Lake Elsinore and Canyon Lake Watersheds Nutrient TMDL Monitoring 2019-2020 Annual Report – FINAL

Prepared for:
Lake Elsinore & San Jacinto Watersheds Project Authority
11615 Sterling Avenue
Riverside, California 92503

Prepared by:
Wood Environment and Infrastructure Solutions Inc.
9210 Sky Park Court
Suite 200
San Diego, CA 92123

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Lake Elsinore & San Jacinto Watersheds Authority

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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	Total Maximum Daily Load
TMDL Task Force	Lake Elsinore and Canyon Lake TMDL Task Force
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 2019-2020 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]. While being a natural lake, the lake has been modified in various ways to enhance its recreational use and aquatic habitat, including creation of a levee at the lake's south end to increase the water depth / reduce evaporation, and water in the lake is supplemented with approximately 6 million gallons per day of recycled water from Elsinore Valley Municipal Water District (EVMWD). 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 approved by the California Regional Water Quality Control Board, Santa Ana Region (RWQCB) as an amendment to the Water Quality Control Plan for the Santa Ana River Basin (Basin Plan) under resolution R8-2017-0019 on June 16, 2017, and became effective on October 15, 2018 after being approved by US EPA.

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, Res. No. 2017-0059. Current 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, and PCBs/DDTs in Lake Elsinore. 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 Basin Plan to incorporate TMDLs for nutrients in Canyon Lake and Lake Elsinore. The amendments were subsequently approved by US EPA on September 30, 2005. The Basin Plan Amendment specifies, among other things,

[1] Based on federally listed Riverside fairy shrimp (*Streptocephalus woottoni*) in adjacent wetlands.

monitoring recommendations to measure progress towards attainment of TMDL thresholds 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 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 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 RWQCB 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 assist the workgroup in participating with the RWQCB in the development and definition of the TMDLs.

After 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 included in the TMDLs.

In November 2006, stakeholders finalized an agreement to form the Lake Elsinore and Canyon Lake TMDL Task Force (hereafter “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 or “SAWPA”) serves as administrator of the TMDL Task Force and oversees the TMDL implementation 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 starting in April 2006 through

October 2012. During this time frame, in-lake monitoring for both lakes was conducted through the EVMWD National Pollutant Discharge Elimination System (NPDES) compliance program (Order No. R8-2005-0003, NPDES No. CA8000027, Regional Water Reclamation Plant, Lake Elsinore, Riverside County). On October 26, 2012, the RWQCB adopted 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 then applied to implementing lake improvement projects aimed at reducing nutrient impacts in Canyon Lake and Lake Elsinore. As a result, the Lake Elsinore and Canyon Lake Nutrient TMDL field compliance monitoring was not conducted during the 2013-2014 and 2014-2015 fiscal year (FY) cycles.

The in-lake and watershed-wide 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. A revised Monitoring Work Plan (Haley & Aldrich 2016) and companion Quality Assurance Project Plan (Amec Foster Wheeler 2016) were prepared and approved by the RWQCB in October 2016. The primary objectives considered in developing the Nutrient TMDL Compliance Monitoring Work Plan were to: 1) evaluate the status and trends toward achieving response targets in both lakes through in-lake monitoring; and 2) to distinguish and quantify the external pollutant loading originating from the watershed above the lakes through stormwater monitoring of the major upstream inputs to Canyon Lake. Additional objectives of the monitoring are to support the stormwater compliance activities underway by other entities in the watershed, including the reissuance of the Riverside County Municipal Stormwater National Pollutant Discharge Elimination Systems Permit (Order R8-2010-0033, Municipal Separate Storm Sewer System (MS4) Permit), and land use monitoring requirements related to the Conditional Waiver for Agricultural Discharges (Adopted Order R8-2017-0023; Amending Order R8-2016-0003). The results of the 2019-2020 FY in-lake and watershed monitoring efforts are summarized herein.

2.0 San Jacinto River Watershed-Wide Monitoring

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.

Watershed monitoring and reporting was performed by Alta Environmental DBA NV5 of San Diego, California.

2.1 Summary of 2019-2020 Wet Weather Watershed Monitoring and Nutrient Loads

A summary of the measured concentrations and estimated annual nutrient loads derived from each of the three monitored locations for the period of July 1, 2019 through June 30, 2020, is presented in Table 2-1. A more detailed account, including storm hydrographs and event loads are presented in the following sections for each monitoring location. In general, the monitoring locations only flow during storm events and the storm flows account for the estimated annual load of nutrients. The complete set of water quality data, including water quality field measurements is included in Appendix A.

Table 2-1. Summary of 2019-2020 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)	1,645	2.37	0.59	14,792	3,705
Site 4 - San Jacinto River at Goetz Road (USGS 11070365)	3,290	1.83	0.67	23,337	8,660
Site 6 - San Jacinto River at Ramona Expressway [b] (USGS 11070210)	7	Not Measured [b]	Not Measured [b]	Not Measured [b]	Not Measured [b]
Site 30 - Canyon Lake Spillway [c] (USGS 11070500)	4,497	1.1	0.16	17,768	2,429

a - Flow data after 03/03/2020 are provisional and may be subject to change.
b - No flows originating from the upper watershed were observed at the TMDL monitoring location just downstream of Mystic Lake, only local flows were observed, and no sampling was conducted.
c –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. In addition, runoff from other local tributaries into Lake Elsinore are not included in this table.
Mgal = million gallons; 1 million gallons = 133,680 cubic feet = 3,785,412 L; mg/L = milligrams per liter; kg = kilograms; USGS = United States Geological Survey.

2.2 Historical Wet Weather Watershed Monitoring and Nutrient Loads

A summary of the historical water quality monitoring data for the period of July 1, 2011 through June 30, 2020, is presented in Table 2-2 and Table 2-3 for total nitrogen and total phosphorus. In general, the monitoring locations only flow during storm events and the storm flows account for the estimated annual load of nutrients.

Table 2-2. Summary of Historical Annual Mean Storm Concentrations

Monitoring Year	Site 3 - Salt Creek at Murrieta Road		Site 4 - San Jacinto River at Goetz Road		Site 30 - Canyon Lake Spillway	
	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
2011-2012	1.9	0.3	2.2	0.5	NS	NS
2012-2013	1.9	0.3	2.1	0.5	NS	NS
2013-2014	2.7	0.9	1.8	0.6	NS	NS
2014-2015	2.2	0.5	1.8	0.4	NS	NS
2015-2016	2.5	0.5	2.4	1.4	NS	NS
2016-2017	2.1	0.6	2.0	1.2	1.9	0.4
2017-2018	2.7	0.4	2.0	0.4	NS	NS
2018-2019	2.4	0.4	1.7	0.6	1.4	0.2
2019-2020	2.4	0.6	1.8	0.7	1.1	0.16

NS – Not sampled when Canyon Lake does not overtop the Canyon Lake Spillway. 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. In addition, runoff from other local tributaries into Lake Elsinore are not included in this table.

Table 2-3. Summary of Historical Estimated Annual Loads

Monitoring Year	Site 3 - Salt Creek at Murrieta Road			Site 4 - San Jacinto River at Goetz Road			Site 30 - Canyon Lake Spillway		
	Total Annual Flow (Mgal)	Total Nitrogen (kg)	Total Phosphorus (kg)	Total Annual Flow (Mgal)	Total Nitrogen (kg)	Total Phosphorus (kg)	Total Annual Flow (Mgal)	Total Nitrogen (kg)	Total Phosphorus (kg)
2011-2012[a]	743	5,371	1,099	881	6,370	3,535	1,290	5,474	3,062
2012-2013	147	1,025	180	424	3,341	822	114	NS	NS
2013-2014	411	4,268	1,409	484	3,252	1,178	148	NS	NS
2014-2015	511	4,661	1,257	570	3,932	1,041	196	NS	NS
2015-2016	515	5,647	1,447	872	7,926	4,624	476	NS	NS
2016-2017	1,596	12,366	4,026	2,802	21,651	14,403	4,850	33,759	6,637
2017-2018	271	2,586	482	393	3,055	810	117	NS	NS
2018-2019	1,394	12,213	2,266	3,208	20,457	7,409	5,893	32,832	5,416
2019-2020	1,645	14,792	3,705	3,290	23,337	8,660	4,497	18,762	2,635

NS – Not sampled when Canyon Lake does not overtop the Canyon Lake Spillway. 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. In addition, runoff from other local tributaries into Lake Elsinore are not included in this table.

[a] - Sum of January 1, 2011 to June 30, 2012. All other monitoring year dates are July 1 to June 30.

2.3 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 2019-2020 monitoring period included collection of samples during three storm events at the designated monitoring stations throughout the San Jacinto River Watershed. Average nutrient concentrations during these three events were used to calculate mass loading during remaining wet weather events that were not monitored to derive total estimated annual mass loads throughout the monitoring year.

2.4 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. Sampling of these locations began in 2006. Sampling station locations were deliberately set up to be within the vicinity of United States Geological Survey (USGS) stream gauge stations. The sampling stations are listed in Table 2-4 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 2-4. 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[a]	11069500	USGS	Site 1 - San Jacinto River at Cranston Guard Station

a - The Cranston Guard Station (Station 792) was monitored between 2007 and 2011 by the San Bernardino National Forest Service in accordance with their agreement for in-lieu obligations to the Task Force. In 2012, the Forest Service pulled out of the Task Force and no longer provides monitoring support.

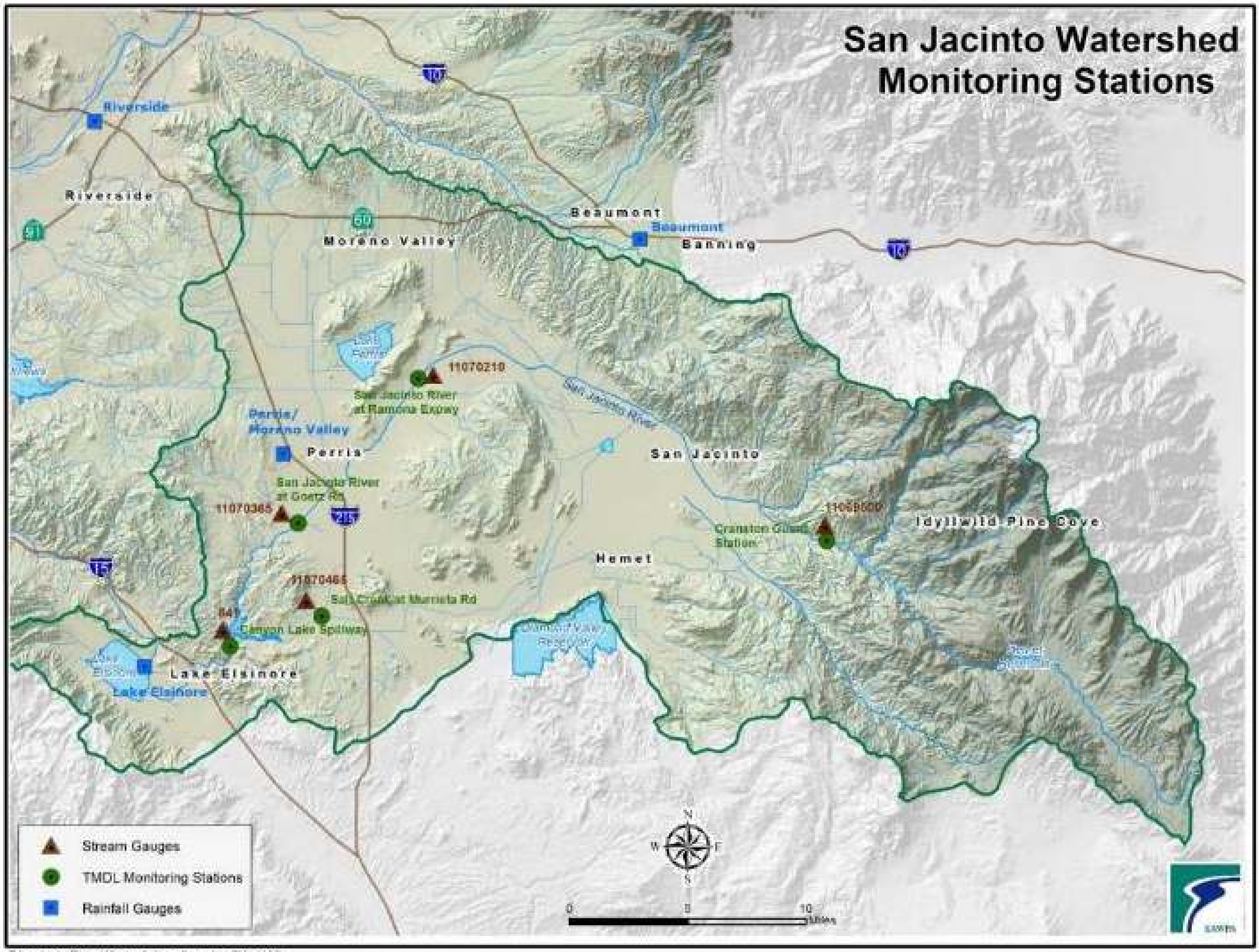


Figure 2-1. San Jacinto River Watershed Monitoring Stations

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. This site only represents a portion of the total load into Lake Elsinore from upstream of Canyon Lake Dam and does not include runoff from the local watershed. 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 and no longer provides monitoring support.

2.5 Stream Gauge Records

The USGS 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 River Watershed Monitoring Program are shown in Figure 2-1 and identified in Table 2-4.

