Lake Elsinore and Canyon Lake Watersheds Nutrient TMDL Monitoring 2017-2018 Annual Report - FINAL

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TABLE OF CONTENTS

Page

1.0 Introduction 1
  1.1 Background 1
2.0 San Jacinto River Watershed-Wide Monitoring 3
  2.1 Summary of 2017-2018 Wet Weather Watershed Monitoring and Nutrient Loads 3
  2.2 Monitoring Strategy 4
  2.3 Monitoring Stations and Stream Gauge Locations 4
  2.4 Stream Gauge Records 6
  2.5 Sampling Strategy 9
  2.6 San Jacinto Watershed Monitoring Events 10
  2.7 San Jacinto Watershed Annual Water Quality Summary 11
    2.7.1 Summary of Monitoring Data – Salt Creek at Murrieta Road 11
    2.7.2 Summary of Monitoring Data – San Jacinto River at Goetz Road 16
    2.7.3 Summary of Monitoring Data – San Jacinto River at Ramona Expressway 20
    2.7.4 Summary of Monitoring Data – Cranston Guard Station 20
    2.7.5 Summary of Monitoring Data – Canyon Lake Spillway 20
  2.8 San Jacinto Watershed Rainfall Records 21
3.0 In-Lake Monitoring 23
  3.1 Background 23
  3.2 Lake Elsinore Monitoring 23
    3.2.1 Sampling Station Locations and Frequency 23
    3.2.2 Sampling Methods 26
    3.2.3 Water Quality Summary 27
  3.3 Canyon Lake Monitoring 44
    3.3.1 Sampling Station Locations and Frequency 44
    3.3.2 Sampling Methods 46
    3.3.3 Water Quality Summary 47
  3.4 Satellite Imagery 66
4.0 References 79

LIST OF APPENDICES

APPENDIX A WATERSHED MONITORING DATA
APPENDIX B QUARTERLY LAKE MONITORING REPORTS
APPENDIX C LAKE MONITORING ANALYTICAL REPORTS
APPENDIX D SATELLITE DATA REPORTS
APPENDIX E CANYON LAKE WATER LEVELS

LIST OF TABLES

Table 2-1. Summary of 2017-2018 Monitoring 4
Table 2-2. San Jacinto River Watershed Monitoring Stations 5
Table 2-3. Summary of Stream Gauge Data (July 2017 through June 2018)....... 7
Table 2-4. Water Quality Concentrations at Salt Creek at Murrieta Road 14
Table 2-5. Water Quality Event and Annual Loads at Salt Creek at Murrieta Road 14
Table 2-6. Water Quality Concentrations at San Jacinto River at Goetz Road....... 18
Table 2-7. Water Quality Event and Annual Loads at San Jacinto River at Goetz Road....... 18
Table 2-8. San Jacinto River Watershed Rainfall Gauges....... 21
Table 2-9. Summary Rainfall Data (July 2017 to June 2018) 22
Table 3-1. Lake Elsinore Sampling Station Locations 26
Table 3-2. In-lake Analytical Constituents and Methods for Lake Elsinore....... 26
Table 3-3. In-Situ Water Quality Parameter Measurements in Lake Elsinore – 2017 Monthly Means for Each Site 28
Table 3-4. In-Situ Water Quality Parameter Measurements in Lake Elsinore – 2018 Monthly Means for Each Site 28
Table 3-5. In-Situ Water Quality Parameter Measurements in Lake Elsinore - Annual Mean Statistics for Each Site 30
Table 3-6. Monthly Analytical Chemistry Results for Lake Elsinore....... 37
Table 3-7. Analytical Chemistry Summary for Lake Elsinore – Annual Mean Statistics 38
Table 3-8. State of California Proposed[d] Cyanobacteria Harmful Algal Bloom Trigger Levels....... 39
Table 3-9. Canyon Lake Sampling Station Locations 44
Table 3-10. In-lake Analytical Constituents and Methods for Canyon Lake....... 47
Table 3-11. In-Situ Water Quality Parameter Measurements for Canyon Lake - 2017 Monthly Means for Each Site 49
Table 3-12. In-Situ Water Quality Parameter Measurements for Canyon Lake - 2018 Monthly Means for Each Site 49
Table 3-13. In-Situ Water Quality Parameter Measurements for Canyon Lake - 2017 Monthly Means for Each Basin 50
Table 3-14. In-Situ Water Quality Parameter Measurements for Canyon Lake - 2018 Monthly Means for Each Basin 50
Table 3-15. In-Situ Water Quality Parameter Measurements for Canyon Lake - Annual Mean Statistics for Each Site 51
Table 3-16. Analytical Chemistry Results for Canyon Lake - 2017 Monthly Depth-Integrated Results....... 58
Table 3-17. Analytical Chemistry Results for Canyon Lake- 2018 Monthly Depth-Integrated Results....... 59
Table 3-18. Analytical Chemistry Results for Canyon Lake- Annual Mean Statistics for Each Site in the Main Basin 60
Table 3-19. Analytical Chemistry Results for Canyon Lake- Annual Mean Statistics for Each Site in the East Basin....... 61
Table 3-20. Analytical Chemistry Results for Canyon Lake- Annual Mean Statistics for Both Main and East Basins....... 62

LIST OF FIGURES

Figure 2-1. San Jacinto River Watershed Monitoring Stations 5
Figure 2-2. Site 3 – Salt Creek at Murrieta Road – Daily Stream Gauge Records 7
Figure 2-3. Site 4 – San Jacinto River at Goetz Road – Daily Stream Gauge Records 8
Figure 2-4. Site 30 – Canyon Lake Spillway – Daily Stream Gauge Records 8
Figure 2-5. Site 1 – San Jacinto River at Cranston Guard Station – Daily Stream Gauge Records 9
Figure 2-6. Storm Event at Salt Creek at Murrieta Road (January 9-10, 2018) 12
Figure 2-7. Storm Event at Salt Creek at Murrieta Road (February 27-28, 2018) 12
Figure 2-8. Storm Event at Salt Creek at Murrieta Road (March 22-23, 2018) 13
Figure 2-9. Hydrograph of First Storm Event at Salt Creek at Murrieta Road (January 9-10, 2018) 15
Figure 2-10. Hydrograph of Second Storm Event at Salt Creek at Murrieta Road (February 27-28, 2018) 15
Figure 2-11. Hydrograph of Third Storm Event at Salt Creek at Murrieta Road (March 22-23, 2018) 16
Figure 2-12. Storm Event at San Jacinto River at Goetz Road (January 9-10, 2018) 17
Figure 2-13. Storm Event at San Jacinto River at Goetz Road (March 22-25, 2018) 17
Figure 2-14. Hydrograph of First Storm Event at San Jacinto River at Goetz Road (January 9-10, 2018) 19
Figure 2-15. Hydrograph of Second Storm Event at San Jacinto River at Goetz Road (March 22-25, 2018) 20
Figure 2-16. Canyon Lake Level at Railroad Canyon Dam Spillway 21
Figure 3-1. Lake Elsinore Sampling Locations 25
Figure 3-2. Water Column Mean Dissolved Oxygen (DO) Rolling Average – Lake Elsinore – Site LE02 31
Figure 3-3. In- Situ Physical Water Quality Parameters - Lake Elsinore - Site LE01 32
Figure 3-4. In- Situ Physical Water Quality Parameters - Lake Elsinore Site LE02 33
Figure 3-4a. In- Situ Secchi Depth Measurements - Lake Elsinore Site LE02 34
Figure 3-5. In- Situ Physical Water Quality Parameters - Lake Elsinore Site LE03 35
Figure 3-6. Lake Elsinore Analytical Chemistry – Depth-Integrated Means (July 2017-June 2018) 40
Figure 3-7. Lake Elsinore Analytical Chemistry – Rolling Averages (August 2016 – June 2018) 41
Figure 3-8. Lake Elsinore Analytical Chemistry – Depth-Integrated and Surface Chlorophyll-a 42
Figure 3-9. Lake Elsinore Microcystin concentrations June 2017 to April 2018 43
Figure 3-10. Canyon Lake Sampling Locations 45
Figure 3-11. Mean In-Situ Physical Water Quality Parameters – Canyon Lake Main Basin 52
Figure 3-12. Mean In-Situ Physical Water Quality Parameters - Canyon Lake East Basin 53
Figure 3-12a. In- Situ Secchi Depth Measurements – Main and East Basins 54
Figure 3-13. Mean In-Situ Physical Water Quality Parameters - Canyon Lake Dissolved Oxygen Epilimnion and Hypolimnion Column Rolling Averages 55
Figure 3-14. Canyon Lake Analytical Chemistry – Depth-Integrated Means 63
Figure 3-15. Canyon Lake Analytical Chemistry – Depth-Integrated Chlorophyll-a 64
Figure 3-16. Canyon Lake Analytical Chemistry- Rolling Averages 65
Figure 3-17. Satellite Imagery of Chlorophyll-a Concentrations in Lake Elsinore 68
Figure 3-18. Satellite Imagery of Turbidity Concentrations in Lake Elsinore 70

LIST OF FIGURES (CONTINUED)

Figure 3-19. Satellite Imagery of Chlorophyll-a Concentrations in Canyon Lake 72
Figure 3-20. Satellite Imagery of Turbidity Measurements Canyon Lake 74
Figure 3-21. Cumulative Distribution of Satellite Derived Chlorophyll-a Concentrations in Lake Elsinore Relative to Field Collected Samples 76
Figure 3-22. Cumulative Distribution of Satellite Derived Chlorophyll-a Concentrations in Canyon Lake Relative to Field Collected Samples..77

ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
µS/cm	microSiemens per centimeter
Basin Plan	Water Quality Control Plan for the Santa Ana River Basin
CCC	criterion continuous concentration
cf	cubic feet
cfs	cubic feet per second
CMC	criterion maximum concentration
DO	dissolved oxygen
EVMWD	Elsinore Valley Municipal Water District
EMC	event mean concentration
Forest Service	San Bernardino Nation Forest Service
FY	fiscal year
kg	kilogram
LESJWA	Lake Elsinore and San Jacinto Watersheds Authority
LA	load allocation
Mgal	million gallons of water
mg/L	milligrams per liter
NPDES	National Pollutant Discharge Elimination System
NWS	National Weather Service
ND	non-detect
QAPP	Quality Assurance Project Plan
RCFC&WCD	Riverside County Flood Control and Water Conservation District
RWQCB	Regional Water Quality Control Board, Santa Ana Region
SAWPA	Santa Ana Watershed Project Authority
TDS	Total Dissolved Solids
TMDL Task Force	Lake Elsinore and Canyon Lake TMDL Task Force
TMDL	Total Maximum Daily Load
US EPA	U.S. Environmental Protection Agency
USGS	United States Geological Survey
WLA	waste load allocation

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1.0 Introduction

The following document summarizes results of compliance monitoring required in support of the Lake Elsinore and Canyon Lake Nutrient Total Maximum Daily Load (TMDL) for the 2017-2018 fiscal year (FY). The monitoring was performed according to the Lake Elsinore & Canyon Lake Nutrient TMDL Monitoring Quality Assurance Project Plan (QAPP) (Amec Foster Wheeler, September 2016), and the associated Compliance Monitoring Work Plan (Haley & Aldrich, Inc., July 2016).

1.1 Background

Lake Elsinore is a natural freshwater lake in southern California that provides a variety of natural habitats for terrestrial and aquatic species. The beneficial uses of the lake include water contact recreation (REC1), non-water contact recreation (REC2), commercial and sportfishing (COMM), warm freshwater habitat (WARM), wildlife habitat (WILD), and rare, threatened or endangered species (RARE)[1]. Canyon Lake was constructed in 1928 as the Railroad Canyon Reservoir. It is located approximately two miles upstream of Lake Elsinore and water spilled from Canyon Lake is a main source of water for Lake Elsinore during wet years. The beneficial uses of Canyon Lake include municipal and domestic water supply (MUN), agricultural supply (AGR), groundwater recharge (GWR), body contact recreation (REC1), non-body contact recreation (REC2), commercial and sportfishing (COMM), warm freshwater aquatic habitat (WARM), and wildlife habitat (WILD). The beneficial uses of COMM and RARE in Lake Elsinore and COMM in Canyon Lake were recently approved by the California Regional Water Quality Control Board, Santa Ana Region (RWQCB) as a Basin Plan Amendment under tentative resolution R8-2017-0019 on June 16, 2017.

In 1994, Lake Elsinore and Canyon Lake were first listed by the RWQCB on its Clean Water Act Section 303(d) list of impaired waterbodies. Both lakes remain on the latest approved 303(d) list finalized in 2010. Impairments identified for these waters included excessive levels of nutrients in both lakes, as well as organic enrichment/low dissolved oxygen (DO), sedimentation/siltation, unknown causes of toxicity in Lake Elsinore, and high bacterial indicators in Canyon Lake[2]. The Clean Water Act Section 303(d) requires the development and implementation of a TMDL for waters that do not or are not expected to meet water quality standards (beneficial uses, water quality objectives). In 2000, the RWQCB initiated the development of TMDLs for nutrients for Lake Elsinore and Canyon Lake.

In December 2004, the RWQCB adopted amendments to the Water Quality Control Plan for the Santa Ana River Basin (Basin Plan) to incorporate TMDLs for nutrients in Canyon Lake and Lake Elsinore. The Regional Board adopted the Resolution, and it was subsequently approved by the U.S. Environmental Protection Agency (US EPA) on September 30, 2005. The Basin Plan Amendment specifies, among other things, monitoring recommendations to track compliance with

[1] Based on federally listed Riverside fairy shrimp (*Streptocephalus woottoni*) in adjacent wetlands.
[2] The 303d listing for bacteria in Canyon Lake was addressed by the TMDL Task Force and Elsinore Valley Municipal Water District (EVMWD) through an enhanced special bacteria indicator monitoring study in 2009 by Montgomery Watson (EVMWD/ MWH, 2009). The results of this study found no exceedances relative to recreational contact water quality standards.

the TMDL and associated waste load allocations (WLAs) and monitoring to measure compliance towards in-lake numeric water quality targets. Numeric targets have been established and incorporated in the TMDL for nutrients (total nitrogen, phosphorous, and ammonia), DO, and chlorophyll-a; however, the ultimate compliance goal for beneficial uses in both lakes is to reduce enhanced eutrophication, which can negatively affect biological communities, result in fish kills, and impact recreational use. The recommendations outlined in RWQCB Resolution No. R8-2004-0037 required stakeholders to develop management plans and conduct long-term monitoring and implementation programs aimed at reducing nutrient loads to Lake Elsinore and Canyon Lake. Task 4 of the adopted Lake Elsinore and Canyon Lake TMDL Amendment required stakeholders to prepare and implement a Nutrient Monitoring Program. The program was to include the following:

1. A watershed-wide monitoring program to determine compliance with interim and/or final nitrogen and phosphorus allocations; compliance with the nitrogen and phosphorus TMDL, and load allocations (LAs), including WLAs.

2. A Lake Elsinore in-lake nutrient monitoring program to determine compliance with interim and final nitrogen, phosphorus, chlorophyll-a, and DO numeric targets.

3. A Canyon Lake in-lake nutrient monitoring program to determine compliance with interim and final nitrogen, phosphorus, chlorophyll-a, and DO numeric targets.

4. An draft annual report summarizing the data collected for the year and evaluating compliance with the TMDL, due August 15 of each year.

Since August 2001, the Lake Elsinore and San Jacinto Watershed Authority (LESJWA) has been working with local stakeholders and the Santa Ana Regional Water Quality Control Board to identify the source of nutrients impairing each lake, and evaluate the impacts to water quality and beneficial uses incurred from nutrient sources.

At that time, LESJWA contracted with the State to serve as a neutral facilitator for the RWQCB to assist in formation of a TMDL workgroup and assisting the workgroup in participating with the RWQCB in the development and definition of the TMDLs.

With formal adoption of the Lake Elsinore and Canyon Lake nutrient TMDLs on December 20, 2004, stakeholders named in the TMDLs began the process to create a formal cost sharing body, or Task Force to implement a number of tasks defined within the TMDLs.

In November 2006, stakeholders finalized an agreement to form the Lake Elsinore and Canyon Lake TMDL Task Force. The TMDL Task Force consists of representatives from local cities, Riverside County, agriculture and dairy, and the regulatory community. At the request of the stakeholders and RWQCB, LESJWA staffed by the Santa Ana Watershed Project Authority (SAWPA) serves as administrator of the Task Force and overseesthe TMDL development process for Lake Elsinore and Canyon Lake.

LESJWA, in support of the TMDL Task Force, provided funding to meet the requirement of the TMDL by developing a single comprehensive watershed-wide nutrient Monitoring Plan. The Lake Elsinore and Canyon Lake Nutrient TMDL Monitoring Plan was approved by the RWQCB in March

2006 and subsequently implemented by the TMDL Task Force in April 2006 through October 2012. During this time frame, the in-lake monitoring for both lakes was conducted through the Elsinore Valley Municipal Water District (EVMWD) National Pollutant Discharge Elimination System (NPDES) compliance program (Order No. R8-2005-0003 for NPDES No. CA8000027 for the Regional Water Reclamation Plant, Lake Elsinore, Riverside County approved March 4, 2005). On October 26, 2012 the Regional Board issued a resolution (Resolution No. R8-2012-0052) granting the TMDL Task Force a temporary suspension of in-lake TMDL monitoring programs to achieve cost savings that were applied to implementing lake improvement projects aimed at reducing nutrient impacts in Canyon Lake and Lake Elsinore. Therefore, the Lake Elsinore and Canyon Lake TMDL field compliance monitoring was not conducted for the 2013-2014 and 2014-2015 FY cycles.

The in-lake water quality monitoring for both lakes was resumed in July 2015 as Phase II of the Lake Elsinore and Canyon Lake Nutrient TMDL Monitoring Program moving forward. Under the Phase II Monitoring Program, concurrent efforts are underway to reevaluate the appropriateness and applicability of the TMDL criteria. The results of the 2017-2018 FY in-lake and watershed monitoring efforts are summarized herein.

2.0 San Jacinto River Watershed-Wide Monitoring

The study design for Phase II of the San Jacinto River Watershed Monitoring Program is to continue to determine nutrient loading into Canyon Lake and Lake Elsinore from upstream watershed sources to add to the historical monitoring data set to evaluate long-term trends. The primary objectives of the Phase II San Jacinto River Watershed Monitoring Program are as follows:

1. Determine the total nutrient loads into Lake Elsinore and Canyon Lake from their tributaries (i.e., the San Jacinto River, Salt Creek, and Cottonwood Creek).
2. Determine the total nutrient load from various sources categorized by land use types, namely, agricultural, urban runoff, and open space sources which drain into the above-mentioned tributaries.
3. Provide water quality data for watershed model updates.
4. Provide water quality data to evaluate TMDL compliance with WLAs and LAs.

Watershed monitoring and reporting was performed by Alta Environmental of San Diego, California.

2.1 Summary of 2017-2018 Wet Weather Watershed Monitoring and Nutrient Loads

A summary of the water quality monitoring data for each of the five monitoring locations for the period of July 1, 2017 through June 30, 2018, is presented in Table 2-1 below. A more detailed account, including storm hydrographs and event loads are presented in Section 2.7 for each monitoring location. The complete set of water quality data, including water quality field measurements is included in Appendix A.

Table 2-1. Summary of 2017-2018 Monitoring

Number and Location Description	Total Annual Flow [a] (Mgal)	Annual Event Mean Storm Concentration (mg/L)		Estimated Annual Load (kg)	
		Total Nitrogen	Total Phosphorus	Total Nitrogen	Total Phosphorus
Site 3 - Salt Creek at Murrieta Road (USGS 11070465)	271	2.73	0.39	2,586	482
Site 4 - San Jacinto River at Goetz Road (USGS 11070365)	393	1.95	0.41	3,055	810
Site 6 - San Jacinto River at Ramona Expressway [b] (USGS 11070210)	0	-	-	-	-
Site 30 - Canyon Lake Spillway [c] (USGS 11070500)	117	Not Measured [c]	Not Measured [c]	Not Measured [c]	Not Measured [c]

a - Flow data after 11/07/2017 are provisional and may be subject to change.
b - No flows occurred at the TMDL monitoring location just downstream of Mystic Lake, which has been actively subsiding.
c – Not measured as the lake did not overtop the Canyon Lake Spillway during the 2017-2018 monitoring period. The USGS stream gauge at Site 30 (USGS 11070500) is located downstream of Canyon Lake on the San Jacinto River close to the river entrance to Lake Elsinore. This downstream location is influenced by local urban runoff and groundwater seepage in addition to the flows from Canyon Lake.
Mgal = million gallons; 1 million gallons = 133,680 cubic feet; mg/L = milligrams per liter; kg = kilograms; USGS = United States Geological Survey.

2.2 Monitoring Strategy

Phase II of the San Jacinto River Watershed Monitoring Program follows the guidelines detailed in the Lake Elsinore and Canyon Lake Nutrient TMDL Compliance Monitoring Plan. The Phase II San Jacinto River Watershed Monitoring Program sampling activities during the 2017-2018 monitoring period included collection of samples during three storm events at the designated monitoring stations throughout the San Jacinto River Watershed.

2.3 Monitoring Stations and Stream Gauge Locations

To monitor TMDL compliance, five sampling stations were carefully selected to reflect various types of land uses within the San Jacinto River Watershed. These locations have been monitored since 2006. Sampling station locations were deliberately set up to be within the vicinity of United States Geological Survey (USGS) or the Riverside County Flood Control and Water Conservation District (RCFC&WCD) stream gauge stations. The sampling stations are listed in Table 2-2 below and shown on Figure 2-1.

Three of the five sites (Station IDs 745, 759, and 741) were selected because they are indicative of inputs to Canyon Lake originating from the main stem of the San Jacinto River, Salt Creek, and the watershed above Mystic Lake. The sampling location along the San Jacinto River at Ramona Expressway (Station 741) is located downgradient of Mystic Lake, an area of land subsidence. Flow has not been observed at this location since a strong El Niño event in the mid-1990s.

Because of the active subsidence, this monitoring station is not expected to flow except under extremely high rainfall conditions.

Table 2-2. San Jacinto River Watershed Monitoring Stations

Station ID	USGS Station ID	Agency	Site Number and Location Description
745	11070465	USGS	Site 3 - Salt Creek at Murrieta Road
759	11070365	USGS	Site 4 - San Jacinto River at Goetz Road
741	11070210	USGS	Site 6 - San Jacinto River at Ramona Expressway
841	11070500	USGS	Site 30 - Canyon Lake Spillway
792	11069500	RCFC&WCD or USGS	Site 1 - San Jacinto River at Cranston Guard Station

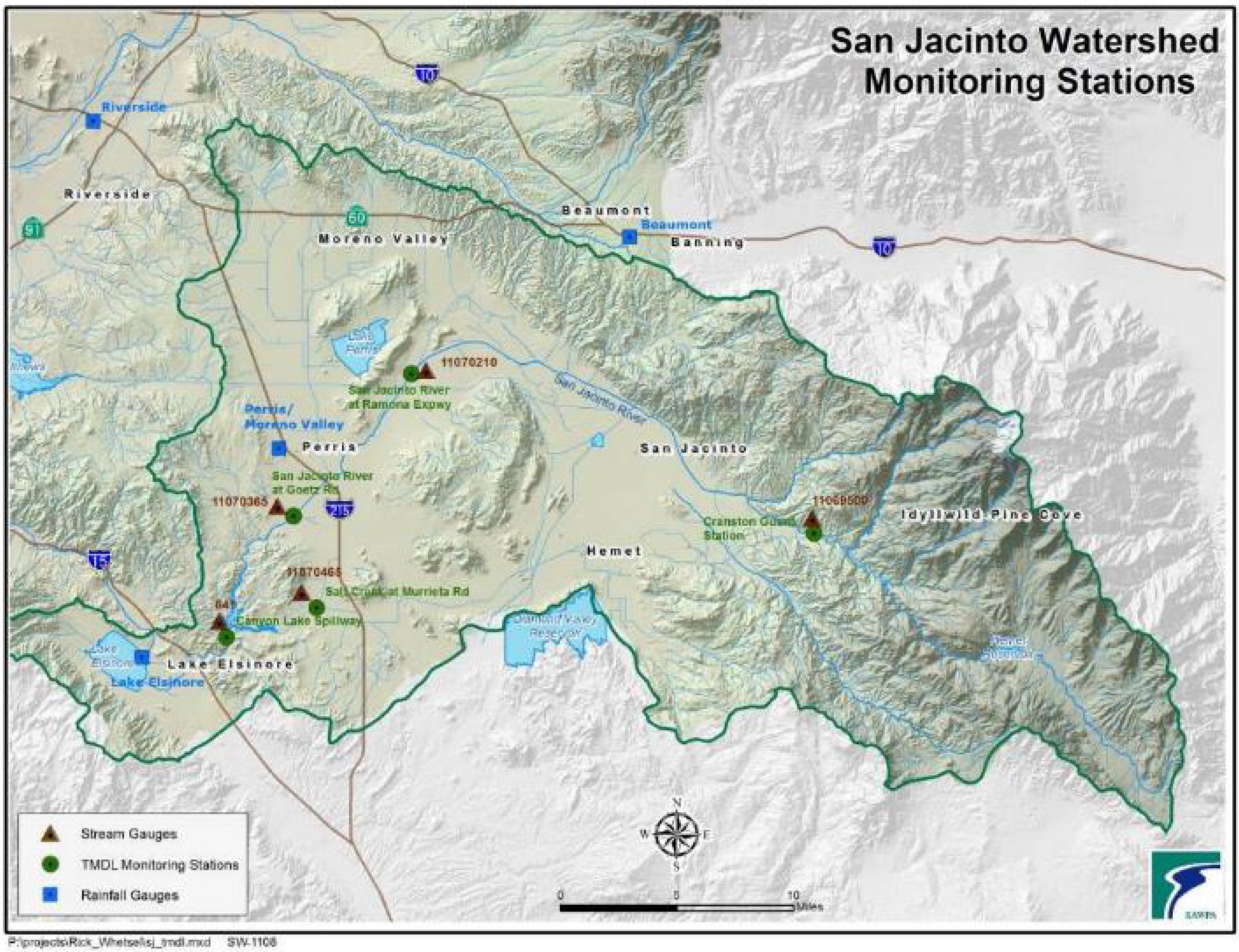

Figure 2-1. San Jacinto River Watershed Monitoring Stations

The fourth site, located below the Canyon Lake Dam (Station ID 841) is indicative of loads entering Lake Elsinore from Canyon Lake and the upstream watershed when the water level overtops the Railroad Canyon Dam Spillway. The Railroad Canyon Dam Spillway elevation at Canyon Lake is 1,381.76 feet. Samples are collected from this location during storm events that create lake levels that overtop the dam spillway elevation. The Canyon Lake level is publicly available at the following website:

http://www.evmwd.com/about/departments/public/lake.asp

The fifth site at the Cranston Guard Station site on the San Jacinto River (Station 792) was only monitored between 2007 and 2011 by the San Bernardino National Forest Service (Forest Service), in accordance with their agreement for in-lieu obligations to the Task Force. This work, however, was dependent on sufficient funds being allocated by Congress to complete the work. In 2012, the Forest Service pulled out of the Task Force and no longer provides monitoring support.

2.4 Stream Gauge Records

The USGS and RCFC&WCD monitor stream flow from several gauging stations in the San Jacinto River Watershed. Stream gauging stations maintained and operated for Phase II of the San Jacinto Watershed Monitoring Program are shown in Figure 2-1 and identified in Table 2-2.

The data record captured per USGS stream gauge is publicly available at the following website:

http://waterdata.usgs.gov/ca/nwis/current/?type=flow

A summary of the stream gauge data recorded at each of the stations with measured flow for the monitoring period of July 1, 2017 through June 30, 2018 is presented in Table 2-3 and visually presented in Figure 2-2 through Figure 2-5. The mean monthly flows reported in Table 2-3 characterize the average instantaneous flow rate at the USGS station during both dry and wet weather conditions. The flow data are downloaded from the USGS website and are considered provisional for approximately six months; therefore, flow data presented after November 7, 2017, in this report are provisional. The provisional data provided by the USGS are subject to change and are not citable until reviewed and approved by the USGS. The complete set of stream gauge data is included as Appendix A.

Table 2-3. Summary of Stream Gauge Data (July 2017 through June 2018)

July 2017-June 2018 Mean Monthly Flow (cfs) [a]	Site 3 - Salt Creek at Murrieta Road (11070465)	Site 4 - San Jacinto River at Goetz Road (11070365)	Site 6 - San Jacinto River at Ramona Expressway [b] (11070210)	Site 30 - Canyon Lake Spillway (11070500)	Site 1 - San Jacinto River at Cranston Guard Station (11069500)
July	0.00	0.00	-	0.00	0.43
August	0.25	0.78	-	0.00	0.32
September	0.00	0.00	-	0.00	0.19
October	0.00	0.00	-	0.05	0.15
November	0.00	0.00	-	0.41	0.15
December	0.00	0.00	-	0.60	0.23
January	12.26	16.25	-	2.53	1.41
February	0.18	0.00	-	0.95	0.59
March	0.77	2.60	-	0.89	8.31
April	0.00	0.00	-	0.38	0.81
May	0.00	0.00	-	0.14	0.23
June	0.00	0.00	-	0.00	0.08
Mean Annual Flow (cfs)	**1.15**	**1.67**	**-**	**0.50**	**1.09**

Notes:
a - This value characterizes the average instantaneous flow rate at the USGS station during both dry and wet weather conditions in a given month. Flow data after 11/07/2017 are provisional and may be subject to change.
b - No flows were reported at Site 6 for the monitoring period.
cfs = cubic feet per second.

