replacement with a different nutrient reduction option is now warranted. Task 5 of the Phase II Implementation Plan involves an

evaluation of the current system and identification of potential enhancements or replacements for in-lake water quality control in Lake Elsinore.

- *Fishery Management* – This program was implemented to reduce the carp population in the lake. From 2003 to 2008, a total of 1.3 million lbs of carp was removed from the lake and by the end of 2008, the estimated carp population was reduced from 375 to 82 fish per acre (City of Lake Elsinore 2008). Findings from a 2019-2020 study showed that carp population remained low less than 9 carp/acre (LESJWA 2020).

While the Santa Ana Water Board cannot specify the method of compliance, it is anticipated that the above management strategies, or their equivalent, would continue to be implemented under the revised TMDLs. To the degree they are implemented in the same manner or are modified will be evaluated as part of the Implementation Plan of the revised TMDLs.

9.2.3.2 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 9.2.3.1.

Implementation of Supplemental Water Quality Controls

The effectiveness of existing water quality controls, or equivalent, as described in Section 9.2.3.1, will be evaluated for implementation in Lake Elsinore and Canyon Lake under the revised TMDLs. The responsible entities with WLAs and LAs in either lake will evaluate the preference for alternative controls or need for additional controls early in the implementation of the revised TMDLs. **Table 9-1** provides an initial list of potential supplemental water quality controls that may be considered for implementation in the future (see additional discussion in Sections 7 and 10); other water quality controls not included in the table may be considered as well.

The phased Implementation Plan (in particular, Tasks 4 and 5 in Phase II; see Section 7.2.2) for the revised TMDLs does not specify which, if any, of the supplemental water quality controls described in **Table 9-1** will be implemented, only that additional or alternative water quality control projects will be considered for future implementation. Entities subject to the proposed Basin Plan amendment, as assigned on a per task basis, 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.

Table 9-1. List of Potential Supplemental Water Quality Controls for Future Implementation (Note: List of potential water quality controls is not intended to be exhaustive)

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 San Jacinto River 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 • Environmental permitting • 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
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 • Environmental permitting

Table 9-1. List of Potential Supplemental Water Quality Controls for Future Implementation (Note: List of potential water quality controls is not intended to be exhaustive)

Project	Action	Waterbody	Description	Water Quality Benefits	Potential Constraints & Limitations
Enhanced Fishery Management	Algae control	Lake Elsinore	Carp removal program already active (though currently suspended due to studies showing carp populations remain low). LESJWA (2005a) and (2020) 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
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

Table 9-1. List of Potential Supplemental Water Quality Controls for Future Implementation (Note: List of potential water quality controls is not intended to be exhaustive)

Project	Action	Waterbody	Description	Water Quality Benefits	Potential Constraints & Limitations
Ultrasonic Algae Control	Algae control	Canyon Lake (East Bay, North Ski Area)	Devices can be deployed that will kill algae within a 50-ft 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
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

Actions Recommended for Implementation by Other Agencies

As part of the implementation of Phase II of revised TMDLs, the Santa Ana Water Board and State Water Board, as applicable, will update existing permits to incorporate Phase II and Phase III provisions from the revised LECL nutrient TMDLs. In addition, these agencies will, as needed incorporate Phase II and Phase III TMDL provisions into new permits adopted within the LECL watershed. The Santa Ana Water Board will also 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 to the maximum extent practicable (MEP) to the expected nutrient load from the watershed reference condition, especially considering the impacts of forest fires and the resultant increases in nutrient loads to surface waters. 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.

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. The phased implementation plans include studies that will support the evaluation of potential water quality controls and facilitate attainment of the milestones and final allocations. The implementation of these studies is not anticipated to trigger new foreseeable methods of compliance that are different from those that would be considered under the existing TMDLs.

- *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. To establish a larger dataset to validate the representation of reference nutrient concentrations in the San Jacinto River watershed, the Phase II Implementation Plan includes a study to validate the basis for the Phase II interim targets/milestones as representative of the reference watershed condition.
- *Cyanobacteria in Lake Elsinore* - Recreational use in Lake Elsinore has been negatively impacted by persistent and toxic HABs. Future water quality control project(s) implemented in Lake Elsinore may or may not provide full or partial control of cyanobacteria needed to protect recreational uses. To provide additional information regarding cyanobacteria control, the Phase II revised TMDLs' Implementation Plan includes a study to estimate future HAB conditions with implementation of lake water quality controls. Based on the findings from the study, supplemental options for managing cyanobacteria populations in all or parts of Lake Elsinore to protect recreational beneficial uses should be identified.

- *Performance of Watershed Controls* – Watershed BMPs have been and will continue to be deployed throughout the San Jacinto River watershed to manage runoff from urban and agricultural lands. The Phase II revised TMDLs' Implementation Plan includes a study to evaluate nutrient load reductions that have been or can be achieved as a result of existing, enhanced, or new watershed controls implemented within the watersheds to the lakes.
- *Lake Bottom Sediment* – To support the evaluation of the effectiveness of water quality controls implemented in the lake watersheds, the revised TMDLs Implementation Plans include studies in Phases II and III to assess changes to nutrient enrichment in sediments following implementation of watershed management plans and other TMDL-related water quality control projects.
- *Fishery Management* – Phases II and III of the revised TMDLs Implementation Plans include fishery studies to periodically evaluate the Common Carp population to determine the need for additional carp management activities. In addition, these studies will help to evaluate the success of ongoing fish stocking activities, assess the potential to modify the species stocked and evaluate populations of other species.

Development and Implementation of Revised Surveillance and Monitoring Program

After the revised TMDLs become effective, the entities responsible for attaining milestones, WLAs and LAs, as applicable, will revise the existing watershed and lake SMP to ensure it provides the data needed to facilitate evaluation of attainment of the revised TMDLs. While this program may be modified at any time, both Phases II and III of the revised TMDLs include a formal review and as needed update to the SMP.

9.3 Environmental Setting

9.3.1 Surrounding Land Uses and Setting

Lake Elsinore and Canyon Lake lie within the San Jacinto River Watershed (**Figure 9-2**), an area encompassing approximately 780 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 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. Year to year variability in annual rainfall is significant in the watershed, thus a long-term analysis is needed to characterize hydrology in this watershed (i.e., years with annual rainfall at the long-term average are rare). Historically, land use development in the San Jacinto River watershed has been associated with open space or agricultural activities.

However, a continual shift from agricultural to urban land use has been occurring for many years (see **Table 2-5** that shows a 43 percent reduction in agricultural lands).

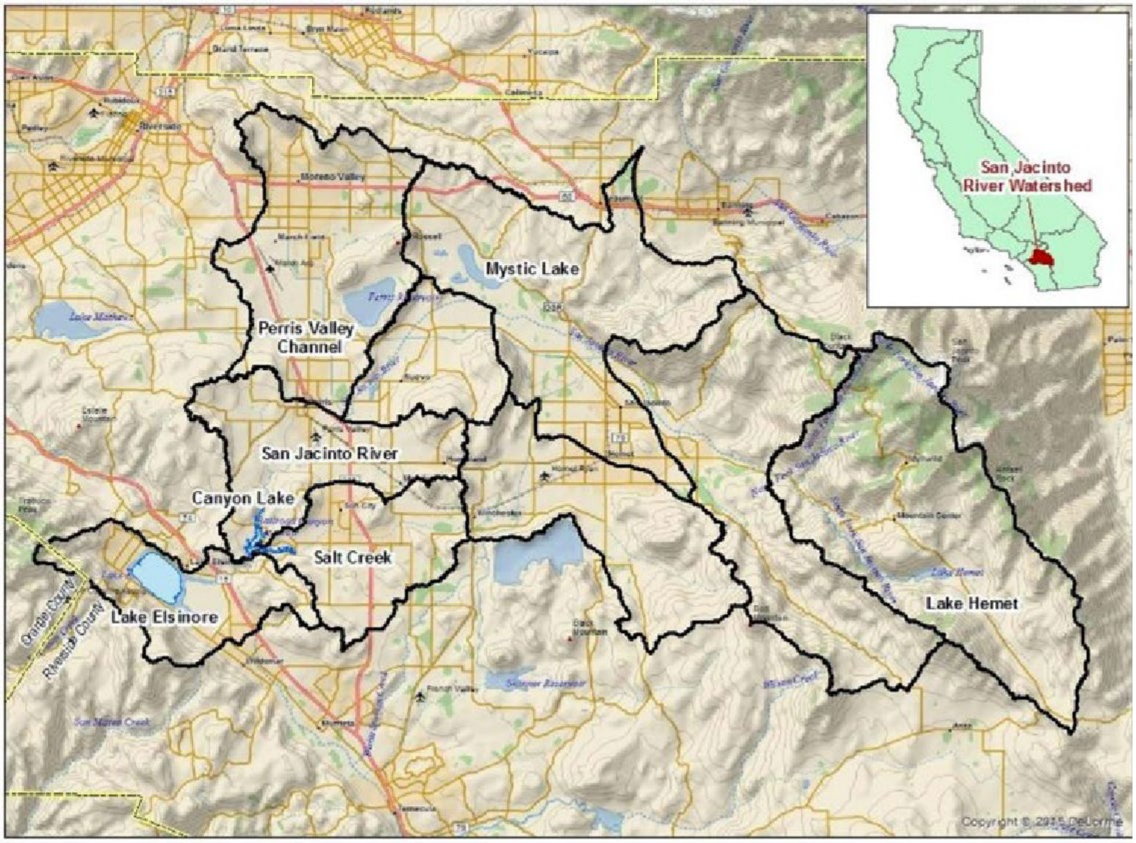

Figure 9-2. San Jacinto River Watershed

Following is a 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.

9.3.2 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, and 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. At a water level elevation of 1,240 ft, the storage capacity is approximately 53,000 AF. Monitoring data indicate that with the exception of infrequent 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 ~5,450 AFY of supplemental water since 2007 to maintain lake levels. Sources of supplemental water include EVMWD recycled 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 2016 for some period of time. 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 2024; State Water Board 2021[36]). Beneficial 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

[36] 2018 Integrated Report approved by USEPA June 9, 2021.

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 the early 1900s. 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, Threadfin Shad (*Dorosoma petenense*) and Silverside Minnow (*Menidia* spp.). The presence of these nuisance species may aggravate the nutrient problem in Lake Elsinore by feeding upon zooplankton that would otherwise graze upon algae.

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.

Zooplankton surveys completed in 2019-2020 found that zooplankton density and biomass varied by season with the highest observed in the fall season, similar to what has been observed in previous surveys dating back to 2003 (LESJWA 2020). In general, the lowest zooplankton densities are observed in the winter and the highest densities are observed in late summer or fall. Fourteen zooplankton taxa, categorized into three major groups (Cladocera, Copepoda and Rotifera), were observed. Copepods and rotifers equally dominated the zooplankton community in the summer survey. Rotifers dominated the community in the fall, but copepods strongly dominated the community in late winter. Cladocera represented only a small portion of the zooplankton community during all surveys carried out in 2019-2020.

Phytoplankton surveys conducted in 2019-2020 showed that algal densities were highest in summer and fall (LESJWA 2020). Blue-green algae dominated during all sample events, consistent with past surveys. A total of 76 phytoplankton taxa were observed, categorized into eight major algal groups. The blue-green algae (Cyanobacteria) were the most dominant group during all sample events. Diatoms (Bacillariophyta) were the second most common group, with the most diatoms observed during the survey conducted in late winter. Green algae (including Chlorophyta, Chrysophyta, and Cryptophyta) were the third most common algae; however, green algae were observed in low densities compared to blue-green algae. While several of the observed blue-green algae taxa are known to potentially produce harmful cyanotoxins, many of the other relatively abundant blue-green algae observed during the 2019-2020 surveys are not known to be harmful. Lastly, a rare bloom of golden algae, *Prymnesium parvum*, occurred in the 2018-19 wet season and was attributed to a fish kill in January 2019 (Wood 2019).

9.3.3 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 mi^2 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 watercrafts 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. For the purposes of these TMDLs, Canyon Lake is divided into two key areas: (1) Main Lake, which is the deepest part of the lake upstream of the dam (over 50 feet near the Dam) and the North Ski Area, which is the north portion of the lake above the causeway; and, (2) the East Bay, the relatively shallow east arm of the lake upstream of the causeway located near where East Bay enters the Main Lake (East Bay is approximately eight feet deep at the upper end near the Salt Creek inflow). Canyon Lake receives inflows from two sources: (1) San Jacinto River, which drains to the North Ski Area above the Main Lake; and (2) Salt Creek, which drains to the East Bay.

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 303(d) impairment assessment (State Water Board 2024).

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. 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 2015-2016 monitoring events.

9.4 Environmental Issues

9.4.1 Overview

This section presents the Environmental Checklist, evaluates the potential impacts of the action relative to 21 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 Project were evaluated in the context of the existing environmental setting (see Sections 9.1 and 9.3 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. Section 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. An economic or social change by itself shall 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.” However, if forecasted economic or social effects of a proposed project could result in a reasonably foreseeable indirect environmental impact, then the lead agency is obligated to assess this impact to determine if it is a significant environmental effect. “An impact which is speculative or unlikely to occur is not reasonably foreseeable.” (See *Joshua Tree Downtown Business Alliance v. County of San Bernardino* (2016) 1 Cal.App. 5^{th} 677, 684).

This section provides an evaluation of, and presents significance findings for, both the proposed revisions to the TMDLs (Proposed Project) and reasonably foreseeable methods of compliance associated with the Proposed Project. For purposes of this analysis, the CEQA baseline is the current physical baseline in the San Jacinto watershed, including the current water quality in the Lake Elsinore and Canyon Lake, as well as current water quality controls such as alum additions, LEAMS and recycled water discharges, at their current rates. Should any new or modified water quality controls be implemented to support compliance with the revised TMDLs in the future, a project specific environmental review pursuant to CEQA would be conducted by the lead agency (i.e., the local agency that will carry out the supplemental project) at that time. Any potential project-specific environmental impacts that might be associated with the water quality control project would be addressed during that process.

Consistent with CEQA guidelines, the following environmental factors were considered as part of this analysis (CEQA Guidelines, Appendix G; Appendix A to the State Water Board's CEQA regulations, Cal. Code. Regs., tit. 23, §§ 3720-3781 and § 3777, subd. (a)(2)):

- Aesthetics
- Agriculture and Forestry Resources
- Air Quality
- Biological Resources
- Cultural Resources
- Energy
- 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
- Transportation
- Tribal Cultural Resources
- Utilities and Service Systems
- Wildfire
- Mandatory Findings of Significance

9.4.2 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 21 resource areas. However, pursuant to Water Code section 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 Project are foreseeable at this time, specific compliance actions (e.g., implementation of a water quality control project to attain TMDL, WLAs or LAs) 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, CEQA lead and responsible agencies 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 Project would not have a significant effect on the environment. The following sections provides the basis for that finding.

9.4.3 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 Project, reasonably foreseeable methods of compliance and findings of significance.