The data record captured per USGS stream gauge is publicly available at the USGS website, where data for the specific gauge numbers provided in Table 2-5 can be found:

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, 2019 through June 30, 2020 is presented in Table 2-5 and visually presented in Figure 2-2 through Figure 2-6. The mean monthly flows reported in Table 2-5 characterize the average instantaneous flow rate at the USGS stations. In general, the flows are only observed during wet weather storm events and dry weather flows are not observed from each of the USGS stations. The flow data are downloaded from the USGS website and are considered provisional for approximately six months; therefore, flow data presented after March 3, 2020 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 2-5. Summary of Stream Gauge Data (July 2019 through June 2020)

July 2019-June 2020 Mean Monthly Flow (cfs) [a]	Site 3 - Salt Creek at Murrieta Road (11070465[c])	Site 4 - San Jacinto River at Goetz Road (11070365 [c])	Site 6 - San Jacinto River at Ramona Expressway [b] (11070210 [c])	Site 30 - Canyon Lake Spillway (11070500 [c])	Site 1 - San Jacinto River at Cranston Guard Station (11069500 [c])
July	0.00	0.00	0.00	0.00	1.44
August	0.00	0.00	0.00	0.00	0.34
September	0.00	0.00	0.00	0.00	1.59
October	0.00	0.00	0.00	0.00	0.35
November	9.65	30.33	0.00	2.57	1.53
December	14.53	36.16	0.00	57.41	11.49
January	0.08	1.49	0.00	7.14	4.75
February	0.33	0.40	0.00	2.77	1.18
March	26.58	49.78	0.00	86.47	20.52
April	32.28	48.46	0.35	69.21	46.20
May	0.00	0.20	0.00	1.38	9.70
June	0.00	0.00	0.00	0.31	0.70
Mean Annual Flow (cfs)	**6.94**	**13.91**	**0.03**	**19.03**	**8.29**

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 03/03/2020 are provisional and may be subject to change.
b - No flows originating from the upper watershed were observed at the TMDL monitoring location just downstream of Mystic Lake, only local flows were observed.
cfs = cubic feet per second.
c – USGS gauge number

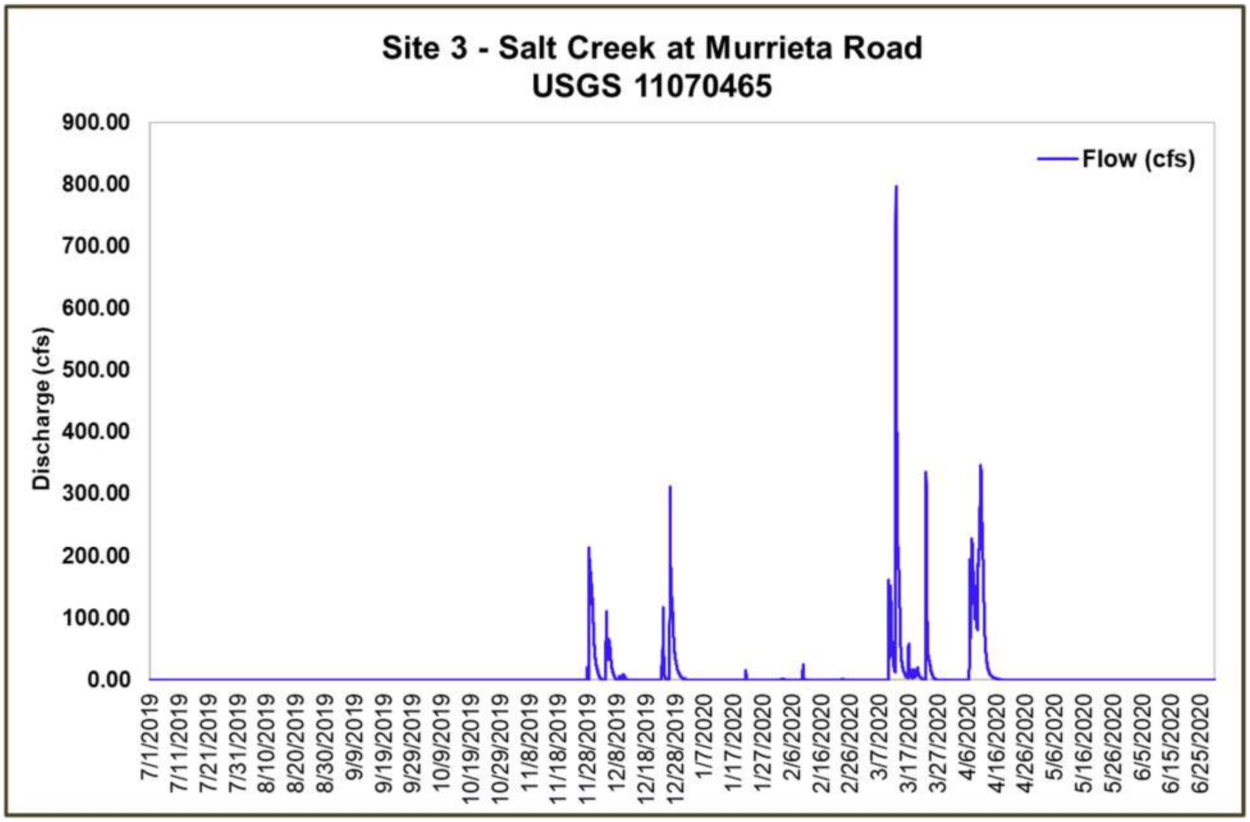


Figure 2-2. Site 3 – Salt Creek at Murrieta Road – Daily Stream Gauge Records

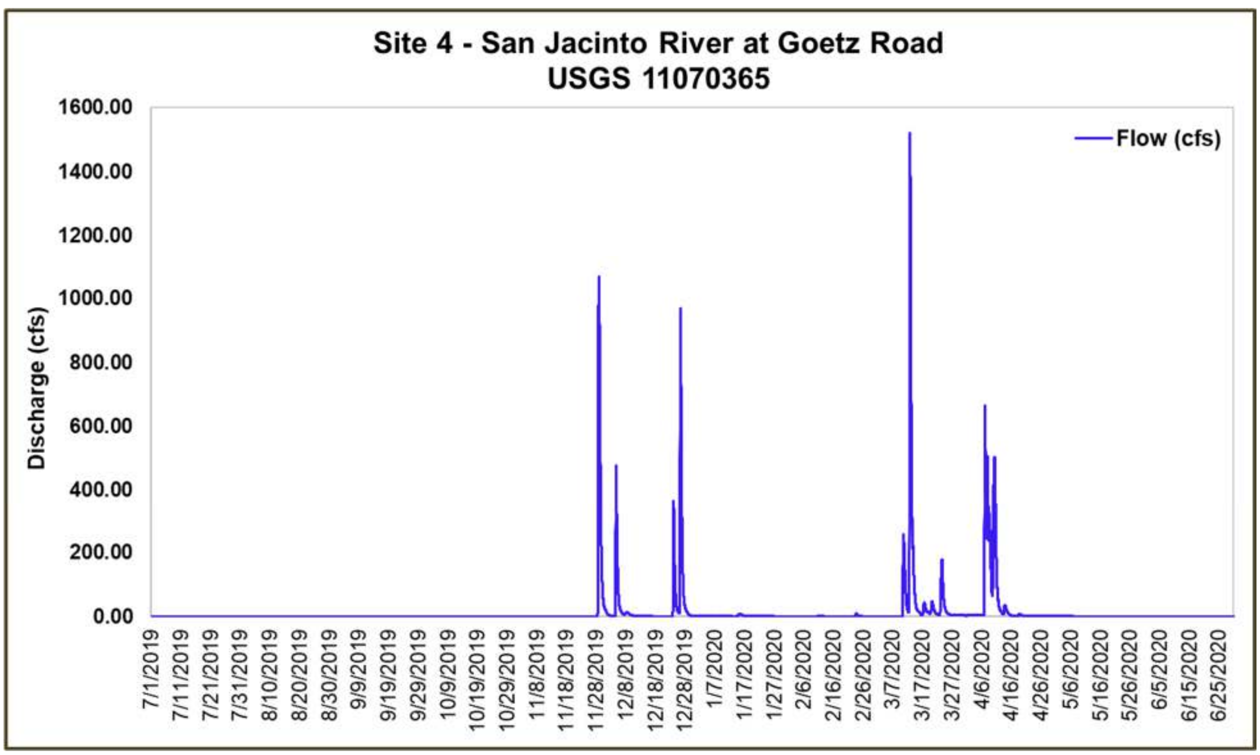


Figure 2-3. Site 4 – San Jacinto River at Goetz Road – Daily Stream Gauge Records

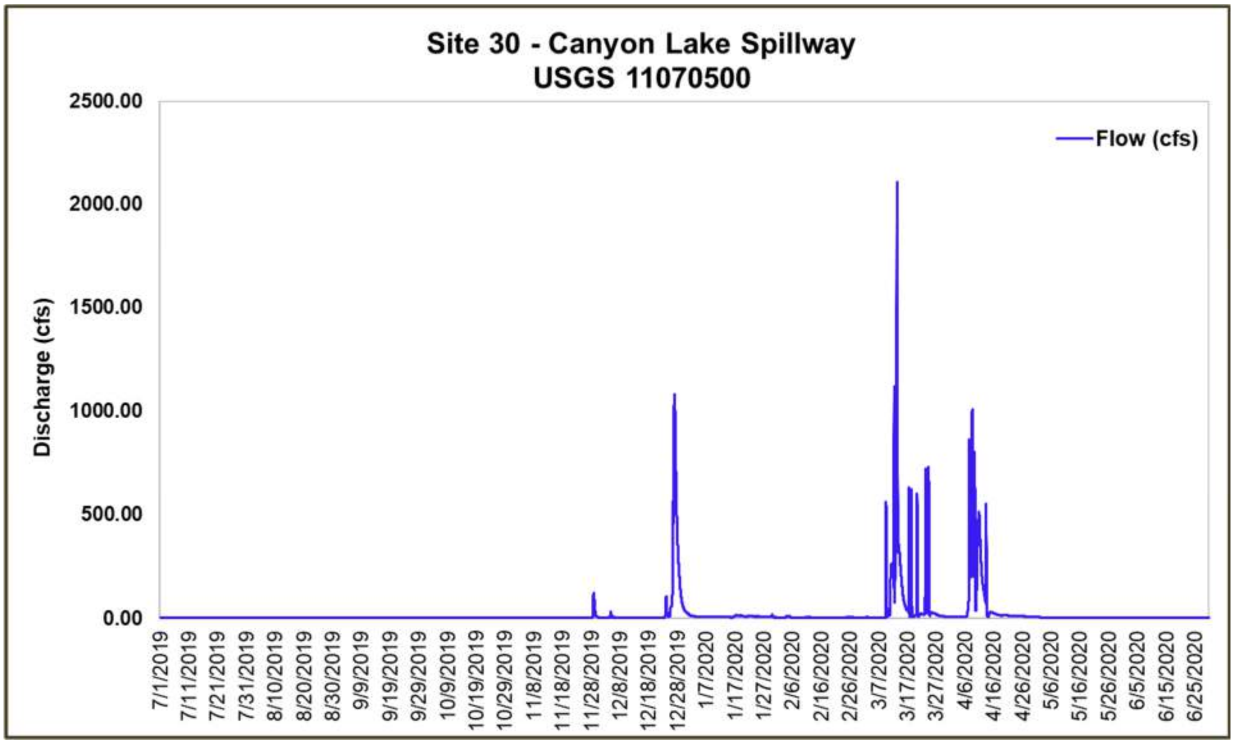


Figure 2-4. Site 30 – Canyon Lake Spillway – Daily Stream Gauge Records

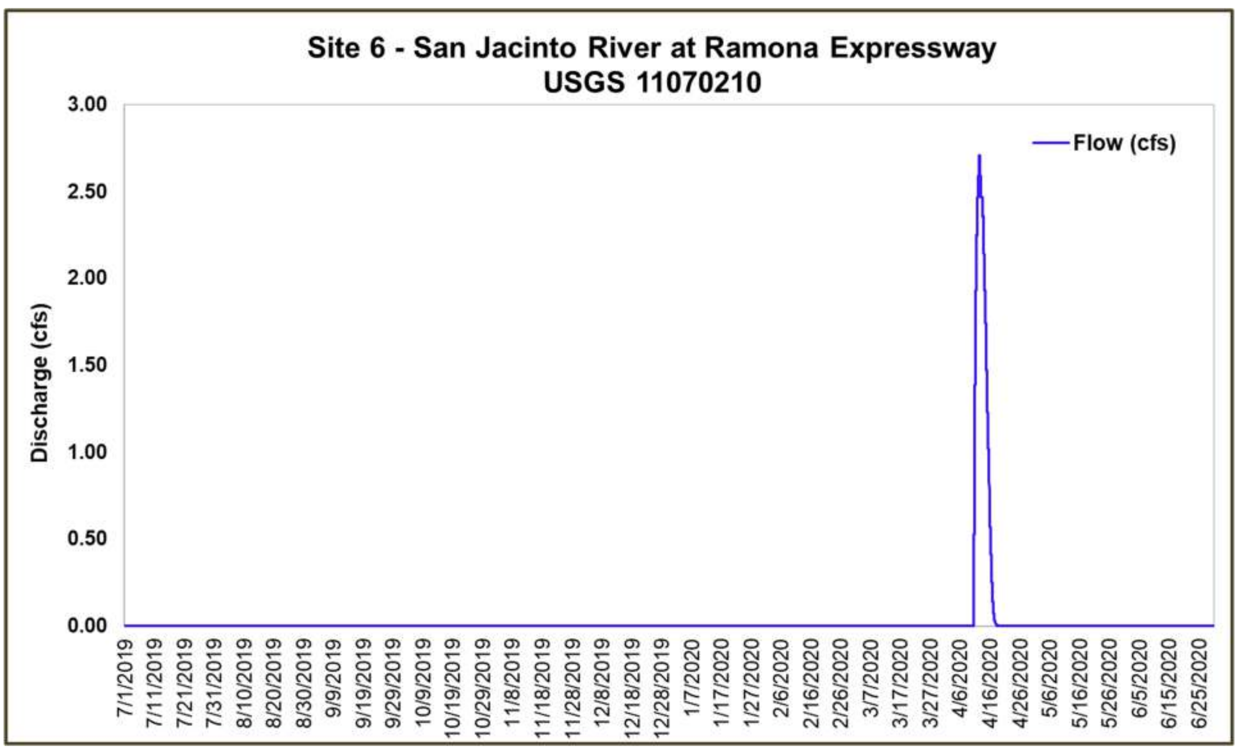


Figure 2-5. Site 6 – San Jacinto River at Ramona Expressway – Daily Stream Gauge Records