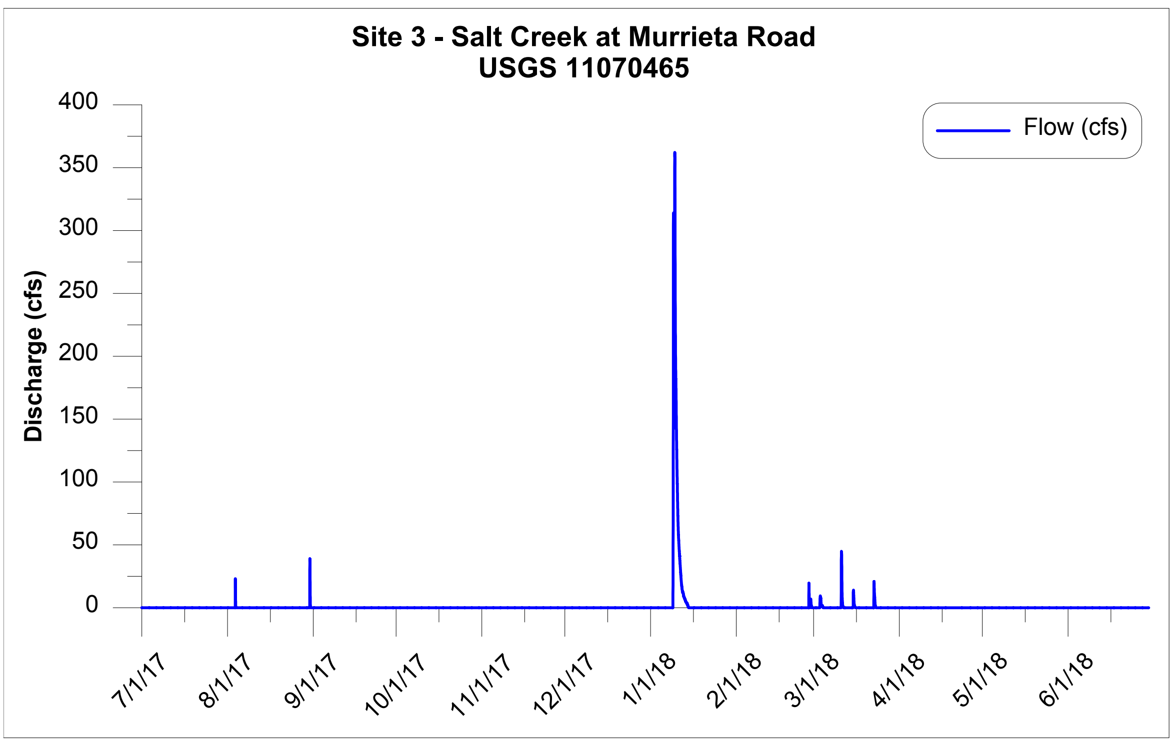

Figure 2-2. Site 3 – Salt Creek at Murrieta Road – Daily Stream Gauge Records

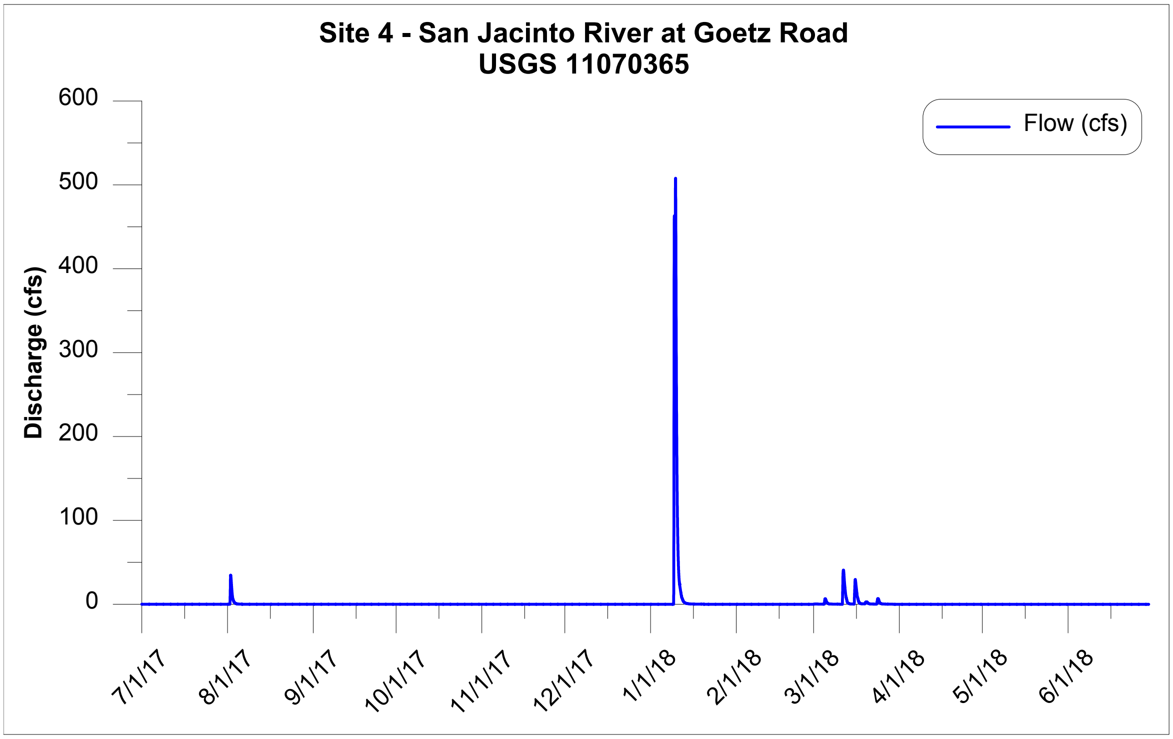

Figure 2-3. Site 4 – San Jacinto River at Goetz Road – Daily Stream Gauge Records

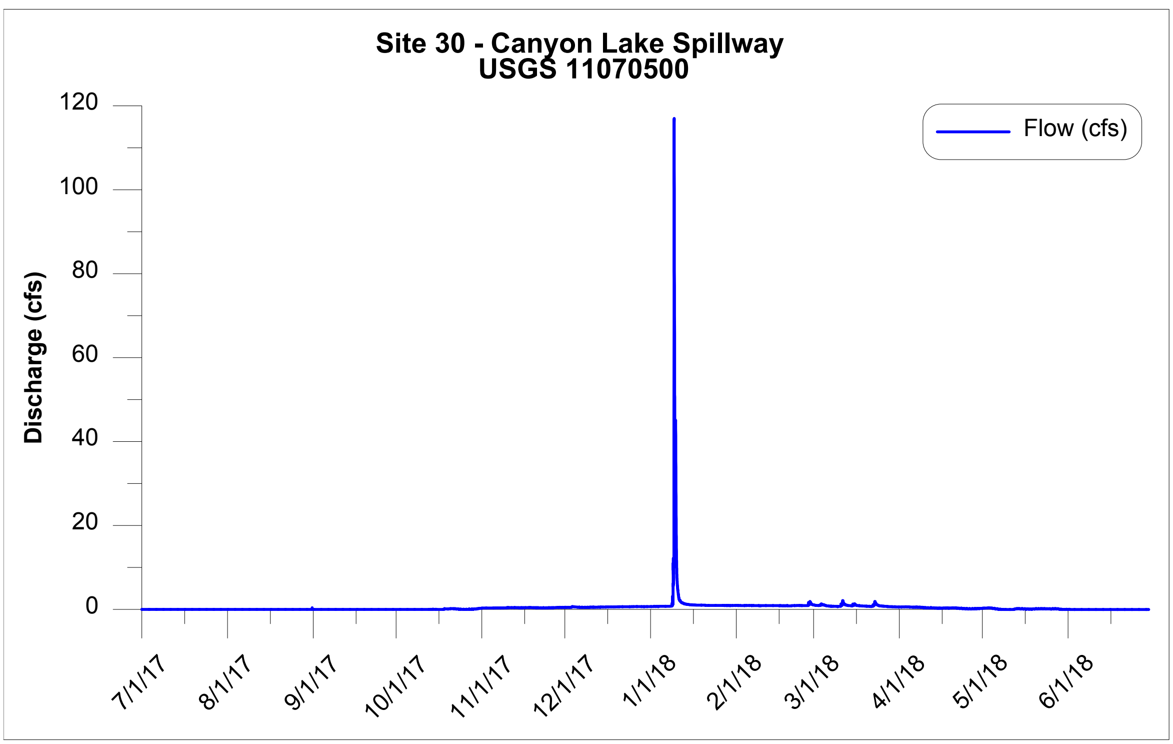

Figure 2-4. Site 30 – Canyon Lake Spillway – Daily Stream Gauge Records

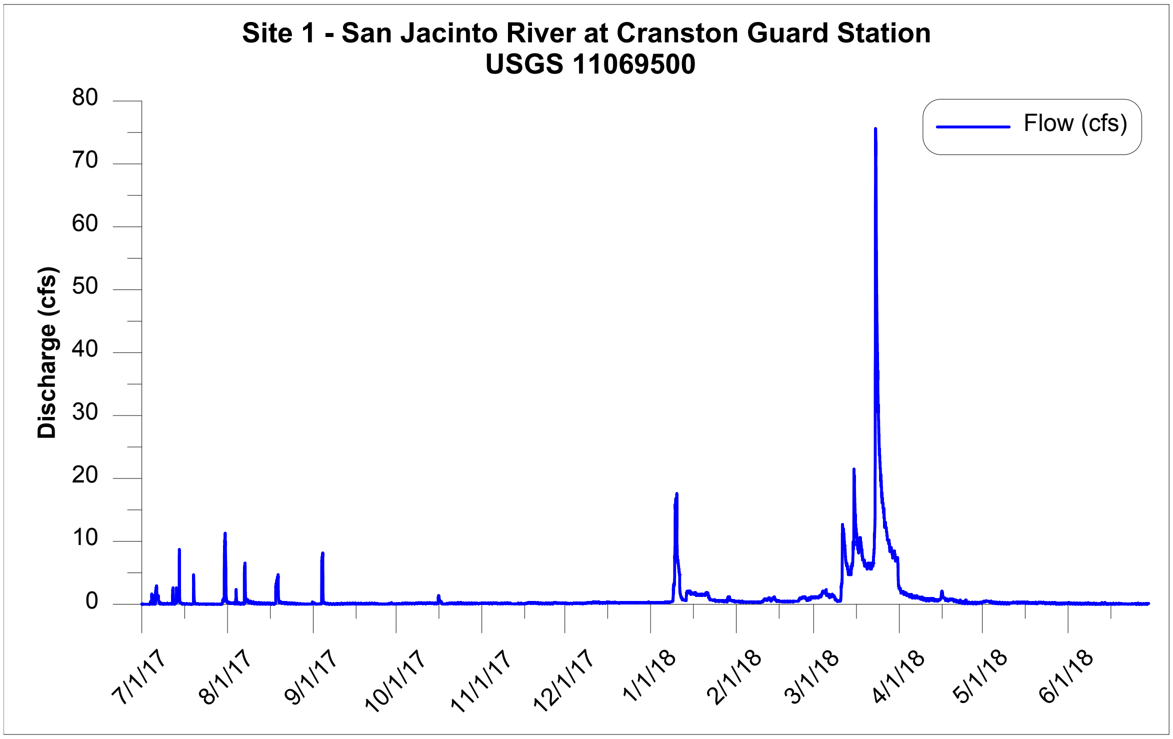

Figure 2-5. Site 1 – San Jacinto River at Cranston Guard Station – Daily Stream Gauge Records

2.5 Sampling Strategy

Phase II of the San Jacinto River Watershed Monitoring Program includes collecting water quality samples during three storm events at the designated monitoring stations throughout the San Jacinto River Watershed. Throughout the wet weather monitoring period from October 1, 2017 to May 31, 2018, the National Weather Service (NWS) forecasts were monitored to determine when storm events met the mobilization criteria. The mobilization criteria for sampling requires a NWS quantitative precipitation forecast greater than a 1.0-inch forecast within 24 hours from October 1 through December 31, and greater than an 0.5-inch forecast within 24 hours from January 1 through May 31.

Flow-weighted composite samples were collected during three storm events at the designated monitoring stations. Discrete sample aliquots were collected over the rising limb (increasing flow) and the falling limb (decreasing flow) of the hydrograph using automatic sampling equipment (e.g., ISCO autosamplers). The first sample aliquot was taken at or shortly after the time that storm water runoff began, and each subsequent aliquot of equal volume was collected at intervals of approximately 1 to 2 hours across the hydrograph, depending on the forecasted size of the storm event. Flow rates and volumes were based on data from USGS stream gauges located near the sampling stations. Upon completion of sampling, field teams downloaded the USGS flow data and subsampled each discrete sample to create a single flow-weighted composite sample for laboratory analysis.

The following protocols were applied:

- Sampling commenced once flow was established in the channel.
- Field measurements (temperature, pH, conductivity, dissolved oxygen, and turbidity) were recorded in the field using portable calibrated YSI multi-parameter meters, or equivalent.
- Biochemical Oxygen Demand and Chemical Oxygen Demand were analyzed for the first discrete grab sample only.

Sampling and analysis followed the guidelines detailed in the Lake Elsinore and Canyon Lake Nutrient TMDL Compliance Monitoring Plan. More detail regarding the sampling approach (e.g., compositing, sample naming conventions) are described in the Lake Elsinore and Canyon Lake Nutrient TMDL Compliance QAPP.

Samples for all analytical chemistry measurements were submitted to Babcock Laboratories Inc. located in Riverside, California.

2.6 San Jacinto Watershed Monitoring Events

Water quality samples were collected during three storm events that met the mobilization criteria during the wet weather monitoring period from October 1, 2017 to April 30, 2018.

The first monitoring event occurred on January 9, 2018 through January 10, 2018. Water quality samples were collected at Salt Creek at Murrieta Road (Station ID 745) and San Jacinto River at Goetz Road (Station ID 759). A peak flow of 362 cubic feet per second (cfs) was recorded at Salt Creek at Murrieta Road (Station ID 745) and a peak flow of 508 cfs was recorded at San Jacinto River at Goetz Road (Station ID 759). No flows exited Canyon Lake during the monitoring event (i.e., the water level in Canyon Lake did not crest the spillway) and no flows were recorded at the San Jacinto River at Ramona Expressway (Station ID 741). A total of 1.83 to 2.34 inches of rainfall was recorded in the region during this storm[3].

The second monitoring event occurred on February 27, 2018 through February 28, 2018. Water quality samples were collected at Salt Creek at Murrieta Road (Station ID 745). A peak flow of 19.6 cfs was recorded at Salt Creek at Murrieta Road (Station ID 745). No flow was recorded at San Jacinto River at Goetz Road (Station ID 759), no flows exited Canyon Lake during the monitoring event, and no flows were recorded at the San Jacinto River at Ramona Expressway (Station ID 741). A total of 0.11 to 0.49 inches of rainfall was recorded in the region during this storm[3].

The third monitoring event occurred on March 22, 2018 through March 25, 2018. Water quality samples were collected at Salt Creek at Murrieta Road (Station ID 745) and San Jacinto River at Goetz Road (Station ID 759). A peak flow of 20.9 cfs was recorded at Salt Creek at Murrieta Road (Station ID 745) and a peak flow of 6.9 cfs was recorded at San Jacinto River at Goetz Road (Station ID 759). No flows exited Canyon Lake during the monitoring event and no flows were

[3] http://rcflood.org/RainFallMap.aspx

recorded at the San Jacinto River at Ramona Expressway (Station ID 741). A total of 0.22 to 0.41 inches of rainfall was recorded in the region during this storm[3].

No additional storm events met the mobilization criteria during the remainder of the wet weather monitoring period through May 31, 2018.

2.7 San Jacinto Watershed Annual Water Quality Summary

A summary of watershed water quality monitoring data for each of the five monitoring locations for the monitoring period of July 1, 2017 through June 30, 2018, is presented below. The complete set of water quality data for the monitoring period is included as Appendix A.

Included with each summary of the monitoring data are the concentrations for each analyte. Also included are the estimated storm event loads and annual loads for each analyte.

2.7.1 Summary of Monitoring Data – Salt Creek at Murrieta Road

Water quality samples were collected during three storm events at Salt Creek at Murrieta Road (Station ID 745) during the wet weather monitoring period from October 1, 2017 to April 30, 2018.

During the first storm event on January 9, 2018 through January 10, 2018, a total of 32 discrete samples were collected across the hydrograph at one-hour intervals and a single flow-weighted composite sample was submitted for analysis. Based on data provided by the nearby USGS stream gauge (Station ID 11070465), flow for the storm event was estimated at 32,874,777 cubic feet (cf) or 246 million gallons (Mgal).

During the second storm event on February 27, 2018 through February 28, 2018, a total of 23 discrete samples were collected across the hydrograph at one-hour intervals and a single flow-weighted composite sample was submitted for analysis. Based on data provided by the nearby USGS stream gauge (Station ID 11070465), flow for the storm event was estimated at 438,336 cf or 3.3 Mgal.

During the third event on March 22, 2018 through March 23, 2018, a total of 17 discrete samples were collected across the hydrograph at one-hour intervals and a single flow-weighted composite sample was submitted for analysis. Based on data provided by the nearby USGS stream gauge (Station ID 11070465), flow for the storm event was estimated at 494,766 cf or 3.7 Mgal.

Photos taken during the storm events are provided in Figure 2-6, Figure 2-7, and Figure 2-8.

Figure 2-6. Storm Event at Salt Creek at Murrieta Road (January 9-10, 2018)

Figure 2-7. Storm Event at Salt Creek at Murrieta Road (February 27-28, 2018)

Figure 2-8. Storm Event at Salt Creek at Murrieta Road (March 22-23, 2018)

Event and annual mean concentrations for each analyte are presented in Table 2-4. Event and annual loads for each analyte are presented in Table 2-5. Concentrations for nutrients for the three storm events range from 1.7 to 4.0 milligrams per liter (mg/L) for total nitrogen, and 0.26 to 0.48 mg/L for total phosphorus (Table 2-4). Based on flow data provided by the nearby USGS stream gauge (Station ID 11070465), the total annual flow was estimated at 36,202,266 cf or 271 Mgal for the period of July 1, 2017 through June 30, 2018. No dry weather flows enter Canyon Lake from Salt Creek at Murrieta Road (Station ID 745) and the storm flows account for the estimated annual load of nutrients. The estimated annual nutrient load was calculated to be 2,586 kg for total nitrogen and 482 kg for total phosphorus (Table 2-5) for the period of July 1, 2017 through June 30, 2018.

Table 2-4. Water Quality Concentrations at Salt Creek at Murrieta Road

Analyte	Units	Event 1	Event 2	Event 3	Annual Mean	Annual Geomean
Ammonia-Nitrogen	mg/L	0.25	0.50	0.18	0.31	0.28
Chemical Oxygen Demand	mg/L	100	55	46	67	63
Kjeldahl Nitrogen	mg/L	1.6	2.4	1.2	1.7	1.7
Nitrate as N	mg/L	0.92	1.50	0.48	0.97	0.87
Nitrite as N	mg/L	0.05	0.11	0.05	0.07	0.07
Organic Nitrogen	mg/L	1.4	19.0	1.0	7.1	3.0
Total Nitrogen	mg/L	2.5	4.0	1.7	2.7	2.6
Total Phosphorus	mg/L	0.48	0.43	0.26	0.39	0.38
Ortho Phosphate Phosphorus	mg/L	0.22	0.42	0.16	0.27	0.25
Total Dissolved Solids	mg/L	390	120	120	210	178
Total Hardness	mg/L	190	51	51	97	79
Total Suspended Solids	mg/L	27	22	19	23	22

Table 2-5. Water Quality Event and Annual Loads at Salt Creek at Murrieta Road

Analyte	Units	Load Event 1	Load Event 2	Load Event 3	Annual Load
Ammonia-Nitrogen	kg	233	6.2	2.5	262
Chemical Oxygen Demand	kg	93,091	683	644	98,961
Kjeldahl Nitrogen	kg	1,489	29.8	16.8	1,654
Nitrate as N	kg	856	18.6	6.7	947
Nitrite as N	kg	46.5	1.4	0.7	53.4
Organic Nitrogen	kg	1,303	235.8	14.0	2,037
Total Nitrogen	kg	2,327	49.6	23.8	2,586
Total Phosphorus	kg	447	5.3	3.6	482
Ortho Phosphate Phosphorus	kg	205	5.2	2.2	230
Total Dissolved Solids	kg	363,055	1,489	1,681	380,464
Total Hardness	kg	176,873	633	715	184,8120
Total Suspended Solids	kg	25,135	273	266	27,211

Hydrographs with flow-weighted sample aliquot times are provided in Figure 2-9, Figure 2-10, and Figure 2-11. The figures were developed based on flow data provided by the nearby USGS stream gauge (Station ID 11070465).

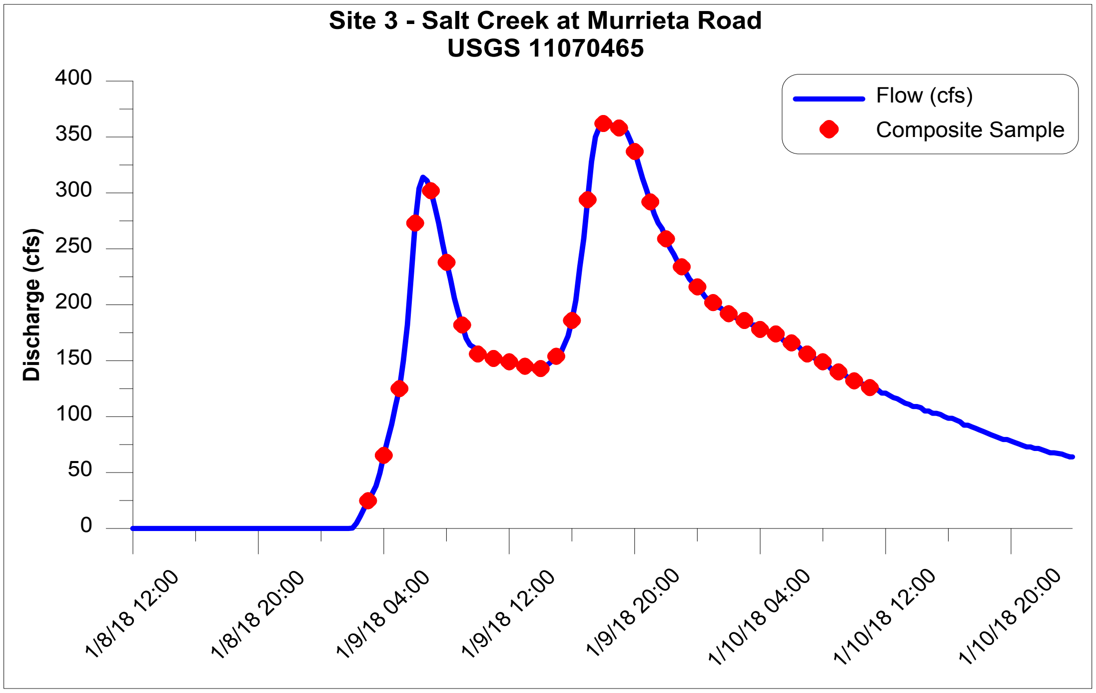

Figure 2-9. Hydrograph of First Storm Event at Salt Creek at Murrieta Road (January 9-10, 2018)

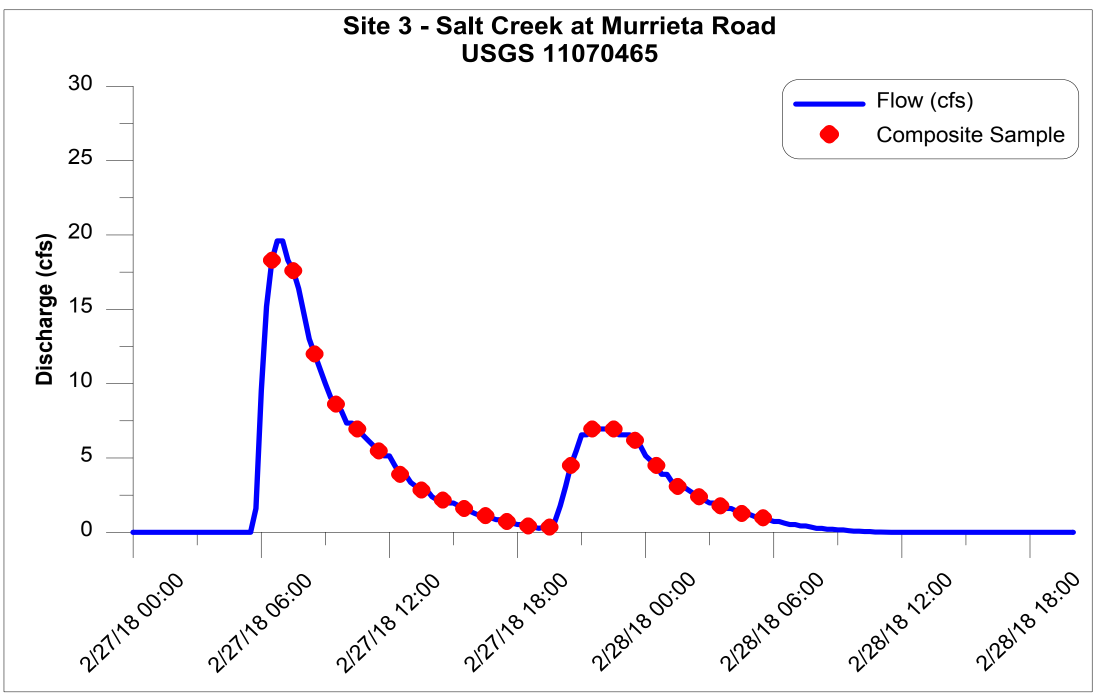

Figure 2-10. Hydrograph of Second Storm Event at Salt Creek at Murrieta Road (February 27-28, 2018)

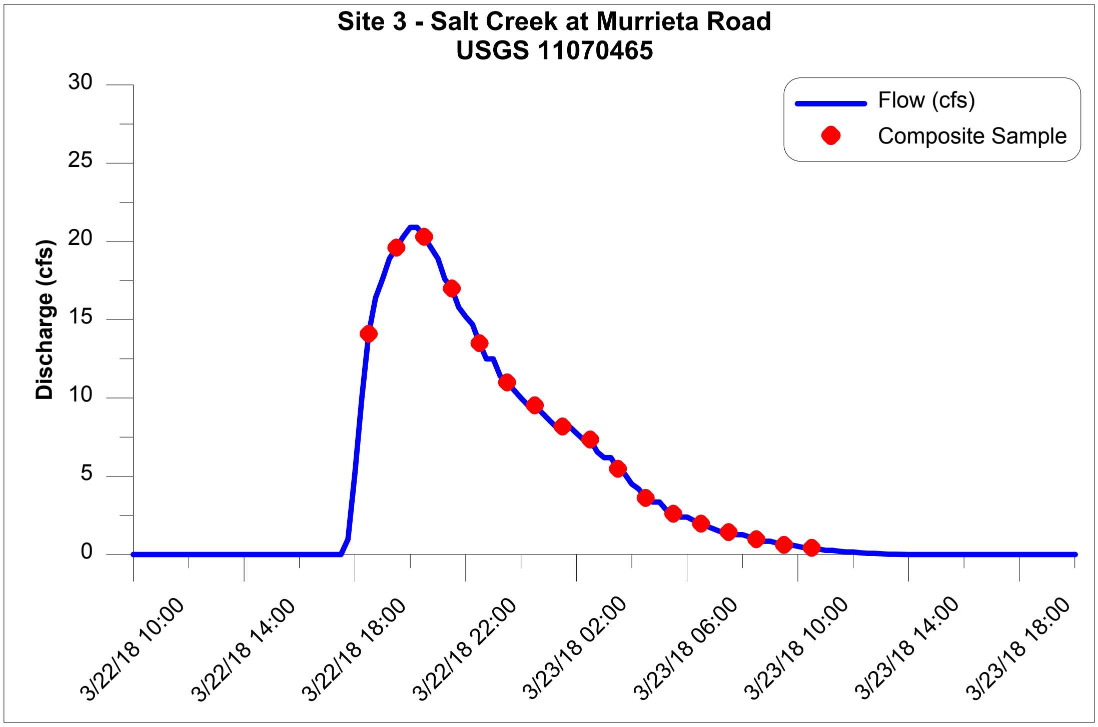

Figure 2-11. Hydrograph of Third Storm Event at Salt Creek at Murrieta Road (March 22-23, 2018)

2.7.2 Summary of Monitoring Data – San Jacinto River at Goetz Road

Water quality samples were collected during two storm events at San Jacinto River at Goetz Road (Station ID 759) during the wet weather monitoring period from October 1, 2017 to April 30, 2018.

During the first storm event on January 9, 2018 through January 10, 2018, a total of 28 discrete samples were collected across the hydrograph at one-hour intervals and a single flow-weighted composite sample was submitted for analysis. Based on data provided by the nearby USGS stream gauge (Station ID 11070365), flow for the storm event was estimated at 45,517,358 cf or 326 Mgal.

During the second storm event on February 27, 2018 through February 28, 2018, no flows were recorded at the USGS stream gauge (Station ID 11070365) and no samples were collected.