9.4.3.1 Aesthetics

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
I. AESTHETICS – Except as provided in Public Resources Code §21099, would the project:				
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) In nonurbanized areas, substantially degrade the existing visual character or quality of the site and its surroundings? (Public views are those that are experienced from publicly accessible vantage point). If the project is in an urbanized area, would the project conflict with applicable zoning and other regulations governing scenic quality?				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 project have a substantial adverse effect on a scenic vista?*

Proposed Revisions to the TMDLs: The Proposed Project 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: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

b) *Would the project 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 project substantially degrade the existing visual character or quality of the site and its surroundings?*

See I. Aesthetics a) above.

d) *Would the project create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?*

See I. Aesthetics a) above.

9.4.3.2 Agriculture and Forestry Resources

In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Department of Conservation as an optional model to use in assessing impacts on agriculture and farmland. 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 FORESTRY RESOURCES - Would the project:				
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 project 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 Revision to the TMDLs: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. As discussed in Section 10.2, the Proposed Project may result in increased costs to agricultural operators and attainment of applicable TMDL LAs for agricultural operations through implementation of hypothetical cover crops may not be possible. However, the Proposed Project does not dictate the manner of compliance for agricultural operators. Furthermore, participation in regional offset projects would likely maintain same or similar costs as associated with the existing TMDLs. As a result, there is not substantial evidence before the agency to support a conclusion that the cost of complying with the Proposed Project will result in the conversion of Farmland and any indirect environmental impacts are speculative. Thus, this revision would not result in any physical changes that would result in conversion of agricultural land to non-agricultural use or otherwise affect agriculture and forestry resources or operations.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

b) *Would the project conflict with existing zoning for agricultural use or a Williamson Act contract?*

See II. Agriculture and Forestry Resources a) above.

c) *Would the project 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))?*

See II. Agriculture and Forestry Resources a) above.

d) *Would the action result in the loss of forest land or conversion of forest land to non-forest use?*

See II. Agriculture and Forestry Resources a) above.

e) *Would the project 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 Forestry Resources a) above.

9.4.3.3 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 project:				
a) Conflict with or obstruct implementation of the applicable air quality plan?				X
b) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard?				X
c) Expose sensitive receptors to substantial pollutant concentrations?				X
d) Result in other emissions (such as those leading to odors) adversely affecting a substantial number of people?				X

Discussion

The Santa Ana Region is within the South Coast Air Basin (SCAB), a 6,600 mi^2 air 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 for both national and state 1-hr 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.

a) *Would the project conflict with or obstruct implementation of the applicable air quality plans?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The Proposed Project does 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. Moreover, the Proposed Project will not result in any increase in emissions of any potential pollutants nor modify potential pollutant receptors. 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: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze

reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

b) *Would the project 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?*

See III. Air Quality a) above.

c) *Would the project expose sensitive receptors to substantial pollutant concentrations?*

See III. Air Quality a) above.

d) *Would the project result in other emissions (such as those leading to odors) adversely affecting a substantial number of people?*

See III. Air Quality a) above.

9.4.3.4 Biological Resources

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
IV. BIOLOGICAL RESOURCES - Would the project:				
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 CDFW or USFWS?				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 CDFW or USFWS?				X
c) Have a substantial adverse effect on federally protected wetlands (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?				X

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
IV. BIOLOGICAL RESOURCES - Would the project:				
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
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 project 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 CDFW or the USFWS?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake to improve surface water quality. The revised TMDLs would meet statutory and regulatory water quality standards and requirements. The Proposed Project would not impact any biological resources. Therefore, the Proposed Project will 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 native resident or migratory fish or wildlife species or migratory 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: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

b) *Would the project 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 CDFW or the USFWS?*

See IV. Biological Resources a) above.

c) *Would the project have a substantial adverse effect on federally protected wetlands (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 project 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 project 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 project conflict with the provisions of adopted habitat conservation plan, natural communities' conservation plan, or any other approved local, regional, or state habitat conservation plan?*

See IV. Biological Resources a) above.

9.4.3.5 Cultural Resources

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
V. CULTURAL RESOURCES - Would the project:				
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) Disturb any human remains, including those interred outside of dedicated cemeteries?				X

Discussion

a) *Would the project cause a substantial adverse change in significance of a historical resource as defined in State CEQA §15064.5?*

Proposed TMDLs Revision: The Proposed Project 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, historic or otherwise, archeological resources or buried cultural resources. As such, the revised TMDLs would not cause a substantial adverse change in significance of a cultural resource.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

b) *Would the project 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 project disturb any human remains, including those interred outside of dedicated cemeteries?*

See V. Cultural Resources a) above.

9.4.3.6 Energy

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
VI. Energy - Would the project:				
a) Result in potentially significant environmental impact due to wasteful, inefficient, or unnecessary consumption of energy resources, during project construction or operation?				X
b) Conflict with or obstruct a state or local plan for renewable energy or energy efficiency?				X

Discussion

a) *Would the project result in potentially significant environmental impact due to wasteful, inefficient, or unnecessary consumption of energy resources, during project construction or operation?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. Adoption of the revised TMDLs will not impact the consumption of energy resources nor will it affect a state or local plan for renewable energy or energy efficiency.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

b) *Would the project conflict with or obstruct a state or local plan for renewable energy or energy efficiency?*

See VI. Energy a) above.

9.4.3.7 Geology and Soils

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
VII. GEOLOGY AND SOILS - Would the project:				
a) Directly or indirectly cause 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

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
VII. GEOLOGY AND SOILS - Would the project:				
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 direct or indirect 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) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?				X

Discussion

a) *Would the project directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving: (i) rupture of a known earthquake fault; (ii) strong seismic ground shaking; (iii) seismic-related ground failure including liquefaction; or (iv) landslides?*

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 Project 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: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water

quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

b) *Would the project result in substantial soil erosion or the loss of topsoil?*

Proposed TMDLs Revision: The Proposed Project 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: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

c) *Is the project 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 Project 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: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

d) *Is the project 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 VII. Geology and Soils a), b), and c) above.

e) *Would the project 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 Project 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: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

f) *Would the project directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not result in activities that could directly or indirectly destroy a unique paleontological resource or site or unique geologic feature

Reasonably Foreseeable Methods of Compliance: The Proposed Project would not result in the implementation of new water quality controls or other compliance methods that would not otherwise already be required to comply with the existing TMDLs. As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

9.4.3.8 Greenhouse Gas Emissions

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
VIII. GREENHOUSE GAS EMISSIONS - Would the project:				
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 project generate greenhouse gas emissions (GHG), either directly or indirectly, that may have a significant impact on the environment?*

Proposed TMDLs Revision: The Proposed Project 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: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

b) *Would the project conflict with an applicable plan, policy or regulation adopted for the purpose of reducing the emissions of greenhouse gases?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. As discussed in VIII. 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: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

9.4.3.9 Hazards and Hazardous Materials

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
IX. HAZARDS AND HAZARDOUS MATERIALS - Would the project:				
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
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 a project 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 project result in a safety hazard for people residing or working in the project area?				X
f) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?				X
g) Expose people or structures, either directly or indirectly, to a significant risk of loss, injury or death involving wildland fires?				X

Discussion

a) *Would the project 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 Project 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: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

b) *Would the project 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 IX. Hazards and Hazardous Materials a) above.

c) *Would the project emit hazardous emissions or handle hazardous materials or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?*

See IX. Hazards and Hazardous Materials a) above.

d) *Is the project 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 Project 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: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

e) *For a project 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 project result in a safety hazard for people residing or working in the action area?*

Proposed TMDLs Revision: The Proposed Project 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 public use airport.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

f) *Would the project impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

g) *Would the project expose people or structures, either directly or indirectly, to a significant risk of loss, injury, or death involving wildland fires?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not expose people or structures to a significant risk of loss, injury or death involving wildland fires.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

9.4.3.10 Hydrology and Water Quality

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
X. HYDROLOGY AND WATER QUALITY - Would the project:				
a) Violate any water quality standards or WDRs or otherwise substantially degrade surface or ground water quality?				X
b) Substantially decrease groundwater supplies or interfere substantially with groundwater recharge such the project may impede sustainable groundwater management of the basin?				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 or through the addition of impervious surfaces, in a manner which would:				X
i) Result in a substantial erosion or siltation on- or off-site;				X
ii) Substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site;				X
iii) 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; or				X
iv) Impede or redirect flood flows?				X
d) In flood hazard, tsunami, or seiche zones, risk release of pollutants due to project inundation?				X
e) Conflict with or obstruct implementation of a water quality control plan or sustainable groundwater management plan?				X

Discussion

a) *Would the project violate any water quality standards or WDRs or otherwise substantially degrade surface or ground water quality?*

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 TMDLs 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, California's 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 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 WDRs.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

b) *Would the project substantially decrease groundwater supplies or interfere substantially with groundwater recharge such the project may impede sustainable groundwater management of the basin?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not deplete groundwater supplies, interfere with groundwater recharge or impede sustainable groundwater management in the basin.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

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 or through the addition of impervious surfaces, in a manner that would result in substantial erosion or siltation* *(on- or off-site), substantially increase surface runoff which would result in flooding (on- or off-site), 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, or impede or redirect flood flows?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not affect surface water flows or drainages in any of the potential manners described above.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

d) *In flood hazard, tsunami, or seiche zones risk release of pollutants due to project inundation?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revised TMDLs would not risk the release of pollutants due to project inundation in flood hazard, tsunami or seiche zones.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

e) *Conflict with or obstruct implementation of a water quality control plan or sustainable groundwater management plan?*

See X. Hydrology and Water Quality a) and b) above.

9.4.3.11 Land Use and Planning

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XI. LAND USE AND PLANNING - Would the project:				
a) Physically divide an established community?				X

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XI. LAND USE AND PLANNING - Would the project:				
b) Cause a significant environmental impact due to a conflict with any land use plan, policy, or regulation adopted for the purpose of avoiding or mitigating an environmental effect?				X

Discussion

a) *Would the project physically divide an established community?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not result in any activities that would cause a physical division that could divide an established community.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

b) *Would the project cause a significant environmental impact due to a conflict with any land use plan, policy, or regulation adopted for the purpose of avoiding or mitigating an environmental effect?*

Proposed TMDLs Revision: The Proposed Project 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 conflict with any land use plan, policy, or regulation adopted for the purpose of avoiding or mitigating an environmental effect.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

9.4.3.12 Mineral Resources

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XII. MINERAL RESOURCES - Would the project:				
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 project 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 Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not involve activities that could result in the loss of availability of a known mineral resource or impact a locally important mineral resource site.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

b) *Would the project 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 XII. Mineral Resources a) above.

9.4.3.13 Noise

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XIII. NOISE - Would the project result in:				
a) Generation of a substantial temporary or permanent increase in ambient noise levels in the action vicinity of the project in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?				X
b) Generation of excessive groundborne vibration or groundborne noise levels?				X
c) For a project located within the vicinity of a private airstrip or 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 project expose people residing or working in the project area to excessive noise levels?				X

Discussion

a) *Would the project generate a substantial temporary or permanent increase in ambient noise levels in the action vicinity of the project in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not result in a substantial increase (temporary or permanent) in ambient noise levels within the vicinity of the project in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

b) *Would the project generate excessive groundborne vibration or groundborne noise levels?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not generate excessive groundborne vibration or groundborne noise levels

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

c) *For a project located within the vicinity of a private airstrip or 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 project expose people residing or working in the project area to excessive noise levels?*

Proposed TMDLs Revision: The Proposed Project 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 private airstrip, airport land use plan or where there is no such plan adopted, within two miles of a public or public use airport.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

9.4.3.14 Population and Housing

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XIV. POPULATION AND HOUSING - Would the project:				
a) Induce substantial unplanned 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 people or housing, necessitating the construction of replacement housing elsewhere?				X

Discussion

a) *Would the project induce substantial unplanned 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 Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not induce population growth to the region, either directly or indirectly; nor would it displace substantial numbers of housing or people.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

b) *Displace substantial numbers of existing people or housing, necessitating the construction of replacement housing elsewhere?*

See XIV. Population and Housing a) above.

9.4.3.15 Public Services

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XV. PUBLIC SERVICES				
a) Would the project 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 XVI. Recreation and Parks below for an evaluation of impacts on parks and other recreational facilities.

Discussion

a) *Would the project 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, including (i) fire protection; (ii) police protection; (iii) schools; (iv) parks; or (v) other public facilities?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not affect public services as described above, including, but not necessarily limited to, fire protection, police protection, schools, or parks.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

9.4.3.16 Recreation

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XVI. RECREATION				
a) Would the project 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 project include recreational facilities or require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment?				X

Discussion

a) *Would the project 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 Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not result in the increased use of existing recreation facilities nor result in need for expanded facilities within the project area.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

b) *Does the project include recreational facilities or require the construction or expansion of recreational facilities that might have an adverse physical effect on the environment?*

See XVI. Recreation a) above.

9.4.3.17 Transportation

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XVII. TRANSPORTATION - Would the project:				
a) Conflict with a program, plan, ordinance or policy addressing the circulation system, including transit, roadway, bicycle and pedestrian facilities?				X
b) Conflict or be inconsistent with CEQA Guidelines §15064.3, subdivision (b)?				X
c) Substantially increase hazards due to a geometric design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?				X
d) Result in inadequate emergency access?				X

Discussion

a) *Would the project conflict with a program, plan, ordinance or policy addressing the circulation system, including transit, roadway, bicycle and pedestrian facilities?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not conflict with a program, plan, ordinance, or policy addressing the circulation system.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

b) *Conflict or be inconsistent with CEQA Guidelines §15064.3, subdivision (b)?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not conflict or be inconsistent with the referenced CEQA Guidelines.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

c) *Would the project 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 Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not substantially increase hazards because of a design feature or incompatible uses.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

d) *Would the project result in inadequate emergency access?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not result in inadequate emergency access.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water

quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

9.4.3.18 Tribal Cultural Resources

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XVIII. TRIBAL CULTURAL RESOURCES - Would the project:				
a) Would the project 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

a)(1) Would the project 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 Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not involve activities which could impact in any manner a site, feature, place, cultural landscape, sacred place, or object with cultural value to a California Native American Tribe.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze

reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

a)(2) Would the project 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??

See XVIII. Tribal Cultural Resources a)(1) above.