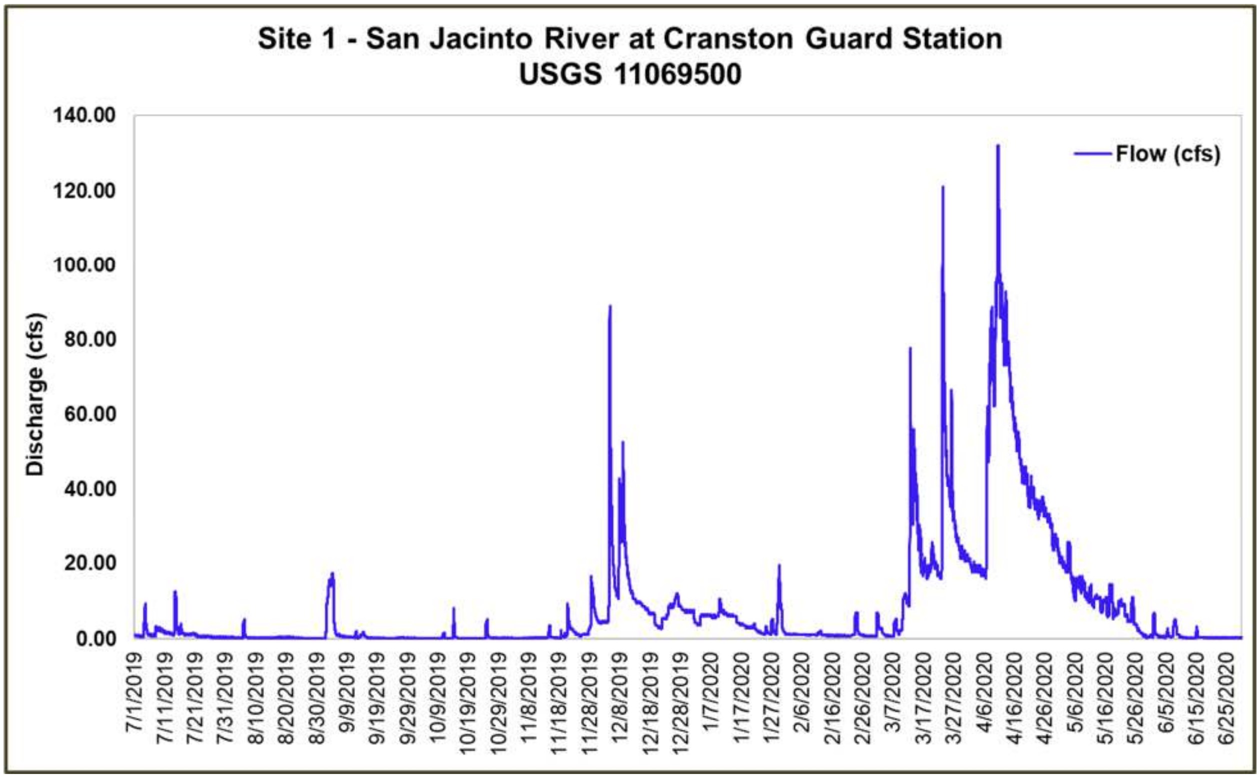


Figure 2-6. Site 1 – San Jacinto River at Cranston Guard Station – Daily Stream Gauge Records

2.6 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, 2019 to May 31, 2020, 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 during the rising limb of the hydrograph 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 (Haley & Aldrich, Inc., July 2016). 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 (Amec Foster Wheeler, September 2016). These documents are available at the following website:

https://sawpa.org/task-forces/lake-elsinore-and-canyon-lake-tmdl-task-force/#monitoring-program

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

2.7 San Jacinto River Watershed Monitoring Events

Water quality samples were collected during four storm events that met the mobilization criteria during the wet weather monitoring period from October 1, 2019 to May 31, 2020, which included a total of three events for each station, except San Jacinto River at Ramona Expressway.

The first monitoring event occurred on November 27, 2019 through December 2, 2019. Water quality samples were collected at Salt Creek at Murrieta Road (Station ID 745) and , San Jacinto River at Goetz Road (Station ID 759).), and Canyon Lake Spillway (Station ID 841). A peak flow of 214 cubic feet per second (cfs) was recorded at Salt Creek at Murrieta Road (Station ID 745) and a peak flow of 1,070 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 1.88 to 2.16 inches of rainfall was recorded in the region during this storm (RCFCWCD 2019).

The second monitoring event occurred on March 10, 2020 through March 12, 2020. Water quality samples were collected at Salt Creek at Murrieta Road (Station ID 745), San Jacinto River at Goetz Road (Station ID 759), and Canyon Lake Spillway (Station ID 841).Salt Creek at Murrieta Road (Station ID 745) and San Jacinto River at Goetz Road (Station ID 759). A peak flow of 161 cfs was recorded at Salt Creek at Murrieta Road (Station ID 745), a peak flow of 259 cfs was recorded at San Jacinto River at Goetz Road (Station ID 759), and a peak flow of 1,120 cfs was recorded at Canyon Lake Spillway (Station ID 841). No flows were recorded at the San Jacinto River at Ramona Expressway (Station ID 741). A total of 0.69 to 1.36 inches of rainfall was recorded in the region during this storm (RCFCWCD 2019).

The third monitoring event occurred on March 12, 2020 through March 16, 2020. Water quality samples were collected at Canyon Lake Spillway (Station ID 841). A peak flow of 2,110 cfs was recorded at Canyon Lake Spillway (Station ID 841). No flows were recorded at the San Jacinto River at Ramona Expressway (Station ID 741). A total of 1.06 to 2.38 inches of rainfall was recorded in the region during this storm (RCFCWCD 2019).

The fourth monitoring event occurred on March 22, 2020 through March 24, 2020. Water quality samples were collected at Salt Creek at Murrieta Road (Station ID 745), San Jacinto River at Goetz Road (Station ID 759), and Canyon Lake Spillway (Station ID 841). A peak flow of 335 cfs was recorded at Salt Creek at Murrieta Road (Station ID 745), a peak flow of 178 cfs was recorded at San Jacinto River at Goetz Road (Station ID 759), and a peak flow of 732 cfs was recorded at Canyon Lake Spillway (Station ID 841). No flows were recorded at the San Jacinto River at Ramona Expressway (Station ID 741). A total of 0.32 to 0.76 inches of rainfall was recorded in the region during this storm (RCFCWCD 2019).

2.8 San Jacinto River Watershed Annual Water Quality Summary

A summary of watershed water quality monitoring data for each of the four monitoring locations for the monitoring period of July 1, 2019 through June 30, 2020, 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.

2.8.1 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, 2019 to May 31, 2020.

During the storm event on November 27, 2019 through December 2, 2019, a total of 55 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 11070465), flow for the storm event was estimated at 611 acre-feet or 199 million gallons (Mgal), which represents approximately 12% of the total annual flow.

During the storm event on March 10, 2020 through March 11, 2020, a total of 20 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 11070465), flow for the storm event was estimated at 315 acre-feet or 103 Mgal, which represents approximately 6% of the total annual flow.

During the storm event on March 22, 2020 through March 24, 2020, a total of 23 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 11070465), flow for the storm event was estimated at 268 acre-feet or 87 Mgal, which represents approximately 5% of the total annual flow.

Photos taken during the storm events are provided in Figure 2-7, Figure 2-8, and Figure 2-9.

Figure 2-7. Storm Event at Salt Creek at Murrieta Road (November 27 – December 2, 2019)

Figure 2-8. Storm Event at Salt Creek at Murrieta Road (March 10-11, 2020)

Figure 2-9. Storm Event at Salt Creek at Murrieta Road (March 22-24, 2020)

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 three storm events ranged from 2.2 to 2.5 milligrams per liter (mg/L) for total nitrogen, and 0.52 to 0.63 mg/L for total phosphorus (Table 2-6). Based on flow data provided by the nearby USGS stream gauge (Station ID 11070465), the total annual flow was estimated at 219,855,420 cubic feet (cf) or 1,645 Mgal for the period of July 1, 2019 through June 30, 2020. No dry weather flows enter Canyon Lake from Salt Creek at Murrieta Road (Station ID 745) so storm flows accounted for the total estimated annual load of nutrients. The event loads were calculated as the product of the event concentrations and the storm volumes for each storm event. The annual loads were calculated as the sum of the three monitored event loads and the storm events where no sampling occurred, which are the product of the storm volumes for the storm events not monitored and the annual mean concentrations. The estimated annual nutrient load was calculated to be 14,792 kg for total nitrogen and 3,705 kg for total phosphorus (Table 2-7) for the period of July 1, 2019 through June 30, 2020.

Table 2-6. 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	0.24	0.10	0.14	0.16	0.15
Chemical Oxygen Demand	mg/L	46	44	58	49	49
Kjeldahl Nitrogen	mg/L	1.8	2.0	1.9	1.9	1.9
Nitrate as N	mg/L	0.75	0.37	0.27	0.46	0.42
Nitrite as N	mg/L	ND(<0.091)	ND(<0.091)	ND(<0.091)	0[a]	0[a]
Organic Nitrogen	mg/L	1.5	1.9	1.8	1.7	1.7
Total Nitrogen	mg/L	2.5	2.4	2.2	2.4	2.4
Total Phosphorus	mg/L	0.63	0.52	0.63	0.59	0.59
Ortho Phosphate Phosphorus	mg/L	0.32	0.21	0.31	0.28	0.28
Total Dissolved Solids	mg/L	540	280	270	363	344
Total Hardness	mg/L	230	140	130	167	161
Total Suspended Solids	mg/L	47	39	53	46	46

ND = not detected (analyte not detected at the indicated method detection limit (MDL)).

a - When a concentration was non-detect, the annual average value for compliance purposes was calculated by converting non-detect (ND) values to zero. If the result of the calculated mean was non-zero but below the corresponding MDL, the average value was reported as ND.

Table 2-7. 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	181	39	46	1,026
Chemical Oxygen Demand	kg	34,659	17,087	19,152	305,409
Kjeldahl Nitrogen	kg	1,356	777	627	11,792
Nitrate as N	kg	565	144	89	3,000
Nitrite as N	kg	0[a]	0[a]	0[a]	0[a]
Organic Nitrogen	kg	1,130	738	594	10,702
Total Nitrogen	kg	1,884	932	726	14,792
Total Phosphorus	kg	475	202	208	3,705
Ortho Phosphate Phosphorus	kg	241	82	102	1,756
Total Dissolved Solids	kg	406,864	108,734	89,154	2,331,902
Total Hardness	kg	173,294	54,367	42,926	1,062,858
Total Suspended Solids	kg	35,412	15,145	17,501	288,309

a - When a concentration was non-detect, the annual load value for compliance purposes was calculated by converting non-detect (ND) values to zero.

Hydrographs with flow-weighted sample aliquot times are provided in Figure 2-7, Figure 2-8, and Figure 2-9. The figures were developed based on flow data provided by the nearby USGS stream gauge (Station ID 11070465).

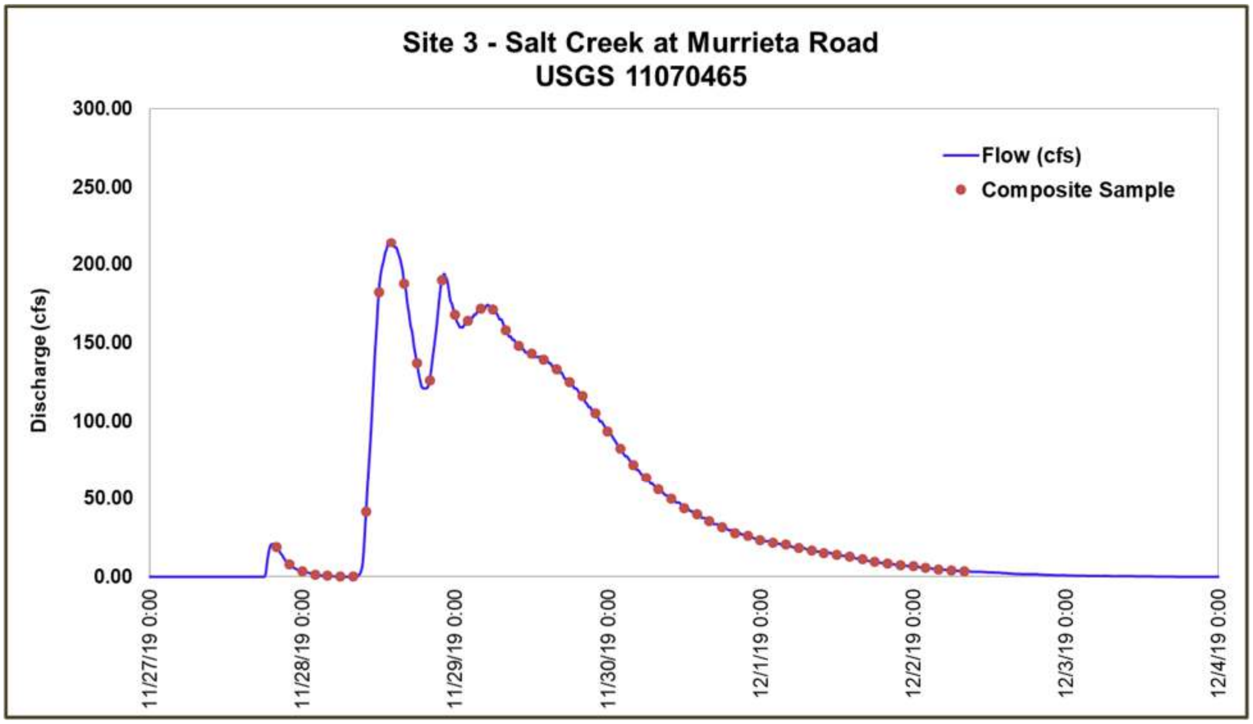


Figure 2-10. Hydrograph of First Storm Event at Salt Creek at Murrieta Road (November 27 – December 2, 2019)