During the third event on March 22, 2018 through March 25, 2018, a total of 22 discrete samples were collected across the hydrograph at two-hour intervals and a single flow-weighted composite sample was submitted for analysis. Based on data provided by the nearby USGS stream gauge (Station ID 11070365), flow for the storm event was estimated at 535,878 cf or 4 Mgal.

Photos taken during the storm events are provided in Figure 2-12 and Figure 2-13.

Figure 2-12. Storm Event at San Jacinto River at Goetz Road (January 9-10, 2018)

Figure 2-13. Storm Event at San Jacinto River at Goetz Road (March 22-25, 2018)

Event and annual mean concentrations for each analyte are presented in Table 2-6. Event and annual loads for each analyte are presented in Table 2-7. Concentrations for nutrients for the two storm events range from 1.8 to 2.1 mg/L for total nitrogen, and 0.23 to 0.58 mg/L for total phosphorus (Table 2-4). Based on flow data provided by the nearby USGS stream gauge (Station ID 11070365), the total annual flow was estimated at 52,563,348 cf or 393 Mgal for the period of July 1, 2017 through June 30, 2018. No dry weather flows enter Canyon Lake from San Jacinto River at Goetz Road (Station ID 759) and the storm flows account for the estimated annual load of nutrients. The estimated annual nutrient load was calculated to be 3,055 kg for total nitrogen and 810 kg for total phosphorus (Table 2-7) for the period of July 1, 2017 through June 30, 2018.

Table 2-6. Water Quality Concentrations at San Jacinto River at Goetz Road

Analyte	Units	Event 1	Event 2	Annual Mean	Annual Geomean
Ammonia-Nitrogen	mg/L	0.120	0.098	0.110	0.108
Chemical Oxygen Demand	mg/L	240	37	139	94
Kjeldahl Nitrogen	mg/L	1.3	1.6	1.5	1.4
Nitrate as N	mg/L	0.81	0.19	0.50	0.39
Nitrite as N	mg/L	0.05	0.05	0.05	0.05
Organic Nitrogen	mg/L	1.2	1.5	1.35	1.3
Total Nitrogen	mg/L	2.1	1.8	1.95	1.9
Total Phosphorus	mg/L	0.58	0.23	0.41	0.37
Ortho Phosphate Phosphorus	mg/L	0.34	0.17	0.26	0.24
Total Dissolved Solids	mg/L	140	210	175	171
Total Hardness	mg/L	67	98	83	81

Table 2-7. Water Quality Event and Annual Loads at San Jacinto River at Goetz Road

Analyte	Units	Load Event 1	Load Event 2	Annual Load
Ammonia-Nitrogen	kg	148	1.5	174
Chemical Oxygen Demand	kg	295,746	562	327,581
Kjeldahl Nitrogen	kg	1,602	24.3	1,954
Nitrate as N	kg	998	2.9	1,114
Nitrite as N	kg	62	0.8	74
Organic Nitrogen	kg	1,479	22.8	1,806
Total Nitrogen	kg	2,588	27.3	3,055
Total Phosphorus	kg	715	3.5	810
Ortho Phosphate Phosphorus	kg	419	2.6	479
Total Dissolved Solids	kg	172,518	3,187	215,221
Total Hardness	kg	82,562	1,487	102,678
Total Suspended Solids	kg	91,188	37.9	99,863

Hydrographs with flow-weighted sample aliquot times is provided in Figure 2-14 and Figure 2-15. The figure was developed based on flow data provided by the nearby USGS stream gauge (Station ID 11070365).

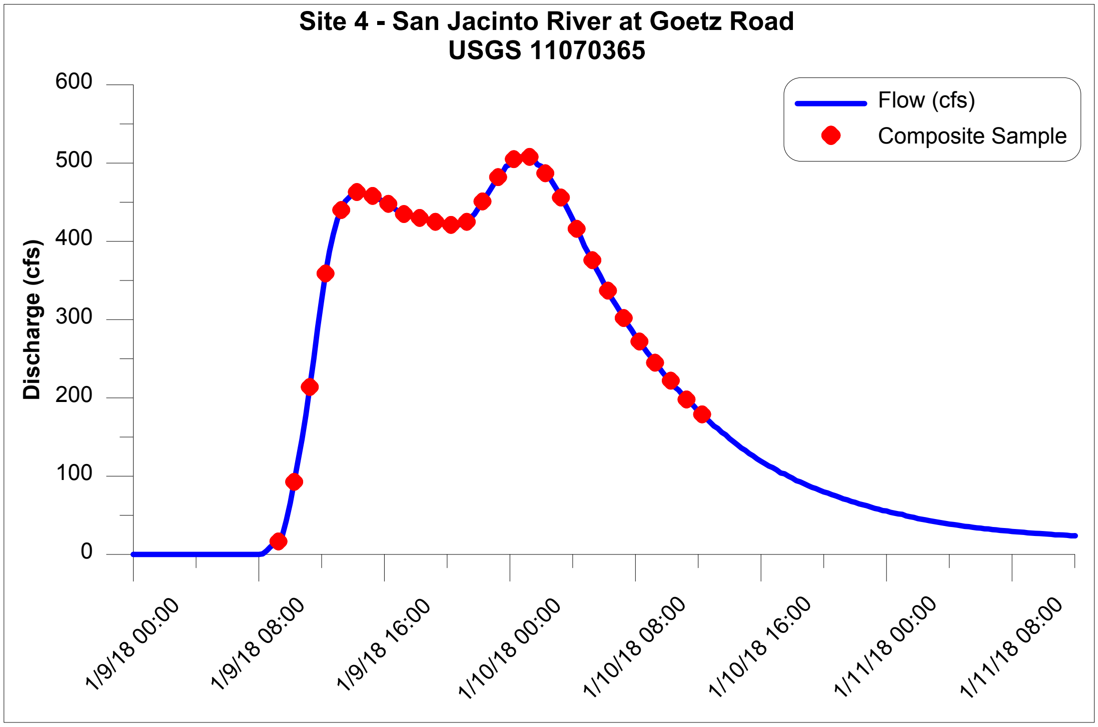

Figure 2-14. Hydrograph of First Storm Event at San Jacinto River at Goetz Road (January 9-10, 2018)

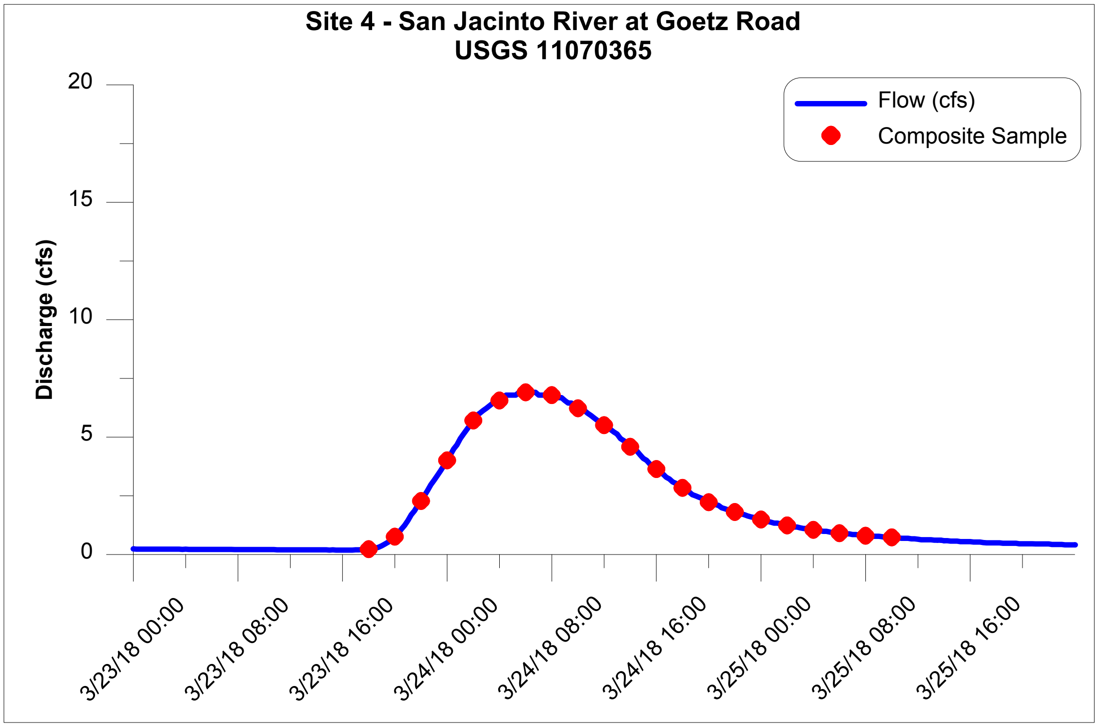

Figure 2-15. Hydrograph of Second Storm Event at San Jacinto River at Goetz Road (March 22-25, 2018)

2.7.3 Summary of Monitoring Data – San Jacinto River at Ramona Expressway

Mystic Lake did not overflow during the wet weather monitoring period from October 1, 2017 to April 30, 2018. Therefore, no samples were collected from the sampling station at San Jacinto River at Ramona Expressway (Station ID 741) during the 2017-2018 monitoring year.

2.7.4 Summary of Monitoring Data – Cranston Guard Station

The Cranston Guard Station site on the San Jacinto River was only monitored between 2007 and 2011 by the Forest Service. This work, however, was dependent on sufficient funds being allocated by Congress to complete the work. In 2012, the Forest Service pulled out of the Task Force and no longer provides monitoring. Thus, no samples were collected during the 2017-2018 monitoring year.

2.7.5 Summary of Monitoring Data – Canyon Lake Spillway

Canyon Lake Dam did not overflow during the wet weather monitoring period from October 1, 2017 to April 30, 2018. Therefore, no samples were collected from the sampling station at the Canyon Lake Spillway (Station ID 841) site during the 2017-2018 monitoring year. A hydrograph of the Canyon Lake Level at Railroad Canyon Dam Spillway compared to the spillway elevation is provided in Figure 2-16.

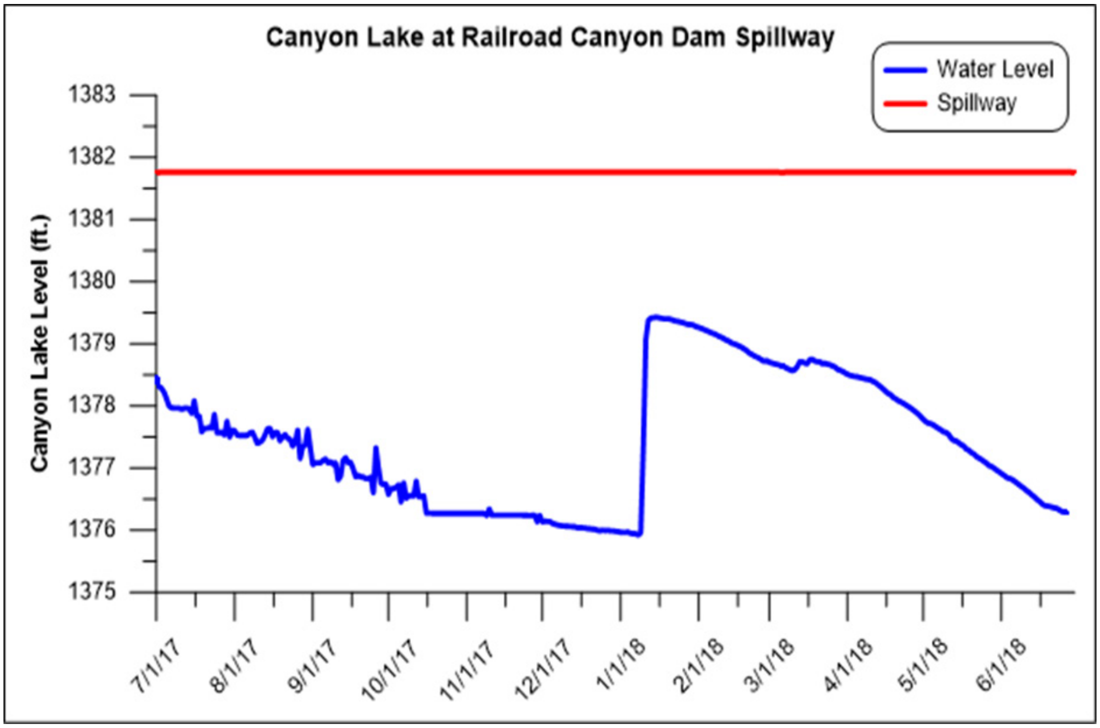

Figure 2-16. Canyon Lake Level at Railroad Canyon Dam Spillway

2.8 San Jacinto Watershed Rainfall Records

The RCFC&WCD maintains rainfall records for rain gauges located within or near the San Jacinto Watershed as shown in Table 2-8.

Table 2-8. San Jacinto River Watershed Rainfall Gauges

Station ID	Station Description	Latitude	Longitude	Elevation (ft.)
67	Lake Elsinore	33.668712	-117.332380	1281
152	Perris	33.786980	-117.231831	1494
155	Perris / Moreno Valley – Pigeon Pass	33.987703	-117.270221	1902
186	Hemet / San Jacinto	33.787067	-116.959024	1554
248	Winchester	33.702903	-117.090382	1466

Rainfall data recorded at these five stations for the period July 1, 2017, through June 30, 2018, are summarized in Table 2-9. The complete set of rainfall gauge data is included as Appendix A.

Table 2-9. Summary Rainfall Data (July 2017 to June 2018)

Monthly Rainfall (inches)	Lake Elsinore	Perris CDF	Pigeon Pass	Hemet / San Jacinto	Winchester
Jul	0.04	0.00	0.00	0.00	0.00
Aug	0.08	0.20	0.17	0.00	0.03
Sep	0.21	0.02	0.07	0.00	0.32
Oct	0.00	0.00	0.00	0.00	0.00
Nov	0.02	0.04	0.09	0.10	0.08
Dec	0.01	0.00	0.00	0.00	0.00
Jan	1.89	1.82	3.25	2.37	2.20
Feb	0.14	0.38	0.53	0.49	0.50
Mar	0.93	1.12	2.42	1.90	1.05
Apr	0.01	0.02	0.00	0.00	0.01
May	0.02	0.06	0.53	0.27	0.03
Jun	0.00	0.00	0.00	0.00	0.00
Annual Rainfall (Inches)	**3.35**	**3.66**	**7.06**	**5.13**	**4.22**

3.0 In-Lake Monitoring

3.1 Background

Routine in-lake monitoring was initiated in 2006 by local stakeholders in cooperation with the RWQCB at three open water locations in Lake Elsinore and four locations in Canyon Lake. Monitoring consisted of monthly sampling October to May, and biweekly sampling June to September, with grab samples collected at the surface, within the water column, and/or as depth-integrated samples (depending on the lake and the analyte). Based on modifications adopted to the sampling program (Regional Board Resolution No. R8-2011-0023), in 2011-2012 sampling locations in Lake Elsinore and Canyon Lake were reduced to one and three stations, respectively for analytical chemistry. This decision was based on a review of available data that indicated consistent 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. This savings also shifted resources toward a number of implementation strategies aimed at reducing nutrient impacts in both lakes as described in RWQCB Resolution No. R8-2011-0023. All in-lake monitoring was then suspended temporarily during the 2013-2014 and 2014-2015 FYs to further redirect additional resources toward implementing in-lake best management practices. However, ongoing in-lake sampling has resumed and is required to estimate progress toward attaining nutrient TMDL targets and calculating annual and 10-year running averages. The following sections describe monitoring methods and results in both lakes for the 2017-2018 FY.

3.2 Lake Elsinore Monitoring

3.2.1 Sampling Station Locations and Frequency

In order to maintain consistency and facilitate the assessment of trends toward meeting compliance goals, the in-lake monitoring design was resumed using the three former stations outlined in the approved Lake Elsinore and Canyon Lake Nutrient TMDL Monitoring Plan (LESJWA, 2006; Figure 3-1, Table 3-1). Analytical chemistry samples and in-situ water quality profile readings were collected at Site LE02 (Figure 3-1), while only in-situ water quality profile readings were performed at the remaining two stations (LE01 and LE03, Figure 3-1). Profile readings for all three stations were taken in both the morning and afternoon. Water chemistry samples collected at Site LE02 were analyzed for those constituents outlined in Table 3-2. Sampling in Lake Elsinore was conducted monthly during summer months (June-September) and bi-monthly (i.e. every other month) for the remainder of the monitoring year. In-lake sampling dates were coordinated to correspond with satellite overpass dates to facilitate the comparison of in-lake and satellite derived chlorophyll-a data (see Section 3.4).

In addition to the routine water chemistry samples, samples for analysis of cyanobacteria toxins (cyanotoxin) were collected July 2017- April 2018 at the request of the TMDL Task Force. This was an effort to evaluate the relationship of cyanotoxins to measured water quality constituents (i.e. nitrogen, phosphorus, etc.). Cyanotoxin analysis is not required under the current TMDL and there are currently no formally adopted thresholds for cyanotoxin concentrations, therefore concentrations were compared against State of California proposed trigger levels. Both surface grab and depth-integrated cyanotoxin samples were collected at the same central location (LE02) and obtained from the same depth-itegrated sample from which the other measured analytes were collected. Specific cyanotoxins analyzed are outlined in Table 3-2, and proposed State of California trigger levels are shown in Table 3-8.

Figure 3-1. Lake Elsinore Sampling Locations

Table 3-1. Lake Elsinore Sampling Station Locations

Site	Latitude	Longitude
LE01	33.668978°	-117.364185°
LE02	33.663344°	-117.354213°
LE03	33.654939°	-117.341653°

Table 3-2. In-lake Analytical Constituents and Methods for Lake Elsinore

Parameter	Analysis Method	Sampling Method
Analytical Chemistry		
Nitrite Nitrogen (NO_2-N)	SM4500-NO2 B	Depth Integrated
Nitrate Nitrogen (NO_3-N)	EPA 300.0	Depth Integrated
Total Kjeldahl Nitrogen (TKN)	EPA 351.3	Depth Integrated
Ammonia Nitrogen (NH4-N)	SM4500-NH_3 H	Depth Integrated
Sulfide	SM 4500S2 D	Depth Integrated
Total Phosphorus (TP)	EPA 365.1	Depth Integrated
Soluble Reactive Phosphorus (SRP / Ortho-P)	SM4500-P E	Depth Integrated
Chlorophyll-a	SM 10200H	Surface (0-2m) & Depth Integrated
Total Dissolved Solids (TDS)	SM 2540 C	Depth Integrated
Cyanobacteria Toxins		
Microcystin	LC-MS/MS	Surface Grab & Depth Integrated
Cylindrospermopsin	LC-MS/MS	Surface Grab & Depth Integrated
Anatoxin-a	LC-MS/MS	Surface Grab & Depth Integrated
Nodularin	LC-MS/MS	Surface Grab & Depth Integrated

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3.2.2 Sampling Methods

Depth-integrated composite samples for analytical chemistry were collected at Site LE02 by utilizing a peristaltic pump and lowering/raising an inlet tube through the water column at a uniform speed, creating a composite sample of the entire water column. Two discrete samples were collected for chlorophyll-a: 1) a full depth-integrated composite sample as described above; and 2) a 0-2-meter (m) depth-integrated composite surface sample. Cyanotoxin samples were collected as a full depth-integrated composite and a surface grab. All samples for chemical analysis were placed and held on wet ice immediately following collection, and transferred to a local courier or shipping company on the same day of collection. Samples for analysis of nutrients, sulfide, TDS, and chlorophyll-a were submitted to Babcock Laboratories Inc. located in Riverside, California. Samples for analysis of cyanotoxins were shipped via overnight delivery to the Ocean Sciences Kudela Laboratory at the University of California, Santa Cruz.

In-situ water column profile data was recorded in the morning at all three Lake Elsinore stations using pre-calibrated hand-held YSI field meters or equivalent for pH, temperature, DO, and specific conductivity at 1-m intervals throughout the water column. This data was used to assess lateral and vertical spatial variability within the lake. End-of-the-day water column profiles (i.e. after ~2:00pm) were also recorded for the same suite of parameters at all three stations to assess any potential temporal variability in these parameters over the course of a day. Water clarity was also assessed with a Secchi disk at all three stations.

Satellite imagery was used as a tool to remotely measure chlorophyll-a and turbidity concentrations. These images provide a more complete picture of spatial variability that can exist for these two parameters at any given point in time. In-lake sampling dates were selected to correspond with satellite overpasses to enable comparison of analytical laboratory and satellite derived chlorophyll-a concentrations. Processed satellite imagery and associated reports were provided by EOMAP GmbH & co. KG (EOMAP) based in Germany (Castle Seefeld Schlosshof).

3.2.3 Water Quality Summary

A summary of the in-lake monitoring events for Lake Elsinore for the period of July 1, 2017 to June 30, 2018 is presented below. A total of eight Lake Elsinore events were sampled during this time period under the TMDL monitoring program, with five occurring in 2017 (July 20, August 21, September 21, October 26 and December 5) and three in 2018 (February 8, April 4 and June 5). Complete water quality profile measurements can be found in the quarterly reports contained in Appendix B. Detailed analytical chemistry lab reports for each event are contained in Appendix C. Satellite imagery reports for each event are provided in Appendix D.

A summary of mean water column profile values for each site and monitoring event are presented in Tables 3-3 and 3-4. Water column profile statistics for each site across the entire monitoring period are presented in Table 3-5. Mean values for water column measurements are also visually summarized in Figures 3-2 through 3-5 for each site. The measurements during the morning and afternoon of any given day were averaged prior to summarizing in the tables and figures below.

Table 3-3. In-Situ Water Quality Parameter Measurements in Lake Elsinore – 2017 Monthly Means for Each Site

Site	Measure	Jul-17		Aug-17		Sep-17		Oct-17		Dec-17	
		Water Column Mean	1m from Bottom	Water Column Mean	1m from Bottom	Water Column Mean	1m from Bottom	Water Column Mean	1m from Bottom	Water Column Mean	1m from Bottom
LE01	Temp (°C)	28.0	27.7	26.3	26.0	23.9	23.9	20.7	20.1	14.7	14.7
	Cond (µS/cm)	3844	3836	4033	4031	4217	4219	4215	4217	4212	4211
	pH	8.98	8.94	8.64	8.61	9.00	9.04	9.12	9.09	9.19	9.19
	DO (mg/L)	4.8	3.0	6.1	4.4	5.4	5.4	9.6	7.4	9.7	9.6
LE02	Temp (°C)	27.9	27.5	26.1	25.7	23.6	23.6	20.7	20.2	14.1	14.1
	Cond (µS/cm)	3840	3830	4029	4027	4215	4217	4220	4217	4207	4210
	pH	8.97	8.91	8.60	8.59	9.00	9.03	9.09	9.03	9.15	9.15
	DO (mg/L)	4.2	2.2	5.4	3.9	4.3	4.9	8.6	4.8	8.8	8.7
LE03	Temp (°C)	27.7	27.6	26.0	26.1	23.4	23.4	20.9	20.7	14.0	14.0
	Cond (µS/cm)	3830	3825	4035	4024	4146	4122	4166	4190	4183	4196
	pH	8.94	8.92	8.60	8.58	9.00	9.02	9.10	9.07	9.05	9.07
	DO (mg/L)	3.7	2.9	5.2	4.5	4.8	4.7	9.5	8.0	8.6	8.5
All Stations Combined	Temp (°C)	27.9	27.6	26.1	25.9	23.6	23.6	20.8	20.3	14.2	14.3
	Cond (µS/cm)	3838	3830	4032	4027	4193	4186	4200	4208	4200	4206
	pH	8.97	8.92	8.61	8.59	9.00	9.03	9.10	9.06	9.13	9.14
	DO (mg/L)	4.2	2.7	5.6	4.2	4.8	5.0	9.2	6.7	9.0	8.9

Notes:
°C = degrees Celsius; µS/cm = microsiemens per centimeter; mg/L = micrograms per liter.

Table 3-4. In-Situ Water Quality Parameter Measurements in Lake Elsinore – 2018 Monthly Means for Each Site

Site	Measure	Feb-18		Apr-18		Jun-18	
		Water Column Mean	1m from Bottom	Water Column Mean	1m from Bottom	Water Column Mean	1m from Bottom
LE01	Temp (°C)	13.7	12.3	18.2	17.9	25.1	24.1
	Cond (µS/cm)	4229	4222	4191	4185	4496	4500
	pH	8.92	8.84	9.10	9.07	8.80	8.73
	DO (mg/L)	6.2	1.8	8.6	6.9	6.7	3.3
LE02	Temp (°C)	13.7	12.3	18.0	17.2	24.0	23.3
	Cond (µS/cm)	4223	4225	4206	4186	4497	4492
	pH	8.95	8.81	9.08	8.99	8.73	8.68
	DO (mg/L)	5.9	0.7	7.8	3.7	3.5	1.3
LE03	Temp (°C)	14.4	13.9	18.4	17.9	23.0	22.4
	Cond (µS/cm)	4208	4209	4186	4185	4495	4491
	pH	8.96	8.92	9.11	9.10	8.72	8.67
	DO (mg/L)	11.7	11.4	9.7	8.7	2.6	0.4
All Stations Combined	Temp (°C)	13.9	12.8	18.2	17.6	24.0	23.2
	Cond (µS/cm)	4220	4218	4194	4185	4496	4494
	pH	8.94	8.86	9.10	9.05	8.75	8.69
	DO (mg/L)	7.9	4.6	8.7	6.4	4.2	1.7

Notes:
°C = degrees Celsius; µS/cm = microsiemens per centimeter; mg/L = micrograms per liter.

Temperature exhibited a typical pattern with lowest values occurring during the winter events (December and February) and highest values in summer months (July and August). The greatest mean DO concentrations throughout the water column were observed in February at Site LE03, and in December at Sites LE01 and LE02. Conductivity increased from July through September 2017, from approximately 3800 to 4200 microsiemens per centimeter (µS/cm). The conductivity remained relatively stable between September 2017 and April 2018, at approximately 4200 µS/cm. Conductvity then rose slightly to approximately 4500 µS/cm, during the June 2018 event. The overall annual average pH in the lake was 8.95. The pH values in August 2017 and June 2018 were approximately 0.4-0.6 units lower than mean values for other events.

Concentrations of DO near the bottom tracked closely with the overall water column mean for Site LE03, the shallowest of the three sites. Concentrations of DO 1-meter from the bottom for Sites LE01 and LE02 remained lower than the water column mean. The water column DO concentration was above the 2015 TMDL target of 5.0 mg/L as a rolling average for all events among the three sites (Figure 3-2). However, the rolling average DO concentration was below the 2020 TMDL target of 5.0 mg/L 1-m from the lake bottom for all 2017-18 monitoring events among all three sites (Figure 3-2).

A minor fish kill in Lake Elsinore was observed May 27th to May 31st, 2018. Wood field staff measured water quality parameters on May 30th at the La Laguna Boat Ramp, where surface DO readings measured just 1.56 mg/L at the surface and dropped to 0.3 mg/L at the bottom (2.5 m). A field data sheet with these water quality measurements is provided in Appendix G. Additionally, in-lake data continuous sondes recorded nightly decreases in DO to near 0 mg/L at the surface of the lake for approximately a month prior to the fish kill. The continuous sonde recorded concentrations of DO at 0 mg/L more frequently leading up to the fish kill which began on May 27th.

Secchi depths for Site LE02 were highest at the beginning of the monitoring period and exhibited a steady decline though December 2017 (0.3-m to 0.1-m, respectively) , followed by an increase through April to 0.25-m, and a slight decrease in June 2018. The Secchi depth pattern observed generally follows the chlorophyll-a concentration (i.e. algal density) measured. Sites LE01 and LE03 both exhibited similar Secchi depths and patterns.

Table 3-5. In-Situ Water Quality Parameter Measurements in Lake Elsinore - Annual Mean Statistics for Each Site

		Measure	LE01	LE02	LE03	Average
Water Column Mean	Min	Temp (°C)	13.7	13.7	14.0	13.8
		Cond (µS/cm)	3844	3840	3830	3838
		pH	8.64	8.60	8.60	8.61
		DO (mg/L)	4.8	3.5	2.6	3.6
	Max	Temp (°C)	28.0	27.9	27.7	27.9
		Cond (µS/cm)	4496	4497	4495	4496
		pH	9.19	9.15	9.11	9.15
		DO (mg/L)	9.7	8.8	11.7	10.1
	Average	Temp (°C)	21.3	21.0	21.0	21.1
		Cond (µS/cm)	4180	4179	4156	4172
		pH	8.97	8.95	8.93	8.95
		DO (mg/L)	7.1	6.1	7.0	6.7
1m from Bottom	Min	Temp (°C)	12.3	12.3	13.9	12.8
		Cond (µS/cm)	3836	3830	3825	3830
		pH	8.61	8.59	8.58	8.6
		DO (mg/L)	1.8	0.7	0.4	0.9
	Max	Temp (°C)	27.7	27.5	27.6	27.6
		Cond (µS/cm)	4500	4492	4491	4494
		pH	9.19	9.15	9.10	9.1
		DO (mg/L)	9.6	8.7	11.4	9.9
	Average	Temp (°C)	20.8	20.5	20.7	20.7
		Cond (µS/cm)	4177	4175	4155	4169
		pH	8.94	8.90	8.92	8.92
		DO (mg/L)	5.2	3.8	6.1	5.0

Notes:
°C = degrees Celsius; µS/cm = microsiemens per centimeter; mg/L = micrograms per liter.