9.4.3.19 Utilities and Service Systems

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XIX. UTILITIES AND SERVICE SYSTEMS - Would the project:				
a) Require or result in the relocation or construction of new or expanded water, wastewater treatment or storm water drainage, electric power, natural gas, or telecommunications facilities, the construction or relocation of which could cause significant environmental effects?				X
b) Have sufficient water supplies available to serve the project and reasonably foreseeable future development during normal, dry and multiple dry years?				X
c) Result in a determination by the waste water treatment provider, which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?				X
d) Generate solid waste in excess of state or local standards, or in excess of the capacity of local infrastructure, or otherwise impair the attainment of solid waste reduction goals?				X
e) Comply with federal, state, and local management and reduction statutes and regulations related to solid waste?				X

Discussion

a) *Require or result in the relocation or construction of new or expanded water, wastewater treatment or storm water drainage, electric power, natural gas, or telecommunications facilities, the construction or relocation of which could cause significant environmental effects?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not result in significant environmental effects from construction of new or expanded water, wastewater treatment or storm water drainage, electric power, natural gas, or telecommunications facilities.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

b) *Have sufficient water supplies available to serve the project and reasonably foreseeable future development during normal, dry and multiple dry years?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not affect water supplies in the project area.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

c) *Result in a determination by the waste water treatment provider, which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not affect capacity or operations of waste water treatment providers in the project area.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water

quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

d) *Generate solid waste in excess of state or local standards, or in excess of the capacity of local infrastructure, or otherwise impair the attainment of solid waste reduction goals?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not affect capacity, infrastructure or operations of solid waste facilities in the project area.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

e) *Comply with federal, state, and local management and reduction statutes and regulations related to solid waste?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not result in any activities that would not comply with federal, state, and local management and reduction statutes and regulations related to solid waste.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

9.4.3.20 Wildfire

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XX. WILDFIRE - If located in or near state responsibility areas or lands classified as very high fire hazard severity zones, would the project:				
a) Substantially impair an adopted emergency response plan or emergency evacuation plan?				X

b) Due to slope, prevailing winds, and other factors, exacerbate wildfire risks, and thereby expose project occupants to pollutant concentrations from a wildfire or the uncontrolled spread of a wildfire?				X
c) Require the installation or maintenance of associated infrastructure (such as roads, fuel breaks, emergency water sources, power lines or other utilities) that may exacerbate fire risk or that may result in temporary or ongoing impacts to the environment?				X
d) Expose people or structures to significant risks, including downslope or downstream flooding or landslides, as a result of runoff, post-fire slope instability, or drainage changes?				X

Discussion

If located in or near state responsibility areas or lands classified as very high fire hazard severity zones, would the project:

a) *Substantially impair an adopted emergency response plan or emergency evacuation plan?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not substantially impair an adopted emergency response plan or emergency evacuation plan.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

b) *Due to slope, prevailing winds, and other factors, exacerbate wildfire risks, and thereby expose project occupants to pollutant concentrations from a wildfire or the uncontrolled spread of a wildfire?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not include any activities that exacerbate wildfire risks that could expose project occupants to pollutant concentrations from a wildfire or the uncontrolled spread of a wildfire.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

c) *Require the installation or maintenance of associated infrastructure (such as roads, fuel breaks, emergency water sources, power lines or other utilities) that may exacerbate fire risk or that may result in temporary or ongoing impacts to the environment?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not require installation or maintenance of infrastructure that may exacerbate fire risk or that may result in temporary or ongoing impacts to the environment.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

d) *Expose people or structures to significant risks, including downslope or downstream flooding or landslides, as a result of runoff, post-fire slope instability, or drainage changes?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. The revision of the TMDLs would not expose people or structures to significant risks, including downslope or downstream flooding or landslides, as a result of runoff, post-fire slope instability, or drainage changes.

Reasonably Foreseeable Methods of Compliance: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

9.4.3.21 Mandatory Findings of Significance

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporation	Less Than Significant Impact	No Impact
XXI. MANDATORY FINDINGS OF SIGNIFICANCE				
a) Does the project have the potential to substantially 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, substantially 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 project 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
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 project have the potential to substantially 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, substantially 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 Project 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: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze

reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

b) *Does the project have impacts that are individually limited, but cumulatively considerable?*

Proposed TMDLs Revision: The Proposed Project 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 in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

c) *Does the project have environmental effects that would cause substantial adverse effects on human beings, either directly or indirectly?*

Proposed TMDLs Revision: The Proposed Project would revise the existing nutrient TMDLs for Lake Elsinore and Canyon Lake. As discussed throughout this section, the Proposed Project 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: As discussed in section 9.2.3 above, potential supplemental projects are too speculative at this time to identify or analyze reasonably foreseeable methods of compliance beyond the preliminary identification of potential projects. Potential environmental impacts associated with the selected water quality control projects, alternatives and mitigation measures will be fully evaluated to comply with CEQA requirements as projects are approved by local agencies.

Finding of Significance: No impacts are anticipated, and no mitigation is necessary.

9.5 Alternatives

Pursuant to the CEQA and the State Water Board's implementing regulations (Cal. Code of Regs, tit. 23, §3777(b)(3)), this environmental review must include an analysis of reasonable alternatives to the Proposed Project. The intent is to consider whether there are reasonable alternatives that would fulfill the underlying purpose of the Proposed Project 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 Project. Further pursuant to CEQA (Pub. Res. Code, §21159; Guideline 15187; 23 Cal. Code of Regs. §3777(b)(4)), 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 9.4), there are no potential adverse environmental impacts associated with the Proposed Project 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 TMDLs 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 9.2.3, existing water quality controls would continue to be implemented and additional supplemental water quality controls may also be implemented. However, at this time it is uncertain whether the water quality controls implemented under the No Action Alternative will result in compliance with the response targets in the 2004 TMDLs.

The process to revise the numeric targets and TMDLs not only allows consideration of 20 years of new data and information, but it also provides the opportunity to establish a new phased Implementation Plan with clear milestones. Thus, implementation of the Proposed Project is expected to facilitate compliance with the TMDLs and result in improved water quality and protection of beneficial uses in Lake Elsinore and Canyon Lake.

10. 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:

- Water Code section 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 section 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.

The proposed revisions to the nutrient TMDLs, which 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 TMDLs and was to be conducted after the completion of necessary modeling analyses and studies (see Task 14, Santa Ana Water Board 2004a).

Compliance with the proposed revised TMDLs will likely require, at a minimum, continued implementation of current (or equivalent) level of controls. In addition, the revised TMDLs will require more nutrient reductions than was needed to attain the 2004 TMDLs; therefore, supplemental water quality control projects will likely be needed to assure compliance. Accordingly, adoption of the revised TMDLs will require that jurisdictions with a TMDL allocation either update existing TMDL implementation plans (e.g., CNRP for MS4 permittees) or develop new TMDL implementation plans to meet the requirements of the revised TMDLs. Through this process potential supplemental projects will be identified for implementation to attain 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 10.1 – Economic Costs*: This section provides a summary of the costs of the types of projects[37] 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.

[37] The described projects are provided as key examples of the types of projects that may be considered for implementation. It is not intended to be an exhaustive list.

- *Section 10.2 – Agricultural Costs*: A brief discussion of potential costs applicable to agriculture is provided along with potential funding sources.
- *Section 10.3 – Economic Value*: The expected economic and environmental benefits associated with implementation of the revised TMDLs are summarized in this section.
- *Section 10.4 – Antidegradation Analysis*: This section addresses compliance with state and federal antidegradation review requirements, as applicable to the revised TMDLs.

10.1 Economic Costs

To evaluate the potential economic cost of the implementation of the revised TMDLs to meet the allocations and in-lake response targets, 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 in more detail below.

10.1.1 Existing Projects

Since 2004, 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. These projects have included activities implemented by MS4 and agricultural dischargers, addition of recycled water to Lake Elsinore by EVWMD, and multi-agency projects implemented through the LECL Task Force, such as alum addition and carp management.[38] **Table 10-1** 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.

Currently, EVMWD operates LEAMS to offset loads associated with recycled water in excess of the TMDL. Recent assessment of LEAMS concluded that its ability to increase oxygen in the bottom of Lake Elsinore has declined in recent years and that the system may have reached the end of its usable life (Horne and Anderson 2021). Supplemental projects to offset excess nutrients in recycled water and watershed runoff will be considered in greater detail under Task 5 of the Phase II Implementation Plan (see Section 7.2.2). The following section presents supplemental project options that could be available to meet requirements of the revised TMDL. Several of the options involve projects within Lake Elsinore that would rehab/enhance or replace LEAMS.

Table 10-1. Summary of Current Annual Average Public Expenditures for Water Quality Control Type

[38] 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.

Project	Core Programs ($/yr)	TMDL Project ($/yr)[3]	Total Cost ($/yr)
Recycled Water Addition (~4,000 AFY)[2]	$5,290,000	--	$5,290,000
Monitoring Program, Task Force Administration[4]	--	$400,000	$400,000
LEAMS[4]	--	$400,000	$400,000
Canyon Lake Alum Addition[4]	--	$300,000	$300,000
Carp Removal (as needed)	--	$100,000	$100,000
Total	**$5,290,000**	**$1,200,000**	**$6,490,000**

[1] Core programs include minimum control measures implemented by MS4 permittees and recycled water addition by EVMWD. These costs would be incurred with or without the downstream nutrient TMDL. Core program related costs were provided by RCFC&WCD (2023). Additional costs that are incurred by private land developers to construct LID BMPs in project WQMPs are not shown.

[2] Annual operational cost of the EVMWD recycled water plant in fiscal year 2022-23, for the proportion of effluent that is discharged to Lake Elsinore for lake level stabilization ~90 percent (data provided by Sudhir Mohleji, Principal Engineer with EVMWD, November 27, 2023).

[3] TMDL projects are implemented collaboratively through the LECL Task Force and funded through funds collected per the Task Force Agreement and grants.

[4] Monitoring program, LEAMS operation, and alum addition implementation costs extracted from LECL TMDL Task Force budget 2022-2023 and LEAMS Accounting Report (https://sawpa.gov/task-force/lake-elsinore-and-canyon-lake-tmdl-task-force/)

Many of the watershed BMPs deployed in the San Jacinto River watershed are associated with meeting core requirements in NPDES Permits for EVMWD recycled water discharge (Santa Ana Water Board 2019), the MS4 permit (Santa Ana Water Board 2010), the Agricultural General Order (Santa Ana Water Board 2023), and programs designed to meet groundwater basin objectives. “Core requirements” are general obligations imposed on all stormwater permittees to minimize pollutants to the MEP by implementing BMPs. The expense 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 TMDLs by helping reduce nutrient loads delivered to the lakes (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).

Agricultural dischargers responsible for TMDL implementation have been participating in the Task Force through WRCAC and partners including the San Jacinto River Watershed Council and San Jacinto NRCS and contribute funds to implement TMDL projects. In addition, agricultural landowners previously subject to the CWAD are implementing specific BMPs as required by the 2023 Agricultural General Order applicable to irrigated lands in the San Jacinto River watershed (Santa Ana Water Board 2023). It is estimated that since adoption of the original TMDLs in 2004, approximately $12 million has been spent by WRCAC and partners on the implementation of agricultural-related BMP projects in the San Jacinto River watershed (Boldt 2023). This does not include costs incurred by individual agricultural operators or BMPs deployed by dairies to comply with the CAFO permit. Implementation of agricultural BMPs as required by the CAF general order and Agricultural General Order and participation in the LECL 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. 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, the LECL Task Force spends approximately $400,000 per year on studies, plans and monitoring (personal communication with Rick Whetsel, Santa Ana Watershed Project Authority, May 17, 2023). The revised TMDLs Implementation Plans includes several requirements for future updates to water quality control plans as well as implementation of a number of studies in both Phases II and III (see Tables 7-7 and 7-12, respectively).

10.1.2 Potential Supplemental Projects

Table 7-9 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. Planning level costs were developed for several of these potential supplemental projects to support a demonstration of multiple reasonable, economically feasible means to attain the revised TMDLs. Tasks planned for implementation during Phase II (see Table 7-7) will evaluate which projects or combinations of projects will be most beneficial to the lakes. While some technologies are effective in pilot testing, the scalability to whole lake application is an important consideration. In the sections below, information from other full-scale applications of lake water quality treatments were used to estimate potential costs if the project were implemented in the project area. Each project discussed includes a description of the project concept, anticipated water quality benefits, implementation assumptions, and a basis for the cost estimate.

When conducting an economic analysis over a future time period, such as from 2023 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 2030, after approval of revised TMDLs' Implementation Plan (e.g., CNRP, see Section 7.2.2) 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 2030-2054) 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 10-1 presents a summary of costs for existing water quality 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, wetland system sizing, 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 attainment by any one option or combination of options is made in this analysis. The effectiveness of an individual project(s) will be evaluated through the development of revised TMDL implementation plans, development of a preferred water quality control option or set of options for each lake (e.g., see Phase II Tasks 4, 5 and 6), or offset program effectiveness demonstrations.
- Estimated costs are expressed as collective amounts with no discussion or assumptions as to how such costs might be distributed among individual stakeholders responsible for TMDL allocations.
- 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.

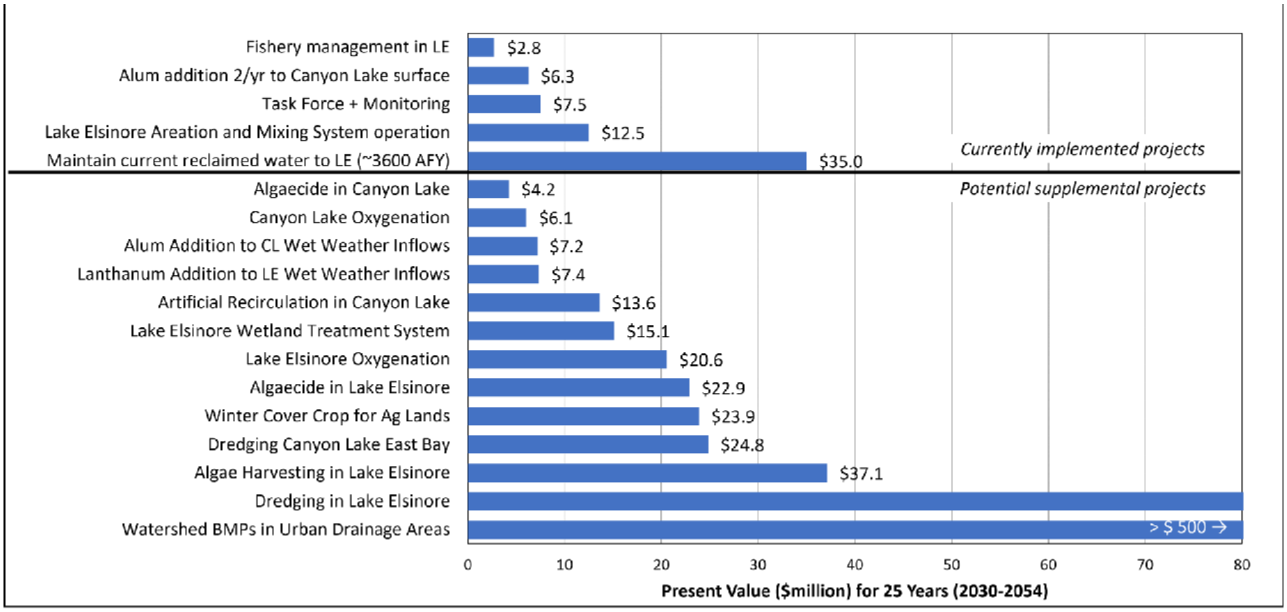

Figure 10-1. Approximate Present Value Over Next 25 years for Existing and Potential Supplemental Projects (CL = Canyon Lake; LE = Lake Elsinore)

10.1.2.1 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 10-2**). These flows to Canyon Lake would result in increased overflows of lower TDS water from Canyon Lake to Lake Elsinore.

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).

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.