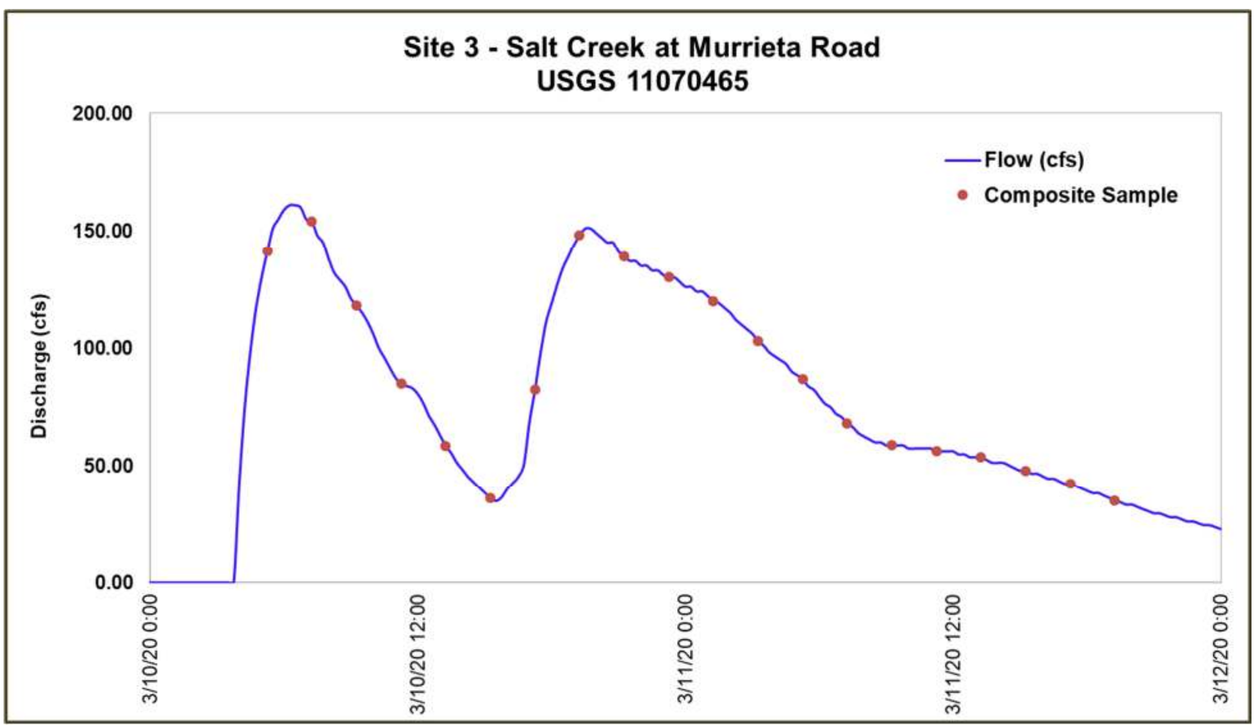


Figure 2-11. Hydrograph of Second Storm Event at Salt Creek at Murrieta Road (March 10 - 11, 2020)

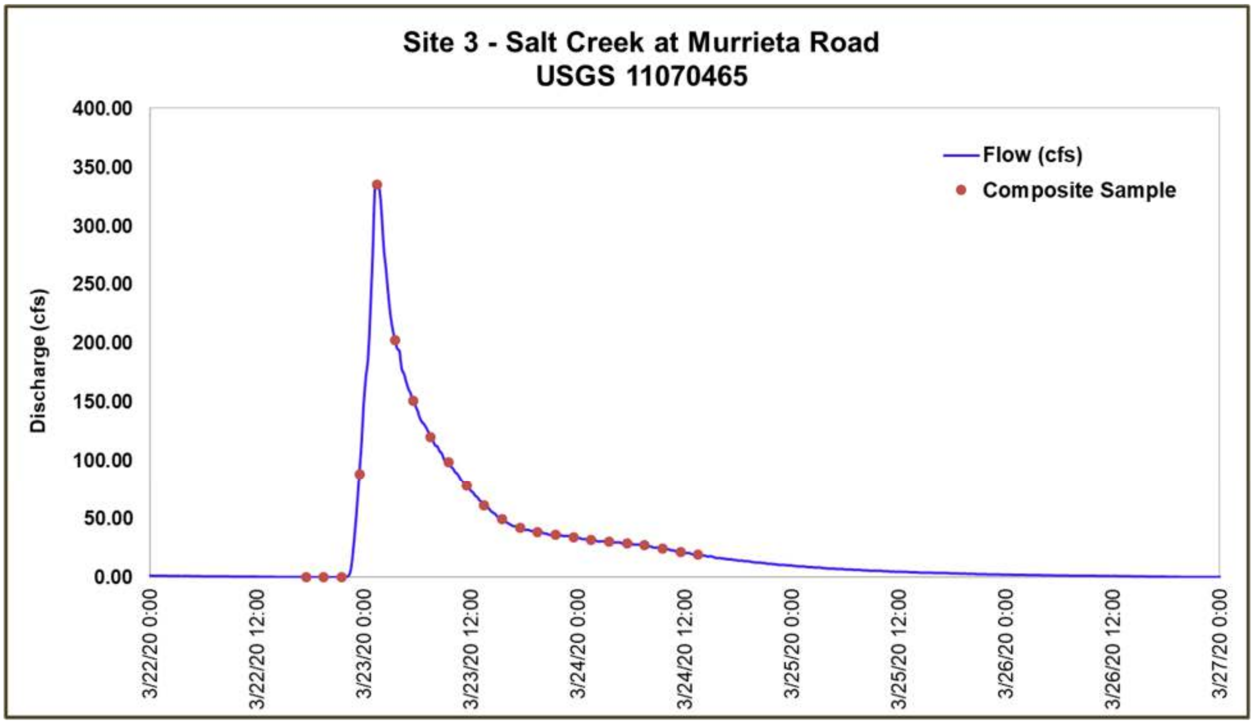


Figure 2-12. Hydrograph of Third Storm Event at Salt Creek at Murrieta Road (March 22 - 24, 2020)

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

Water quality samples were collected during three storm events at San Jacinto River at Goetz Road (Station ID 759) during the wet weather monitoring period from October 1, 2019 to May 31, 2020.

During the storm event on November 28, 2019 through December 2, 2019, a total of 44 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 1,851 acre-feet or 603 Mgal, which represents approximately 18% of the total annual flow.

During the storm event on March 10, 2020 through March 11, 2020, a total of 19 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 404 acre-feet or 132 Mgal, which represents approximately 4% of the total annual flow.

During the storm event on March 22, 2020 through March 24, 2020, a total of 23 discrete samples were collected across the hydrograph at two-hour intervals for the first 11 discrete samples 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 341 acre-feet or 111 Mgal, which represents approximately 3% of the total annual flow.

Photos taken during the storm events are provided in Figure 2-13, Figure 2-14, and Figure 2-15.

Figure 2-13. Storm Event at San Jacinto River at Goetz Road (November 28, 2019 – December 2, 2019)

Figure 2-14. Storm Event at San Jacinto River at Goetz Road (March 10 - 11, 2020)

Figure 2-15. Storm Event at San Jacinto River at Goetz Road (March 22 - 24, 2020)

Event and annual mean concentrations for each analyte are presented in Table 2-8. Event and annual loads for each analyte are presented in Table 2-9. Concentrations for nutrients for the three storm events ranged from 1.5 to 2.1 mg/L for total nitrogen, and 0.44 to 0.83 mg/L for total phosphorus (Table 2-8). Based on flow data provided by the nearby USGS stream gauge (Station ID 11070365), the total annual flow was estimated at 439,858,845 cf or 3,290 Mgal for the period of July 1, 2019 through June 30, 2020. No dry weather flows enter Canyon Lake from San Jacinto River at Goetz Road (Station ID 759) so storm flows accounted for the total estimated annual load of nutrients. The event loads were calculated as the product of the event concentrations and the storm volumes for each storm event. The annual loads were calculated as the sum of the three monitored event loads and the storm events where no sampling occurred, which are the product of the storm volumes for the storm events not monitored and the annual mean concentrations. The estimated annual nutrient load was calculated to be 23,337 kg for total nitrogen and 8,660 kg for total phosphorus (Table 2-9) for the period of July 1, 2019 through June 30, 2020.

Table 2-8. Water Quality Concentrations at San Jacinto River at Goetz Road

Analyte	Units	Event 1	Event 2	Event 3	Annual Mean	Annual Geomean
Ammonia-Nitrogen	mg/L	0.11	0.47	0.47	0.35	0.29
Chemical Oxygen Demand	mg/L	55	97	55	69	66
Kjeldahl Nitrogen	mg/L	1.4	1.5	1.5	1.5	1.5
Nitrate as N	mg/L	0.71	0.34	ND(<0.160)	0.38[a]	0.27[a]
Nitrite as N	mg/L	ND(<0.091)	ND(<0.091)	ND(<0.091)	0[a]	0[a]
Organic Nitrogen	mg/L	1.2	1.0	1.0	1.07	1.06
Total Nitrogen	mg/L	2.1	1.9	1.5	1.83	1.82
Total Phosphorus	mg/L	0.83	0.44	0.75	0.67	0.65
Ortho Phosphate Phosphorus	mg/L	0.51	ND(<0.050)	ND(<0.050)	0.19[a]	0.07[a]
Total Dissolved Solids	mg/L	120	95	120	111.7	111.0
Total Hardness	mg/L	76	57	76	69.7	69.1
Total Suspended Solids	mg/L	200	92	43	111.7	92.5

ND = not detected (analyte not detected at the indicated MDL).

a - When a concentration was non-detect, the annual average value for compliance purposes was calculated by converting non-detect (ND) values to zero. If the result of the calculated mean was non-zero but below the corresponding MDL, the average value was reported as ND.

Table 2-9. Water Quality Event and Annual Loads at San Jacinto River at Goetz Road

Analyte	Units	Load Event 1	Load Event 2	Load Event 3	Annual Load
Ammonia-Nitrogen	kg	251	234	197	3,922
Chemical Oxygen Demand	kg	125,579	48,370	23,108	835,538
Kjeldahl Nitrogen	kg	3,197	748	630	18,146
Nitrate as N	kg	1,621	170	0[a]	5,029
Nitrite as N	kg	0[a]	0[a]	0[a]	0[a]
Organic Nitrogen	kg	2,740	499	420	13,529
Total Nitrogen	kg	4,795	947	630	23,337
Total Phosphorus	kg	1,895	219	315	8,660
Ortho Phosphate Phosphorus	kg	1,164	0[a]	0[a]	2,738
Total Dissolved Solids	kg	273,991	47,372	50,417	1,405,072
Total Hardness	kg	173,527	28,423	31,931	878,533
Total Suspended Solids	kg	456,651	45,876	18,066	1,553,885

a - When a concentration was non-detect, the annual load value for compliance purposes was calculated by converting non-detect (ND) values to zero.

Hydrographs with flow-weighted sample aliquot times is provided in Figure 2-16, Figure 2-17, and Figure 2-18. The figure was developed based on flow data provided by the nearby USGS stream gauge (Station ID 11070365).

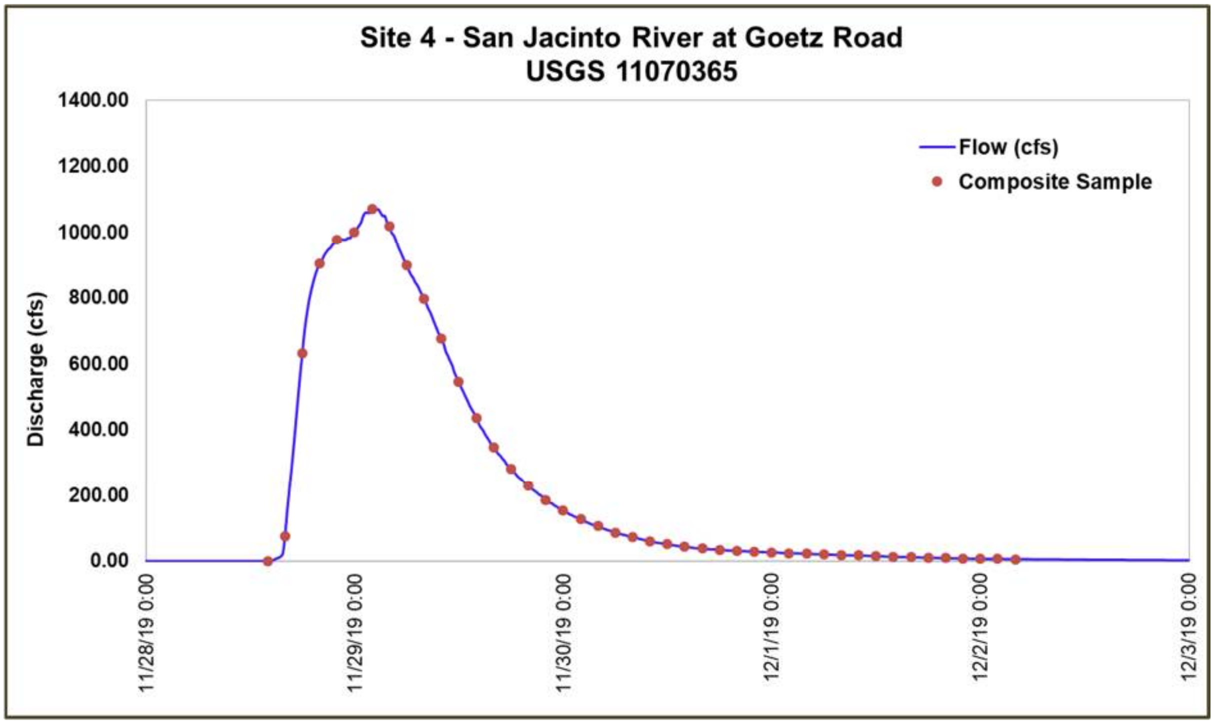


Figure 2-16. Hydrograph of First Storm Event at San Jacinto River at Goetz Road (November 28 – December 2, 2019)