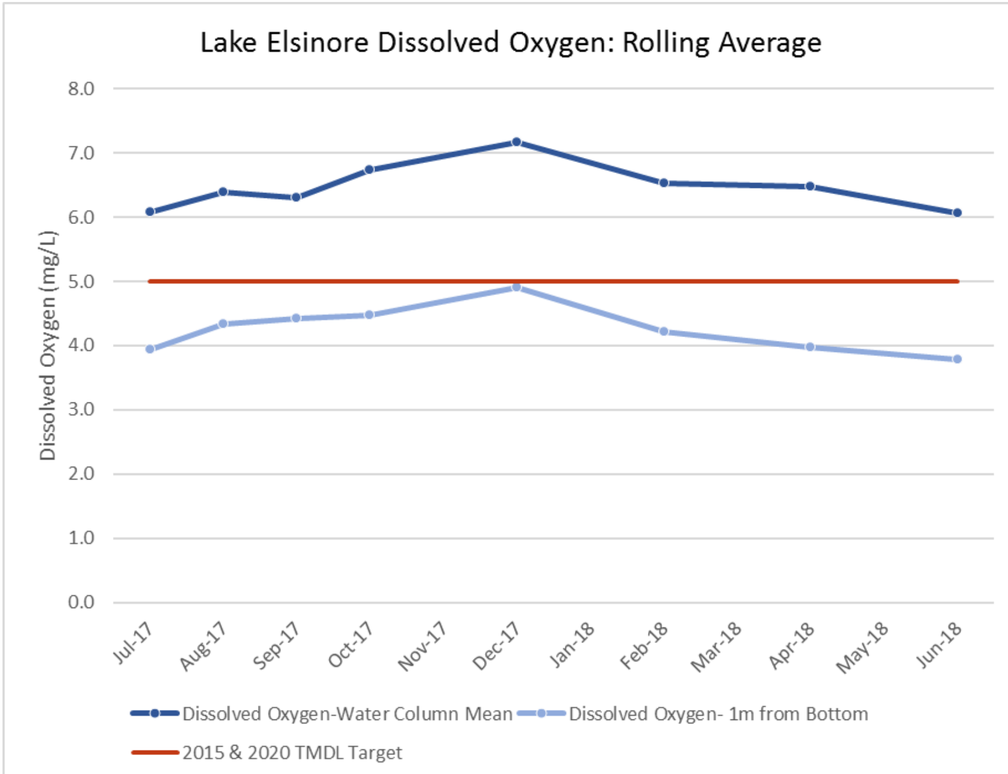


Figure 3-2. Water Column Mean Dissolved Oxygen (DO) Rolling Average – Lake Elsinore – Site LE02

Values are calculated by averaging the measurement from each event with the previous seven events (i.e. one year of data) to obtain a rolling average.

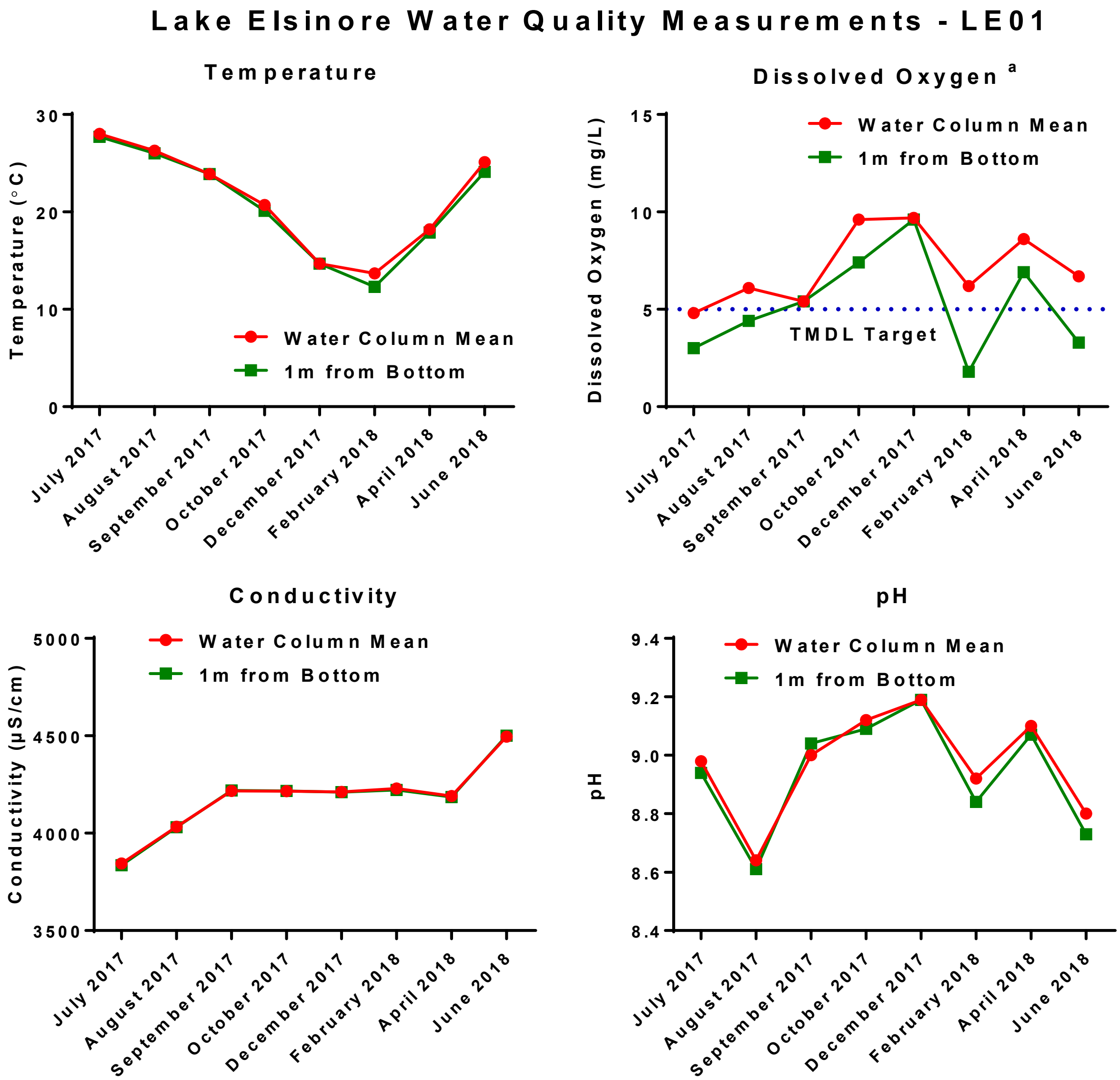


Figure 3-3. In- Situ Physical Water Quality Parameters - Lake Elsinore - Site LE01

[a] - TMDL Target for dissolved oxygen is depth average no less than 5 mg/L no later than 2015, no less than 5 mg/L 1 meter above lake bottom no later than 2020

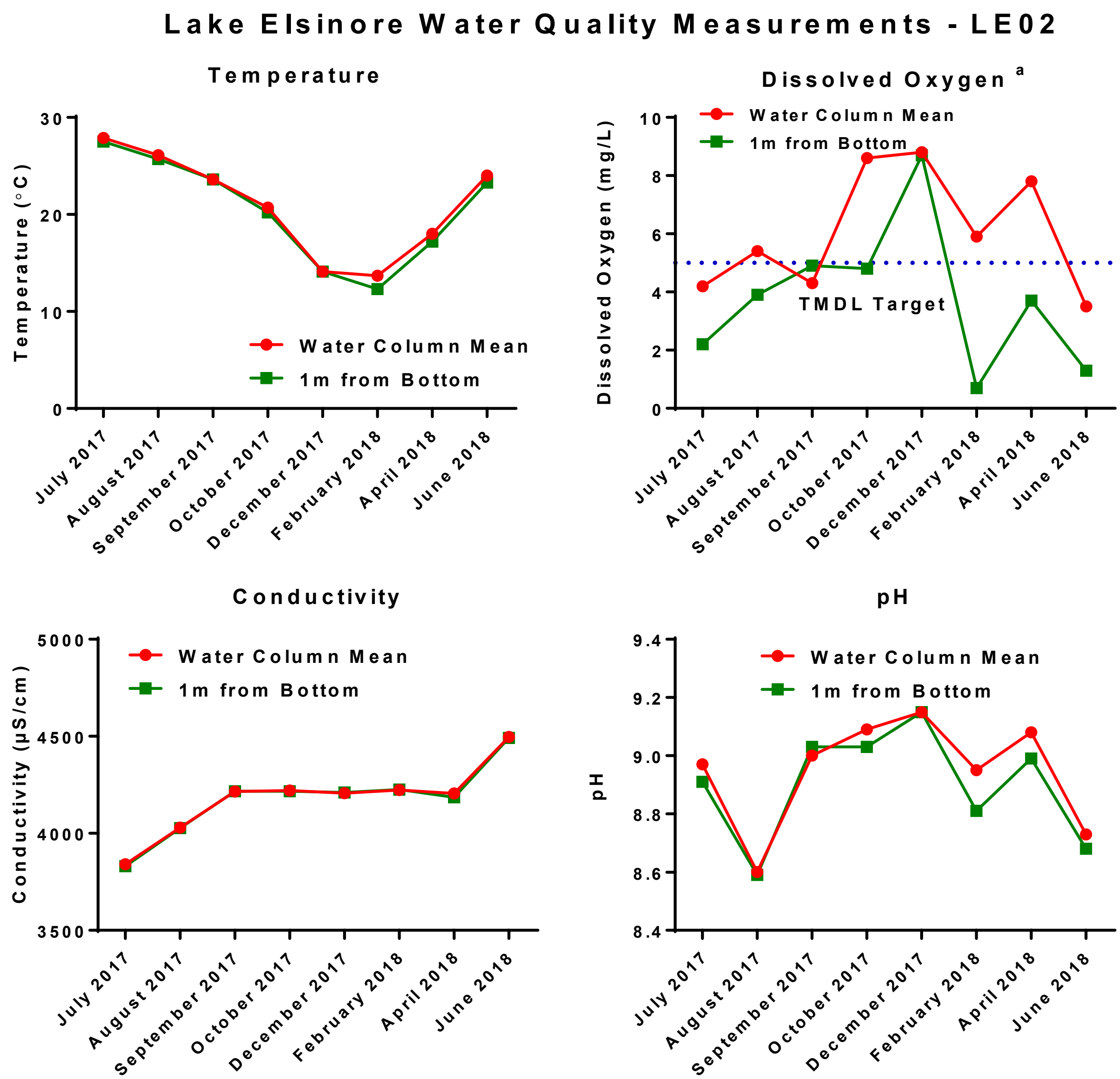


Figure 3-4. In- Situ Physical Water Quality Parameters - Lake Elsinore Site LE02

[a]-TMDL Target for dissolved oxygen is depth average no less than 5 mg/L no later than 2015, no less than 5 mg/L 1 meter above lake bottom no later than 2020

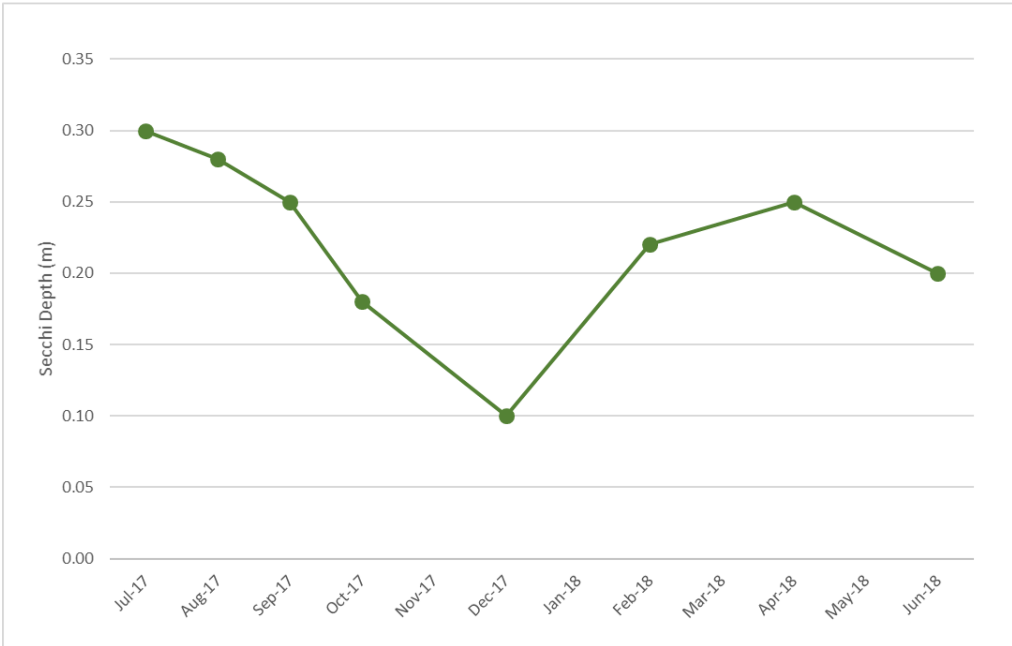


Figure 3-4a. In- Situ Secchi Depth Measurements - Lake Elsinore Site LE02

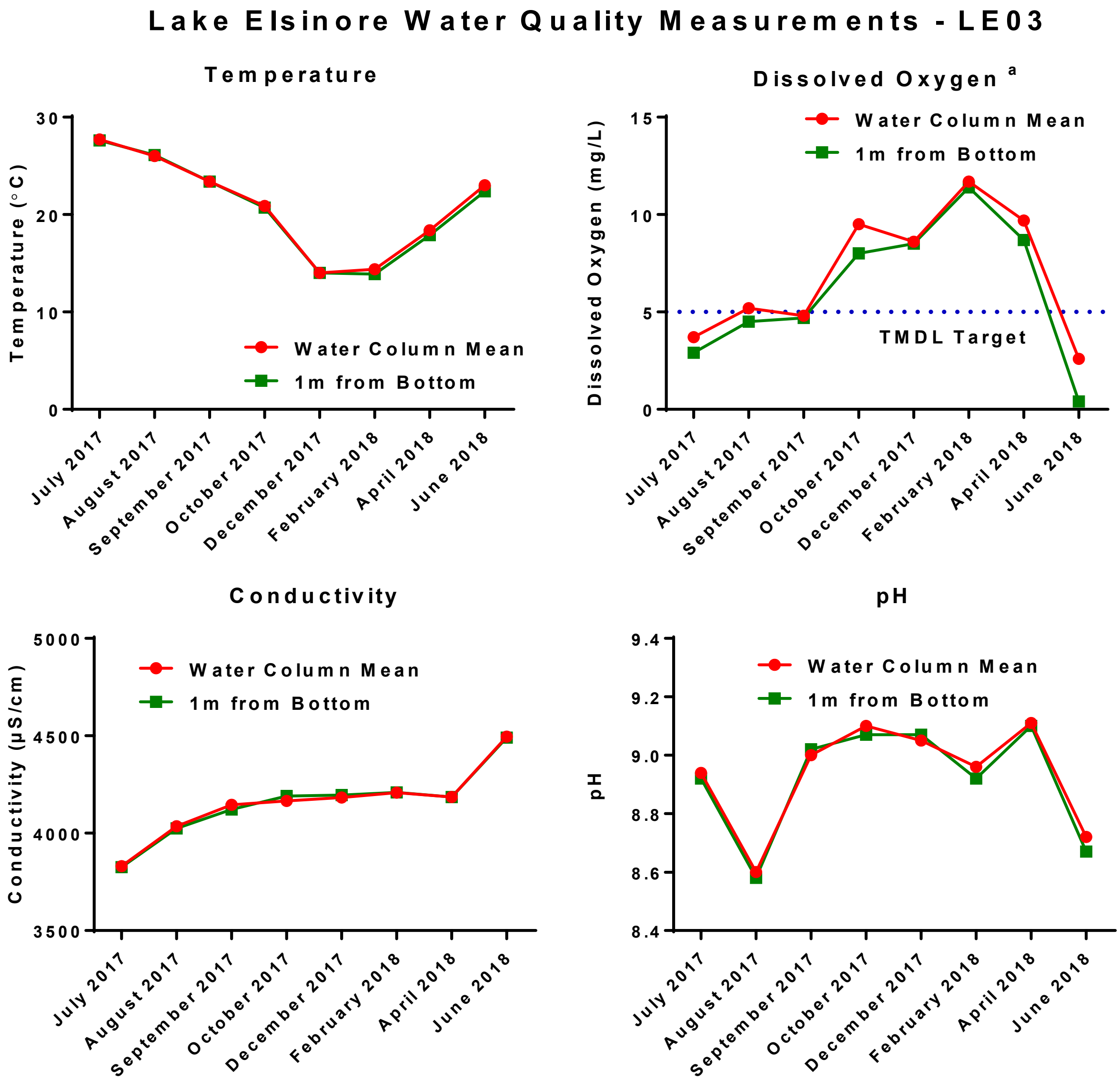


Figure 3-5. In- Situ Physical Water Quality Parameters - Lake Elsinore Site LE03

[a]-TMDL Target for dissolved oxygen is depth average no less than 5 mg/L no later than 2015, no less than 5 mg/L 1 meter above lake bottom no later than 2020

Analytical Chemistry

Monthly analysis and summaries of analytical chemistry concentrations for each monitoring event at Site LE02 across the entire monitoring period are presented in Tables 3-6 and 3-7, respectively. Concentrations of analytes at Site LE02 are graphically presented in Figures 3-6 through 3-9.

With the exception of a single elevated value of 7.2 mg/L in August 2017, total nitrogen concentrations were consistent throughout the year at approximately 5 mg/L. The annual mean concentration of total nitrogen was 5.1 mg/L (6.3 mg/L in the previous monitoring year). The total nitrogen rolling average concentration exceeded the current 2020 TMDL target of 0.75 mg/L for each event.

Total phosphorus concentrations ranged from 0.05 to 0.21 mg/L, with the annual mean of 0.14 mg/L, down from the 0.39 mg/L annual mean from the previous monitoring year. The total phosphorus rolling average concentration exceeded the current 2020 TMDL target of 0.1 mg/L for each event, however it exhibited a steady decline across the year from 0.35 to 0.15 mg/L.

Total ammonia-N concentrations ranged from <0.048 to 0.32 mg/L. The July 2017 sample concentration of 0.3 mg/L total ammonina-N exceeded the Criterion Continuous Concentration (CCC) value of 0.211 mg/L for the protection of aquatic life. No other samples exceeded the CCC or the US EPA acute water quality Criterion Maximum Concentration (CMC) value (Table 3-7).

Total dissolved solids (TDS) concentration gradually increased throughout the 2017-2018 monitoring year, and has remained above the Basin Plan Objective of 2000 mg/L. Values ranged from 2300 to 2700 mg/L, with an annual mean concentration of 2488 mg/L. While there was an increasing trend over the monitoring year, TDS has decreased overall from 2016, where concentrations were measured at >3000 mg/L (Amec Foster Wheeler 2017).

Chlorophyll-a concentrations at the surface were typically greater than the depth-integrated concentrations for each sampling event, but both samples exhibited similar temporal patterns over the year. Chlorophyll-a depth-integrated concentrations across all eight sampling events ranged from 30.9 to 201 µg/L. Surface (0-2m) concentrations of chlorophyll-a ranged from 102 to 284 µg/L. These concentrations have decreased from the previous monitoring year, where depth integrated values ranged from 72-349 µg/L and 52-309 µg/L for surface samples (Amec Foster Wheeler 2017). The mean chlorophyll-a concentration observed in samples collected during the summer months (June 2017 through September 2017) was 149 µg/L for depth-integrated samples and 161 µg/L for surface samples. These summer chlorophyll-a concentrations exceed the current 2015 and 2020 TMDL summer average targets of 40 and 25 µg/L, respectively. Chlorophyll-a concentrations steadily increased from July 2017 to October 2017, where peak concentrations were observed at 284 µg/L and 201 µg/L for surface and depth-integrated samples, respectively. The remaining sampling events from December 2017 through June 2018 exhibited lower concentrations ranging from 102 µg/L to 139 µg/L for surface samples, and 31 µg/L to 96 µg/L for depth-integrated samples.

While analysis of cyanbacterial toxins is not required as part of the TMDL compliance program, sample collection of these toxins was incorporated into the monitoring program from June 2017 to April 2018 in order to investigate the relationship between TMDL analytes measured and toxins present. During the 2017-2018 sampling period, microcystin, anatoxin, and cylindrospermopsin were identified in one or more samples. Microcystin was detected in all samples with the exception of February 2018. Detected concentrations ranged from 0.18 µg/L to 67.4 µg/L. The latter value collected in July 2017, was over three times the 'Danger' threshold developed by the State of California (See Table 3-8). The depth-integrated and surface grab concentrations of microcystins throughout the monitoring period are illustrated in Figure 3-9. Anatoxin-a was detected at 0.3 µg/L in the August 2017 depth-integrated sample, and at 0.194 µg/L in the October 2017 surface grab. Both of these values were just above the State of California "Caution" threshold of 1 µg/L. Cylindosperopsin was detected in April 2018 at 0.8 µg/L in the depth-integrated sample and 0.85 µg/L in the surface grab sample. These values are below the State's lowest threshold of 1 µg/L for cylindospermopsin. Further cyanotoxin analysis and its relationship to other analytes measured is presented in Appendix G.

The current 2017-2018 FY Lake Elsinore data in the context of historical data can be found in Appendix H.

Table 3-6. Monthly Analytical Chemistry Results for Lake Elsinore

Method	Compound	Units	MDL	RL	Depth Integrated or Surface Sample	July 2017	August 2017	September 2017	October 2017	December 2017	February 2018	April 2018	June 2018
General Chemistry													
SM 2540C	Total Dissolved Solids	mg/L	10-100	10-100	DI	2300	2400	2300	2500	2500	2600	2600	2700
SM 4500S2 D	Sulfide	mg/L	0.1	0.1	DI	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
EPA 300.0	Nitrate as N	mg/L	0.055	0.2	DI	<0.055	<0.055	<0.055	0.07	<0.055	<0.055	<0.055	<0.055
SM 4500NO2 B	Nitrite as N	mg/L	0.042-0.1	0.1	DI	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
EPA 351.2	Kjeldahl Nitrogen	mg/L	0.13-0.32	0.1-0.5	DI	4.70	7.20	5.20	4.70	4.20	4.30	5.00	5.70
Calculated	Total Nitrogen[a]	mg/L	NA	--	DI	4.70	7.20	5.20	4.77	4.20	4.30	5.00	5.70
SM4500NH3H	Ammonia-Nitrogen	mg/L	0.048	0.1	DI	0.3	0.32	<0.048	<0.048	<0.048	0.19	<0.048	0.093 J
Calculated	Unionized Ammonia[b,c]	mg/L	--	--	DI	0.120	0.060	0.017	0.016	0.013	0.033	0.015	0.019
SM 4500P E	Ortho Phosphate Phosphorus	mg/L	0.024	0.05	DI	0.026 J	<0.024	<0.024	<0.024	<0.024	<0.024	<0.024	<0.024
SM 4500P B E	Total Phosphorus	mg/L	NA	0.01-0.05	DI	0.05	0.15	0.14	0.15	0.14	0.09	0.17	0.21
Chlorophyll-a													
EPA 10200 H	Chlorophyll-a	µg/L	NA	1.0	Surf	104	153	225	284	104	139	102	125
EPA 10200 H	Chlorophyll-a	µg/L	NA	1.0	DI	138	110	199	201	83	98.2	87.7	30.9
Algae Toxins													
LC-MS/MS	Total Microcystin	µg/L	NA	0.001	DI	2.33	2.82	10.3	7.63	0.42	<0.001	0.36	NS
					SG	67.4	4.9	10.3	21.2	0.23	<0.001	0.18	NS
LC-MS/MS	Total Nodularin	µg/L	NA	0.001	DI	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NS
					SG	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NS
LC-MS/MS	Total Anatoxin-a	µg/L	NA	0.001	DI	<0.001	0.3	<0.001	<0.001	<0.001	<0.001	<0.001	NS
					SG	<0.001	<0.001	<0.001	0.194	<0.001	<0.001	<0.001	NS
LC-MS/MS	Total Cylindospermopsin	µg/L	NA	0.001	DI	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.8	NS
					SG	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.85	NS

Notes:
a - Total Nitrogen = TKN+NO_2+NO_3
b - Values are site specific dependent upon pH and temperature recorded at each location. Calculated using equation by Thursby (1986).
c – Un-ionized ammonia concentrations calculated based on ½ detection limit when ammonia nitrogen was ND
NS – Not sampled; ND – Not detected; NA – Not Applicable/ available
DI = Depth integrated; SG = Surface grab; Surf = Surface 0-2m
mg/L – micrograms per liter; ug/L – milligrams per liter; m – meters; RL – reporting limit; J- Reported value was detected above the Method Detection Limit (MDL), but below the Reporting Limit (RL)

Table 3-7. Analytical Chemistry Summary for Lake Elsinore – Annual Mean Statistics

Method	Compound	Units	MDL	RL	Basin Plan or TMDL Target	Depth Integrated or Surface Sample	Min	Max	Annual Average	Summer Average[e]
General Chemistry										
SM 2540C	Total Dissolved Solids	mg/L	10-100	10-100	2000[3]	DI	2300	2700	**<u>2488</u>**	2333
SM 4500S2 D	Sulfide	mg/L	0.1	0.1	NA	DI	ND	ND	ND	ND
EPA 300.0	Nitrate as N	mg/L	0.055	0.2	NA	DI	<0.055	0.07	0.03	ND
SM 4500NO2 B	Nitrite as N	mg/L	0.042-0.1	0.1	NA	DI	ND	ND	ND	ND
EPA 351.2	Kjeldahl Nitrogen	mg/L	0.13-0.32	0.1-0.5	NA	DI	4.2	7.2	5.1	4.3
Calculated	Total Nitrogen[a]	mg/L	NA	--	0.75[b1]	DI	4.2	7.2	**<u>5.1</u>**	5.7
SM4500NH3H	Ammonia-Nitrogen	mg/L	0.048	0.1	CMC: 1.06-2.65[1] CCC: 0.21-0.52[1]	DI	<0.048	0.32	0.12	0.21
Calculated	Unionized Ammonia[d,f]	mg/L	--	--	NA	DI	0.01	0.12	0.04	0.07
SM 4500P E	Ortho Phosphate Phosphorus	mg/L	0.024	0.05	NA	DI	<0.024	0.03	0.01	0.02
SM 4500P B E	Total Phosphorus	mg/L	NA	0.01-0.05	0.1[b1]	DI	0.05	0.21	**<u>0.14</u>**	0.11
Chlorophyll-a										
EPA 10200 H	Chlorophyll-a	µg/L	NA	1.0	25[1c], 40[2c]	Surf	102	284	155	**<u>161</u>**
EPA 10200 H	Chlorophyll-a	µg/L	NA	1.0	25[1c], 40[2c]	DI	30.9	201	118	**<u>149</u>**

Notes:
a - Total Nitrogen = TKN+NO_2+NO_3
b - Annual average
c - Summer average
d - Values calculated using water column mean ammonia, temperature, salinity and pH. Calculated using equation by Thursby (1986).
e - Values are the mean of June through September 2017 results
f – Un-ionized ammonia concentrations calculated based on ½ detection limit when ammonia nitrogen was ND
1 – 2020 TMDL Target, based on Table 5-9n of 2004 TMDL
2 – 2015 TMDL Target, based on Table 5-9n of 2004 TMDL
3 – Santa Ana Region Basin Plan Objective
NA – Not applicable/ available
DI = Depth integrated; Surf = Surface 0-2m
mg/L – micrograms per liter; ug/L – milligrams per liter; m – meters; RL – reporting limit
Bold Underline - Indicates exceedance of Basin Plan/TMDL target
.