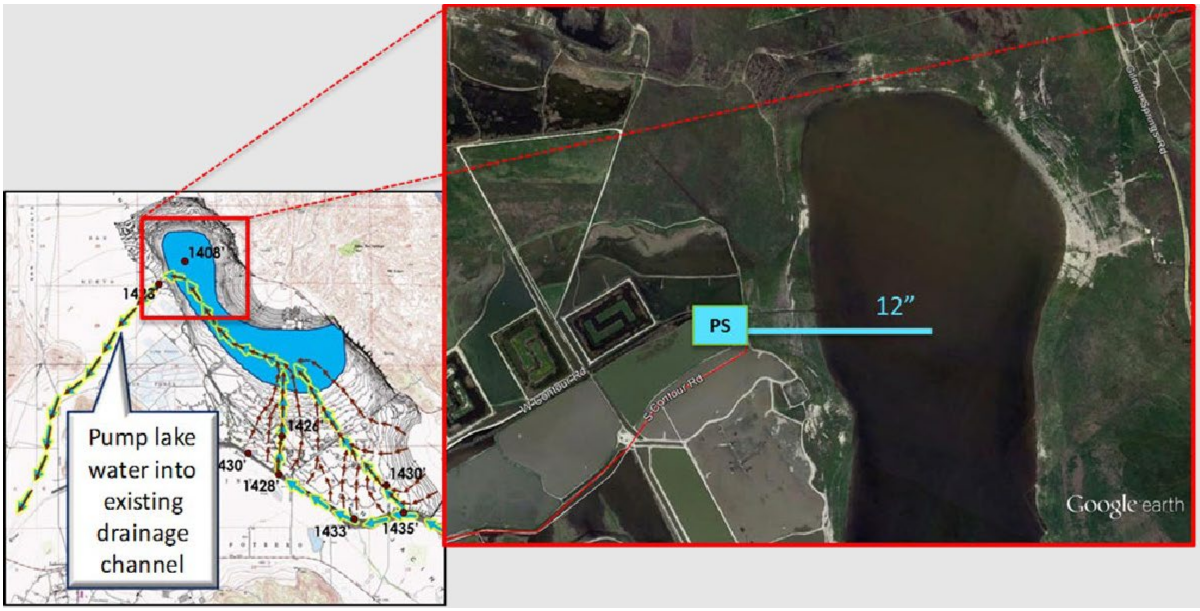

Figure 10-2. Conceptual Mystic Lake Drawdown Project

Potential Implementation Issues

Water from Mystic Lake would be available in wetter hydrologic years, when Canyon Lake and 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 or cause other environmental impacts.

Mystic Lake is a water of the state and is listed in the Basin Plan. Pumping of water out of the lake and transfer to the San Jacinto River would impact the beneficial uses of the lake (intermittent uses: MUN, REC1, REC2, WARM; existing or potential beneficial use: BIOL, WILD, RARE)

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 10-2** 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. This volume represents about half of the total volume of Canyon Lake. If higher drawdown rates were to be achieved, there would involve construction of more extensive pipelines, which could increase the capital cost significantly compared with the estimate in **Table 10-2**.

Table 10-2. Estimated Implementation and O&M Costs for Potential Mystic Lake Drawdown Project

Facilities	Cost ($)
Intake pipeline (2500’, 12” diameter)[1,4]	$1,200,000
Pump Station (25 horsepower [HP])[2,4]	$125,000
Discharge pipeline (500’, 12” diameter)[3,4]	$120,000
Capital Cost (scaled to 2022)[4]	$1,700,000
O&M[5] ($/yr)	$34,000
Present Value for 25 years ($)[6]	**$1,900,000**

[1] Pipeline cost assumes $480 per linear foot for trenchless construction – 2X open trench cost basis (Carollo 2017)

[2] Pump station cost assumes $5,000 per HP (Carollo 2017)

[3] Pipeline cost assumes $240 per linear foot for open trench construction (Carollo 2017)

[4] Costs based on Carollo 2017 were scaled to 2022 based on Engineering News Record (ENR) Construction Cost Index ($13,007 in 2022 versus $11,062 in 2017)

[5] Assumes 2% of capital for annual O&M including power to run pumps and facility maintenance, including equipment replacement.

[6] Assumes 3% discount rate with capital expenditure in 2030 and O&M in 2030-2054

10.1.2.2 Chemical 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 enhancement 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 decrease 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 elsewhere (Churchill et al. 2009; Cooke and Carlson 1986). Alum addition to wet weather inflows could be applied in Canyon Lake. An alternative was considered using lanthanum based chemical treatment for inflows to Lake Elsinore.

Potential Water Quality/Other Benefits

The addition of alum or lanthanum based chemical flocculants to wet weather inflows allows for the reduction of bioavailable phosphorus as it enters the lake. Chemicals form a floc that has the capacity to bind with Ortho-P. The use of alum is most effective when the pH of the water is less than 8.0. Due to higher ambient pH in Lake Elsinore, use of a lanthanum based chemical could provide more effective treatment.

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 chemical addition would be dependent upon real-time flow measurements to provide a consistent dose to the inflows. There is the potential for chemical 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 within the inflow channels 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 material, and labor to manage the site. **Table 10-3** provides estimated costs for a typical in-line system, including the variable amounts of 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. 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 additional cost for a project involving chemical additions with wet weather inflows.

Table 10-3. 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)
TP Reduction Needed (kg/yr)[1]	2,500	1,000	2,500
Chemical Material (kg/yr)[2]	375,000	150,000	125,000
Capital Cost (2022)	$194,000	$194,000	$194,000
O&M Cost ($/yr) including Material[2]	$320,000	$135,000	$480,000
Present Value for 25 years ($)[3]	**$5,000,000**	**$2,200,000**	**$7,350,000**

[1] Reduction needed to reduce baseline loads to lake inflows to Phase II milestones
[2] Alum for Canyon Lake at $0.83/kg, Lanthanum for Lake Elsinore at $3.75/kg
[3] Assumes 3% discount rate with capital expenditure in 2030 and O&M in 2030-2054

10.1.2.3 Wetland Treatment System

Description

A constructed wetland treatment system can provide nutrient reduction in recycled water prior to discharge to the lake, and/or recirculated lake water. Several project alternatives involve wetland treatment including a system to polish recycled water inflow, riparian restoration in the San Jacinto River inflow to the lake, and lake recirculation in the southeastern part of Lake Elsinore. Similar projects on large hypereutrophic lakes use multiple cells to facilitate multiple day hydraulic residence time (HRT), facilitate maintenance and reduce short-circuiting (Dunne et al.

2015). Land area sufficient to provide multi-day HRT needed to achieve meaningful nutrient load reduction near the shore of Lake Elsinore could be created at several locations near the EVMWD recycled water discharge or in and around the levee.

Potential Water Quality/Other Benefits

Prior studies have shown wetland treatment systems can provide significant removal (as high as 75 percent) of both nitrogen and phosphorus (Jacquemin et al. 2020). By operating year-round to treat recycled water addition and/or recirculated lake water, the system would maximize nutrient removal and remain wet to support the wetland ecosystem. Other benefits include creation of habitat for wildlife, lakeshore aesthetics, and new opportunities for environmental education.

Potential Implementation Issues

A new wetland treatment system will increase water loss through evapotranspiration. The extent of water loss and ability for the wetland to operate must be considered as part of any evaluation of this option. Depending upon the size and proposed layout of the system, changes to the lake basin may be required, which would involve application for environmental permits. Land availability behind the levee could also pose an implementation challenge if the proposed project exceeds the limits of space available at the existing location. Lastly, the ability for wetland treatment systems to remove phosphorus may require sedimentation of particulates in recirculated lake water, which could pose additional implementation challenges.

Estimated Cost

Kadlec and Wallace (2009) provides characteristics and costs for multiple constructed treatment wetlands designed to provide sufficient residence time and loading rate for nutrient removal. A constructed wetland of ~60 acres would provide 4-5 days of HRT with a recirculating hydraulic loading rate of ~75 ft/yr. Estimated costs based on normalized values reported in Kadlec and Wallace (2009) and escalated to current dollars using ENR index (**Table 10-4**).

Table 10-4. Planning-Level Cost Estimate for a Recirculation Wetland Treatment Facility in Lake Elsinore

Facilities	Cost ($)
Capital Cost (2022)[1]	$14,000,000
O&M ($/yr)[2]	$230,000
Present Value for 25 years ($)[3]	**$15,100,000**

[1] Capital cost of $240,000 per acre based on median of 18 treatment wetlands in North American as reported in Kadlec and Wallace (2009) and escalated to 2022 dollars
[2] Annual O&M cost of $2,500 per acre per year based on median of 18 treatment wetlands in North American as reported in Kadlec and Wallace (2009) and escalated to 2022 dollars
[3] Assumes 3% discount rate with capital expenditure in 2030 and O&M in 2030-2054

10.1.2.4 Artificial Recirculation in Canyon Lake

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 10-3**). 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 which would be expected to reduce the duration of algal blooms. Over time, the reduced cycling of nutrients 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
- An alternative not included in the cost estimate below would be to provide nutrient removal from the recirculated water such as by media filtration or alum addition prior to discharge to East Bay

Figure 10-3. 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 WTP.

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 of 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 (~31 AF/day) of Main Lake water, or roughly one month to completely flush the ~1,000 AF volume in East Bay back 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 AEM3D.

Table 10-5 summarizes the estimated costs for construction and 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, which would include an evaluation of potential environmental impacts.

10.1.2.5 Algaecide

Description

The application of an algaecide directly to the surface of either Lake Elsinore or Canyon Lake could be effective at killing algae and limit algal blooms (**Figure 10-4**). Multiple USEPA-registered algaecides are available for use in lakes. Some algaecides work through an oxidation process, releasing hydrogen peroxide into the water supply, which has been shown to provide selective treatment for cyanobacteria while being non-toxic to other forms of aquatic life. Another type includes chelated copper-based algaecides which are highly effective for all types of algae and less toxic than historically used copper sulfate crystals.

Table 10-5. Planning-Level Cost Estimate for a Recirculation Facility in Canyon Lake

Facilities	Cost ($)
Intake pipeline (16,000 ft, 30-inch diameter)[1]	$9,940,000
Intake, outfall with rock protection	$590,000
Pump Station (400 HP)[2]	$1,410,000
Capital Cost (2022)[3]	$11,930,000
O&M ($/yr)[4]	$240,000
Present Value for 25 years ($)[5]	**$13,600,000**

[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] Costs based on Carollo 2017 were scaled to 2022 based on ENR Construction Cost Index
[4] Assumes 2% of capital for annual O&M including power to run pumps and facility maintenance, including equipment replacement.
[5] Assumes 3% discount rate with capital expenditure in 2030 and O&M in 2030-2054

Algaecides may be used on an as-needed basis or as part of a treatment train with alum or other treatment methods. The State Water Board has a statewide general NPDES permit (Order 2013-0002-DWQ) for use of algaecides or aquatic herbicides registered for use in California (State Water Board 2013, as amended). Costs were estimated for two applications per year to be timed prior to typical blooms.

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.

Figure 10-4. Example of Application of Algaecide to a Surface Waterbody (Source: http://www.peroxygensolutions.com/pak-27/how-to-apply)

Costs & Assumptions

Table 10-6 summarizes the estimated planning level costs for this BMP project. The analysis assumes the top four ft of both Lake Elsinore and Canyon Lake are treated annually with a hydrogen peroxide based product at an application rate of 30 lbs/AF. The cost per pound is assumed at ~$2.00, based on discussions with a leading algaecide provider in 2022 (quote provided by Cygnet Enterprises, 2022). Additional costs are assumed for shipping and application by lake staff.

Table 10-6. 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
Algaecide Product Cost ($/Event)	$120,000	$720,000
Shipping and Application Labor ($/Event)	$20,000	$40,000
Total Annual Cost for Two Events ($/yr)	$280,000	$1,520,000
Present Value ($)[2]	$4,240,000	$22,860,000

[1] Treated volume is top 4 ft of water column
[2] Assumes 3% inflation rate and a 25-year period with annual applications in years 2030 - 2054

10.1.2.6 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 is conducted commercially to produce a dietary supplement from nitrogen-fixing cyanobacterium *Aphanizomenon flos-aquae* (AFA) (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. Other uses of harvested algae include creation of biofuels or composts.

Multiple recent applications of dissolved air floatation technology to remove algae from recirculated lake water in a shoreline treatment train facility have been shown to be effective (Tetra Tech 2022) (**Figure 10-5**). A bench scale test of Lake Elsinore water yielded ~90 percent reduction in algae biomass and pilot application is currently in development.

Potential Water Quality/Other Benefits

Physical removal of algae will reduce concentrations of chlorophyll-*a* in lake water and may reduce releases of cyanotoxins and 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 cause a release into treated effluent or may constitute a hazardous waste and involve additional disposal requirements. Regular operation of a floating barge or a series of large shoreline facilities may disturb recreational use within the lakes.

Figure 10-5. Image of AECOM's 1 mgd Shoreline Treatment Unit for Algae Harvesting (see Tetra Tech 2022)

Sizing Assumptions and Estimated Costs

Cost estimates were developed based on capital and O&M costs for recent installations of recirculating algae removal systems involving hydro-nucleation floatation technology as reviewed in Tetra Tech 2022 (**Table 10-7**). Typical shoreline recirculation facilities are designed for 1 mgd. In the case of Lake Elsinore, it was assumed that at least 5 mgd of treatment capacity would be needed to achieve significant water quality benefits. The same flow rate was used in estimating costs for recirculating wetland treatment in Lake Elsinore.

Table 10-7. Estimated Costs for Algal Biomass Harvesting (based on AECOM HFT Technology as report in Tetra Tech 2022)

Cost Item	Cost ($)
Total Capital Cost[1]	$8,500,000
Annual O&M[2]	$2,000,000
Present Value[3]	$37,100,000

[1] Estimated cost provided by AECOM for complete system with conveyance (June 2024)

[2] Estimated cost provided by AECOM includes full system operation and algae solids disposal (June 2024)

[3] Assumes 3% inflation rate and a 25-year period with annual applications in years 2030 -2054

10.1.2.7 Oxygenation Systems

Description

The LEAMS system was designed to bring oxygen rich surface water to the lake bottom through multiple elements to enhance vertical mixing, as described above (see Section 7.1.2.2). Reducing the temporal and spatial extent of anoxic conditions at the sediment-water interface will reduce diffusive flux of nutrients (ammonia-N and SRP) from the lake bottom sediments to the overlying water column. A recent assessment by Horne and Anderson (2021) showed that the system is no longer providing sufficient oxygen to the lake bottom to meet sediment oxygen demand on a consistent basis. Oxygenation is an alternative strategy to deliver oxygen directly to the lake bottom. Oxygenation systems have been considered for both Canyon Lake and Lake Elsinore.

In Canyon Lake, a HOS has previously been considered. PACE (2011) provided a preliminary design, described as follows (**Figure 10-6**): System was designed to inject liquid oxygen into the lake bottom during periods of thermal stratification. Pumped lake water becomes oxygen enriched in a lakeshore chamber and is then piped back to the lake bottom. The increase in DO at the sediment-water interface 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.

The HOS was considered for inclusion in the CNRP and AgNMP, but ultimately the LECL Task Force, which includes participation by Santa Ana Water Board staff, 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.