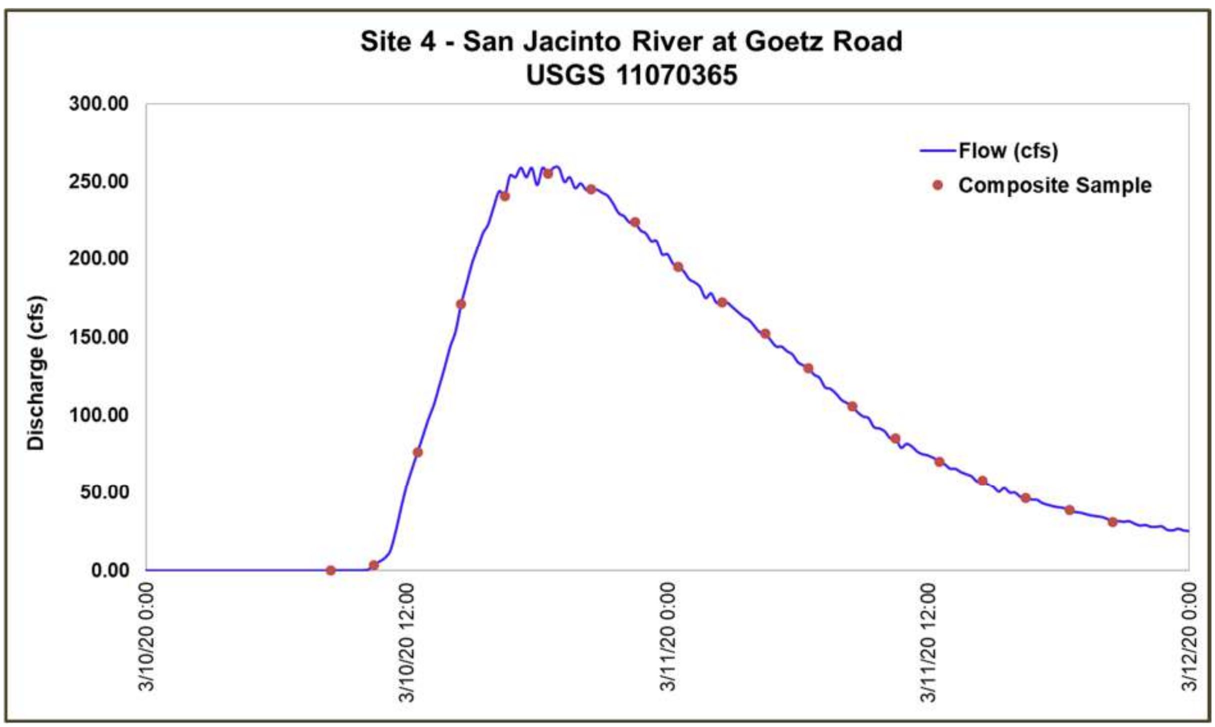


Figure 2-17. Hydrograph of Second Storm Event at San Jacinto River at Goetz Road (March 10 - 11, 2020)

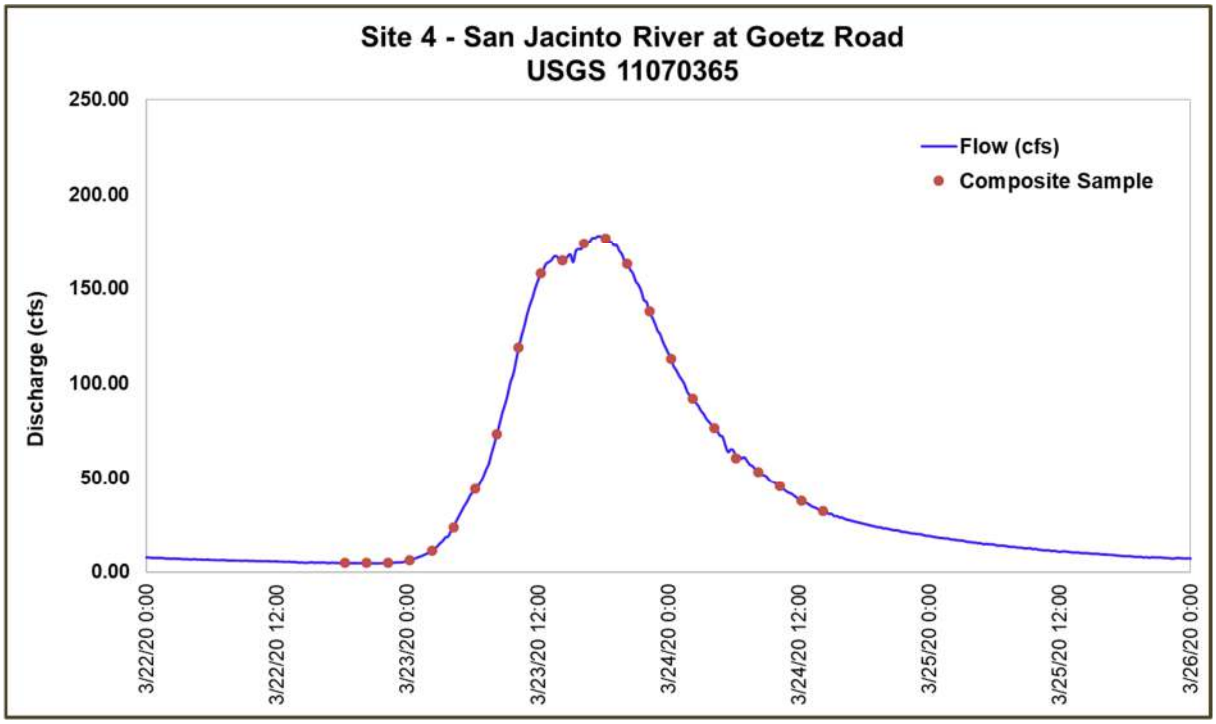


Figure 2-18. Hydrograph of Third Storm Event at San Jacinto River at Goetz Road (March 22 - 24, 2020)

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

Mystic Lake did not overflow during the wet weather monitoring period from October 1, 2019 to May 31, 2020. Therefore, no samples were collected from the sampling station at San Jacinto River at Ramona Expressway (Station ID 741) during the 2019-2020 monitoring year. Flows from the local area were observed at the San Jacinto River at Ramona Expressway (Station ID 741) from April 10,2020 through April 18, 2020, however, no flows originating from the upper watershed were observed and no flows exited Mystic Lake.

2.8.4 Summary of Monitoring Data – Canyon Lake Spillway

Water quality samples were collected during three storm events at Canyon Lake Spillway (Station ID 841) during the wet weather monitoring period from October 1, 2019 to May 31, 2020. During the storm event on November 27, 2019 through December 2, 2019 Canyon Lake Dam did not overflow, and no samples were collected at Canyon Lake Spillway (Station ID 841).

During the storm event on March 10, 2020 through March 12, 2020, 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 11070500), flow for the storm event was estimated at 916 acre-feet or 299 Mgal, which represents approximately 7% of the total annual inflow to Lake Elsinore from Canyon Lake.

During the storm event on March 12, 2020 through March 16, 2020, a total of 36 discrete samples were collected across the hydrograph at two-hour intervals for the first 35 discrete samples and at the last sample after twenty-two hours due to a debris clog in the sample intake tubing. A single flow-weighted composite sample was submitted for analysis. Based on data provided by the nearby USGS stream gauge (Station ID 11070500), flow for the storm event was estimated at 2,943 acre-feet or 959 Mgal, which represents approximately 21% of the total annual inflow to Lake Elsinore from Canyon Lake.

During the storm event on March 22, 2020 through March 24, 2020, a total of 24 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 11070500), flow for the storm event was estimated at 631 acre-feet or 206 Mgal, which represents approximately 5% of the total annual inflow to Lake Elsinore from Canyon Lake.

The flows from Canyon Lake do not include runoff from the local surrounding watershed into Lake Elsinore. Photos taken during the storm events are provided in Figure 2-19, Figure 2-20, and Figure 2-21.

Figure 2-19. Storm Event Sampling Below the Canyon Lake Spillway (March 10 - 12, 2020)

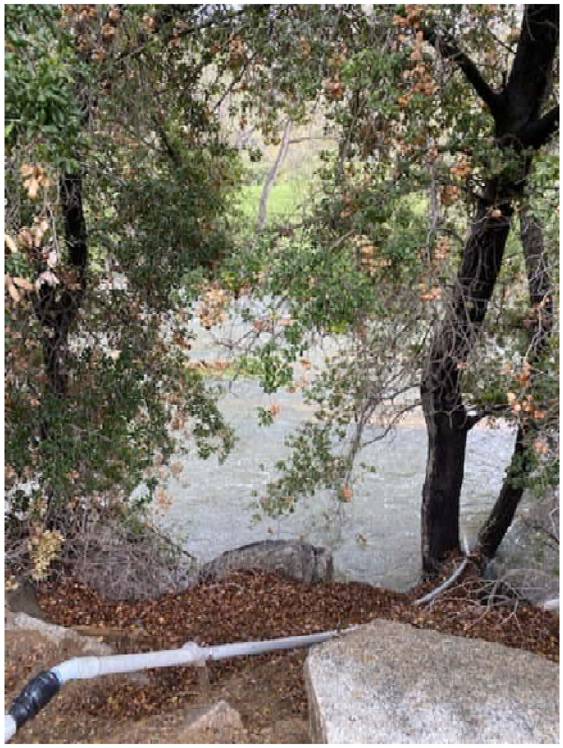


Figure 2-20. Storm Event Sampling Below the Canyon Lake Spillway (March 12 - 16, 2020)

Figure 2-21. Storm Event Sampling Below the Canyon Lake Spillway (March 22 - 24, 2020)

Event and annual mean concentrations of each analyte are presented in Table 2-10. Event and annual loads for each analyte are presented in Table 2-11. Concentrations of nutrients for the three storm events ranged from 1.0 to 1.2 mg/L for total nitrogen, and 0.12 to 0.20 mg/L for total phosphorus (Table 2-10). Based on flow data provided by the nearby USGS stream gauge (Station ID 11070500), the total annual flow was estimated at 601,198,038 cf or 4,497 Mgal for the period of July 1, 2019 through June 30, 2020. The USGS stream gauge (Station ID 11070500) located downstream of the Canyon Lake Spillway (Station ID 841) sampling location has minimal dry weather flow and storm flows account for the vast majority of the estimated annual load of nutrients exiting Canyon Lake. The event loads were calculated as the product of the event concentrations and the storm volumes for each storm event. The annual loads were calculated as the sum of the three monitored event loads and the storm events where no sampling occurred, which are the product of the storm volumes for the storm events not monitored and the annual mean concentrations. The estimated annual nutrient load was calculated to be 18,762 kg for total nitrogen and 2,635 kg for total phosphorus (Table 2-11) for the period of July 1, 2019 through June 30, 2020.

Table 2-10. Water Quality Concentrations at Canyon Lake Spillway

Analyte	Units	Event 1	Event 2	Event 3	Annual Mean	Annual Geomean
Ammonia-Nitrogen	mg/L	0.048 J	0.18	0.28	0.17	0.13
Chemical Oxygen Demand	mg/L	30	ND(<7.4)	35	23 [a]	16 [a]
Kjeldahl Nitrogen	mg/L	1.2	1.1	1	1.1	1.1
Nitrate as N	mg/L	ND(<0.160)	ND(<0.160)	ND(<0.160)	0[a]	0[a]
Nitrite as N	mg/L	ND(<0.091)	ND(<0.091)	ND(<0.091)	0[a]	0[a]
Organic Nitrogen	mg/L	1.1	0.9	0.7	0.9	0.9
Total Nitrogen	mg/L	1.2	1.1	1.0	1.1	1.1
Total Phosphorus	mg/L	0.12	0.15	0.20	0.16	0.15
Ortho Phosphate Phosphorus	mg/L	ND(<0.050)	ND(<0.050)	0.095	0.05[a]	ND(<0.050)[a]
Total Dissolved Solids	mg/L	390	400	380	390	390
Total Hardness	mg/L	200	200	200	200	200
Total Suspended Solids	mg/L	12	26	19	19	18

ND = not detected (analyte not detected at the indicated MDL).
J- Reported value was detected above the MDL, but below the RL.

a - When a concentration was non-detect, the annual average value for compliance purposes was calculated by converting non-detect (ND) values to zero. If the result of the calculated mean was non-zero but below the corresponding MDL, the average value was reported as ND.

Table 2-11. Water Quality Event and Annual Loads at Canyon Lake Spillway

Analyte	Units	Load Event 1	Load Event 2	Load Event 3	Annual Load
Ammonia-Nitrogen	kg	54	653	218	2,870
Chemical Oxygen Demand	kg	33,904	0[a]	27,233	310,005
Kjeldahl Nitrogen	kg	1,356	3,993	778	18,762
Nitrate as N	kg	0[a]	0[a]	0[a]	0[a]
Nitrite as N	kg	0[a]	0[a]	0[a]	0[a]
Organic Nitrogen	kg	1,243	3,267	545	15,392
Total Nitrogen	kg	1,356	3,993	778	18,762
Total Phosphorus	kg	136	544	156	2,635
Ortho Phosphate Phosphorus	kg	0[a]	0[a]	74	438
Total Dissolved Solids	kg	440,748	1,451,846	295,671	6,667,888
Total Hardness	kg	226,025	725,923	155,616	3,404,807
Total Suspended Solids	kg	13,561	94,370	14,784	340,953

a - When a concentration was non-detect, the annual load value for compliance purposes was calculated by converting non-detect (ND) values to zero.

Hydrographs with flow-weighted sample aliquot time are provided in Figure 2-22, Figure 2-23, and Figure 2-24. The figure was developed based on flow data provided by the nearby USGS stream gauge (Station ID 11070365). A hydrograph of the Canyon Lake Level at Railroad Canyon Dam Spillway compared to the spillway elevation is provided in Figure 2-25. The two valves in the Railroad Canyon Dam Spillway were replaced and testing of the valves was conducted from March 9, 2020 through April 7, 2020. Any irregularities in the hydrographs for the March sampling events are attributed to the storm flows being released through the valves for testing instead of flowing over the spillway.