Table 3-8. State of California Proposed[d] Cyanobacteria Harmful Algal Bloom Trigger Levels

	Caution Action Trigger	Warning TIER I	Danger TIER II
Primary Triggers [a]			
Total Microcystins [b]	0.8 µg/L	6 µg/L	20 µg/L
Anatoxin-a	Detection [c]	20 µg/L	90 µg/L
Cylindrospermopsin	1 µg/L	4 µg/L	17 µg/L
Secondary Triggers			
Cell Density *(Toxin Producers)*	4,000 cells/mL	--	--
Site Specific Indicators of Cyanobacteria	Blooms, scums, mats, ect.	--	--

[a] The primary triggers are met when ANY toxin exceeds criteria
[b] Microcystins refers to the sum of all measured microcystin variants
[c] Must use an analytical method that detects ≤1 µg/L Anatoxin-a
[d] These trigger levels have not been formally adopted or approved by the EPA, Regional Water Board or State Water Board

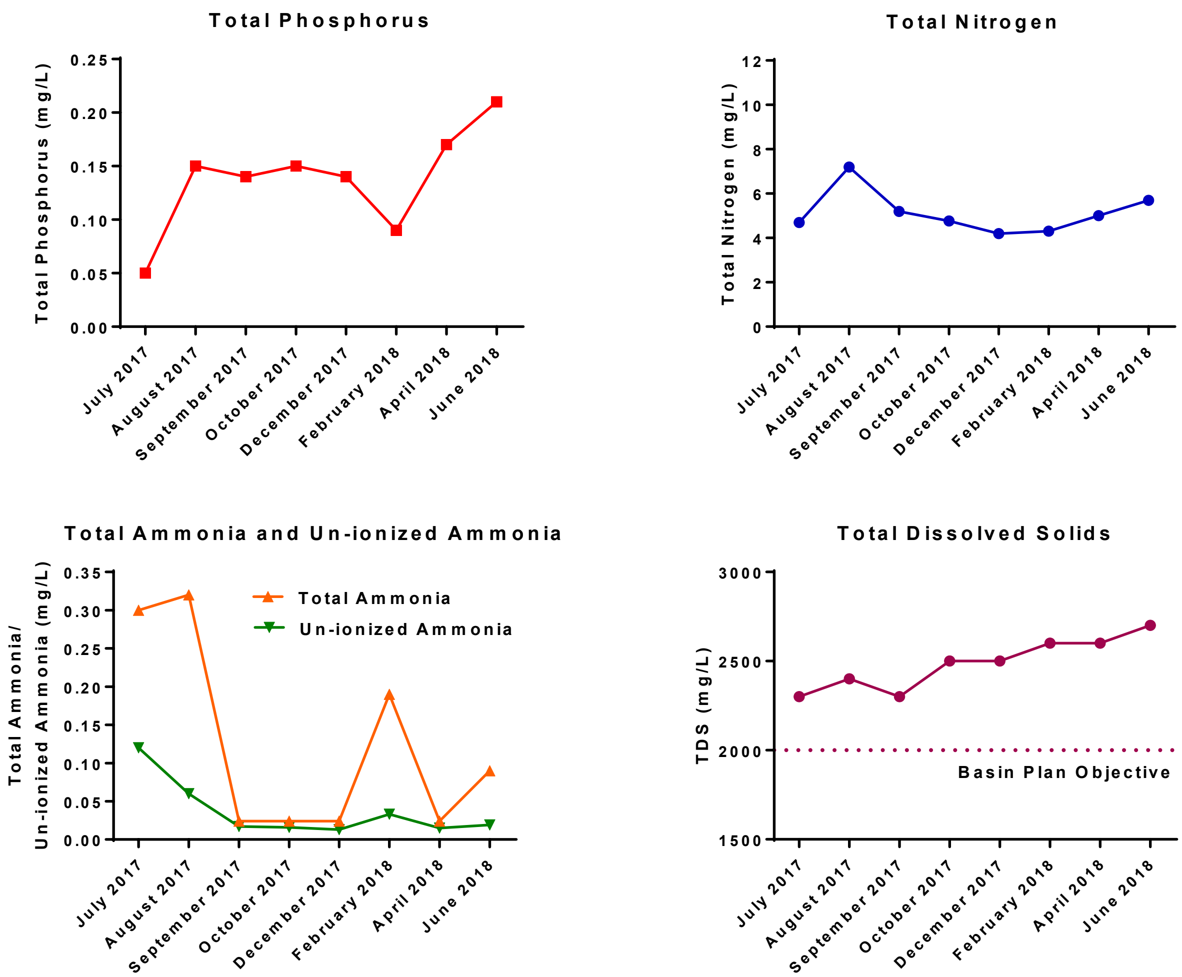
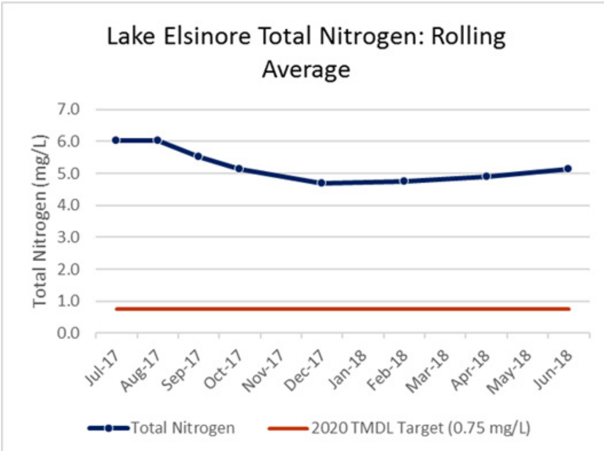


Figure 3-6. Lake Elsinore Analytical Chemistry – Depth-Integrated Means (July 2017-June 2018)



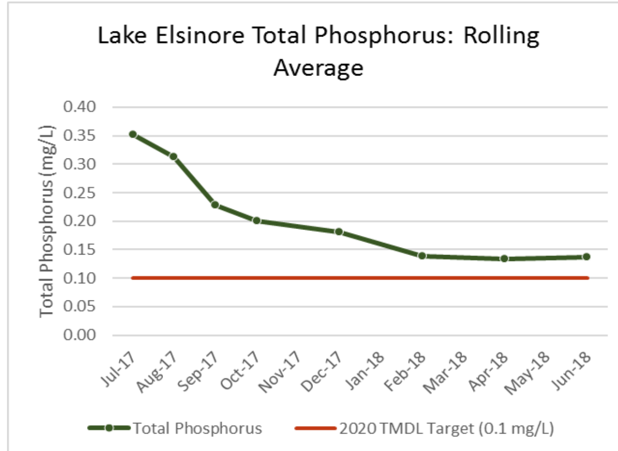


Figure 3-7. Lake Elsinore Analytical Chemistry – Rolling Averages (August 2016 – June 2018)

Values are calculated by averaging the value of each event with the previous seven events (i.e. one year of data) to obtain a rolling average.

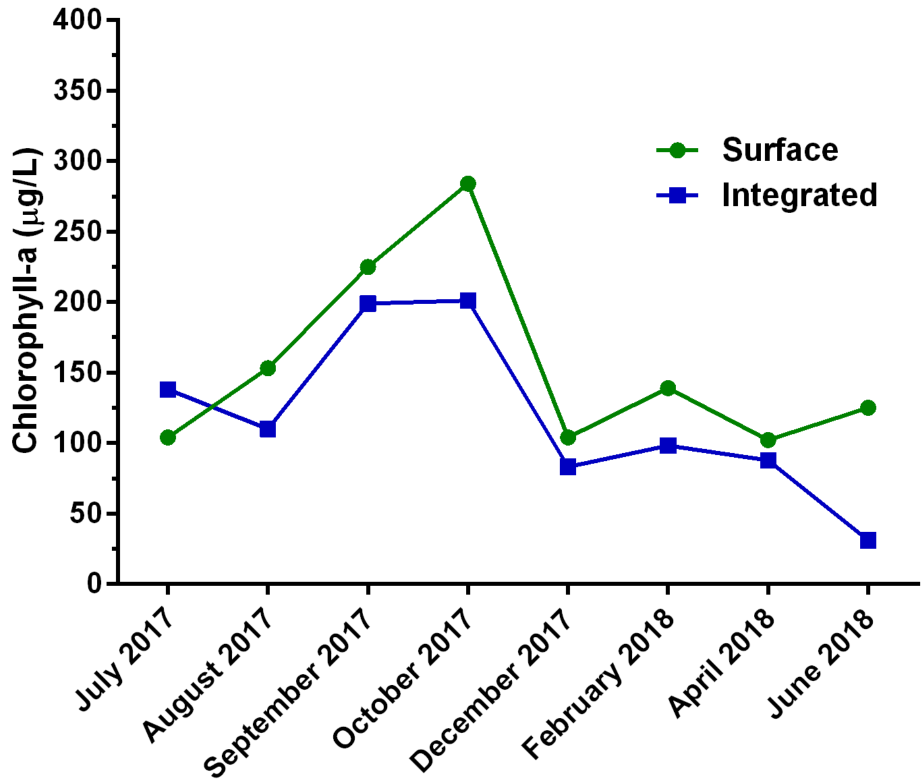


Figure 3-8. Lake Elsinore Analytical Chemistry – Depth-Integrated and Surface Chlorophyll-a

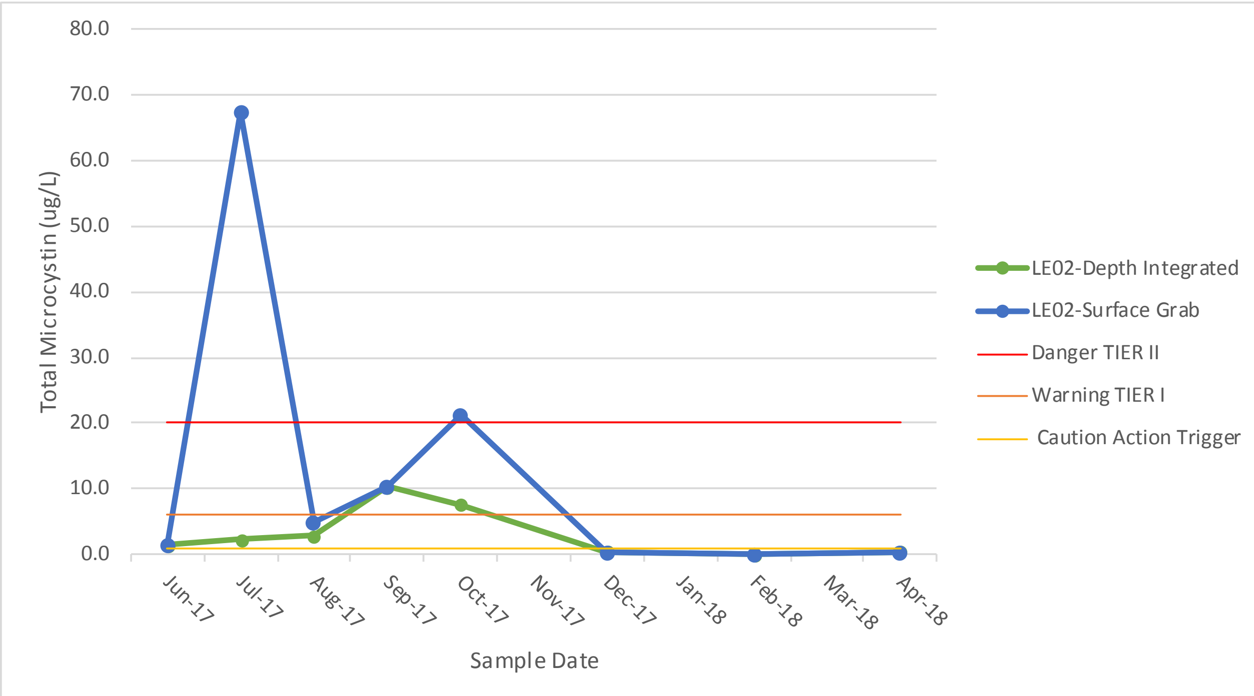


Figure 3-9. Lake Elsinore Microcystin concentrations June 2017 to April 2018

Note: Due to bimonthly monitoring conducted in non-summer months, samples were not collected for November 2017, or January, March, and May 2018. Sample collection ended in April 2018.

3.3 Canyon Lake Monitoring

3.3.1 Sampling Station Locations and Frequency

Similar to Lake Elsinore, sampling parameters and locations in Canyon Lake were based on the TMDL monitoring conducted between 2006 and 2012 to provide consistency in assessing trends toward meeting compliance goals. The in-lake monitoring design halted in 2012 resumed using the four stations outlined in the approved Lake Elsinore and Canyon Lake Nutrient TMDL Monitoring Plan (LESJWA, 2006; Figure 3-10, Table 3-9). These include two in the main body of the lake (CL07 near the dam and CL08 in the northern arm), and two in the East Bay (CL09 and CL10). Samples for analytical chemistry, chlorophyll-a, and algae toxins were collected at Sites CL07, CL08, CL09 and CL10 in addition to morning and afternoon in-situ water quality profile readings.

Sampling in Canyon Lake was conducted bi-monthly (i.e., every other month) concurrent to the TMDL sampling in Lake Elsinore, and also coordinated with satellite overpass dates (see Section 3.4).

Table 3-9. Canyon Lake Sampling Station Locations

Site	Latitude	Longitude
CL07	33.678027°	-117.275135°
CL08	33.688211°	-117.268944°
CL09	33.681100°	-117.258892°
CL10	33.679495°	-117.250669°

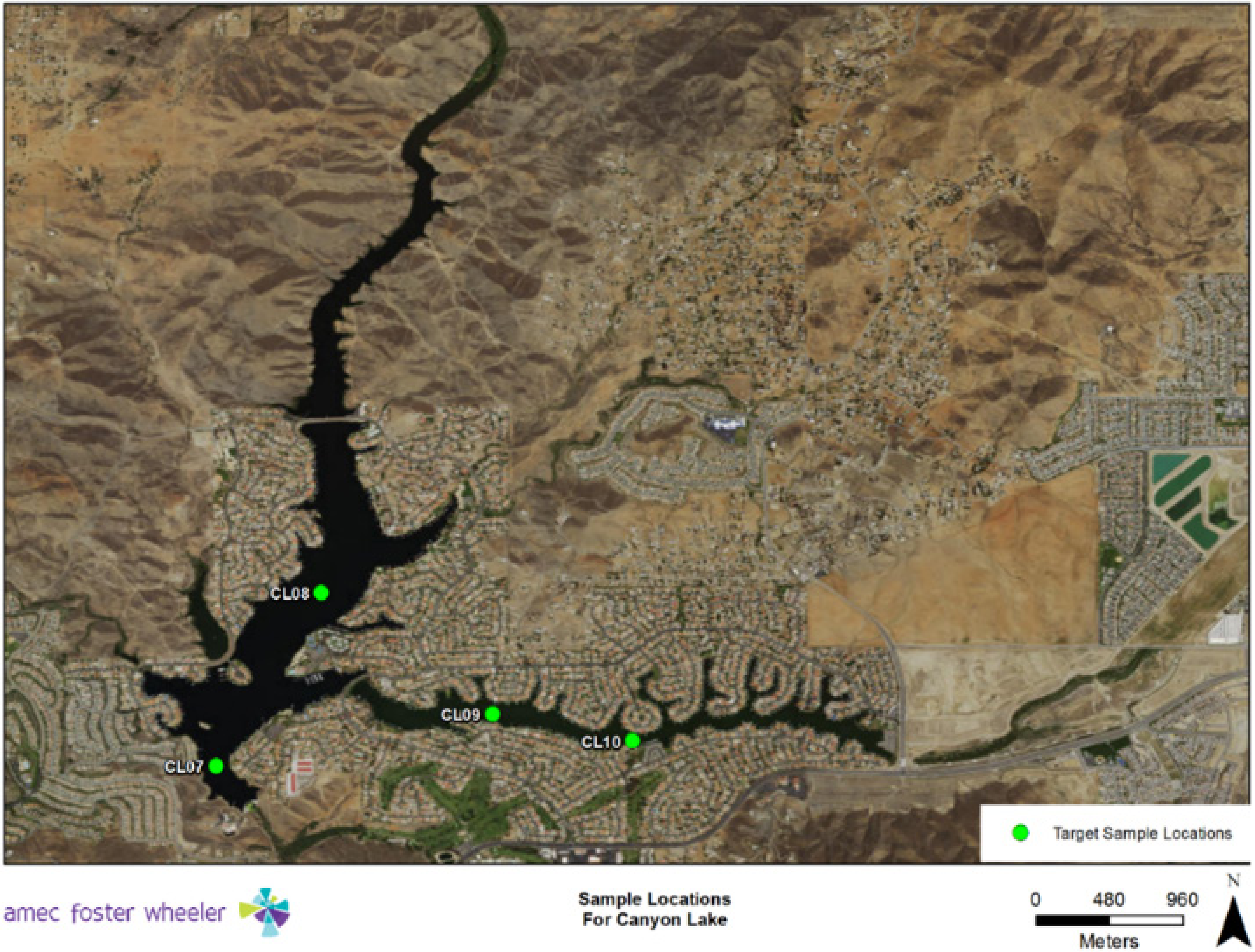


Figure 3-10. Canyon Lake Sampling Locations

3.3.2 Sampling Methods

Samples for analytical chemistry were collected in the same manner as in Lake Elsinore using a peristaltic pump. Two discrete samples were collected for chlorophyll-a: 1) a full depth-integrated composite sample; and 2) a 0-2-meter (m) depth-integrated composite surface sample. Cyanotoxin samples were collected as a full depth-integrated composite and a surface grab. All analytical samples were held on wet ice immediately following collection, and transferred to a local courier or shipping company on the same day of collection. Samples for analysis of nutrients, sulfide, TDS, and chlorophyll-a were, submitted to Babcock Laboratories Inc. located in Riverside, California. Samples for analysis of cyanotoxins were shipped via overnight delivery to the University of California, Santa Cruz (Table 3-10).

Canyon Lake alum applications were performed by Aquatechnex on September 25-29, 2017 and February 12-16, 2018. Beginning with the February 2017 sampling event, the TMDL Task Force directed that the pre- and post-alum application monitoring be integrated into the routine TMDL monitoring, given that the monitored analytes were largely identical to the TMDL monitoring, with the exception of aluminum and total suspended solids. Given this directive, total/dissolved aluminum and total suspended solids were added to the nutrient TMDL monitoring analyte list for all subsequent routine TMDL monitoring events. A separate monitoring event on September 21, 2017 and a TMDL monitoring event on February 8, 2018 served as the pre-alum effectiveness monitoring events, with the subsequent respective bi-monthly TMDL event serving as the post-alum application monitoring.

In-situ water column profile data was recorded in the morning at all four Canyon Lake stations using pre-calibrated hand-held YSI field meters or equivalent for pH, temperature, DO, and specific conductivity at 1-m intervals throughout the water column. These data were used to assess lateral and vertical spatial variability within the lake. End-of-the-day water column profiles (i.e. after ~2:00pm) were also recorded for the same suite of parameters at all stations to assess any potential temporal variability in these parameters over the course of a day. Water clarity was also assessed with a Secchi disk at all stations.

Satellite imagery was used to remotely measure chlorophyll-a and turbidity concentrations in Canyon Lake. In-lake sampling dates were selected to correspond with satellite overpasses.

Similar to Lake Elsinore, two types of cyanobacterial toxin samples were collected: 1) a subsample of the depth-integrated composite sample at all four sites, and 2) a surface grab at Site CL07, due to the known diurnal vertical migration of some cyanobacteria. Collection of cyanobacteria samples is not part of the TMDL compliance program, but was integrated into the monitoring from June 2018- April 2018 to assess the relationship of cyanotoxins to other constituents being measured. Samples were held on wet ice and shipped the following day to the University of California, Santa Cruz for analysis of cyanotoxins.

Table 3-10. In-lake Analytical Constituents and Methods for Canyon Lake

Parameter	Analysis SOP #	Sampling Method
Analytical Chemistry		
Nitrite Nitrogen (NO_2-N)	SM4500-NO2 B	Depth Integrated
Nitrate Nitrogen (NO_3-N)	EPA 300.0	Depth Integrated
Total Kjeldahl Nitrogen (TKN)	EPA 351.3	Depth Integrated
Ammonia Nitrogen (NH4-N)	SM4500-NH_3 H	Depth Integrated
Sulfide	SM 4500S2 D	Depth Integrated
Total Phosphorus (TP)	SM4500-P E	Depth Integrated
Soluble Reactive Phosphorus (SRP / Ortho-P)	SM4500-P E	Depth Integrated
Chlorophyll-a	SM 10200H	Surface (0-2m) & Depth Integrated
Total Dissolved Solids (TDS)	SM 2540 C	Depth Integrated
Total Suspended Solids (TSS)[a]	SM 2540D	Depth Integrated
Total Aluminum[a]	EPA 200.7	Depth Integrated
Dissolved Aluminum[a]	EPA 200.7	Depth Integrated
Cyanobacteria Toxins		
Microcystin	LC-MS/MS	Surface Grab (CL07) & Depth Integrated
Cylindrospermopsin	LC-MS/MS	Surface Grab (CL07) & Depth Integrated
Anatoxin-a	LC-MS/MS	Surface Grab (CL07) & Depth Integrated
Nodularin	LC-MS/MS	Surface Grab (CL07) & Depth Integrated

Note:
[a] measured as part of the pre- and post-alum application monitoring program only

3.3.3 Water Quality Summary

A summary of the in-lake monitoring events for Canyon Lake for the period of July 1, 2017 to June 30, 2018 is presented below. A total of six events were sampled under the TMDL monitoring program, with three occurring in 2017 (August 21, October 26, December 5) and three in 2018 (February 8, April 4, and June 5). Complete water quality profile measurements can be found in the quarterly reports contained in Appendix B. Detailed analytical chemistry lab reports for each event are contained in Appendix C. Satellite imagery reports for each event are provided in Appendix D. A summary of Canyon Lake water quality profiles for June 2018 is provided in Appendix E.

Water Column Profiles

A summary of water column profile mean values for each site and monitoring event are presented in Tables 3-11 and 3-12. A summary of water column profile mean values for each basin (i.e. Main Lake and Eastern Arm) are presented in Tables 3-13 and 3-14. Water column profile mean statistics for each site across the entire monitoring period are presented in Table 3-15. Mean water column values across the annual cycle are visually summarized in Figures 3-11 and 3-12.

For the purposes of this report, the epilimnion is defined as the region of the water column above the thermocline, while the hypolimnion is the region of the water column below the thermocline, with both of these regions exhibiting relatively stable temperatures. The thermocline portion of the water column was defined as the region between the epilimnion and hypolimnion where a marked drop in temperature per unit of depth was evident. Measurements within the thermocline were excluded from epilimnion and hypolimnion averaging. Full water column means included data recorded from all three zones, if present.

For both the Main Basin and East Basin, temperature exhibited a typical pattern with lowest values occurring during the winter events (December and February) and highest values in summer months (August and June). Dissolved oxygen concentrations for both basins were relatively stable from August 2017 to June 2018 when averaged throughout the water column, with the exception of higher values observed in April 2018. When the thermocline developed, DO concentrations within the epilimnion and hypolimnion diverged, with hypolimnion concentrations falling substantially during that timeframe to <1.2 mg/L. The DO concentration rolling annual average within the epilimnion was greater than the current 2015 TMDL target of 5.0 mg/L for all five events when stratification was present (Figure 3-13). However, the DO concentration rolling average was never above the target of 5.0 mg/L in the hypolimnion when stratification was present.

Conductivity within the epilimnion and hypolimnion (when present) remained consistent throughout the monitoring period. Average specific conductivity in the Main Basin of Canyon Lake ranged from 717-870 µS/cm, slowly increasing over the monitoring year. In the East Basin, water column conductivity means were higher, ranging from 920-1074 µS/cm. In both basins, values for pH generally remained around 8.00, with a decrease of approximately 0.5 units observed in the Main Basin during the December 2017 event. The East Basin exhibited higher pH values, approximately 8.35 from July 2017-February 2018 before dropping to 8.00 in April 2018 after rain event. Values for pH within the epilimnion and hypolimnion tended to diverge as the thermocline developed, with pH generally 1.0 unit greater in the epilimnion relative to that in the hypolimnion.

Secchi depths were generally limited to a narrow range for both basins, with the exception of the April 2018 measurement in the Main Basin. Within the Main Basin (mean of CL07 & CL08), Secchi depths ranged from 0.55 to 1.1-m, but spiked to 2.2-m in April 2018. Within the East Basin (mean of CL09 & CL10), Secchi depths ranged from 0.35 to 0.88-m across the monitoring period. The East Basin exhibited a slight increase in Secchi depths following each alum treatment, while the Main Basin exhibited a large increase in Secchi depth folowng the February 2018 application, but a slight decrease after the September 2017 application.

Table 3-11. In-Situ Water Quality Parameter Measurements for Canyon Lake - 2017 Monthly Means for Each Site

Basin	Site	Measure	Aug-17			Oct-17			Dec-17		
			Water Column Mean - All	Water Column Mean - Epi	Water Column Mean - Hypo	Water Column Mean - All	Water Column Mean - Epi	Water Column Mean - Hypo	Water Column Mean - All	Water Column Mean - Epi	Water Column Mean - Hypo
Main Basin	CL07	Temp (°C)	20.7	27.5	13.7	18.4	21.0	14.2	16.0	NA	NA
		Cond (µS/cm)	698	744	659	753	801	687	817	NA	NA
		pH	7.99	9.06	7.18	7.71	8.18	7.14	7.52	NA	NA
		DO (mg/L)	3.6	8.7	0.2	3.2	5.8	0.2	2.3	NA	NA
	CL08	Temp (°C)	26.2	27.7	19.7	20.8	21.0	20.1	15.9	NA	NA
		Cond (µS/cm)	736	744	686	799	800	793	825	NA	NA
		pH	8.50	8.97	7.09	8.21	8.31	7.53	7.74	NA	NA
		DO (mg/L)	5.0	7.0	0.2	6.3	7.1	0.5	5.1	NA	NA
East Basin	CL09	Temp (°C)	25.2	26.9	19.1	20.8	21.0	20.0	15.4	NA	NA
		Cond (µS/cm)	937	909	1020	1014	1013	1019	916	NA	NA
		pH	8.29	8.80	7.00	8.03	8.16	7.27	8.03	NA	NA
		DO (mg/L)	4.6	6.4	0.2	5.3	6.1	0.4	7.1	NA	NA
	CL10	Temp (°C)	27.0	NA	NA	21.4	NA	NA	14.9	NA	NA
		Cond (µS/cm)	931	NA	NA	1091	NA	NA	923	NA	NA
		pH	8.74	NA	NA	8.45	NA	NA	8.58	NA	NA
		DO (mg/L)	8.3	NA	NA	8.7	NA	NA	10.7	NA	NA

NA – not applicable due to lack of thermocline

Table 3-12. In-Situ Water Quality Parameter Measurements for Canyon Lake - 2018 Monthly Means for Each Site

Basin	Site	Measure	Feb-18			Apr-18			Jun-18		
			Water Column Mean - All	Water Column Mean - Epi	Water Column Mean - Hypo	Water Column Mean - All	Water Column Mean - Epi	Water Column Mean - Hypo	Water Column Mean - All	Water Column Mean - Epi	Water Column Mean - Hypo
Main Basin	CL07	Temp (°C)	13.3	16.2	12.5	15.7	19.6	13.4	18.8	25.5	14.4
		Cond (µS/cm)	842	829	845	859	835	871	869	864	871
		pH	7.82	9.04	7.44	7.73	8.57	7.17	7.83	8.73	7.26
		DO (mg/L)	3.9	14.0	1.0	5.9	14.7	0.3	2.9	8.8	0.2
	CL08	Temp (°C)	13.6	16.2	12.6	17.2	19.6	13.7	21.8	25.5	16.7
		Cond (µS/cm)	835	825	841	850	833	875	871	866	872
		pH	7.99	8.90	7.51	8.07	8.57	7.17	8.06	8.70	7.28
		DO (mg/L)	5.0	12.8	1.4	9.1	14.4	0.3	4.4	8.4	0.2
East Basin	CL09	Temp (°C)	13.7	NA	NA	17.3	19.6	13.7	21.1	25.9	15.2
		Cond (µS/cm)	1020	NA	NA	1034	1017	1066	1048	1009	1078
		pH	8.17	NA	NA	7.76	8.33	7.01	7.91	8.78	7.07
		DO (mg/L)	7.0	NA	NA	6.0	11.4	0.3	4.9	9.5	0.2
	CL10	Temp (°C)	15.2	NA	NA	20.1	NA	NA	25.9	NA	NA
		Cond (µS/cm)	1062	NA	NA	1054	NA	NA	1100	NA	NA
		pH	8.77	NA	NA	8.29	NA	NA	8.52	NA	NA
		DO (mg/L)	11.5	NA	NA	10.9	NA	NA	8.2	NA	NA

NA – not applicable due to lack of thermocline

Table 3-13. In-Situ Water Quality Parameter Measurements for Canyon Lake - 2017 Monthly Means for Each Basin

Basin	Measure	Aug-17			Oct-17			Dec-17		
		Water Column Mean - All	Water Column Mean - Epi	Water Column Mean - Hypo	Water Column Mean - All	Water Column Mean - Epi	Water Column Mean - Hypo	Water Column Mean - All	Water Column Mean - Epi	Water Column Mean - Hypo
Main	Temp (°C)	23.4	27.6	16.7	19.6	21.0	17.1	15.9	NA	NA
	Cond (µS/cm)	717	744	672	776	801	740	821	NA	NA
	pH	8.24	9.01	7.13	7.96	8.24	7.34	7.63	NA	NA
	DO (mg/L)	4.3	7.9	0.2	4.7	6.4	0.3	3.7	NA	NA
East	Temp (°C)	26.1	26.9	19.1	21.1	21.0	20.0	15.2	NA	NA
	Cond (µS/cm)	934	909	1020	1053	1013	1019	920	NA	NA
	pH	8.51	8.80	7.00	8.24	8.16	7.27	8.30	NA	NA
	DO (mg/L)	6.5	6.4	0.2	7.0	6.1	0.4	8.9	NA	NA

NA – not applicable due to lack of thermocline

Table 3-14. In-Situ Water Quality Parameter Measurements for Canyon Lake - 2018 Monthly Means for Each Basin

Basin	Measure	Feb-18			Apr-18			Jun-18		
		Water Column Mean - All	Water Column Mean - Epi	Water Column Mean - Hypo	Water Column Mean - All	Water Column Mean - Epi	Water Column Mean - Hypo	Water Column Mean - All	Water Column Mean - Epi	Water Column Mean - Hypo
Main	Temp (°C)	13.4	16.2	12.6	16.5	19.6	13.6	20.3	25.5	15.5
	Cond (µS/cm)	838	827	843	854	834	873	870	865	871
	pH	7.91	8.97	7.48	7.90	8.57	7.17	7.94	8.72	7.27
	DO (mg/L)	4.4	13.4	1.2	7.5	14.6	0.3	3.6	8.6	0.2
East	Temp (°C)	14.4	NA	NA	18.7	19.6	13.7	23.5	25.9	15.2
	Cond (µS/cm)	1041	NA	NA	1044	1017	1066	1074	1009	1078
	pH	8.47	NA	NA	8.03	8.33	7.01	8.21	8.78	7.07
	DO (mg/L)	9.3	NA	NA	8.4	11.4	0.3	6.5	9.5	0.2