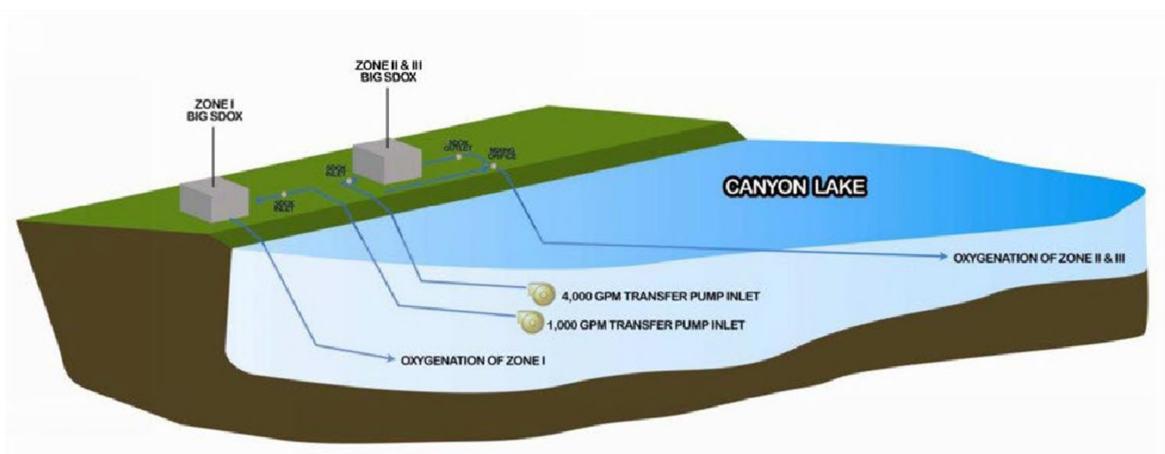

Figure 10-6. Conceptual Drawing of Canyon Lake Dual On-Shore Oxygenation System (adapted from Figure ES-4, PACE 2011)

Consideration of oxygenation in Lake Elsinore was a key recommendation of Horne and Anderson (2021), following the finding that the current LEAMS is no longer keeping up with sediment oxygen demand in the lake bottom. Multiple alternatives were presented for delivering oxygen directly to the lake bottom; advantages and disadvantages of each are discussed in detail. A key task in the implementation of the revised TMDLs is to evaluate in-lake treatment options to enhance or replace the current LEAMS system (see Section 7, Phase II Tasks 5 and 6). Oxygenation would be an enhanced approach to achieve the same objective of increasing DO at the sediment-water interface.

Potential Water Quality/Other Benefits

Oxygenation 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 in both lakes. 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

Oxygenation systems may 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 in Canyon Lake, the recommended alternative (10b) in the preliminary design report was evaluated (PACE 2011). This alternative included two shoreline oxygen generation locations, ~10,000 ft of underwater oxygen delivery pipe along the lake bottom, pumps, and other equipment. **Table 10-8** provides the estimated implementation and operational cost; costs were updated to reflect 2022 dollars using the standard ENR index. For Lake Elsinore, planning levels costs were provided based on preliminary engineering analysis for a target delivery of 15,000 lbs/day of DO at the deep hole (PACE 2024).

10.1.2.8 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 LID BMPs in urbanized areas (**Figure 10-7**). Examples of LID BMPs include bioretention facilities, porous pavement, detention basins, media filtration, and regional infiltration basins. As required by the Santa Ana Region’s Riverside County MS4 permit (Order number R8-2010-0033), LID BMPs are required in new urban development and significant re-development projects implemented within the San Jacinto River watershed (Santa Ana Water Board 2010).

Collectively, MS4 permittees have overseen the construction of numerous LID BMPs within ~10,000 acres of new development in the San Jacinto River watershed. These LID BMPs are designed to capture, at a minimum, all runoff from storm events up to the 85th percentile depth.

Table 10-8. Estimated Costs to Implement HOS in Canyon Lake and Speece Cone in Lake Elsinore

Cost Item	Canyon Lake Cost ($)[1]	Lake Elsinore Cost ($)[2,3]
Total Capital Cost	$4,100,000	$12,000,000
Annual O&M	$180,000	$700,000
Present Value[4]	$6,000,000	$20,600,000

[1] Cost for capital and O&M from PACE 2011 escalated to 2022 dollars using ENR index 13007 (December 2022)
[2] Based on preliminary engineering analysis for delivery of 15,000 lbs/day DO to the deep hole (PACE 2024). Top end of estimated range of cost ($4 -12 million) in Horne and Anderson 2021
[3] Based on preliminary engineering analysis of energy, maintenance, oxygen, and labor needed for delivery of 15,000 lbs/day DO to the deep hole (PACE 2024).
[4] Assumes 3% discount rate with capital expenditure in 2030 and O&M in 2030-2054

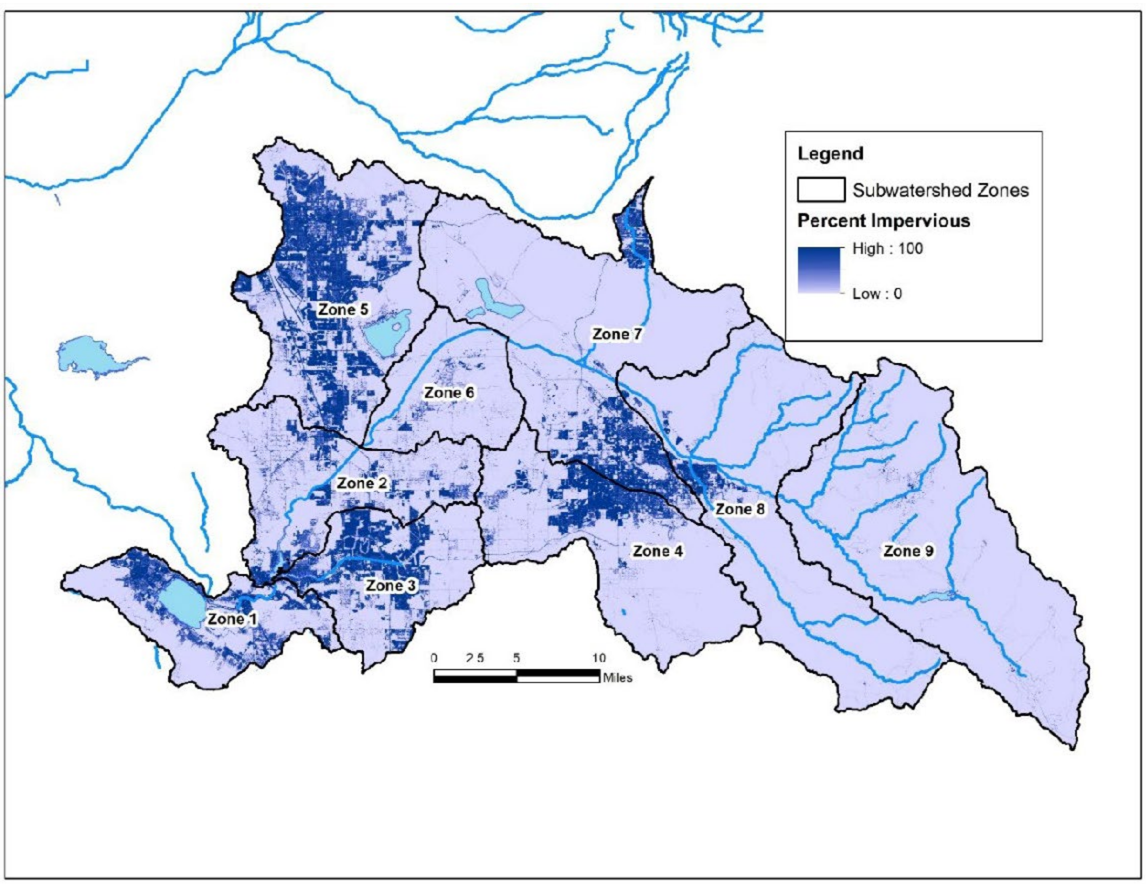

Figure 10-7. Urbanized Area of the San Jacinto River Watershed (darker blue areas indicate higher percent imperviousness)

Nutrient loads from watershed runoff account for about 70 percent of total nutrient loading to Canyon Lake over a long-term hydrologic period. Internal load from bottom sediment flux and atmospheric deposition account for the remainder. Retention of nutrient load from watershed runoff is highly variable in Canyon Lake with dry years retaining all runoff and wet years having nearly all runoff overflowing to Lake Elsinore (see Figures 4-13 and 4-14).

For Lake Elsinore, nearly all watershed nutrient load is retained within the lake (the most recent overflow to Temescal Creek occurred in 1993). Despite this condition, inflows of watershed runoff (both local and as Canyon Lake overflow) account for less than 20 percent of the total annual nutrient load in Lake Elsinore over the long-term hydrologic period. The majority of annual nutrient load to Lake Elsinore comes from flux out of the lake bottom sediments. Enrichment of nutrients within the lake bottom stems from multiple decades of external loading and a nearly complete lack of flushing. Thus, a watershed scale program of urban stormwater BMP deployment should be implemented in coordination with in-lake controls to achieve the greatest water quality benefits.

In the future, jurisdictions could retrofit other urbanized areas in the San Jacinto River watershed (up to ~90,000 acres, see Figure 10-7) 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

A key benefit of LID BMPs is the reduction of nutrient loads from urban areas within the areas that drain to the MS4 in the Lake Elsinore and Canyon Lake watersheds. Water quality benefits from watershed nutrient load reductions occur indirectly by reducing the enrichment of deposited sediment during the wet season that can be released to the water column via internal loading in seasons when algae blooms are more prevalent.

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 attain WLAs applicable to watershed runoff could reduce the volume of water arriving at the lakes that is needed to support downstream uses. Sensitivity analysis using the GLM model for Lake Elsinore showed that reduced volume (and associated nutrient load) has a net negative impact on long-term water quality (CDM Smith 2022).

Sizing Assumptions and Estimated Costs

The load reductions required to meet final allocations reported in Table 6-3 requires an approximately 70 percent reduction of TP and TN from MS4 permittees across the San Jacinto River watershed. Based on available data, approximately 70,000 acres within the area draining to the MS4 within subwatersheds downstream of Mystic Lake (Subwatershed Zones 1-6) do not include post-construction BMPs associated with a WQMP. For MS4 areas in Subwatershed Zones 7-9, it is presumed that load reductions would be met through in-lake offset programs after accounting for retention of ~96 percent of runoff volume and associated nutrient load in Mystic Lake. The cost estimate for the widespread deployment of watershed BMPs to capture stormwater assumes that infiltrating BMPs will be implemented on 50,000 urbanized acres (70,000 acres * 70% nutrient load reduction target = ~ 50,000 acres). This widespread deployment of stormwater BMP retrofits could be sufficient to meet WLAs in the TMDLs for MS4 jurisdictions. To develop a cost estimate, three types of stormwater BMPs were evaluated: (a) Regional BMPs on public land; (b) bioretention; and (c) 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-ft for all three BMP types (regional BMP, bioretention, and permeable pavement).
- BMPs sized to capture 1 inch rainfall event from drainage areas with runoff coefficient of 0.4, which translates to the first 0.25 inches of runoff over the watershed. Applied to 50,000 acres of urbanized drainage area, this amounts to a target per event capture volume of ~1670 AF.

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 lowest cost relative to other categories (**Table 10-9**). 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 as a standalone watershed scale approach but could be useful when incorporated into large multi-element retrofits. 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 capture volumes are shown to meet target load reductions.

Table 10-9. Estimated Costs to Deploy Selected BMPs in the San Jacinto River Watershed to Meet Total MS4 Load Reductions to Achieve Final Allocation

Cost to Control 1 inch Storm from 50,000 acres of Urban Drainage Area	Regional BMP on Public Land ($)	Bioretention ($)	Permeable Pavement ($)
Capital[1]	$450,000,000	$870,000,000	$1,840,000,000
O&M ($/year)[1]	$34,800,000	$123,000,000	$126,000,000
Total Net Present Value[2]	$900,000,000	$2,600,000,000	$3,400,000,000

[1] Capital and O&M cost based on functions developed for Los Angeles County (Upper Los Angeles River Watershed Management Group 2016) escalated to 2022 based on ENR Construction Cost Index
[2] Assumes 3% discount rate with capital expenditure in 2030 and O&M in 2030-2054

10.1.2.9 Dredging

Project Description

A project to remove bottom material from the lakes would reduce the pool of potentially mobile nutrients and thereby reduce internal loads. Incubation chamber studies and lake water quality models have shown that diffusive flux from the lake bottom sediments represents a large source of nutrients to both lakes (see Section 4.3 above).

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 10-8**). Dredging of the top 2 ft of bottom sediment in Lake Elsinore was also evaluated to provide order of magnitude cost for planning purposes.

Potential Water Quality/Other Benefits

Dredging, which would reduce the internal diffusive sediment nutrient flux for both TP and TN, would improve water quality in the lakes by reducing bioavailable nutrients. 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.

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 ~65 acres with the greatest thickness of soft bottom sediments, based on the recent hydroacoustic survey analysis (see **Figure 10-8**; Anderson 2016a). Dredging this area to this depth would require removal of approximately 200,000 CY of sediment. For Lake Elsinore, the dredging of two feet was assumed to occur lake-wide to estimate a volume of sediment removal for planning purposes, but focused areas of greater dredging would be a more likely approach if implemented in the future. To develop a cost estimate, the following factors were considered:

a) The 2000 cost 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 2023), this cost escalated to 2022 dollars is ~$28/CY. This estimate is consistent with the dredging cost estimate developed for the Machado Lake Nutrient TMDL (Los Angeles Water Board 2008).

b) The 2000 Canyon Lake East Bay cost estimate states that sediment disposal to a landfill would cost $45/CY, or $114 per CY escalated to 2022 dollars using the CWCCIS index. Disposal cost would be drastically reduced if a local disposal area was identified.

c) Dredging is assumed to occur once, with no annual O&M.

Based on the above considerations, **Table 10-10** provides a summary of the estimated cost to dredge and dispose of sediments from Canyon Lake East Bay and Lake Elsinore.