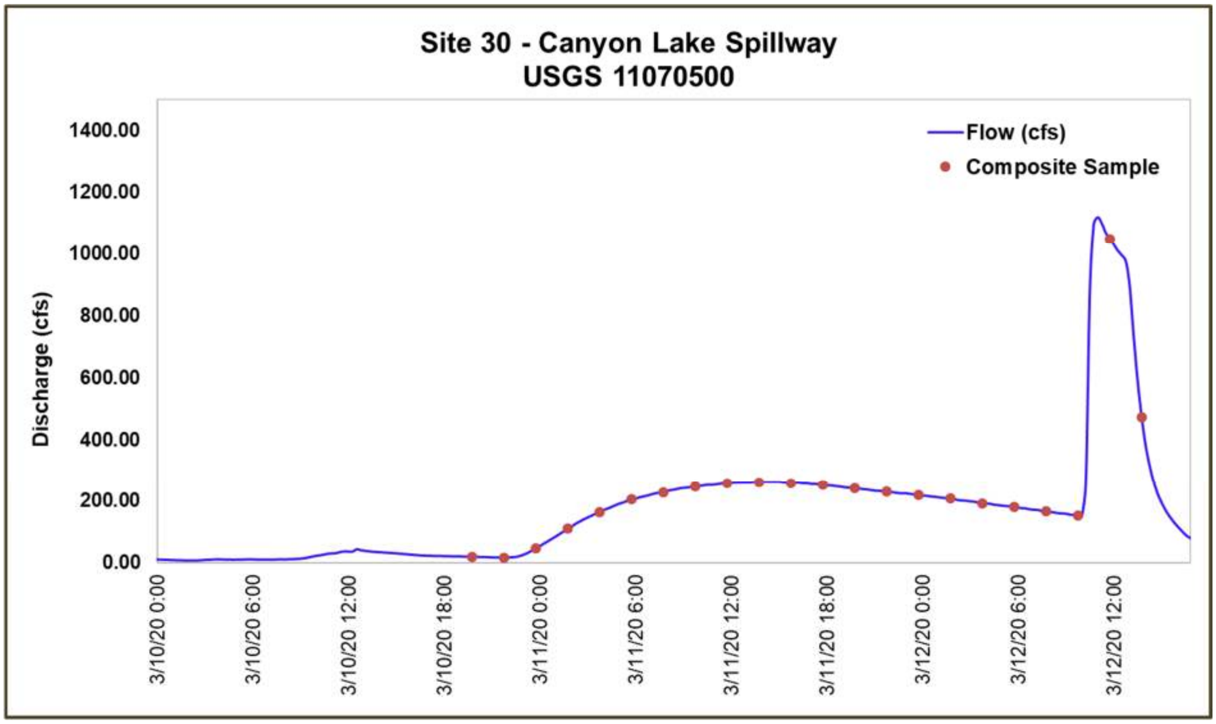


Figure 2-22. Hydrograph of First Storm Event at Canyon Lake Spillway (March 10 - 12, 2020)

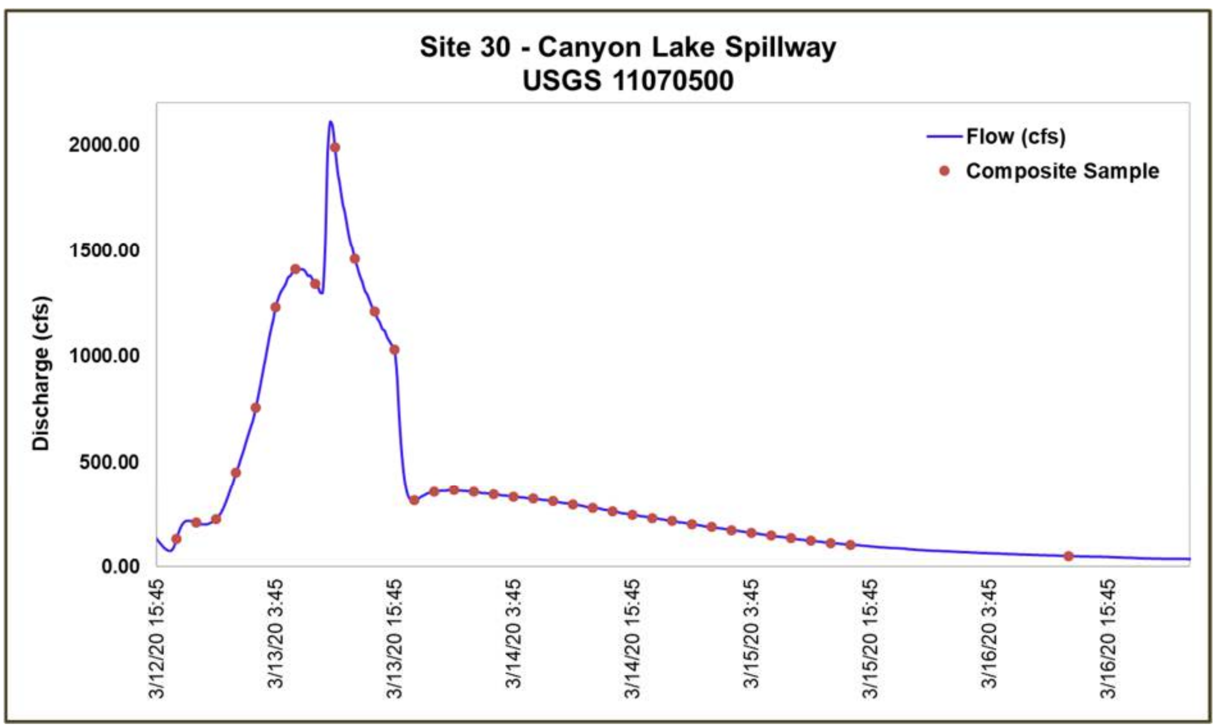


Figure 2-23. Hydrograph of Second Storm Event at Canyon Lake Spillway (March 12 - 16, 2020)

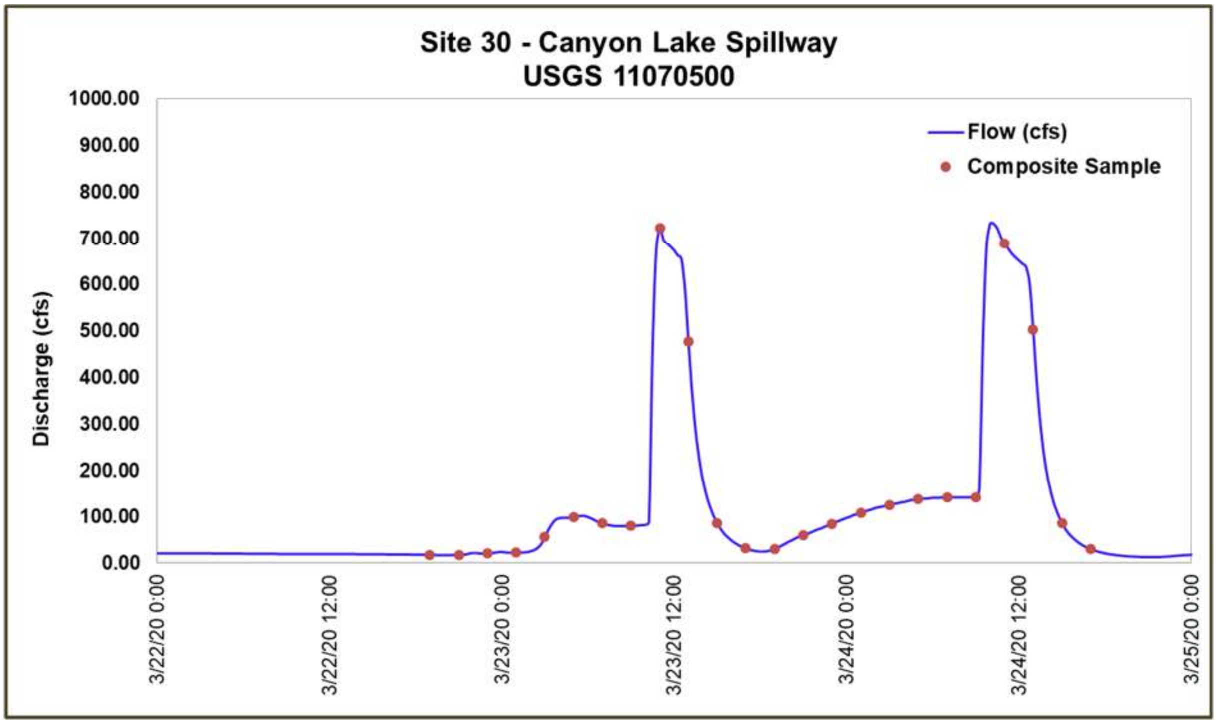


Figure 2-24. Hydrograph of Third Storm Event at Canyon Lake Spillway (March 22 - 24, 2020)

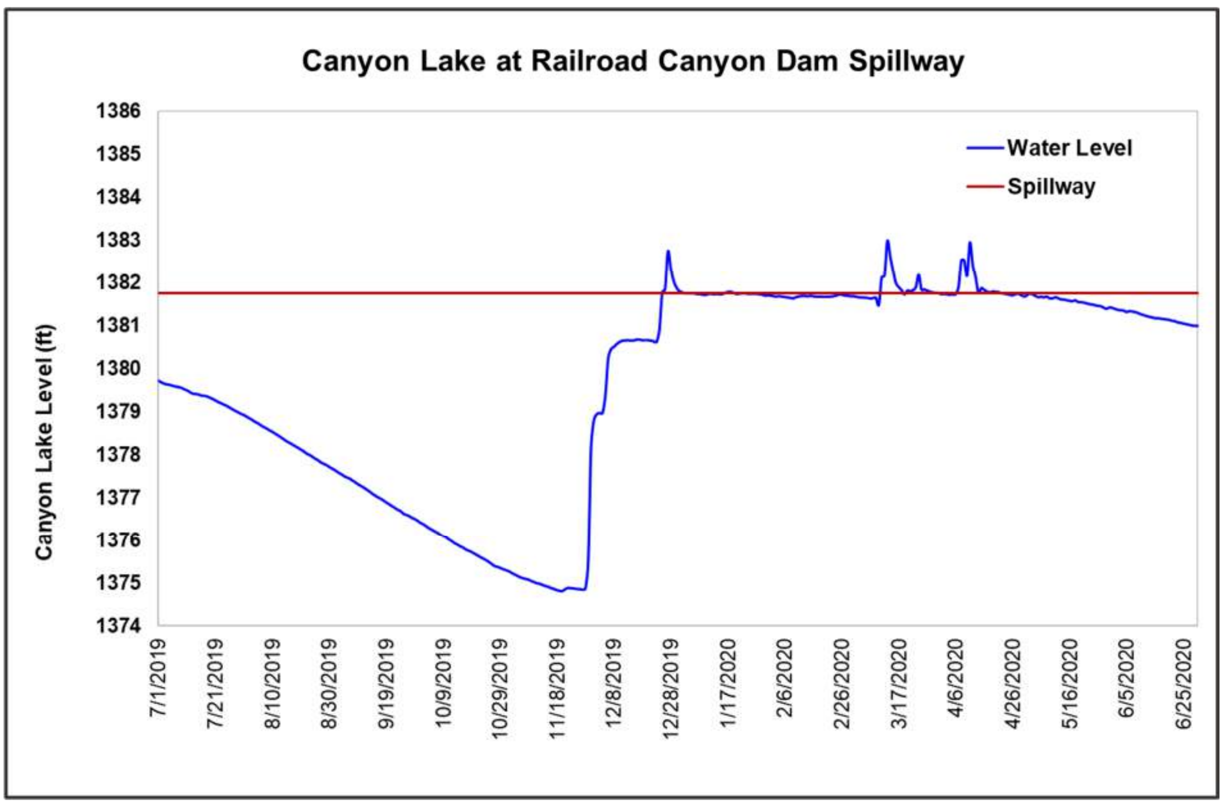


Figure 2-25. Canyon Lake Level at Railroad Canyon Dam Spillway

2.9 San Jacinto River Watershed Rainfall Records

The RCFC&WCD maintains rainfall records for rain gauges located within or near the San Jacinto River Watershed as shown in Table 2-12.

Table 2-12. 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, 2019, through June 30, 2020, are summarized in Table 2-13. A complete set of rainfall gauge data is included in Appendix A.

Table 2-13. Summary Rainfall Data (July 2019 to June 2020)

Monthly Rainfall (inches)	Lake Elsinore	Perris CDF	Pigeon Pass	Hemet / San Jacinto	Winchester
Jul	0.11	0.00	0.01	0.00	0.00
Aug	0.02	0.00	0.00	0.00	0.00
Sep	0.00	0.00	0.02	0.02	0.02
Oct	0.02	0.00	0.00	0.00	0.00
Nov	2.26	2.29	2.51	2.46	2.27
Dec	3.79	3.10	3.14	2.30	2.49
Jan	0.29	0.10	0.42	0.19	0.50
Feb	0.26	0.51	0.45	0.42	0.40
Mar	3.19	3.82	4.80	3.97	4.16
Apr	2.46	2.97	4.34	3.79	3.82
May	1.41	0.00	0.00	0.02	0.18
Jun	0.02	0.02	0.11	0.00	0.00
Annual Rainfall (Inches)	**13.83**	**12.81**	**15.80**	**13.17**	**13.84**

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. Initially, 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 (RWQCB 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 East Basin of Canyon Lake. This cost savings allowed for shifting resources toward several 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 resources toward implementing in-lake best management practices. Starting in FY 2015-2016, ongoing in-lake sampling was 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 2019-2020 FY.

3.2 Lake Elsinore Monitoring

3.2.1 Sampling Station Locations and Frequency

To maintain consistency and facilitate the assessment of trends toward meeting compliance goals, the in-lake monitoring design was resumed in July 2015 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, while only in-situ water quality profile readings were performed at the remaining two stations (LE01 and LE03). 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, for a total of eight sampling events per year. In-lake TMDL sampling events 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).

Figure 3-1. Lake Elsinore Sampling Locations

Table 3-1. Lake Elsinore TMDL Monitoring Locations

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

Table 3-2. 2019-2020 In-lake Analytical Constituents and Methods for Lake Elsinore

Parameter	Analysis Method	Sampling Method
Analytical Chemistry		
Nitrite Nitrogen (NO_2-N)	EPA 300.0	Depth Integrated
Nitrate Nitrogen (NO_3-N)	EPA 300.0	Depth Integrated
Total Kjeldahl Nitrogen (TKN)	EPA 351.3	Depth Integrated
Total Nitrogen (TN)[1]	Calculated	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)	SM 4500-P E & EPA 300.0	Depth Integrated
Chlorophyll-a	SM 10200H	Surface (0-2m) & Depth Integrated
Total Dissolved Solids (TDS)	SM 2540 C	Depth Integrated

NA – not applicable

[1] Total Nitrogen calculated as TKN+NO_2+NO_3

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 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. 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, ammonia, sulfide, TDS, and chlorophyll-a were submitted to Babcock Laboratories Inc., located in Riverside, California.

Secchi disk readings for water clarity, as well as in-situ water column profile data were typically recorded between 7:00 and 9:00 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.

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). Satellite imagery was also used to estimate the likelihood of a harmful algae bloom.