NA – not applicable due to lack of thermocline

Table 3-15. In-Situ Water Quality Parameter Measurements for Canyon Lake - Annual Mean Statistics for Each Site

		Measure	CL07	CL08	Main Basin	CL09	CL10	East Basin
Water Column Mean	Min	Temp (°C)	13.3	13.6	13.4	13.7	14.9	14.3
		Cond (µS/cm)	698	736	717	916	923	920
		pH	7.52	7.74	7.63	7.76	8.29	8.03
		DO (mg/L)	2.3	4.4	3.3	4.6	8.2	6.4
	Max	Temp (°C)	20.7	26.2	23.4	25.2	27.0	26.1
		Cond (µS/cm)	869	871	870	1048	1100	1074
		pH	7.99	8.50	8.24	8.29	8.77	8.53
		DO (mg/L)	5.9	9.1	7.5	7.1	11.5	9.3
	Average	Temp (°C)	17.1	19.3	18.2	18.9	20.7	19.8
		Cond (µS/cm)	806	819	813	995	1027	1011
		pH	7.77	8.09	7.93	8.03	8.56	8.29
		DO (mg/L)	3.6	5.8	4.7	5.8	9.7	7.8
Epilimnion	Min	Temp (°C)	16.2	16.2	16.2	19.6	NA	19.6
		Cond (µS/cm)	744	744	744	909	NA	909
		pH	8.18	8.31	8.24	8.16	NA	8.16
		DO (mg/L)	5.8	7.0	6.4	6.1	NA	6.1
	Max	Temp (°C)	27.5	27.7	27.6	26.9	NA	26.9
		Cond (µS/cm)	864	866	865	1017	NA	1017
		pH	9.06	8.97	9.01	8.80	NA	8.80
		DO (mg/L)	14.7	14.4	14.6	11.4	NA	11.4
	Average	Temp (°C)	21.9	22.0	22.0	23.3	NA	23.3
		Cond (µS/cm)	814	814	814	987	NA	987
		pH	8.72	8.69	8.70	8.52	NA	8.52
		DO (mg/L)	10.4	9.9	10.2	8.3	NA	8.3
Hypolimnion	Min	Temp (°C)	12.5	12.6	12.6	13.7	NA	13.7
		Cond (µS/cm)	659	686	672	1019	NA	1019
		pH	7.14	7.09	7.11	7.00	NA	7.00
		DO (mg/L)	0.2	0.2	0.2	0.2	NA	0.2
	Max	Temp (°C)	14.4	20.1	17.2	20.0	NA	20.0
		Cond (µS/cm)	871	875	873	1078	NA	1078
		pH	7.44	7.53	7.48	7.27	NA	7.27
		DO (mg/L)	1.0	1.4	1.2	0.4	NA	0.4
	Average	Temp (°C)	13.6	16.5	15.1	17.0	NA	17.0
		Cond (µS/cm)	786	813	800	1046	NA	1046
		pH	7.24	7.32	7.28	7.09	NA	7.09
		DO (mg/L)	0.4	0.5	0.4	0.3	NA	0.3

NA – not applicable due to lack of thermocline
Values for epilimnion and hypolimnion when present

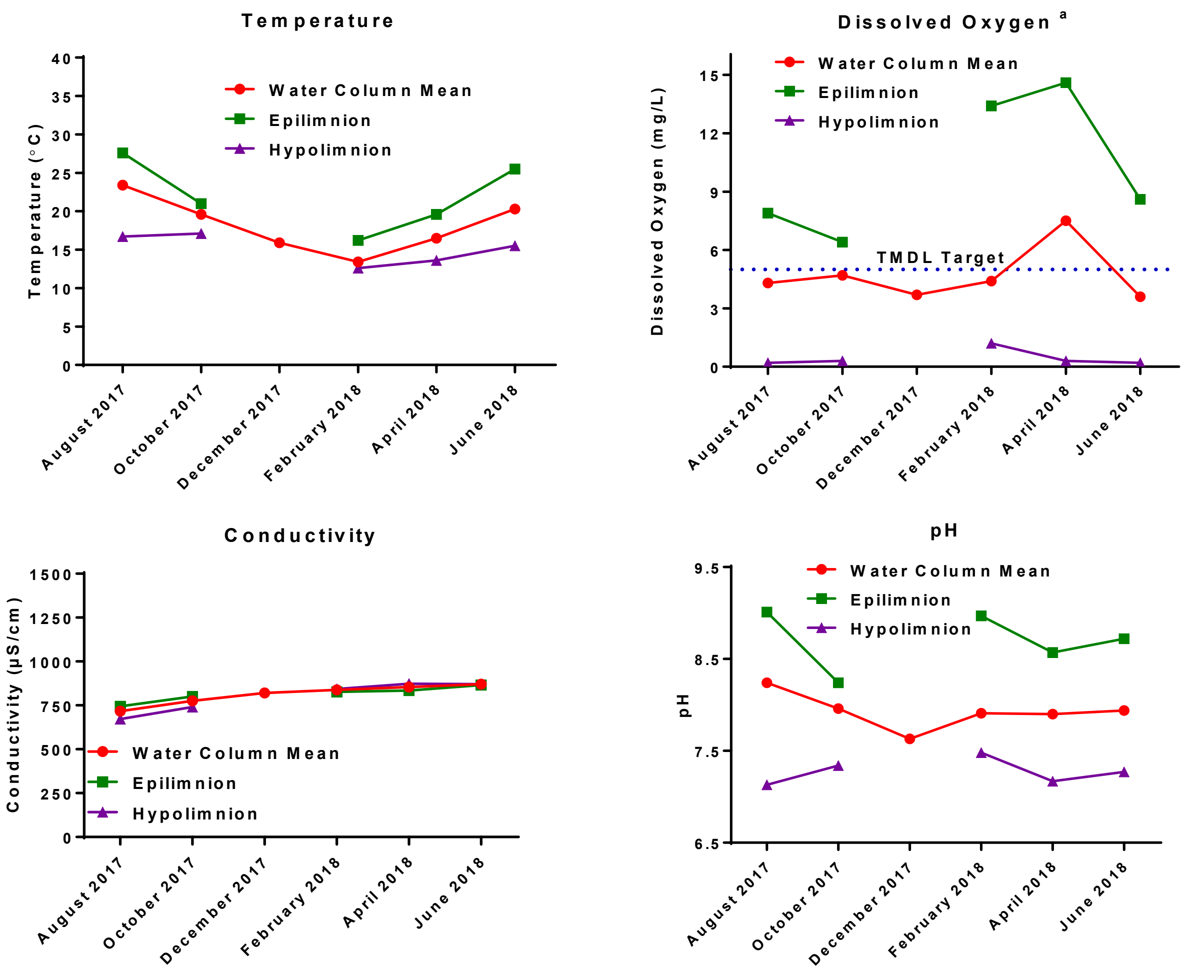


Figure 3-11. Mean In-Situ Physical Water Quality Parameters – Canyon Lake Main Basin

[a] - TMDL Target for dissolved oxygen is no less than 5 mg/L above thermocline no later than 2015, no less than 5 mg/L in hypolimnion no later than 2020

(Values represent the mean of Sites CL07 & CL08. Missing values represent time periods when no stratification was present)

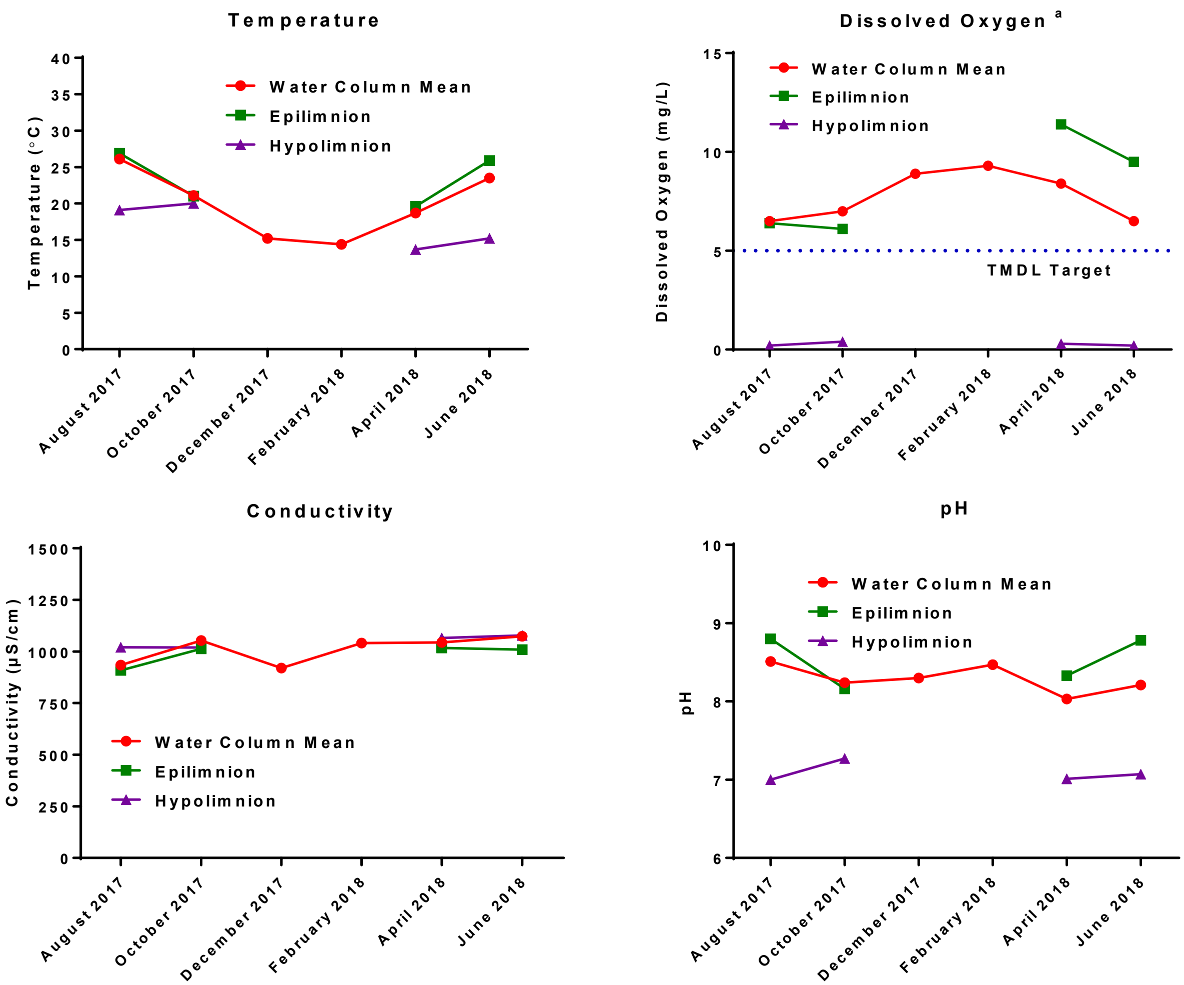


Figure 3-12. Mean In-Situ Physical Water Quality Parameters - Canyon Lake East Basin

[a] -TMDL Target for dissolved oxygen is no less than 5 mg/L above thermocline no later than 2015, no less than 5 mg/L in hypolimnion no later than 2020

(Values represent the mean of Sites CL09 & CL10. Missing values represent time periods when no stratification was present.)

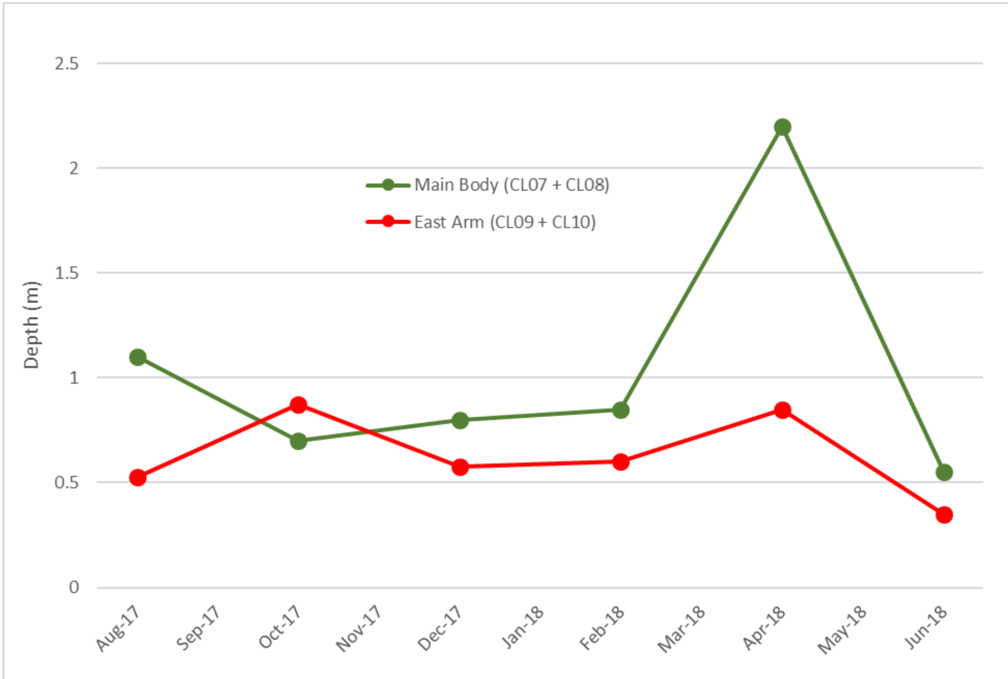


Figure 3-12a. In- Situ Secchi Depth Measurements – Main and East Basins

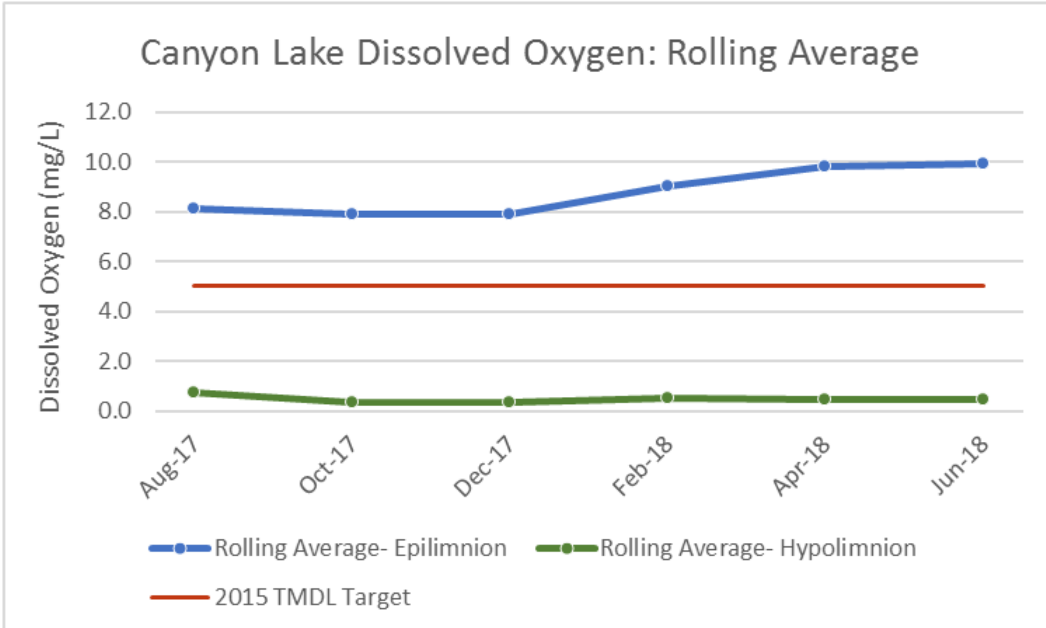


Figure 3-13. Mean In-Situ Physical Water Quality Parameters - Canyon Lake Dissolved Oxygen Epilimnion and Hypolimnion Column Rolling Averages

Values are calculated by averaging the value from each event with the previous five event values (i.e. one year of data) to obtain a rolling average.

Analytical Chemistry

Summaries of analytical chemistry concentrations for each monitoring event in Canyon Lake are presented in Tables 3-16 and 3-17. A summary of analytical chemistry mean statistics for each site across the entire monitoring period are presented in Tables 3-18 through 3-20. Concentrations of analytes are graphically presented in Figures 3-14 and 3-15.

Total nitrogen concentrations in the Main Basin (average of monthly values from CL07 and CL08) ranged from 0.97 to 1.45 mg/L across the six sampling events, with an annual mean of 1.20 mg/L (down from the 2016-17 annual mean of 1.44 mg/L). Total nitrogen concentrations in the East Basin ranged from 0.86 to 1.55 mg/L across the six sampling events, with the annual mean of 1.17 mg/L (down from the 2016-17 annual mean of 1.46 mg/L). The total nitrogen rolling average of all sites exceeded the current 2020 TMDL target of 0.75 mg/L for all events (Figure 3-16).

Total phosphorus concentrations in the Main Basin across the monitoring year ranged from non-detect (ND <0.01 to <0.05 mg/L) to 0.23 mg/L, with an annual mean of 0.08 mg/L. Total phosphorus concentrations in the East Basin ranged from ND to 0.08 mg/L, with an annual mean of 0.06 mg/L. This demonstrates an overall decrease in total phosphorus in both basins, with 0.21 and 0.19 mg/L observed in the 2016-17 monitoring period for the Main Basin and East Basin, respectively. The total phosphorus rolling average of all sites exceeded the current 2020 TMDL target of 0.1 mg/L for the first four events, but then met and decreased below the target during the last two events of the monitoring year (Figure 3-16).

Depth-integrated samples in the Main Basin exhibited a steady decline in chlorophyll-a concentrations through the year until April 2018, when concentrations began to increase. The East Basin exhibited more of a seasonal pattern with lower concentrations of chlorophyll-a in the fall and early spring, and greater concentrations during the summer and late winter months. Depth-integrated concentrations in the Main Basin (mean of Sites CL07 and CL08) across all six sampling events ranged from 6 to 46 µg/L, with a mean of 28 µg/L. Depth-integrated concentrations of chlorophyll-a in the East Basin (Sites CL09 and CL10) across all events ranged from 25 to 79 µg/L, with a mean of 52 µg/L. The lake-wide chlorophyll-a rolling average was below the 2020 TMDL target of 25 µg/L for the first two events, but the exceeded target for the last four (Figure 3-16).

Total ammonia concentrations observed in the Main and Eastern Basins showed somewhat contrasting patterns. While concentrations in the East Basin were relatively stable across the monitoring year, the Main Basin exhibited a distinct decrease across the winter months and then an increase in spring 2018. However, no individual samples exceeded the US EPA CMC or CCC values for the protection of aquatic life.

Total dissolved solids concentrations for both basins followed an increasing pattern over the course of the monitoring year. The Main Basin steadily increased from approximately 415 to 540 mg/L, while East Basin concentrations climbed from approximately 580 to 685 mg/L. TDS concentrations during all sampling events were below the Basin Plan water quality objective of 700 mg/L.

Concentrations of total aluminum ranged from ND (< 37 µg/L) to 120 µg/L in the Main Basin and 46 to 390 µg/L in the East Basin. Dissolved aluminum was not detected at concentrations greater than the MDL in any sample, with the exception of a June 2018 CL10 sample with a concentration just above the MDL at 39 µg/L. Concentrations of aluminum had no obvious temporal relationship with the timing of the alum applications.

Cyanobacterial toxin sampling for Canyon Lake was conducted between August 2017 and April 2018. The cyanotoxins nodularin and cylindospermopsin were not detected at any of the sites during the monitoring period. Low concentrations of anatoxin-a were detected in August 2017 for all sites, ranging from 0.276 to 0.343 µg/L. All of these concentrations exceeded the State's "Caution" threshold of any detection of anatoxin-a. Microcystin was detected in all samples from the August 2017 and April 2018 monitoring events, ranging in concentration from 0.01 to 0.199 µg/L. Microcystin was also detected during the October 2017 monitoring event at Sites CL09 and CL10. All of these microcystin levels were below the State of California's lowest "Caution" threshold of 0.8 µg/L.

The current 2017-2018 FY Canyon Lake data in the context of historical data can be found in Appendix H.

Table 3-16. Analytical Chemistry Results for Canyon Lake - 2017 Monthly Depth-Integrated Results

Method	Compound	Units	MDL	RL	Depth Integrated or Surface Sample	August 2017				October 2017				December 2017			
						Main Basin		East Basin		Main Basin		East Basin		Main Basin		East Basin	
						CL07	CL08	CL09	CL10	CL07	CL08	CL09	CL10	CL07	CL08	CL09	CL10
General Chemistry																	
SM 2540C	Total Dissolved Solids	mg/L	10-12	10-40	DI	420	410	590	580	400	470	630	650	480	460	600	610
SM 4500S2 D	Sulfide	mg/L	0.1	0.1	DI	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
EPA 300.0	Nitrate as N	mg/L	0.055	0.2	DI	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055	<0.055	0.062	<0.055	<0.055	<0.055	<0.055
SM 4500NO2 B	Nitrite as N	mg/L	0.042-0.1	0.1	DI	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
EPA 351.2	Kjeldahl Nitrogen	mg/L	0.063- 0.25	0.1-0.4	DI	1.8	0.66	1.5	1.4	2.1	0.73	0.84	0.82	1.1	0.84	0.91	0.85
Calculated	Total Nitrogen[a]	mg/L	NA	--	DI	1.8	0.66	1.5	1.4	2.1	0.73	0.84	0.88	1.1	0.84	0.91	0.85
SM4500NH3H	Ammonia-Nitrogen	mg/L	0.048	0.1	DI	1.1	ND	0.3	<0.048	1.5	<0.048	0.065	<0.048	0.44	0.2	0.12	<0.048
Calculated	Unionized Ammonia[b,c]	mg/L	--	--	DI	0.040	0.008	0.030	0.018	0.026	0.003	0.002	0.004	0.004	0.003	0.003	0.003
SM 4500P E	Ortho Phosphate Phosphorus	mg/L	0.024	0.05	DI	0.36	0.035	<0.024	<0.024	0.23	<0.024	<0.024	<0.024	0.037	<0.024	<0.024	<0.024
SM 4500P B E	Total Phosphorus	mg/L	NA	0.01	DI	0.38	0.08	0.08	0.07	0.27	0.03	0.03	0.04	0.06	0.03	0.04	0.07
EPA 200.7	Total Aluminum	µg/L	37	100	DI	<37	<37	72 J	130	53 J	99 J	76 J	200	39 J	120	210	390
EPA 200.7	Dissolved Aluminum	µg/L	37	100	DI	<37	<37	<37	<37	<37	<37	<37	<37	<37	<37	<37	<37
Chlorophyll-a																	
EPA 10200 H	Chlorophyll-a	µg/L	NA	1.0	Surf	21	24	39	46	46	53	24	31	40	39	50	74
EPA 10200 H	Chlorophyll-a	µg/L	NA	1.0	DI	37	55	87	47	45	39	35	23	40	32	44	62
Algae Toxins																	
LC-MS/MS	Total Microcystin	µg/L	NA	0.001	DI	0.183	0.199	0.173	0.174	<0.001	<0.001	0.014	0.099	<0.001	<0.001	<0.001	<0.001
					SG	0.161	NS	NS	NS	<0.001	NS	NS	NS	<0.001	NS	NS	NS
LC-MS/MS	Total Nodularin	µg/L	NA	0.001	DI	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
					SG	<0.001	NS	NS	NS	<0.001	NS	NS	NS	<0.001	NS	NS	NS
LC-MS/MS	Total Anatoxin-a	µg/L	NA	0.001	DI	<0.001	0.286	0.296	0.276	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
					SG	0.343	NS	NS	NS	<0.001	NS	NS	NS	<0.001	NS	NS	NS
LC-MS/MS	Total Cylindospermopsin	µg/L	NA	0.001	DI	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
					SG	<0.001	NS	NS	NS	<0.001	NS	NS	NS	<0.001	NS	NS	NS

Notes:
a - Total Nitrogen = $TKN+NO_2+NO_3$
b - Values are site specific dependent upon pH and temperature recorded at each location. Calculated using equation by Thursby (1986).
c - Unionized ammonia concentrations calculated based on ½ detection limit when ammonia nitrogen was ND
NS - Not sampled; DI = Depth integrated; SG = Surface grab; Surf = Surface 0-2m
mg/L – micrograms per liter; ug/L – milligrams per liter; m – meters; RL – reporting limit; J- Reported value was detected above the Method Detection Limit (MDL), but below the Reporting Limit (RL)

Table 3-17. Analytical Chemistry Results for Canyon Lake- 2018 Monthly Depth-Integrated Results

Method	Compound	Units	MDL	RL	Depth Integrated or Surface Sample	February 2018				April 2018				June 2018			
						Main Basin		East Basin		Main Basin		East Basin		Main Basin		East Basin	
						CL07	CL08	CL09	CL10	CL07	CL08	CL09	CL10	CL07	CL08	CL09	CL10
General Chemistry																	
SM 2540C	Total Dissolved Solids	mg/L	10-12	10-40	DI	500	490	600	640	520	530	640	660	550	530	660	710
SM 4500S2 D	Sulfide	mg/L	0.1	0.1	DI	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
EPA 300.0	Nitrate as N	mg/L	0.055	0.2	DI	0.31	0.19 J	0.07 J	<0.055	0.08 J	0.09 J	<0.055	0.1 J	<0.055	<0.055	<0.055	<0.055
SM 4500NO2 B	Nitrite as N	mg/L	0.042-0.1	0.1	DI	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
EPA 351.2	Kjeldahl Nitrogen	mg/L	0.063- 0.25	0.1-0.4	DI	0.71	0.79	1.10	1.20	1.10	1.00	0.99	1.10	1.80	1.10	1.70	1.40
Calculated	Total Nitrogen[a]	mg/L	NA	--	DI	1.02	0.98 J	1.17	1.20	1.18 J	1.09 J	0.99	1.2 J	1.80	1.10	1.70	1.40
SM4500NH3H	Ammonia-Nitrogen	mg/L	0.048	0.1	DI	0.14	0.15	0.16	<0.048	0.31	0.097 J	<0.048	<0.048	0.92	0.13	0.47	<0.048
Calculated	Unionized Ammonia[b,c]	mg/L	--	--	DI	0.019	0.004	0.005	0.006	0.005	0.003	0.001	0.003	0.018	0.006	0.015	0.007
SM 4500P E	Ortho Phosphate Phosphorus	mg/L	0.024	0.05	DI	0.03 J	0.025 J	0.041 J	<0.024	<0.024	<0.024	<0.024	<0.024	<0.024	<0.024	<0.024	<0.024
SM 4500P B E	Total Phosphorus	mg/L	NA	0.01	DI	0.04	0.03	0.07	0.05	0.02	0.02	0.04	0.07	0.03	0.04	0.06	0.05
EPA 200.7	Total Aluminum	µg/L	37	100	DI	51 J	54 J	79 J	160	43 J	43 J	46 J	140	40 J	56 J	49 J	120
EPA 200.7	Dissolved Aluminum	µg/L	37	100	DI	<37	<37	<37	<37	<37	<37	<37	<37	<37	<37	<37	39 J
Chlorophyll-a																	
EPA 10200 H	Chlorophyll-a	µg/L	NA	1.0	Surf	38	80	80	114	26	18	19	33	21	25	36	48
EPA 10200 H	Chlorophyll-a	µg/L	NA	1.0	DI	11	61	61	97	6	20	30	20	18	33	78	40
Algae Toxins																	
LC-MS/MS	Total Microcystin	µg/L	NA	0.001	DI	<0.001	<0.001	<0.001	<0.001	0.13	0.14	0.06	0.01	NS	NS	NS	NS
					SG	<0.001	NS	NS	NS	0.10	NS	NS	NS	NS	NS	NS	NS
LC-MS/MS	Total Nodularin	µg/L	NA	0.001	DI	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NS	NS	NS	NS
					SG	<0.001	NS	NS	NS	<0.001	NS	NS	NS	NS	NS	NS	NS
LC-MS/MS	Total Anatoxin-a	µg/L	NA	0.001	DI	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NS	NS	NS	NS
					SG	<0.001	NS	NS	NS	<0.001	NS	NS	NS	NS	NS	NS	NS
LC-MS/MS	Total Cylindospermopsin	µg/L	NA	0.001	DI	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NS	NS	NS	NS
					SG	<0.001	NS	NS	NS	<0.001	NS	NS	NS	NS	NS	NS	NS

Notes:
a - Total Nitrogen = $TKN+NO_2+NO_3$
b - Values are site specific dependent upon pH and temperature recorded at each location. Calculated using equation by Thursby (1986).
c - Unionized ammonia concentrations calculated based on ½ detection limit when ammonia nitrogen was ND
NS - Not sampled; DI = Depth integrated; SG = Surface grab; Surf = Surface 0-2m
mg/L – micrograms per liter; ug/L – milligrams per liter; m – meters; RL – reporting limit; J- Reported value was detected above the Method Detection Limit (MDL), but below the Reporting Limit (RL)

Table 3-18. Analytical Chemistry Results for Canyon Lake- Annual Mean Statistics for Each Site in the Main Basin