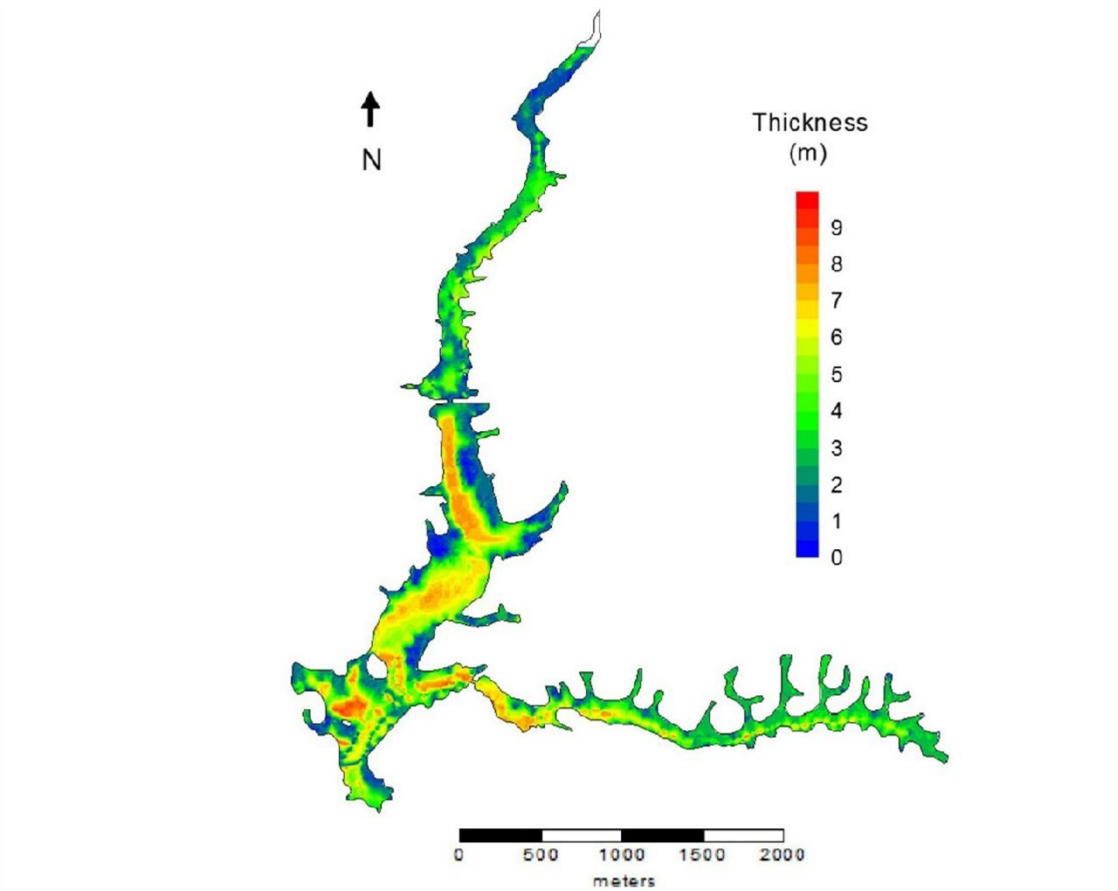

Figure 10-8. Sediment Thickness (Meters) in Canyon Lake (from Anderson 2016a)

Table 10-10. Summary of Estimated Costs to Dredge East Bay of Canyon Lake and Lake Elsinore

Cost Item	Canyon Lake East Bay	Lake Elsinore
Sediment Removal (CY)	200,000	10,000,000
Excavation Cost (200,000 CY)	$5,800,000	$270,000,000
Landfill Disposal Cost	$23,800,000	$1,100,000,000
Present Value[1] (capital cost only; no annual O&M)	$25,000,000	$1,150,000,000

[1] Assumes 3% discount rate with capital expenditure in 2025

10.2 Agricultural Costs

California Water Code section 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. Costs associated with implementation of the TMDLs are only speculative at this time. Costs associated with the TMDLs for agricultural operators subject to the TMDLs include costs associated with: (1) studies and monitoring performed by the LECL Task Force or by individual agricultural operators; (2) operational costs associated with implementation of BMPs to control nutrients from leaving agricultural fields during storm events; (3) costs for purchasing offsets; or (4) any combination of the above. For example, where in-lake projects are identified for implementation, offsets are available and operators opt to participate in regional offset programs, the portion of costs for agricultural operators to meet allocations will be determined as part of the development and implementation of the project or through an agreement between LECL Task Force members and operators of any regional offset program. Notably, with ongoing urban development in the San Jacinto River watershed, the excess load to be offset with in-lake projects for agricultural operators is expected to be reduced from historical levels. Conversely, the number of agricultural operators to fund regional programs and projects is also reduced, which may result in increased costs for individual agricultural operators for budget items that are currently shared equally across upstream dischargers. To avoid having individual agricultural operators from being subject to disproportional costs due to the diminishing number of agricultural acres, fair-share cost accounting for implementation of Phase II and Phase III program tasks, including offsets, may be employed by any approved third party or Coalition to avoid imposing a disproportionate burden on any one jurisdiction as it relates to the TMDLs and their implementation.

As noted, cost estimates at this time are speculative. It is difficult to estimate the level of increased costs that agricultural operations may incur associated with implementation of the TMDLs, or more specifically, increases above current costs associated with implementation of the 2004 TMDLs. At most, examples of costs associated with implementation of certain BMPs may be estimated if they were implemented by agricultural operations to reduce loads of TP and TN to meet TMDL allocations. However, regional water boards are prohibited from dictating the manner of compliance, which prevents the Santa Ana Water Board from dictating to any agricultural operator the type of BMP that must be implemented, and agricultural operators are permitted to comply with the requirements in any lawful manner (Water Code, §13360).

For illustrative purposes only, costs associated with the use of cover crops for controlling the release of nutrients in sediment from agricultural operations were estimated from the survey of members produced by the Sustainable Agriculture Research and Education group (SARE) in 2012 (SARE 2019) and the more recent, detailed estimate of cover crop costs produced by the University of California (UC) Agriculture and Natural Resources Cooperative Extension at the UC Davis Department of Agricultural and Resource Economics in 2022 (UC Davis 2022). Costs for seed, labor and fuel, adjusted for 2024 and assuming annual inflation of 3%, ranges between $53/acre and $111/acre as the average and high end of SARE member costs, respectively, and up to $119/acre in the UC Davis estimate (adjusted for 2024). UC Davis also estimated costs for cover crop irrigation of $47/acre (adjusted for 2024) assuming two irrigation events of two inches each and including labor and fuel. For the same amount of winter cover crop irrigation using EMWD recycled water rate for Winter – Ag ($99.51/AF), the cost per acre for irrigation is reduced to $33/acre. Therefore, average and high annual cost estimates for cover crops including two irrigation events are $86/acre and $166/acre, respectively.

To determine the potential load reduction benefits associated with employment of cover crops, nutrient removal rates were calculated. However, according to existing literature, estimates of cover crop removals of nutrients are highly variable (Howarth et.al. 2007). Based on review of other studies in Howarth et al (2007), we have assumed a constant rate of 50% removal of TP and TN from edge of field runoff for the purposes of this example. This reduction of baseline nutrient load from irrigated cropland (see Table 4-9 above) results in an estimated load reduction from use of cover crops of 0.016 kg/ac/yr and 0.015 kg/ac/yr for TP and TN, respectively. The range of cover crop cost reported above was used in conjunction with these estimated load reductions to estimate a range of cost per nutrient removal for generalized application of cover crops in the San Jacinto River watershed (**Table 10-11**).

Table 10-11. Estimated Costs to Deploy Cover Crop on Irrigated Cropland in the San Jacinto River Watershed

Variable	Low	High
Seed & labor ($/acre)	$53	$119
Irrigation ($/acre)	$33	$47
Total Cost ($/acre)	$86	$166
Cost per TP Removed ($/kg)[1]	$5,370	$10,344
Cost per TN Removed ($/kg)[1]	$5,926	$11,414

[1] Assumes baseline nutrient load reduced by 50 percent with cover crop practice (TP: 0.032 kg/ac/yr * 0.5 = 0.016 kg/ac/yr; TN: 0.029 kg/ac/yr * 0.5 = 0.015 kg/ac/yr)

Further consideration was given to whether these cover crop nutrient reduction costs of $86-166 per acre are beyond many farm's fields net profit depending on the crop being produced. The USDA Economic Research Service (ERS) tracks crop Recent Cost and returns data for different regions across the United States. The San Jacinto River Watershed sits within the multistate Fruitful Rim region which includes parts of Washington, Oregon, Idaho, California, Arizona, Texas, Mississippi, Florida, and South Carolina. ERS generates enterprise budgets estimated annually based on census survey data for average Total Operating Costs and Total Gross Value of Production. The ERS enterprise budget estimated a return (gross value of production minus operating cost) for wheat in the Fruitful Rim of $172 per planted acre. The additional cost of cover crop estimated above is 50-97 percent of the ERS estimated return. When accounting for the increased irrigation demand and cost of water in semi-arid southern California relative to the average over the Fruitful Rim, it is likely that the cost to implement cover crops would exceed the estimated return, thereby making farming of a property non-viable.

As noted above, the use of cover crops is not mandated by the TMDLs, and this example is for illustrative purposes only. It is possible that other agricultural field management measures could be implemented at lower cost. In addition, alternative methods to reach attainment are available to some agricultural operators such as the use of the WQI_{ag} Tool (see Section 7.1.2.1 and discussion below) and participation in more cost effective in-lake nutrient reduction offset programs. For example, ~70 percent of the annual TP load from an irrigated cropland agricultural field (0.022 kg/acre reduction) can be removed at less than $3.00/acre through participation in the alum addition program, with a current cost of ~$125/kg TP removed.

Irrigated agricultural operators who are members of the Agricultural General Order San Jacinto Coalition Group (SJCG) administered by EMWD use the WQI_{ag} Tool developed by WRCAC to account for critical field and field management attributes to fulfill the Agricultural General Order surface water monitoring and reporting requirements. This index considers a field's physical factors (slope, soil type, etc.), nutrient management (e.g., timing of fertilizer applications), tillage management, pesticide management, use of BMPs, drainage and its management, and irrigation and its management. The WQI_{ag} tools tracks each field's BMPs, as well as nutrient and tillage management systems. The annual report for members of the SJCG demonstrates that many operators in the San Jacinto River watershed are currently managing nutrient sources, farming practices, and implementing BMPs that reduce edge-of-field nutrient discharge. These existing reductions may be sufficient to achieve the Phase II milestones or final allocations for some agricultural operators. WRCAC assists EMWD by providing WQI_{ag} technical assistance to operators, and completion of the annual report. The 2023 cropping year annual report, and thereafter, will include the required AgNMP assessment as an annual update.

Funding for selected projects may be available through the following potential sources:

- Private financing by individual and/or group sources;
- Bonded indebtedness or loans from governmental institutions;
- Federal grants or low-interest loan programs, such as the USDA Natural Resources Conservation Service's Environmental Quality Incentive Program (EQIP) (e.g., in 2023 the EQIP program incentive payment for a basic cover crop for organic and non-organic crops was $61.23/acre in California);
- Single-purpose appropriations from federal or State legislative bodies; and
- Grant and loan programs administered by the State Water Board and California DWR. Grants and loan programs may be directed to agricultural specific projects or in-lake projects. Such grants or loans would help to decrease costs for implementation of the Phase II and Phase III Implementation Plans for the TMDLs. These programs currently include:
  - Clean Water Act funds (State Water Board);
  - Agricultural Water Quality Grant Program (State Water Board);
  - Clean Water State Revolving Fund (State Water Board); and
  - Integrated Regional Water Management grants (State Water Board, CDWR).

10.3 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.[39] Instead, this section provides qualitative information on the economic and environmental benefits associated with implementation of revised TMDLs.

[39] Detailed quantitative analyses of this type would be expected to be conducted as part of Phase II implementation, which focuses on identifying a preferred option or set of options to improve water quality in Canyon Lake (Task 4) and Lake Elsinore (Task 5).

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 7, 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 is a key step toward supporting 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).
- The purchase of day use passes for Lake Elsinore has ranged from 15,000 to 45,000 per year from 2007 through 2022 (Figure 10-9). Water quality conditions can have a significant impact on recreational use in Lake Elsinore. For example, an extended cyanobacteria bloom (harmful algal bloom or HAB) resulted in swimming beach closures over 8 months in 2022.
- 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 10-9**).

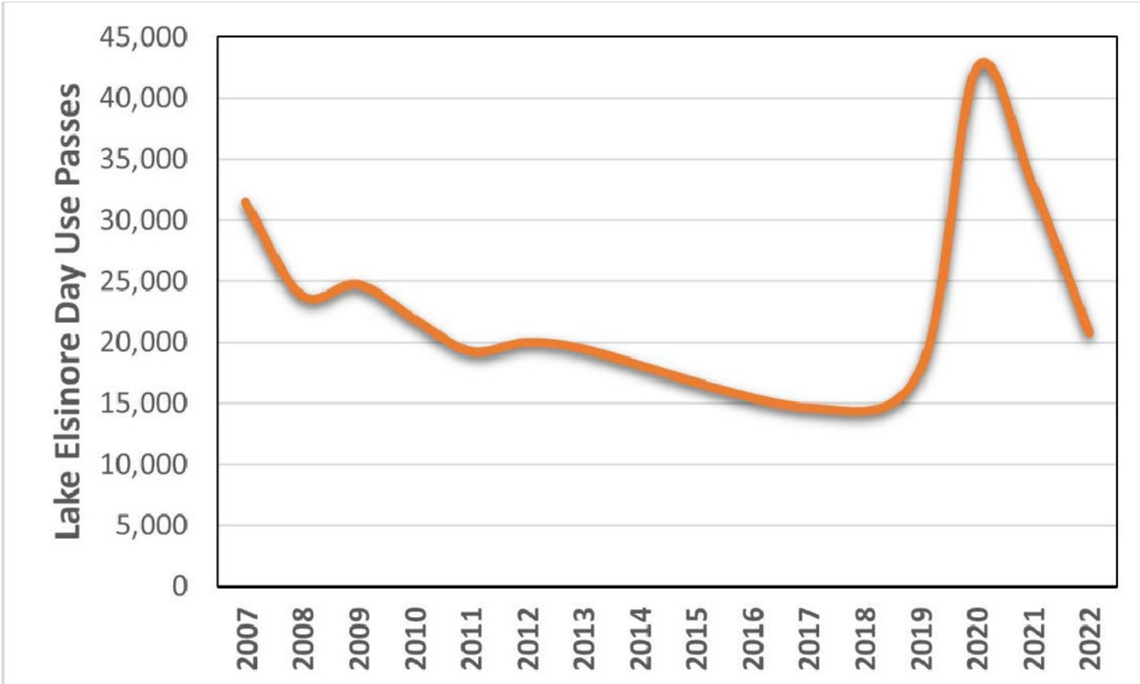

Figure 10-9. Declining Trend in Purchases of Lake Elsinore Day Use Passes (Data provided by Nicole Dailey, City of Lake Elsinore)

- 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.
- Reduced algae growth in Canyon Lake Main Lake will improve the treatability of water drawn from the lake by EVMWD for municipal water supply. Treatability for drinking water would be improved 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.
- Lastly, the water quality in lakes used for recreation has been proven to impact surrounding parcel scale property values. Voigt et al. (2015) found that a 1-m 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.

10.4 Antidegradation Analysis

EPA regulations, 40 C.F.R. section 131.12(a)(2), provide guidance on the protection of beneficial uses in high quality waters. In California, high-quality waters are determined on a parameter by parameter and pollutant by pollutant basis to minimize the potential for waters to not receive antidegradation protection. Under this section, discharges that would result in the degradation of high quality waters is prohibited, unless it is determined that lowering the water quality is (1) necessary to accommodate important economic and/or social developments in the watershed (2) satisfactory to all intergovernmental coordination and public participation provisions (3) assured the highest statutory and regulatory requirements for point sources and BMPs for nonpoint source controls are achieved.