3.2.3 Water Quality Summary

A summary of the in-lake monitoring events for Lake Elsinore for the period of July 1, 2019 to June 30, 2020 is presented below. A total of eight Lake Elsinore events were sampled during this period under the TMDL monitoring program, with five occurring in 2019 (July 26, August 27, September 26, October 17 and December 20) and three in 2020 (February 18, April 13 and June 26). 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. The figures presented in Appendix E include historical water quality monitoring results from 2002-present.

A summary of mean water column profile values for each site and monitoring event are presented in Tables 3-3 and 3-4 for the 2019 and 2020 monitoring events, respectively. Water column mean profile statistics for each site across the entire monitoring period are presented in Table 3-5. Mean values for water column measurements for each site, as well as the lake-wide mean are also summarized graphically in Figures 3-2 through 3-7. The measurements during the morning and afternoon of any given monitoring event were averaged prior to summarizing in the tables and figures below.

Table 3-3. In-Situ Water Quality Parameter Measurements in Lake Elsinore – 2019 Monthly Means for Each Site (July – Dec 2019)

Site	Measure	Jul-19		Aug-19		Sep-19		Oct-19		Dec-19	
		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)	27.4	26.8	27.3	26.6	24.3	24.2	20.0	19.9	11.8	11.6
	Cond (µS/cm)	3647	3645	3764	3759	3851	3851	3896	3897	3845	3845
	pH	9.00	8.94	9.05	8.95	9.23	9.18	9.29	9.28	ME	ME
	DO (mg/L)	3.4	2.3	7.0	2.9	5.8	3.5	5.0	4.5	2.4	1.7
LE02	Temp (°C)	27.3	27.2	27.1	26.6	24.0	24.0	19.7	19.6	12.1	11.9
	Cond (µS/cm)	3646	3646	3769	3760	3851	3852	3896	3895	3841	3841
	pH	9.04	9.01	9.03	8.95	9.20	9.18	9.24	9.21	ME	ME
	DO (mg/L)	3.2	2.2	5.7	3.0	5.2	4.0	3.9	3.1	1.8	1.4
LE03	Temp (°C)	27.6	27.5	27.1	26.8	24.1	23.9	20.1	19.8	12.2	12.0
	Cond (µS/cm)	3644	3643	3756	3758	3845	3847	3895	3897	3826	3828
	pH	9.07	9.06	9.08	8.99	9.22	9.19	9.26	9.19	ME	ME
	DO (mg/L)	4.3	3.7	6.9	3.7	6.2	5.1	4.3	2.1	4.2	3.6
Lake-wide Average	Temp (°C)	27.4	27.2	27.2	26.6	24.1	24.0	19.9	19.8	12.0	11.8
	Cond (µS/cm)	3646	3645	3763	3759	3849	3850	3895	3896	3837	3838
	pH	9.04	9.00	9.05	8.96	9.22	9.18	9.27	9.23	ME	ME
	DO (mg/L)	3.6	2.7	6.5	3.2	5.7	4.2	4.4	3.2	2.8	2.2

Notes:
°C = degrees Celsius; µS/cm = microsiemens per centimeter; mg/L = milligrams per liter; ME = meter error

Table 3-4. In-Situ Water Quality Parameter Measurements in Lake Elsinore – 2020 Monthly Means for Each Site (Feb – June 2020 & July 2019-June 2020 Annual Average)

Site	Measure	Feb-20		Apr-20		Jun-20		Annual Average	
		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)	13.0	12.0	15.5	15.2	25.1	23.9	20.5	20.0
	Cond (µS/cm)	3575	3576	2914	3016	3053	3051	3568	3580
	pH	9.05	8.93	9.22	9.09	9.28	9.12	9.16	9.07
	DO (mg/L)	13.1	9.8	7.5	4.6	4.7	0.1	6.1	3.7
LE02	Temp (°C)	12.4	11.4	15.6	15.4	24.7	23.9	20.3	20.0
	Cond (µS/cm)	3576	3582	2886	3035	3050	3051	3564	3583
	pH	8.95	8.80	9.22	9.19	9.26	9.13	9.13	9.07
	DO (mg/L)	10.3	6.2	8.4	7.3	3.0	0.1	5.2	3.4
LE03	Temp (°C)	13.0	11.8	15.7	15.5	25.0	24.1	20.6	20.2
	Cond (µS/cm)	3575	3583	2840	2970	3051	3051	3554	3572
	pH	8.98	8.84	9.22	9.17	9.29	9.16	9.16	9.08
	DO (mg/L)	11.5	7.8	8.6	7.3	4.2	0.1	6.3	4.2
Lake-wide Mean	Temp (°C)	12.8	11.7	15.6	15.4	24.9	23.9	20.5	20.1
	Cond (µS/cm)	3575	3580	2880	3007	3051	3051	3562	3578
	pH	8.99	8.85	9.22	9.15	9.28	9.13	9.15	9.07
	DO (mg/L)	11.6	8.0	8.2	6.4	4.0	0.1	5.9	3.7

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

Morning and afternoon average water quality readings were similar overall, with increases in pH (up to 0.1 SU), DO (between 0.5 and 2.8 mg/L), and temperature (up to 1 degree Celsius) consistently observed. These increases were especially prominent in summer months, while little deviation was observed during winter and spring monitoring events.

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 (both water column mean and 1-meter from bottom) were observed in February at all three sites. Concentrations of DO near the bottom, while lower, generally tracked with the overall water column mean for all three sites, with the exception of June 2020, for which the bottom of the lake averaged 0.1 mg/L across all sites during this monitoring event, compared to the lake-wide average of 4.0 mg/L for the water column mean. These measurements indicate that the lake may be starting to stratify, and is further supported by: 1.) associated temperatures recorded during the June event, 2.) the temperature and DO measurements recorded during the July and August 2020 monitoring events, and 3.) historical trends that demonstrate stratification in portions of the lake during this period. The 12-month rolling mean water column DO concentration for all events at Site LE02 was at or above the 2015 TMDL target of 5.0 mg/L (Figure 3-2). The rolling mean DO concentration 1-m above the lake bottom at Site LE02 hovered just below the 2020 TMDL target of 5.0 mg/L, ranging from 3.1 to 4.2 mg/L.

Conductivity increased from July through October 2019, from approximately 3600 to 3900 microsiemens per centimeter (µS/cm). The conductivity dropped slightly between October 2019 and December 2019, as a series of storms moved through the region beginning November 22, 2019. Conductivity then continued to decline between December 2019 and April 2020 as additional storms moved through. Overall, there has been a decline in lake-wide conductivity compared to recent monitoring years, with a peak of 5200 µS/cm observed in October 2018. This has been largely attributed to large storm events that occurred during the 2018-19 and 2019-20 winter seasons after several years of drought in the region.

The overall annual average pH across all sites was 9.15. The pH values remained within a relatively narrow band across the monitoring year, only varying by approximately 0.3 units. This elevated pH is likely the result of algae removing carbon dioxide during photosynthesis, which causes pH to rise by increasing the level of hydroxide. In lakes with a large algal biomass, such as Lake Elsinore, this can cause a lake-wide increase in pH.

Water clarity measured using a Secchi disk decreased at LE02 across the summer and fall months from 1.6 feet (ft) to 0.66 ft. These measurements are slightly increased from those recorded in the same period during the 2017-18 and 2018-19 monitoring years (approximately 1.0 ft to 0.3 ft and 0.8 ft to 0.5 ft, respectively), indicating a visible increase in clarity. This was followed by a period of variability across the winter and spring months alternating increasing and decreasing values (Figure 3-7). The Secchi depths observed generally exhibited an inverse relationship with algal density (i.e. chlorophyll-a concentrations) at Site LE02, as the algal density increased the Secchi depths decreased. Sites LE01 and LE03 both displayed similar Secchi depths and patterns as those exhibited at Site LE02.

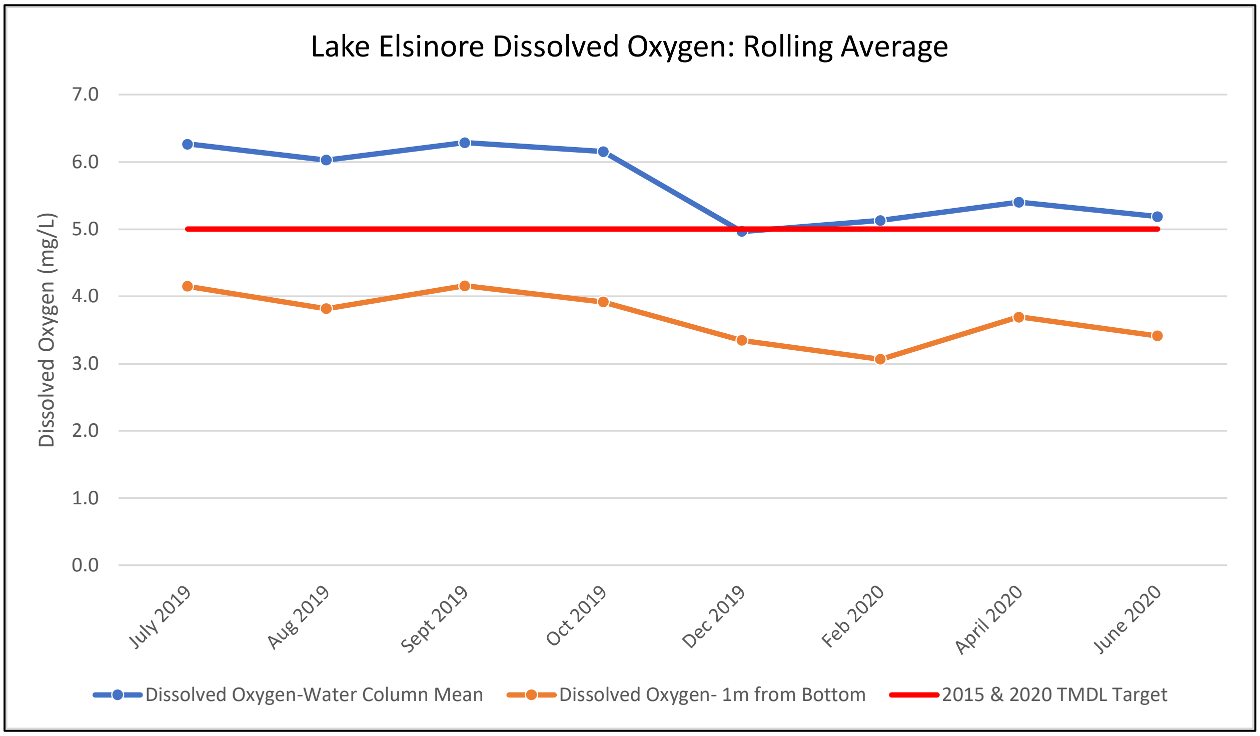
For further comparisons regarding in-situ water quality parameters, Table 3-5 includes lake-wide averages observed during the 2018-19 monitoring year, in addition to this 2019-20 monitoring period.

Table 3-5. In-Situ Water Quality Parameter Measurements in Lake Elsinore – 2019-2020 Annual Mean Statistics for Each Site

		Measure	LE01	LE02	LE03	Lake-wide Average (July 2019-June 2020)	Lake-wide Average (July 2018-June 2019)
Water Column Mean	Min	Temp (°C)	11.8	12.1	12.2	12.0	11.4
		Cond (µS/cm)	2914	2886	2840	2880	3329
		pH	9.00	8.95	8.98	8.97	8.76
		DO (mg/L)	2.4	1.8	4.2	2.8	3.9
	Max	Temp (°C)	27.4	27.3	27.6	27.4	28.3
		Cond (µS/cm)	3896	3896	3895	3895	5224
		pH	9.29	9.26	9.29	9.28	9.10
		DO (mg/L)	13.1	10.3	11.5	11.6	10.4
	Average	Temp (°C)	20.5	20.3	20.6	20.5	20.9
		Cond (µS/cm)	3568	3564	3554	3562	4473
		pH	9.16	9.13	9.16	9.15	8.93
		DO (mg/L)	6.1	5.2	6.3	5.9	6.6
1m from Bottom	Min	Temp (°C)	11.6	11.4	11.8	11.6	11.2
		Cond (µS/cm)	3016	3035	2970	3007	3330
		pH	8.93	8.80	8.84	8.85	8.70
		DO (mg/L)	0.1	0.1	0.1	0.1	1.3
	Max	Temp (°C)	26.8	27.2	27.5	27.2	27.7
		Cond (µS/cm)	3897	3895	3897	3896	5232
		pH	9.28	9.21	9.19	9.23	9.03
		DO (mg/L)	9.8	7.3	7.8	8.3	8.8
	Average	Temp (°C)	20.0	20.0	20.2	20.1	20.5
		Cond (µS/cm)	3580	3583	3572	3578	4478
		pH	9.07	9.07	9.08	9.07	8.88
		DO (mg/L)	3.7	3.4	4.2	3.7	4.5

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

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



Each data point is calculated by averaging the measurement from each event with the previous seven events (i.e. one year of data) to obtain a rolling average. Therefore, the graph represents data collected from August 2018 to June 2020.