Method	Compound	Units	MDL	RL	Basin Plan or TMDL Target	Depth Integrated or Surface Sample	CL07			CL08			Main Basin[e]		
							Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
General Chemistry															
SM 2540C	Total Dissolved Solids	mg/L	10-12	10-40	700 [3]	DI	400	550	478	410	530	482	415	540	480
SM 4500S2 D	Sulfide	mg/L	0.1	0.1	NA	DI	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
EPA 300.0	Nitrate as N	mg/L	0.055	0.2	NA	DI	0.03[c]	0.31	0.08[c]	0.03[c]	0.19	0.07[c]	0.03[c]	0.25	0.07[c]
SM 4500NO2 B	Nitrite as N	mg/L	0.042-0.1	0.1	NA	DI	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
EPA 351.2	Kjeldahl Nitrogen	mg/L	0.063- 0.25	0.1-0.4	NA	DI	0.71	2.10	1.44	0.66	1.10	0.85	0.75	1.45	1.14
Calculated	Total Nitrogen[a]	mg/L	NA	--	0.75[b1]	DI	1.02	2.1	**1.5**	0.66	1.10	**0.90**	0.97	1.45	**1.20**
Calculated	Unionized Ammonia[c,d]	mg/L	0.048	0.1	--	DI	0.004	0.04	0.0	0.00	0.01	0.00	0.01	0.02	0.01
SM4500NH3H	Ammonia-Nitrogen	mg/L	--	--	CMC: 1.46-20.49[1] CCC: 0.25-4.06[1]	DI	0.14	1.50	0.74	0.02[c]	0.02	0.10[c]	0.15[c]	0.76	0.419[c]
SM 4500P E	Ortho Phosphate Phosphorus	mg/L	0.024	0.05	NA	DI	0.01[c]	0.36	0.11[c]	0.01[c]	0.04	0.02[c]	0.01[c]	0.20	0.07[c]
SM 4500P B E	Total Phosphorus	mg/L	NA	0.01	0.1[b1]	DI	0.02	0.38	**0.14**	0.02[c]	0.08	0.04[c]	0.02[c]	0.23	0.08[c]
EPA 200.7	Total Aluminum	µg/L	37	100	NA	DI	<37	53 J	41[c]	43 J	120	74	18.5 J	79.5 J	53
EPA 200.7	Dissolved Aluminum	µg/L	37	100	NA	DI	<37	<37	<37	<37	<37	<37	<37	<37	<37
Chlorophyll-a															
EPA 10200 H	Chlorophyll-a	µg/L	NA	1.0	25[1], 40[2]	Surf	21	46	**32**	18	80	**40**	22	59	**36**
EPA 10200 H	Chlorophyll-a	µg/L	NA	1.0	25[1], 40[2]	DI	6	45	**26**	20	61	**40**	6	46	**28**

Notes:
a - Total Nitrogen = TKN+NO_2+NO_3
b - Annual average
c - Concentrations calculated based on ½ detection limit (MDL) when a value in calculation was ND
d - Values calculated using water column mean ammonia, temperature, salinity and pH. Calculated using equation by Thursby (1986).
e - Main Basin values are an average of minimum and maximum values for CL07 and CL08 and an overall mean of all values from both sites.
1 – 2020 TMDL Target, based on Table 5-9n of 2004 TMDL
2 – 2015 TMDL Target, based on Table 5-9n of 2004 TMDL
3 – Santa Ana Region Basin Plan Objective
NA – Not applicable/ available
NS - Not sampled
DI = Depth integrated; Surf = Surface 0-2m
mg/L – micrograms per liter; ug/L – milligrams per liter; m – meters; RL – reporting limit
Bold Underline - Indicates exceedance of Basin Plan/TMDL target

Table 3-19. Analytical Chemistry Results for Canyon Lake- Annual Mean Statistics for Each Site in the East Basin

Method	Compound	Units	MDL	RL	Basin Plan or TMDL Target	Depth Integrated or Surface Sample	CL09			CL10			East Basin[e]		
							Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
General Chemistry															
SM 2540C	Total Dissolved Solids	mg/L	10-12	10-40	700 [3]	DI	590	660	620	580	**710**	642	580	685	630
SM 4500S2 D	Sulfide	mg/L	0.1	0.1	NA	DI	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
EPA 300.0	Nitrate as N	mg/L	0.055	0.2	NA	DI	0.03[c]	0.07	0.03[c]	0.03[c]	0.10	0.05[c]	0.03[c]	0.05	0.03[c]
SM 4500NO2 B	Nitrite as N	mg/L	0.042-0.1	0.1	NA	DI	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
EPA 351.2	Kjeldahl Nitrogen	mg/L	0.063- 0.25	0.1-0.4	NA	DI	0.84	1.70	1.17	0.82	1.55	1.15	0.83	1.55	1.15
Calculated	Total Nitrogen[a]	mg/L	NA	--	0.75[b1]	DI	0.84	1.70	**1.19**	0.85	1.55	**1.18**	0.86	1.55	**1.17**
SM4500NH3H	Ammonia-Nitrogen	mg/L	0.048	0.1	NA	DI	0.02[c]	0.47	0.19[c]	<0.048	<0.048	<0.048	0.02[c]	0.25	0.12[c]
Calculated	Unionized Ammonia[b,c]	mg/L	--	--	CMC: 1.46-20.49[1] CCC: 0.25-4.06[1]	DI	0.00	0.03	0.01	0.00	0.02	0.01	0.00	0.02	0.01
SM 4500P E	Ortho Phosphate Phosphorus	mg/L	0.024	0.05	NA	DI	0.01[c]	0.04	0.02[c]	0.1[c]	0.03	0.1[c]	0.01[c]	0.03	0.01[c]
SM 4500P B E	Total Phosphorus	mg/L	NA	0.01	0.1[b1]	DI	0.03	0.08	0.06	0.04	0.07	0.06	0.04	0.08	0.06
EPA 200.7	Total Aluminum	µg/L	37	100	NA	DI	46 J	210	89	84.5 J	390	184	84.5 J	300	139
EPA 200.7	Dissolved Aluminum	µg/L	37	100	NA	DI	<37	<37	<37	18.5[c]	39	22[c]	18.5[c]	29	20[c]
Chlorophyll-a															
EPA 10200 H	Chlorophyll-a	µg/L	NA	1.0	25[1], 40[2]	Surf	19	80	**41**	31	114	**57**	26	97	**50**
EPA 10200 H	Chlorophyll-a	µg/L	NA	1.0	25[1], 40[2]	DI	30	87	**56**	20	97	**51**	25	79	**52**

Notes:
a - Total Nitrogen = TKN+NO_2+NO_3
b - Annual average
c - Concentrations calculated based on ½ detection limit (MDL) when a value in calculation was ND
d - Values calculated using water column mean ammonia, temperature, salinity and pH. Calculated using equation by Thursby (1986).
e - East Basin values are an average of minimum and maximum values for CL09 and CL10 and an overall mean of all values from both sites.
1 – 2020 TMDL Target, based on Table 5-9n of 2004 TMDL
2 – 2015 TMDL Target, based on Table 5-9n of 2004 TMDL
3 – Santa Ana Region Basin Plan Objective
NA – Not applicable/ available
NS - Not sampled
DI = Depth integrated; Surf = Surface 0-2m
mg/L – micrograms per liter; ug/L – milligrams per liter; m – meters; RL – reporting limit
Bold Underline - Indicates exceedance of Basin Plan/TMDL target

Table 3-20. Analytical Chemistry Results for Canyon Lake- Annual Mean Statistics for Both Main and East Basins

Method	Compound	Units	MDL	RL	Basin Plan or TMDL Target	Depth Integrated or Surface Sample	Main Basin[e]			East Basin[e]		
							Min	Max	Avg	Min	Max	Avg
General Chemistry												
SM 2540C	Total Dissolved Solids	mg/L	10-12	10-40	700 [3]	DI	415	540	480	580	685	630
SM 4500S2 D	Sulfide	mg/L	0.1	0.1	NA	DI	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
EPA 300.0	Nitrate as N	mg/L	0.055	0.2	NA	DI	0.03[c]	0.25	0.07[c]	0.03[c]	0.05	0.03[c]
SM 4500NO2 B	Nitrite as N	mg/L	0.042-0.1	0.1	NA	DI	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
EPA 351.2	Kjeldahl Nitrogen	mg/L	0.063- 0.25	0.1-0.4	NA	DI	0.75	1.45	1.14	0.83	1.55	1.15
Calculated	Total Nitrogen[a]	mg/L	NA	--	0.75[b1]	DI	0.97	1.45	**<u>1.20</u>**	0.86	1.55	**<u>1.17</u>**
SM4500NH3H	Ammonia-Nitrogen	mg/L	0.048	0.1	NA	DI	0.15[c]	0.76	0.42[c]	0.02[c]	0.25	0.12[c]
Calculated	Unionized Ammonia[b,c]	mg/L	--	--	CMC: 1.46-20.49[1] CCC: 0.25-4.06[1]	DI	0.01	0.02	0.01	0.00	0.02	0.01
SM 4500P E	Ortho Phosphate Phosphorus	mg/L	0.024	0.05	NA	DI	0.01[c]	0.20	0.07[c]	0.01[c]	0.03	0.01[c]
SM 4500P B E	Total Phosphorus	mg/L	NA	0.01	0.1[b1]	DI	0.02[c]	0.23	0.09[c]	0.04	0.08	0.06
EPA 200.7	Total Aluminum	µg/L	37	100	NA	DI	19	80	53	85	300	139
EPA 200.7	Dissolved Aluminum	µg/L	37	100	NA	DI	<37	<37	<37	18.5[c]	29	20[c]
Chlorophyll-a												
EPA 10200 H	Chlorophyll-a	µg/L	NA	1.0	25[1], 40[2]	Surf	22	59	**<u>36</u>**	26	97	**<u>50</u>**
EPA 10200 H	Chlorophyll-a	µg/L	NA	1.0	25[1], 40[2]	DI	6	46	**<u>28</u>**	25	79	**<u>52</u>**

Notes:
a - Total Nitrogen = TKN+NO_2+NO_3
b - Annual average
c - Concentrations calculated based on ½ detection limit (MDL) when a value in calculation was ND
d - Values calculated using water column mean ammonia, temperature, salinity and pH. Calculated using equation by Thursby (1986).
e - East Basin values are an average of minimum and maximum values for CL09 and CL10 and an overall mean of all values from both sites.
1 – 2020 TMDL Target, based on Table 5-9n of 2004 TMDL
2 – 2015 TMDL Target, based on Table 5-9n of 2004 TMDL
3 – Santa Ana Region Basin Plan Objective
NA – Not applicable/ available
NS - Not sampled
DI = Depth integrated; Surf = Surface 0-2m
mg/L – micrograms per liter; ug/L – milligrams per liter; m – meters; RL – reporting limit
<u>Bold Underline</u> - Indicates exceedance of Basin Plan/TMDL target

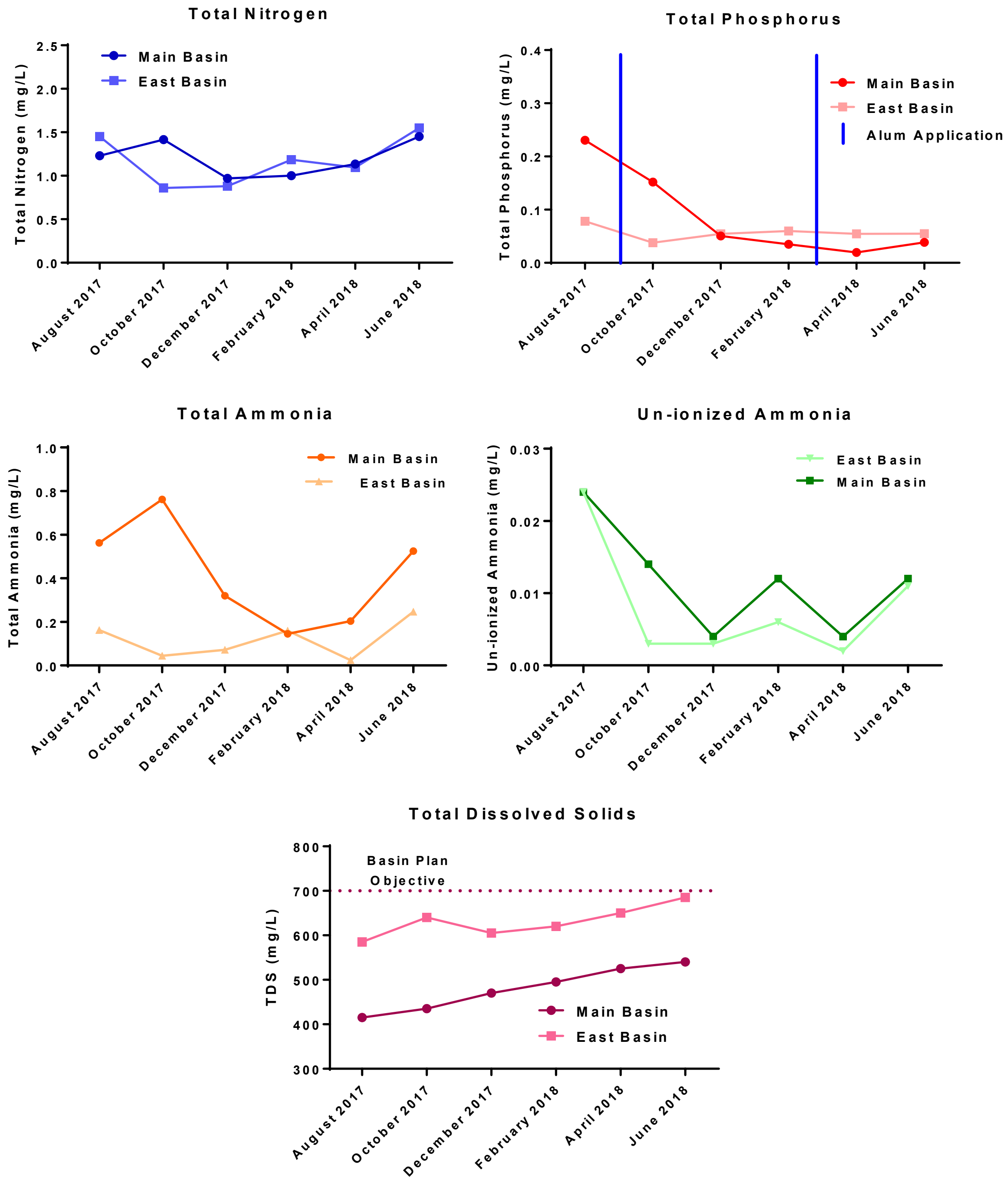


Figure 3-14. Canyon Lake Analytical Chemistry – Depth-Integrated Means
(Main Basin values represent Sites CL07 & CL08 mean, East Basin values represent Sites CL09 & CL10 mean)

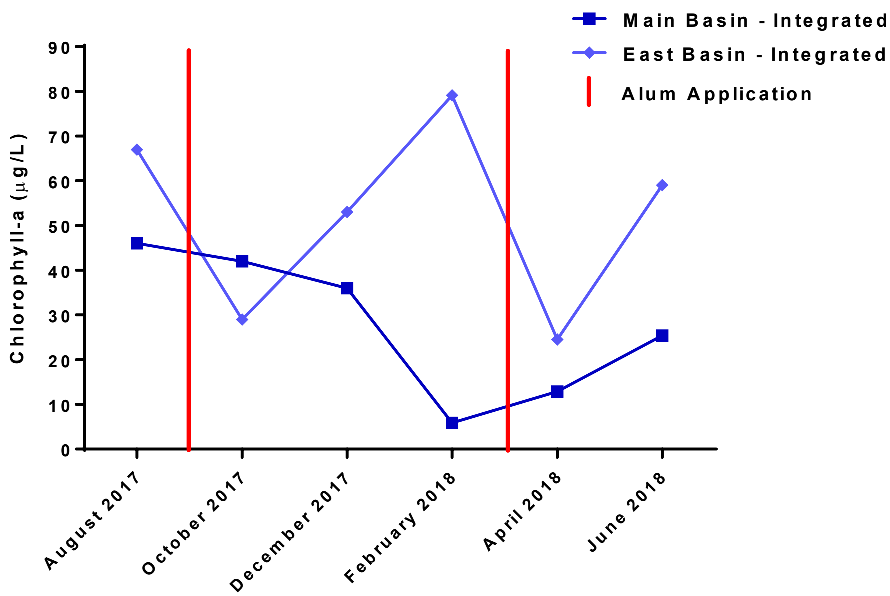


Figure 3-15. Canyon Lake Analytical Chemistry – Depth-Integrated Chlorophyll-a

(Main Basin values represent mean of Sites CL07 & CL08, East Basin values represent mean of Sites CL09 & CL10 samples)

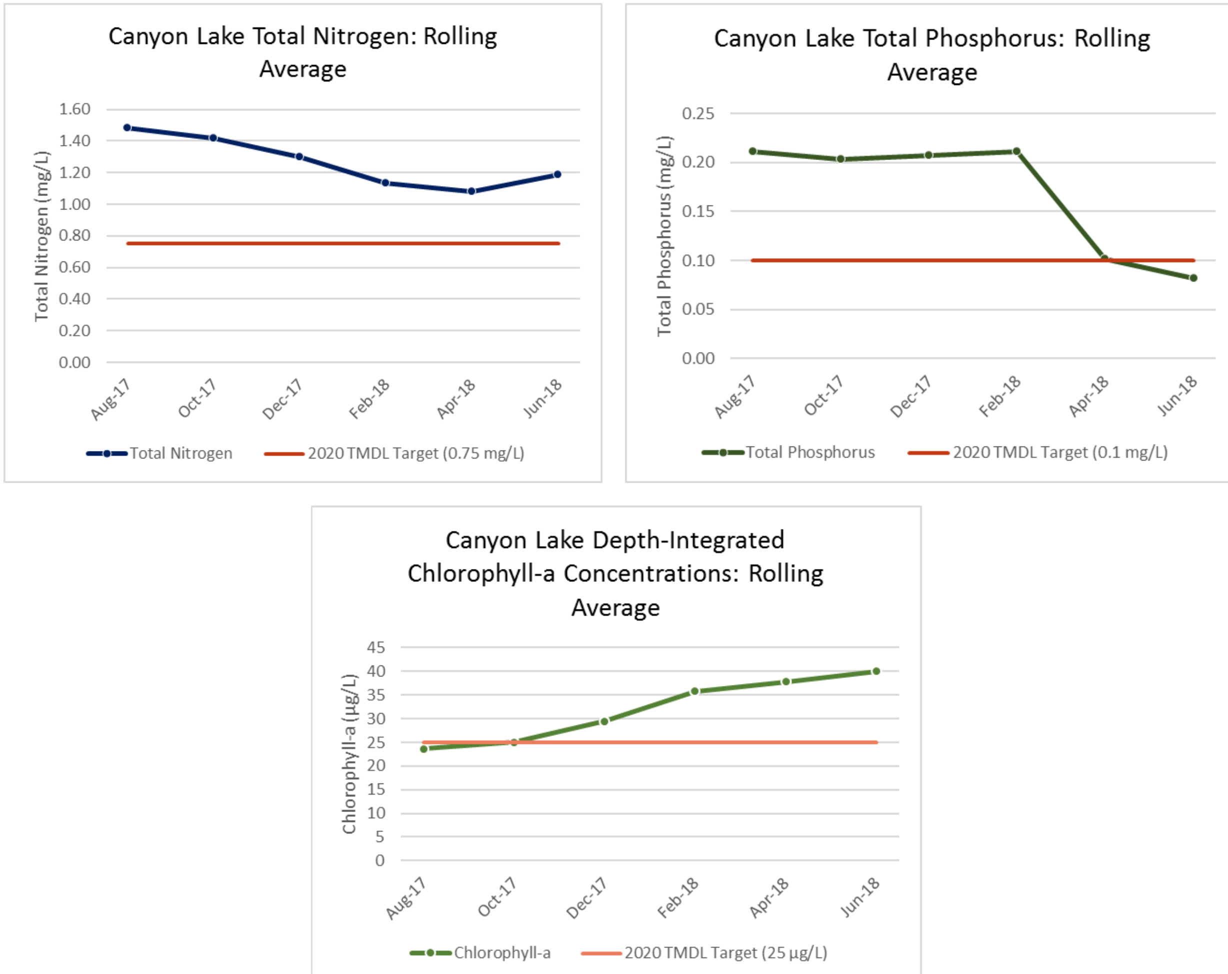


Figure 3-16. Canyon Lake Analytical Chemistry- Rolling Averages

Values are calculated by averaging the value from each event with the previous five events (i.e. one year of data) to obtain a rolling average.

3.4 Satellite Imagery

Beginning with the 2015-2016 FY, the TMDL Task Force contracted with satellite vendor EOMAP to conduct remote sensing using LandSat satellite imagery to estimate chlorophyll-a and turbidity concentrations in Lake Elsinore and Canyon Lake. Using 30-m pixel resolution, this effort produced maps of the lake showing graphical, color-coded images of chlorophyll-a and turbidity concentrations at up to approximately 1,000 unique data points across Canyon Lake and approximately 11,000 unique data points across Lake Elsinore. This tool provides a snapshot of conditions throughout the entire lake at a given point in time, as opposed to the single data points provided at water quality collection locations and dates; however, the satellite imagery only represents approximately the upper 4 feet of the water column depending on water clarity, and therefore cannot completely replace manual sampling where depth-integrated values are required.

As part of the TMDL compliance monitoring, satellite imagery depicting lake-wide chlorophyll-a and turbidity concentrations in Lake Elsinore and Canyon Lake were generated for each in-lake monitoring event. Satellite images for each lake during the eight monitoring events evaluated in the report are presented in Figures 3-17 through 3-20. Significant spatial variability in chlorophyll-a is evident providing a more complete assessment of algal density conditions across each lake.

The satellite images for Lake Elsinore show a generalized lakewide chlorophyll-a concentration increase through February 2018, followed by a decrease in April and June 2018.

Chlorophyll-a concentrations in Canyon Lake derived from satellite imagery remained relatively consistent in the main body of the lake. The eastern arm of the lake did experience some periods of elevated chlorophyll-a values, generally in the far eastern end. Some of this may be due to edge effects as a result of land and water pixels mixing near the edges of the narrow channel. This effect is diminished during non-summer months when Sentinel-2 satellite data is used, which generates a smaller pixel size (10m resolution), than the LandSat satellite (30m resolution) used during summer months (June – Sept). The Sentinel 2 satellite cannot be used during summer months due to a glare from the sun caused by the angle of satellite viewing, and thereby reducing the image quality.

It was evident that chlorophyll-a concentrations generated from the satellite images of Lake Elsinore did not match well with analytical in-lake water samples collected during some monitoring events. This was likely due to the high chlorophyll-a concentrations observed in this lake. During the initial satellite validation performed over the initial 2015-2016 sampling season, it was determined that satellite chlorophyll-a concentrations tended to diverge from those observed in the lake when in-lake concentrations were above approximately 100 µg/L. Satellite chlorophyll-a concentrations in Canyon Lake matched in-lake concentrations much closer, and were overall lower than those observed in Lake Elsinore. While the satellite imagery does tend to under-predict chlorophyll-a in Lake Elsinore, it does provide a sense of the relative variability in algae across the lake that a single data location cannot provide. Wood Environment and Infrastructure staff is and will continue to work with EOMAPS to improve the satellite algorithms necessary to provide accurate and representative image data.

Cumulative frequency distribution plots showing lake-wide chlorophyll-a concentrations based on individual satellite data pixels is provided in Figures 3-21 and 3-22. Median values along with measured chlorophyll-a concentrations collected in-lake are provided for each date showing these single data points relative to concentrations throughout the entire lake. Median values were derived from satellite imagery data treating each pixel as a unique individual data point.

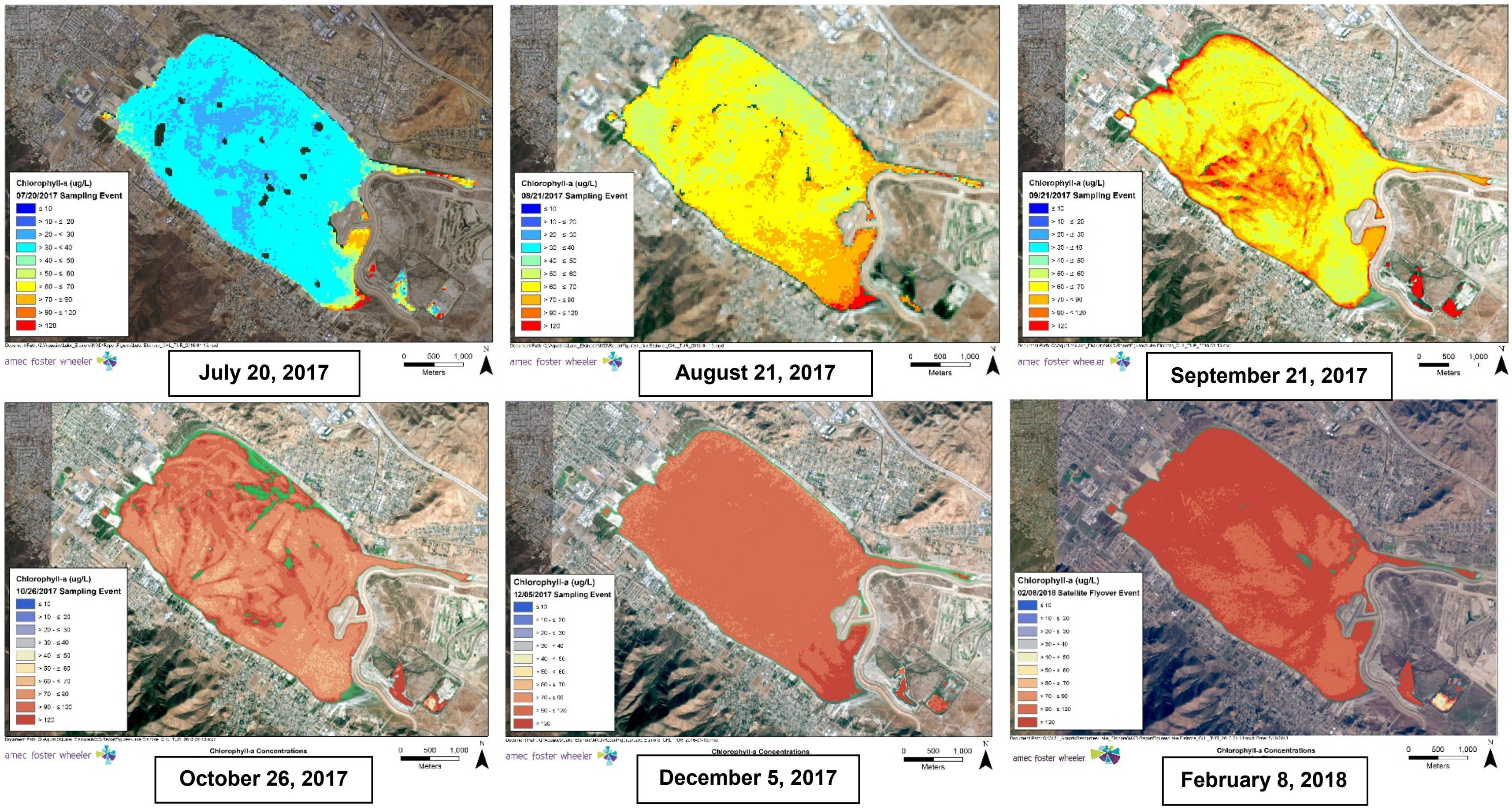


Figure 3-17. Satellite Imagery of Chlorophyll-a Concentrations in Lake Elsinore

(Data gaps in July and October are due to surface cyanobacterial slicks. Note the changes to the legend colors initiated in October 2017.)

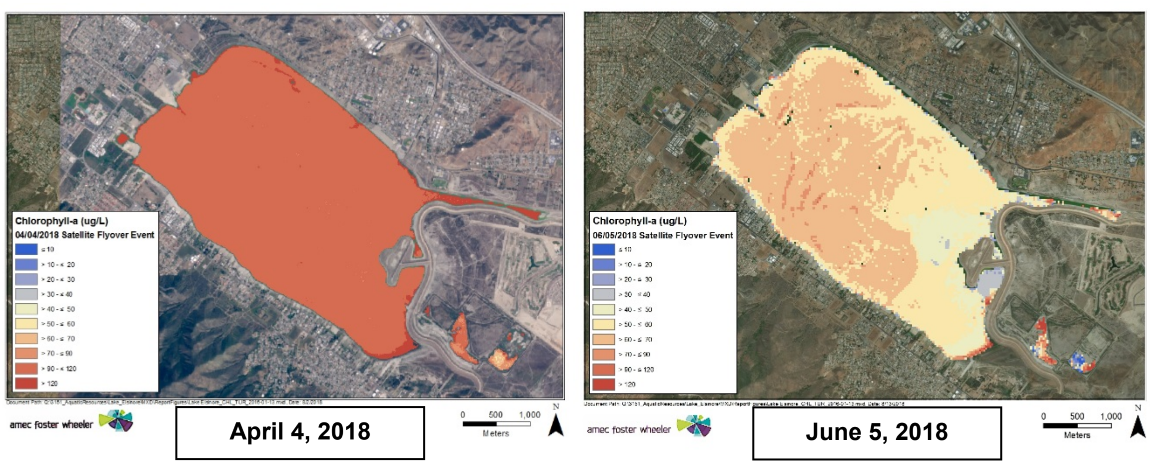


Figure 3-17 (cont). Satellite Imagery of Chlorophyll-a Concentrations in Lake Elsinore

(Data gaps in July and October are due to surface cyanobacterial slicks. Note the changes to the legend colors initiated in October 2017.)