Lake Elsinore is a terminal lake with a wide range of water quality conditions, including historical records of a completely dry lakebed. Of the most significant water quality problems identified in Lake Elsinore is hypereutrophication due to elevated phosphorous and nitrogen concentrations, resulting in high algal production and periodic fish kills. In the 1980's the physical structure of the lake was modified to reduce its surface area to reduce evaporative losses. In addition, recycled water has been added to the lake since 2006 to help maintain lake levels. Canyon Lake has also historically experienced high algal production and periodic fish kills due to elevated concentrations of phosphorus and nitrogen, though not as significant as Lake Elsinore. Given the historical water quality conditions experienced in both lakes, neither Lake Elsinore nor Canyon Lake are high quality waters as defined in 40 C.F.R. section 131.12(a)(2) or State Water Board Resolution 68-16, which incorporates state and federal antidegradation policies. Accordingly, existing uses and the level of water quality necessary to protect the existing uses shall be maintained and protected. (40 C.F.R. § 131.12.) This is done by ensuring that water quality in Lake Elsinore and Canyon Lake supports beneficial uses and meets applicable water quality objectives.

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 WQOs 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 revisions 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 revisions and the modified compliance schedules will not result in a reduction in expected lake water quality for any of the constituents listed in Table 2-1.

EPA regulations, 40 C.F.R. section 131.12(a)(3), apply to Outstanding National Resource Waters, such as National and State Parks. Neither Lake Elsinore nor Canyon Lake are part of an Outstanding National Resource Waters area.

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 certain categories of agriculture. Where necessary, the Santa Ana Water Board will revise WDRs to incorporate the requirements of the revised TMDLs (see Table 7-7, Phase II Task 2). Any authorized reduction in discharge quantity or quality for any type of discharger will trigger further an antidegradation analysis at that time. However, the revised TMDLs are not expected to result in such reductions.

11. References

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Appendix A– Supporting Biological Data

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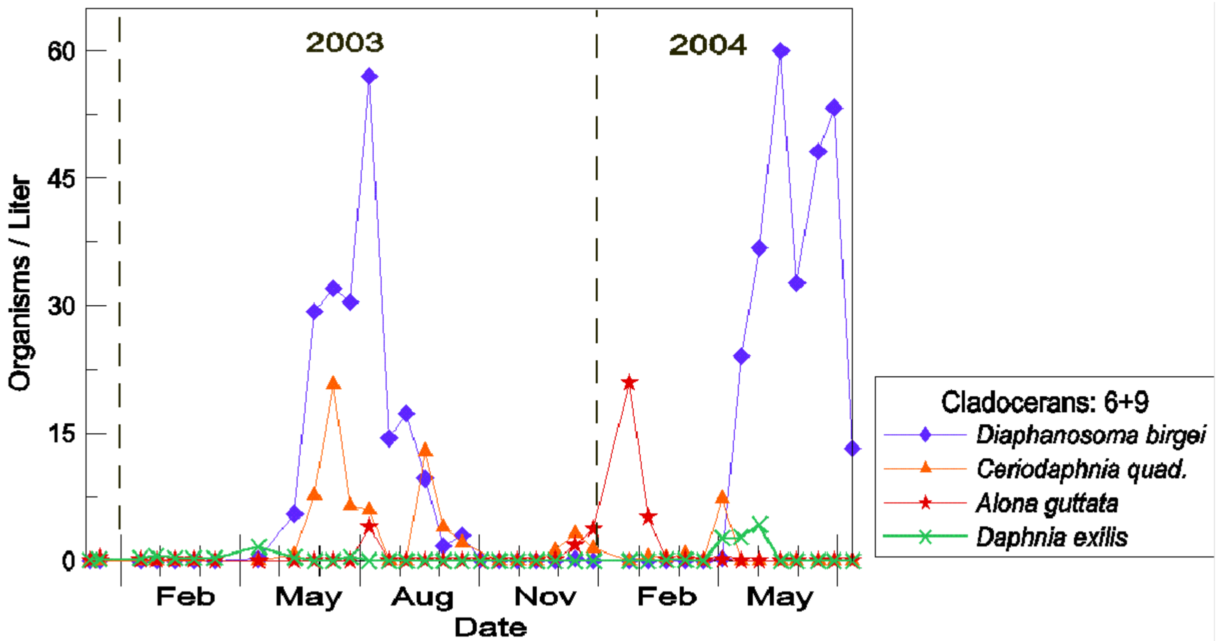


Figure A-1. Cladoceran Population Density at Deep Sites in Lake Elsinore (Sites 6+9) (Veiga Nascimento 2004)

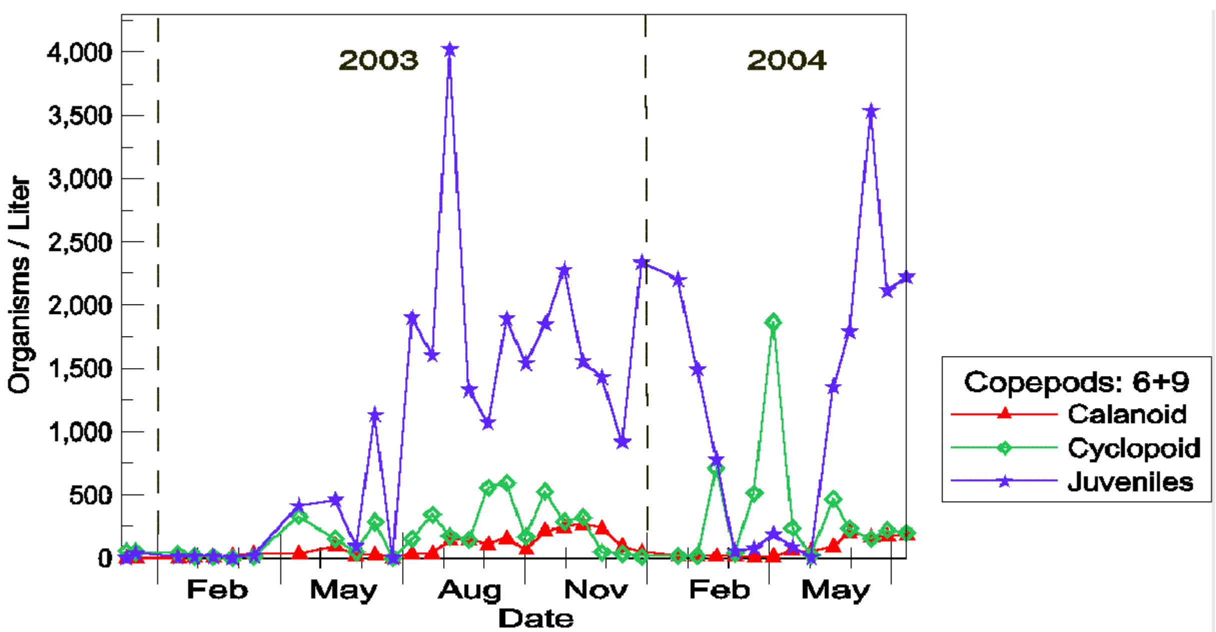


Figure A-2. Copepod Population Density at Deep Sites in Lake Elsinore (Sites 6+9) (Veiga Nascimento 2004)

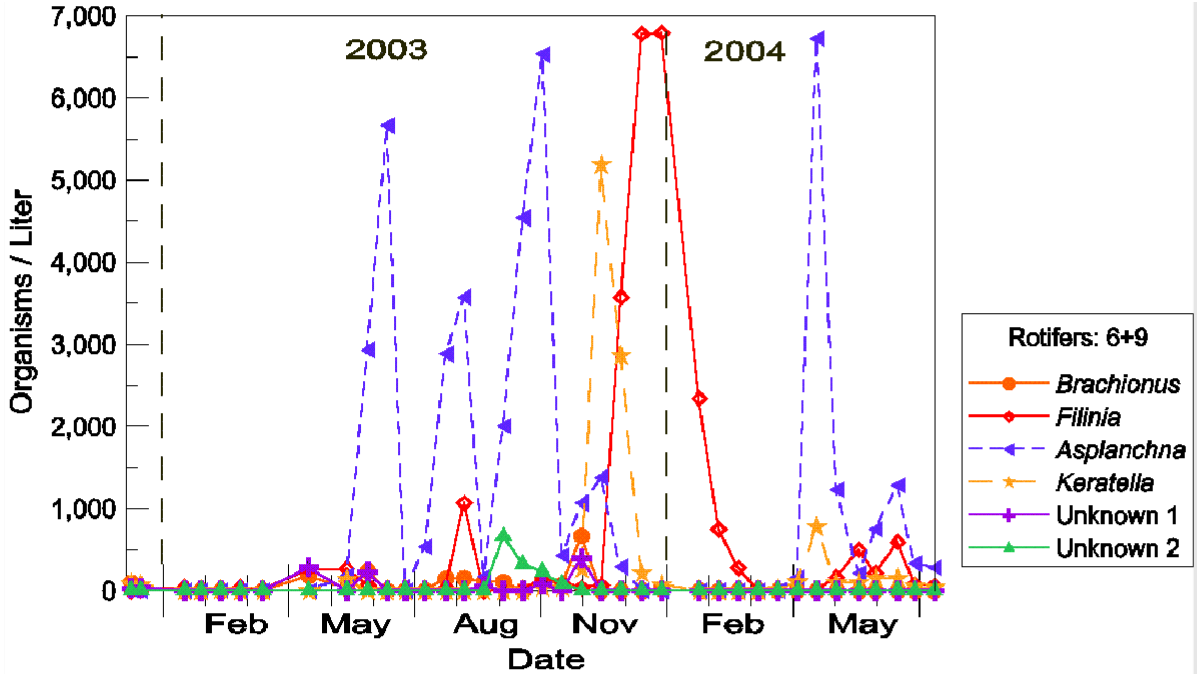


Figure A-3. Rotifer Population Density at Deep Sites in Lake Elsinore (Sites 6+9) (Veiga-Nascimento 2004)

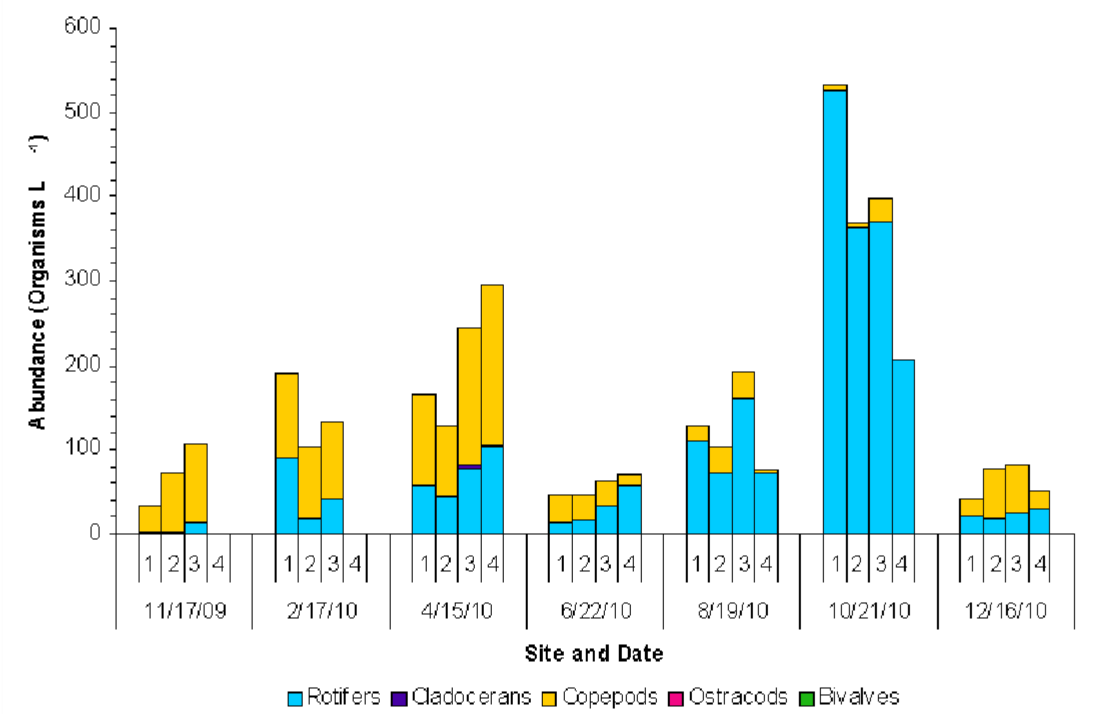


Figure A-4. Zooplankton Abundance by Major Groups at the Four Sampling Sites in Lake Elsinore from November 2009 through December 2010 (Tobin 2011)

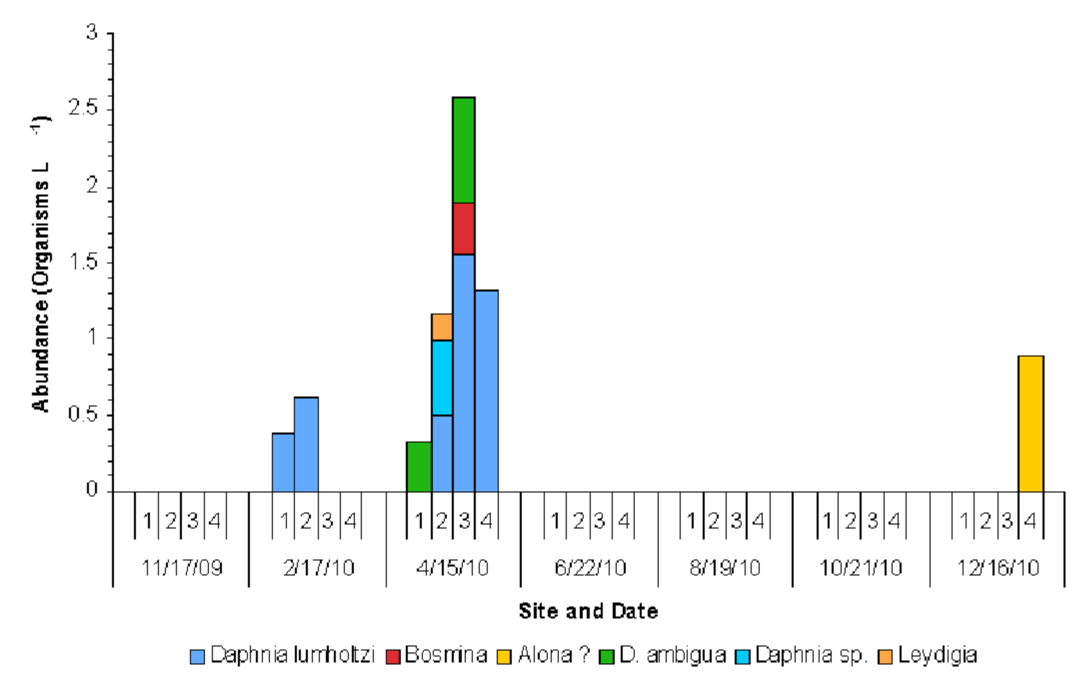
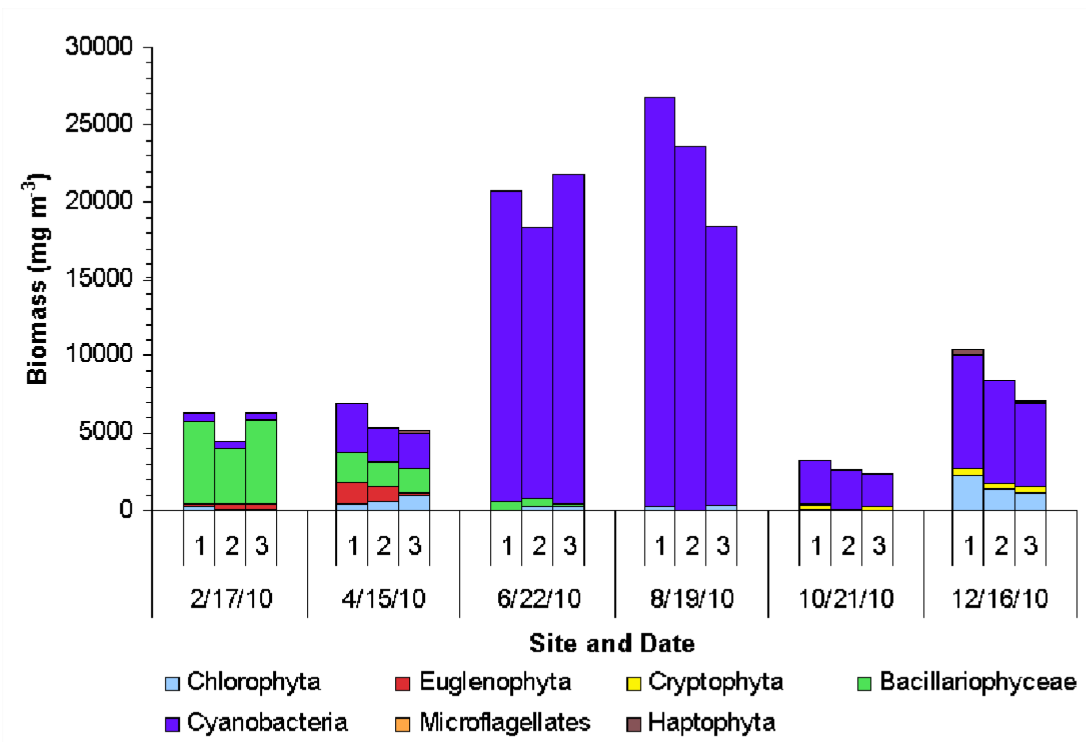