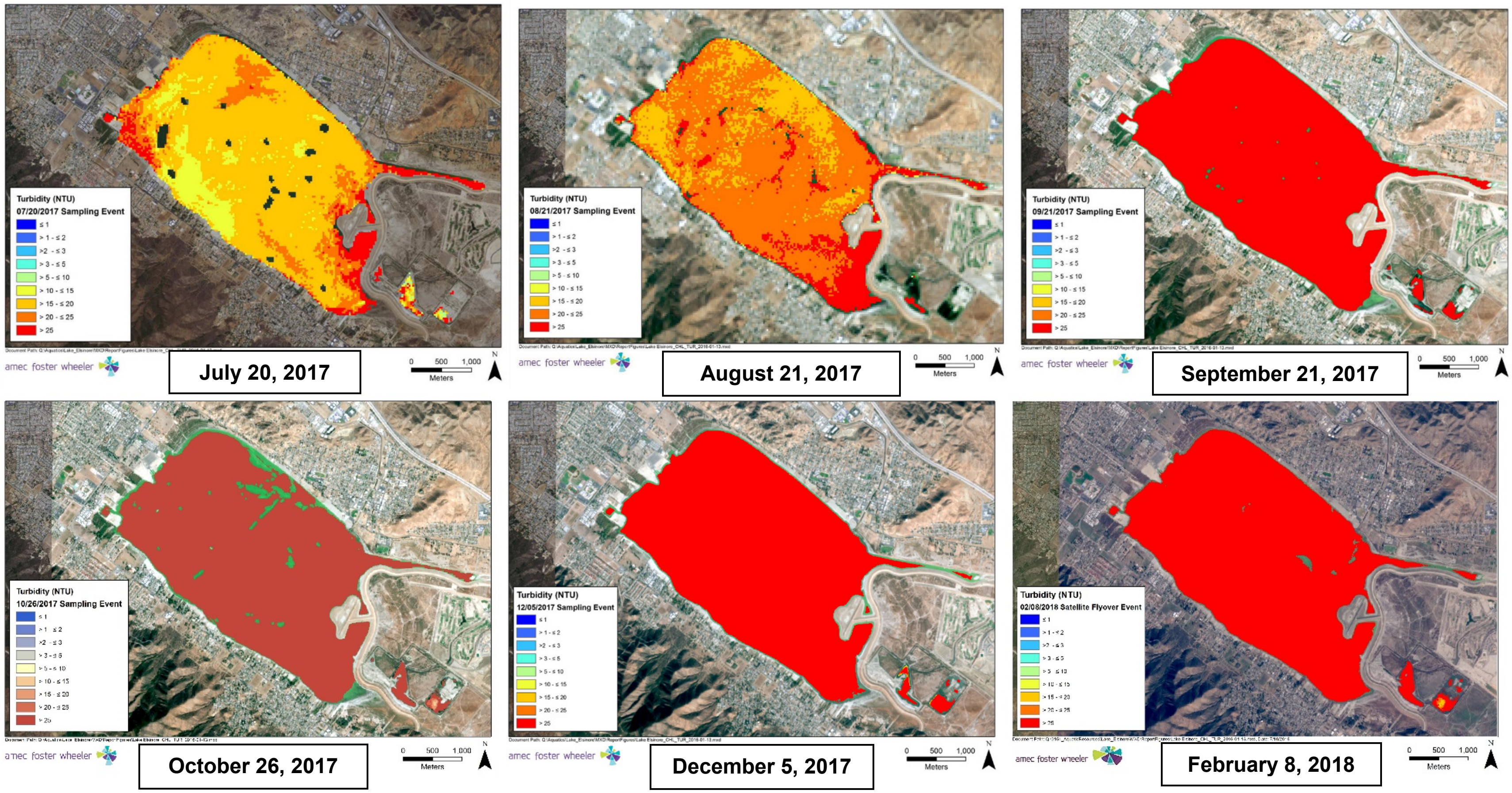


Figure 3-18. Satellite Imagery of Turbidity Concentrations in Lake Elsinore

(Data gaps in July and October are due to surface cyanobacterial slicks. Note the changes to the legend colors in October 2017.)

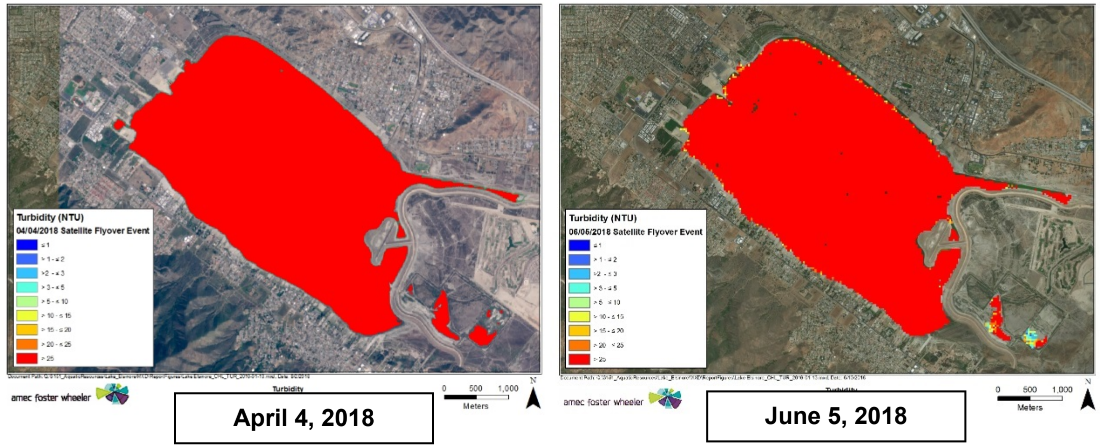


Figure 3-18 (cont). Satellite Imagery of Turbidity Concentrations in Lake Elsinore

(Data gaps in July and October are due to surface cyanobacterial slicks. Note the changes to the legend colors in October 2017.)

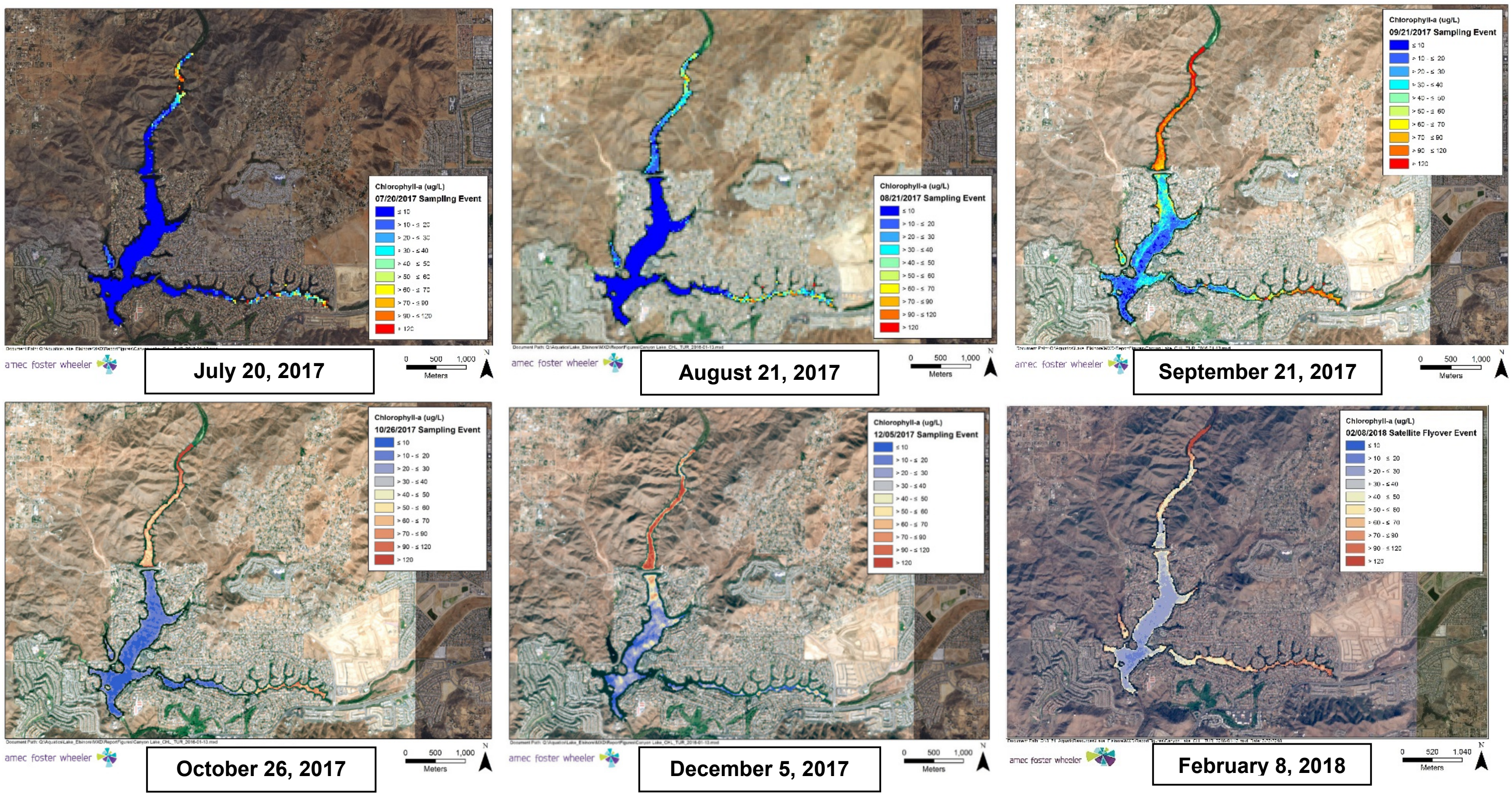


Figure 3-19. Satellite Imagery of Chlorophyll-a Concentrations in Canyon Lake

(High cirrus cloud interference caused data gaps in June 2018, and decreased clarity in August 2017. Note the changes to the legend colors initiated in October 2017. Additional images from July & August when in-lake sampling did not occur are included, as they were part of the minimum image satellite scene.)

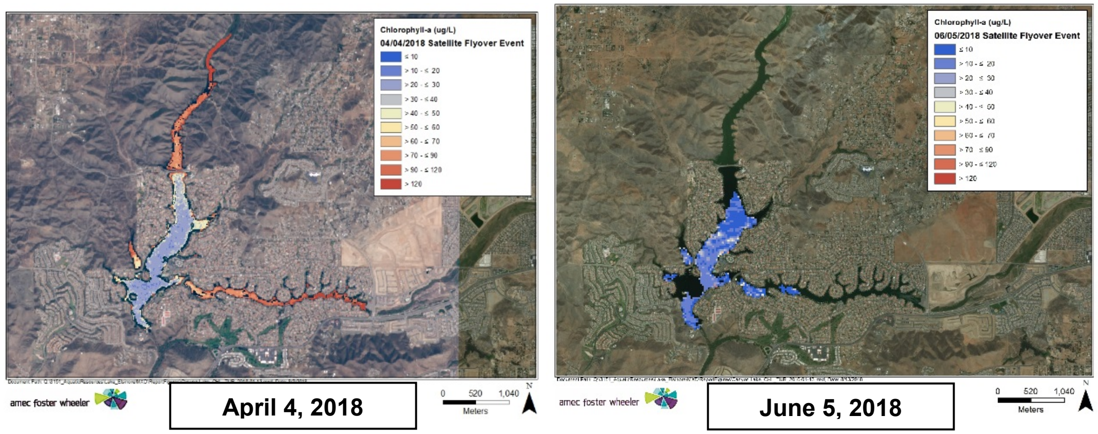


Figure 3-19 (cont). Satellite Imagery of Chlorophyll-a Concentrations in Canyon Lake

(High cirrus cloud interference caused data gaps in June 2018, and decreased clarity in August 2017. Note the changes to the legend colors initiated in October 2017.)

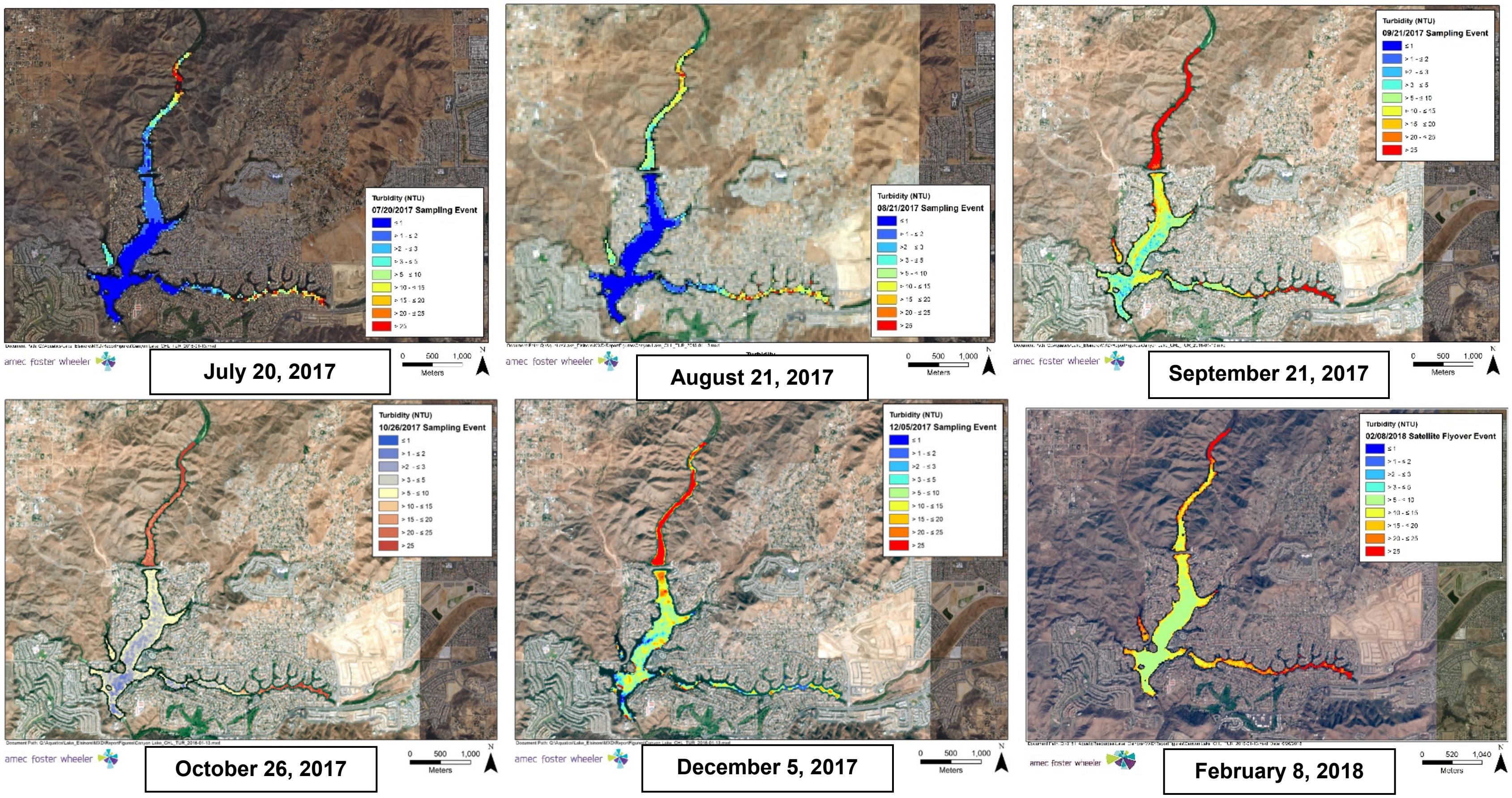


Figure 3-20. Satellite Imagery of Turbidity Measurements Canyon Lake

(High cirrus cloud interference caused data gaps in June 2018, and decreased clarity in August 2017. Note the changes to the legend colors in October 2017.)

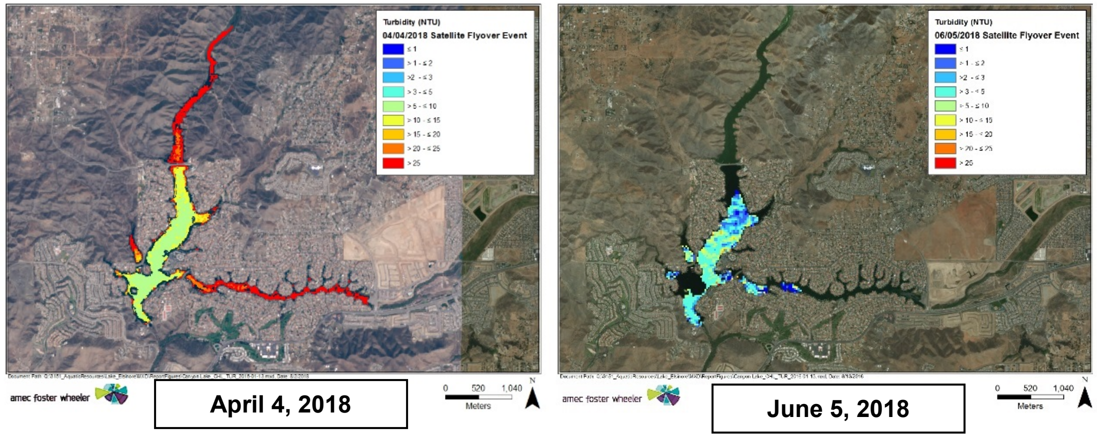


Figure 3-20 (cont). Satellite Imagery of Turbidity Measurements Canyon Lake

(High cirrus cloud interference caused data gaps in June 2018, and decreased clarity in August 2017. Note the changes to the legend colors in October 2017.)

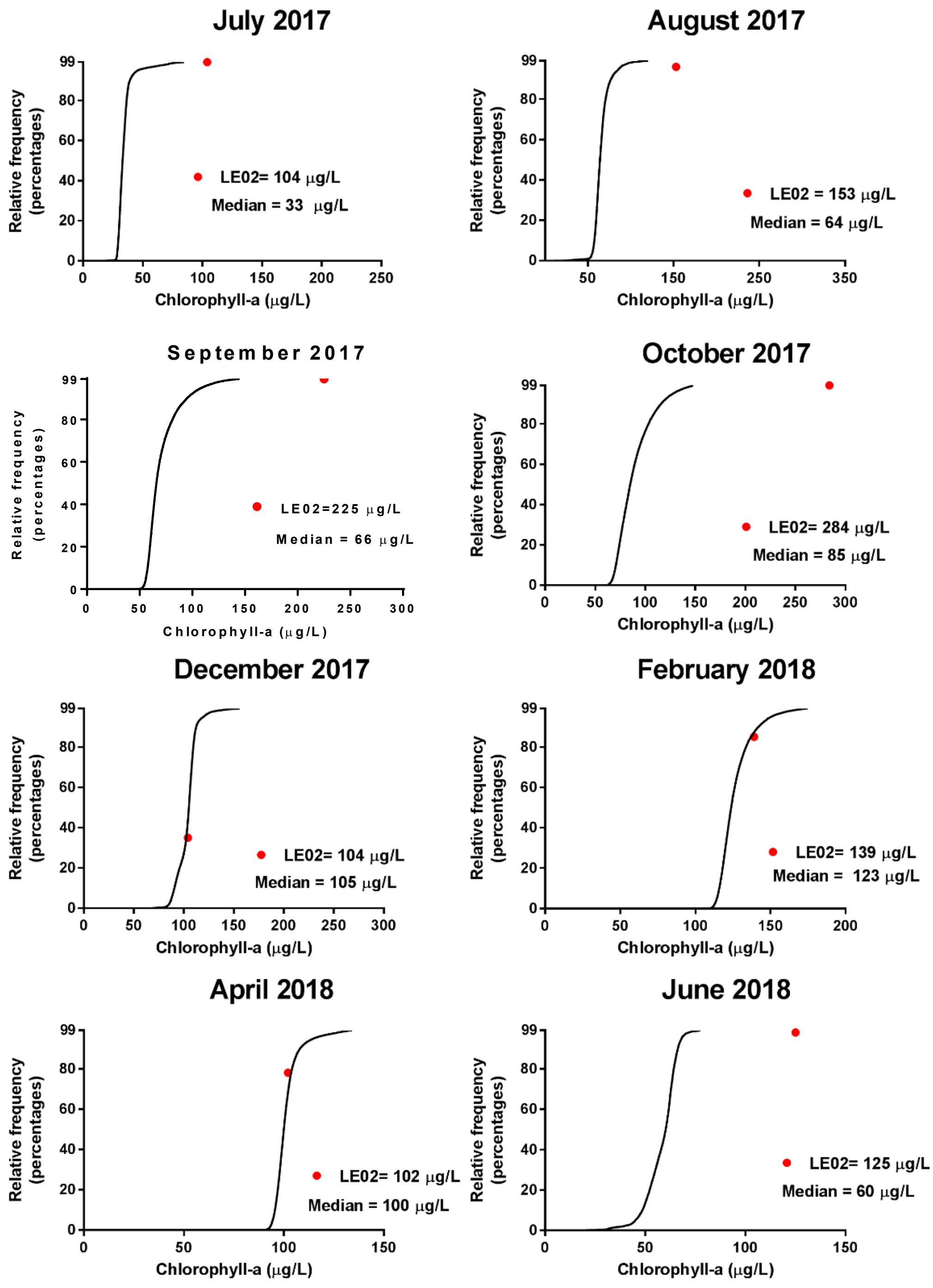


Figure 3-21. Cumulative Distribution of Satellite Derived Chlorophyll-a Concentrations in Lake Elsinore Relative to Field Collected Samples

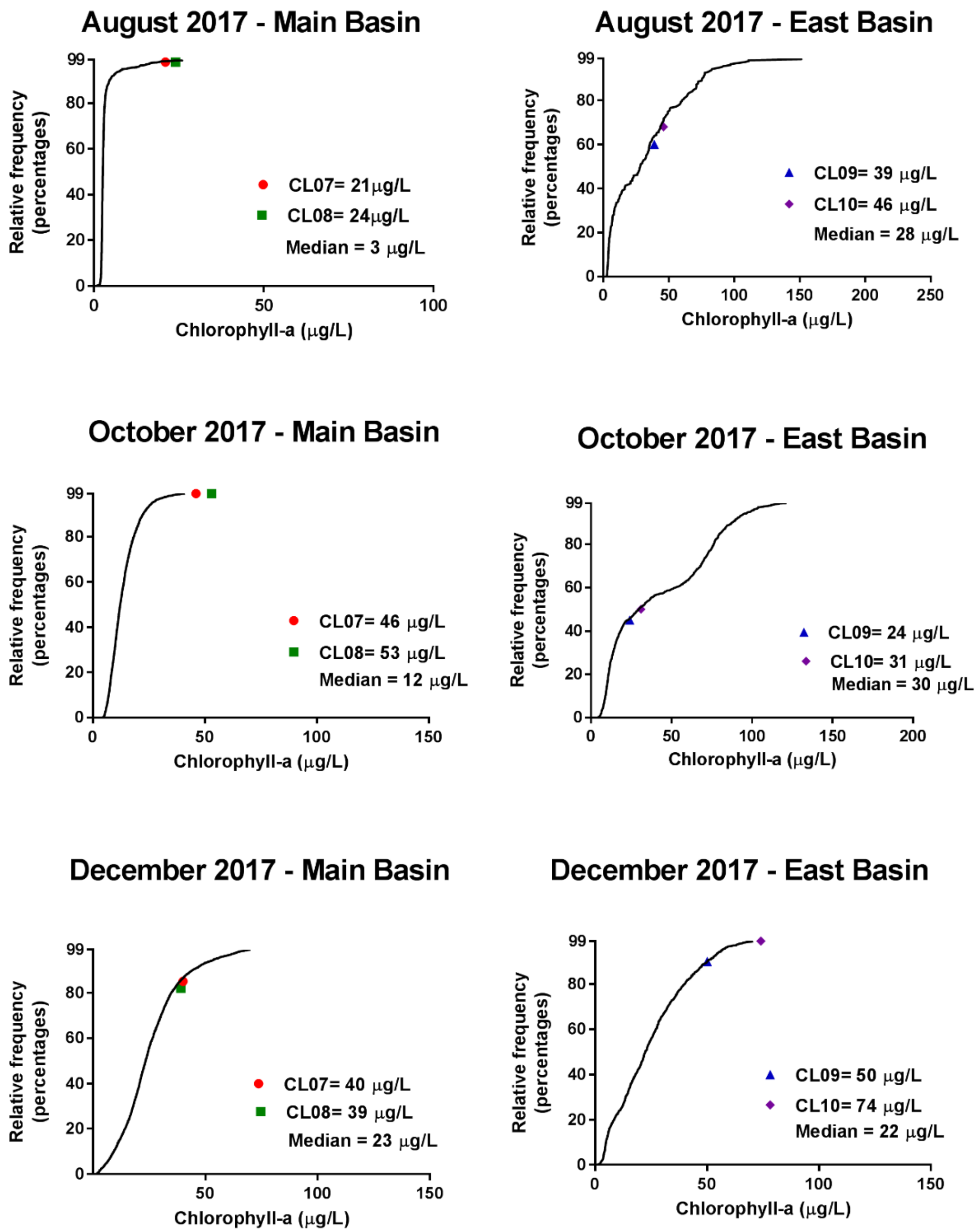


Figure 3-22. Cumulative Distribution of Satellite Derived Chlorophyll-a Concentrations in Canyon Lake Relative to Field Collected Samples

(See discussion in section 3.4)

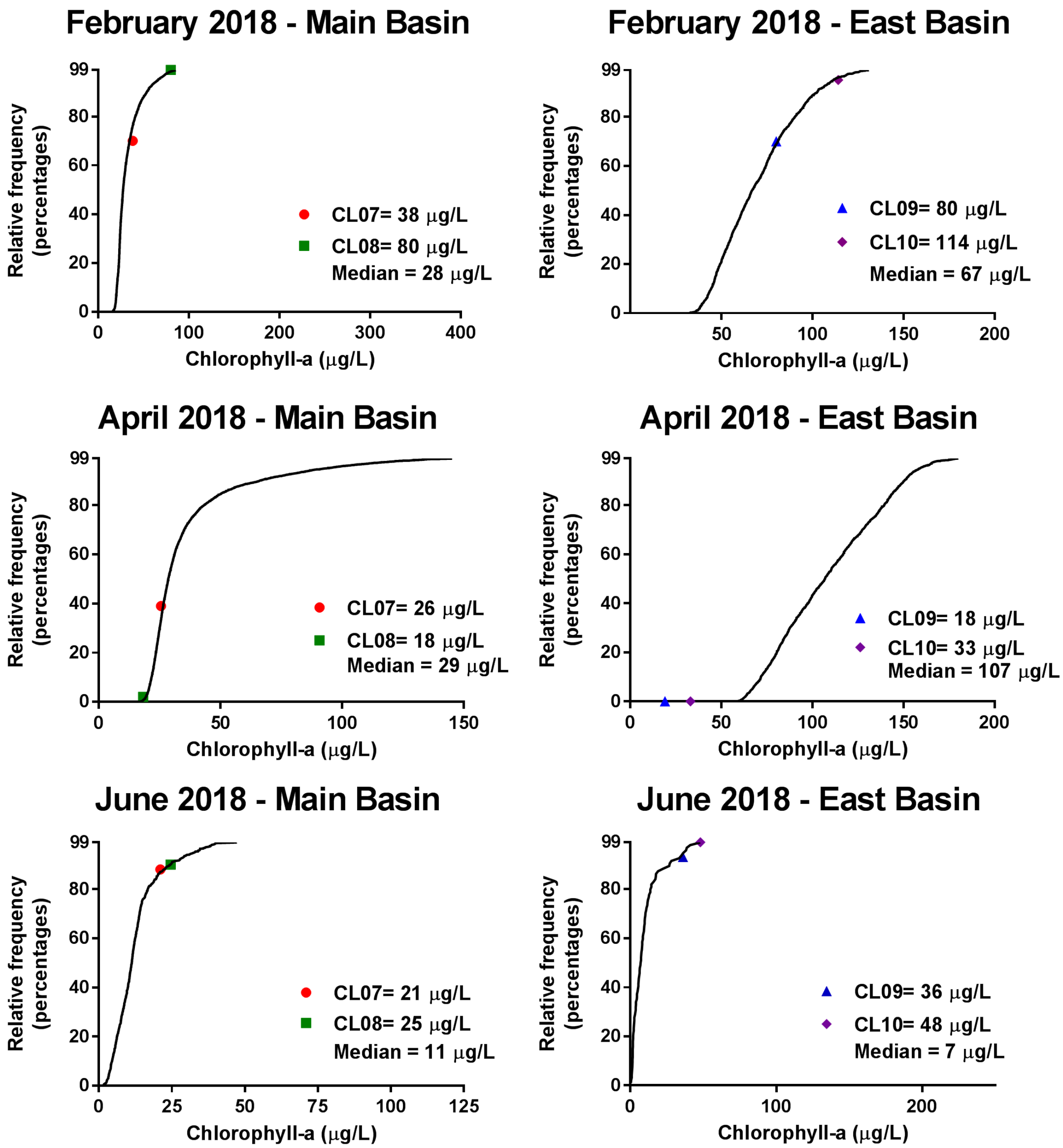


Figure 3-22 (cont). Cumulative Distribution of Satellite Derived Chlorophyll-a Concentrations in Canyon Lake Relative to Field Collected Sample
(See discussion in section 3.4)

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