Figure A-5. Cladoceran Abundances by Species at the Four Sampling Sites in Lake Elsinore from November 17, 2009 through December 16, 2010 (Tobin 2011)



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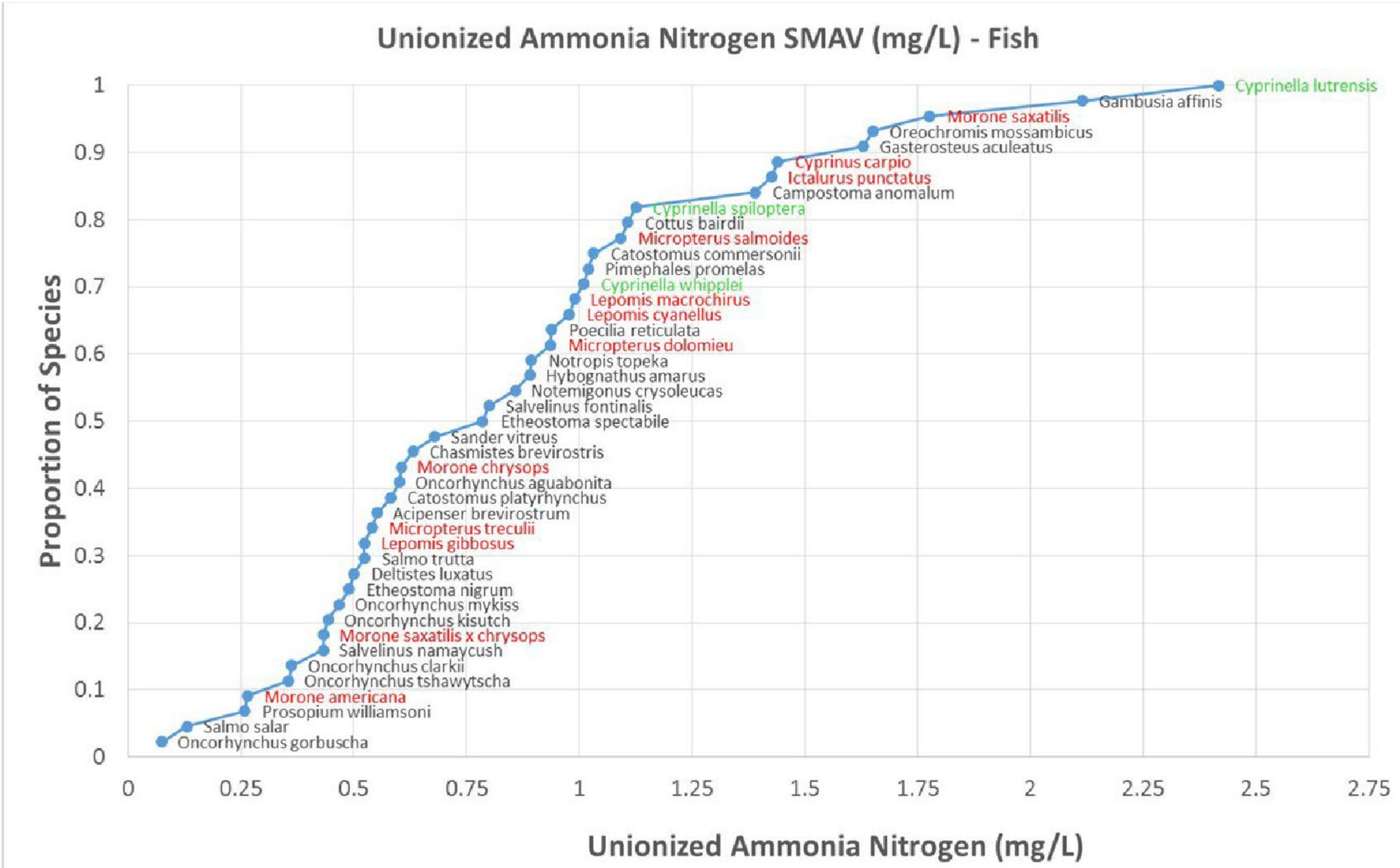


Figure A-7. Species Sensitivity Distribution of Fish Species, Plotting the Species Mean Acute Value (SMAV) Relative to Un-ionized Ammonia (those highlighted in red and green are species found in the lakes [red], or closely related species [green])

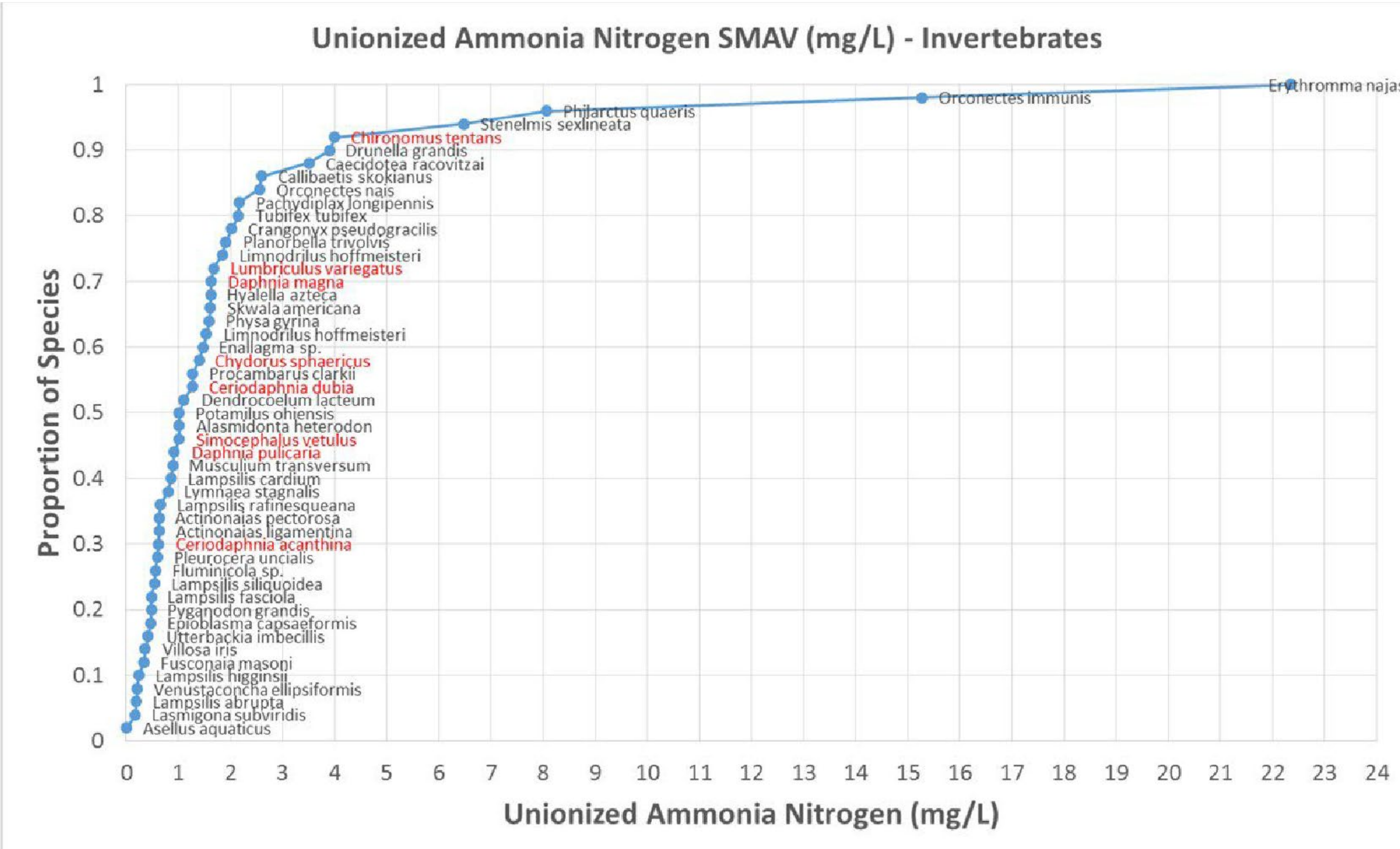


Figure A-8. Species Sensitivity Distribution of Various Aquatic Invertebrate Species, Plotting the Species Mean Acute Value (SMAV) Relative to Un-ionized Ammonia (those highlighted in red are species either found in the lakes or closely related species [i.e., same genus]).

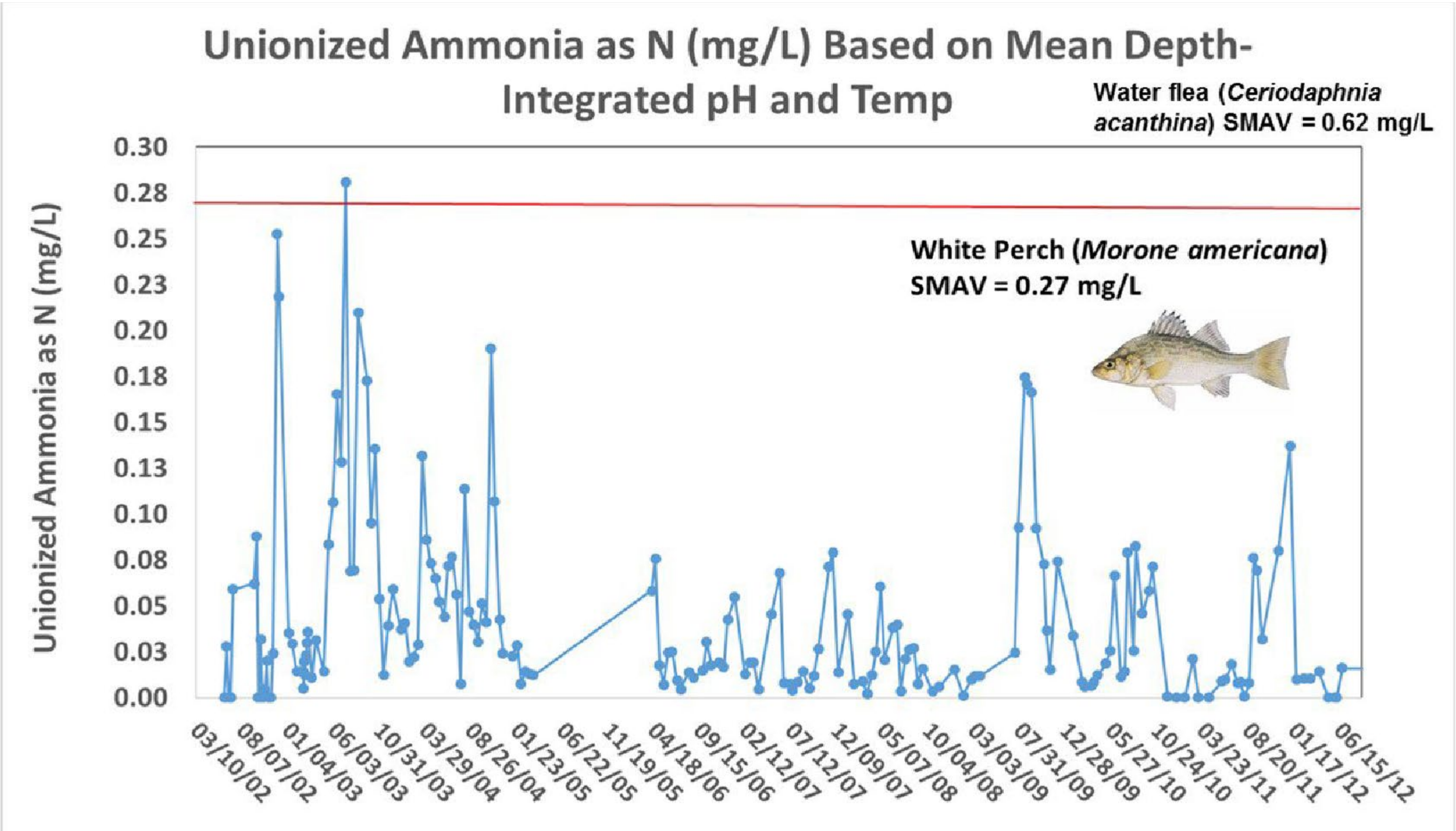


Figure A-9. Historical Un-ionized Ammonia Concentrations for Lake Elsinore (Site LEE2) Calculated from Depth Integrated Total Ammonia, pH, Temperature, and Salinity

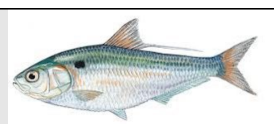
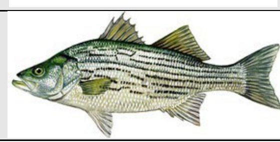
Table A-1. Hydroacoustic Fish Survey Results from Lake Elsinore Comparing Most Current Survey (April 2015) with Surveys Conducted in 2008 and 2010 (Anderson 2016b)

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*

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

Appendix B – PLOAD Model Data