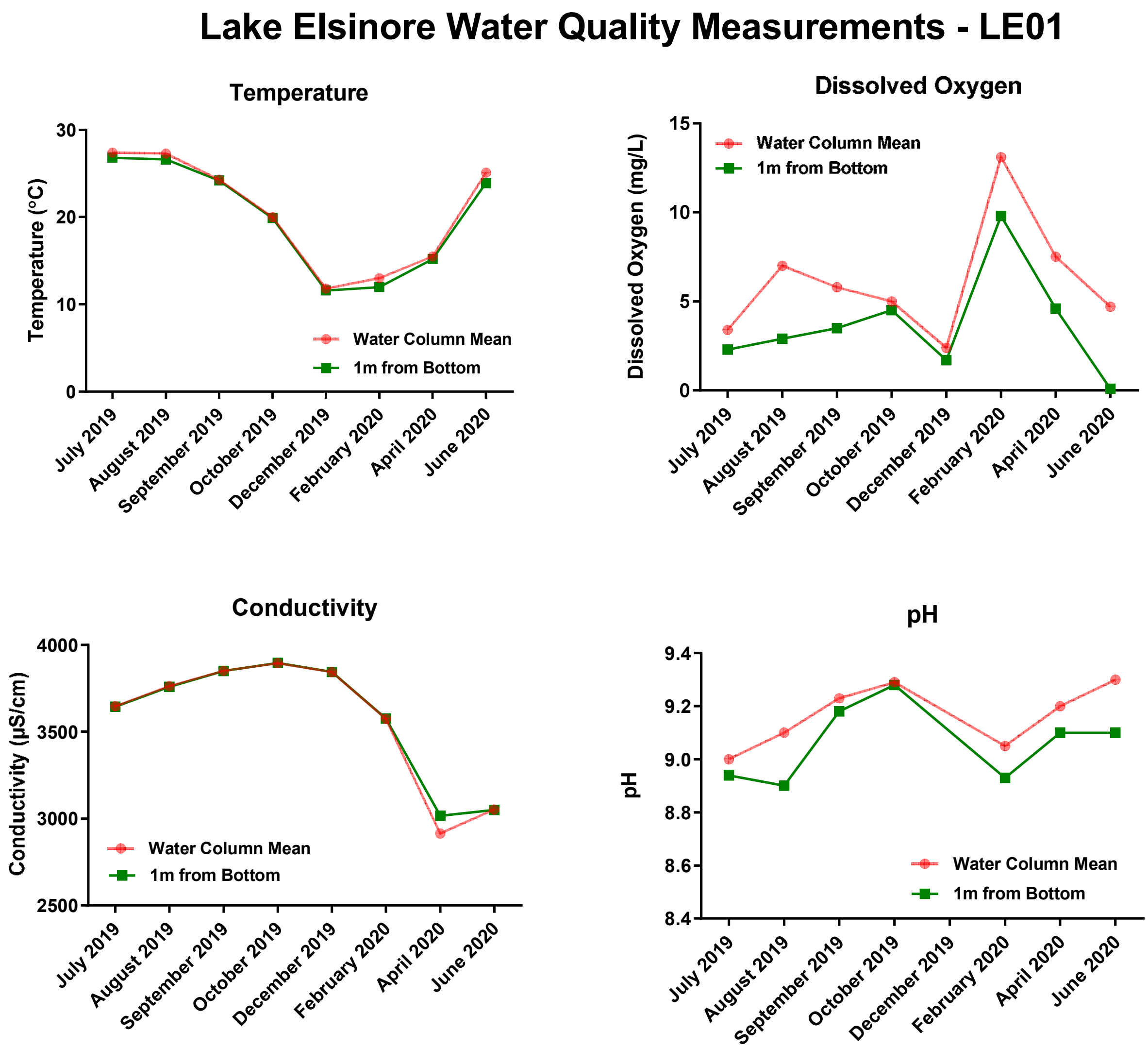


Figure 3-3. In-Situ Physical Water Quality Parameters - Lake Elsinore - Site LE01

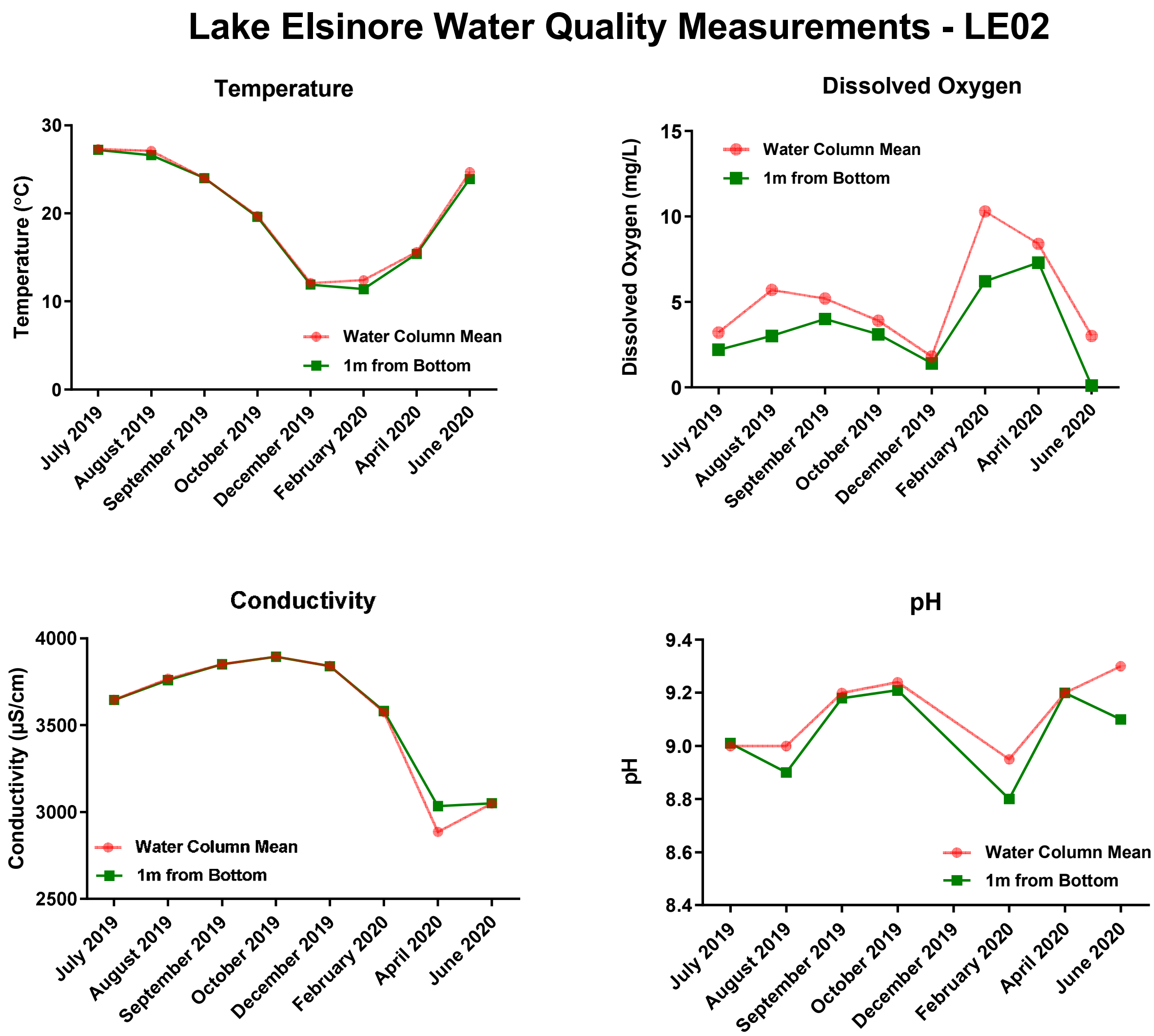


Figure 3-4. In- Situ Physical Water Quality Parameters - Lake Elsinore Site LE02

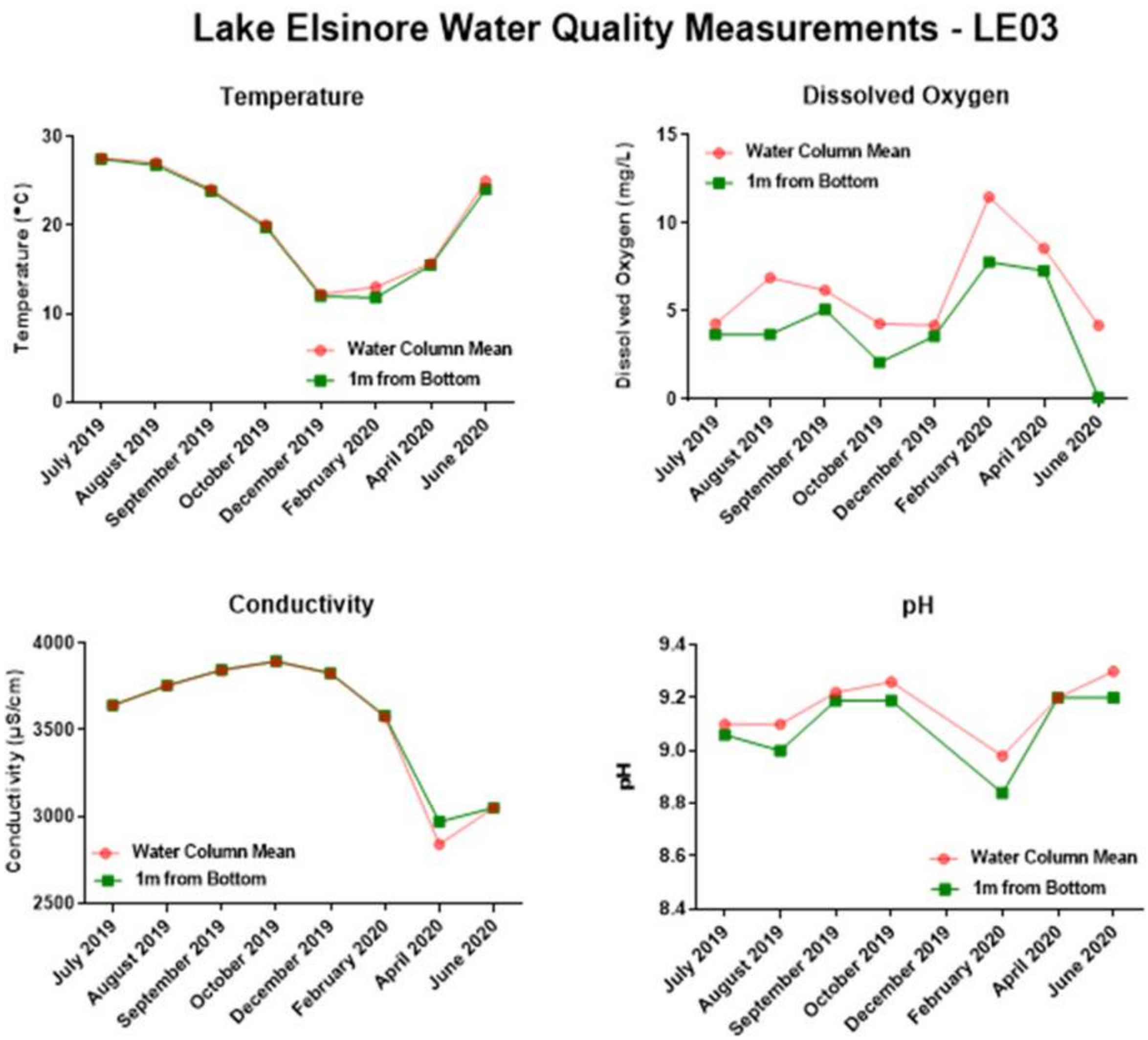


Figure 3-5. In- Situ Physical Water Quality Parameters - Lake Elsinore Site LE03

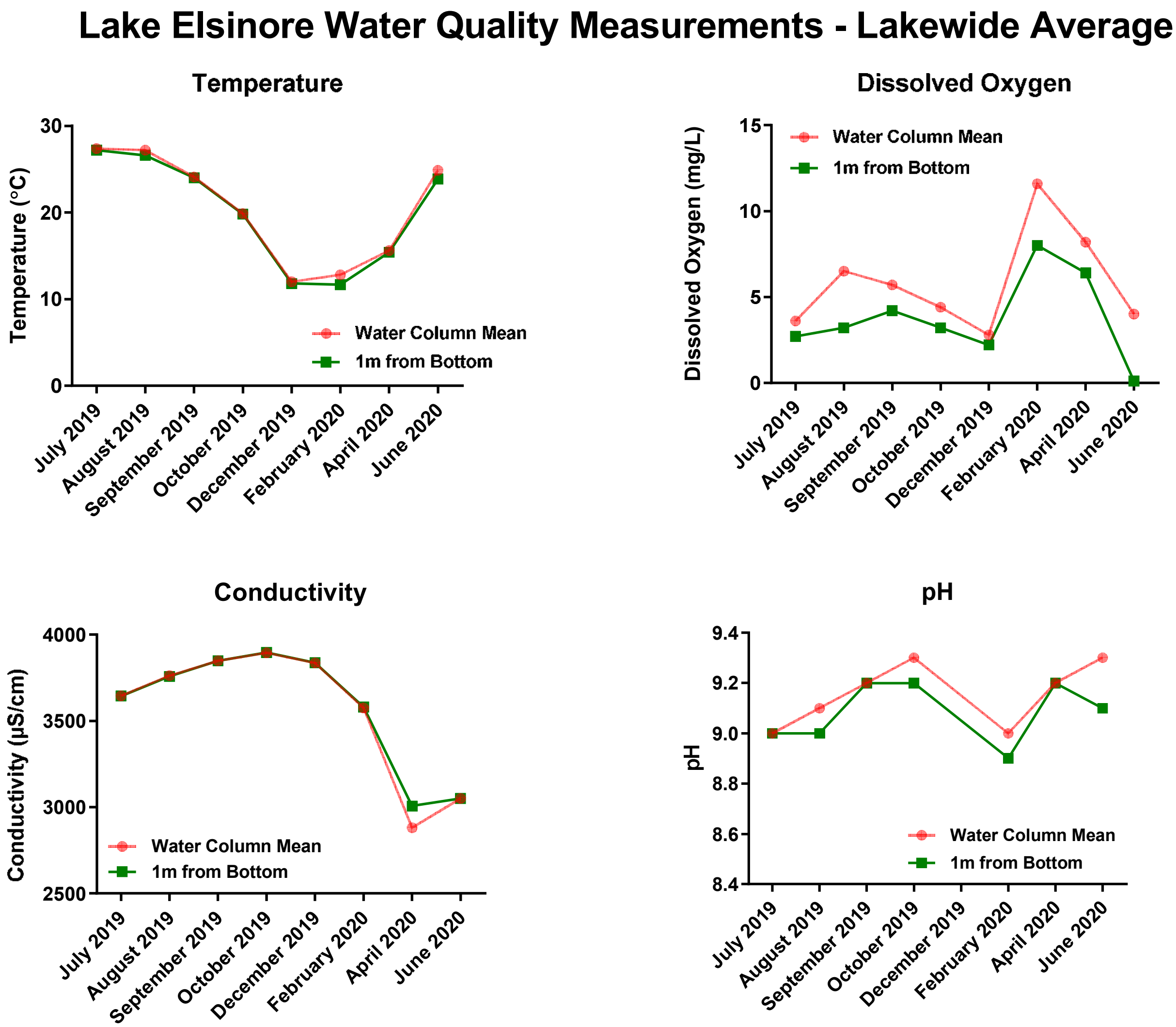


Figure 3-6. Monthly Lake-wide Mean of In-Situ Physical Water Quality Parameters – Mean of All Three Stations

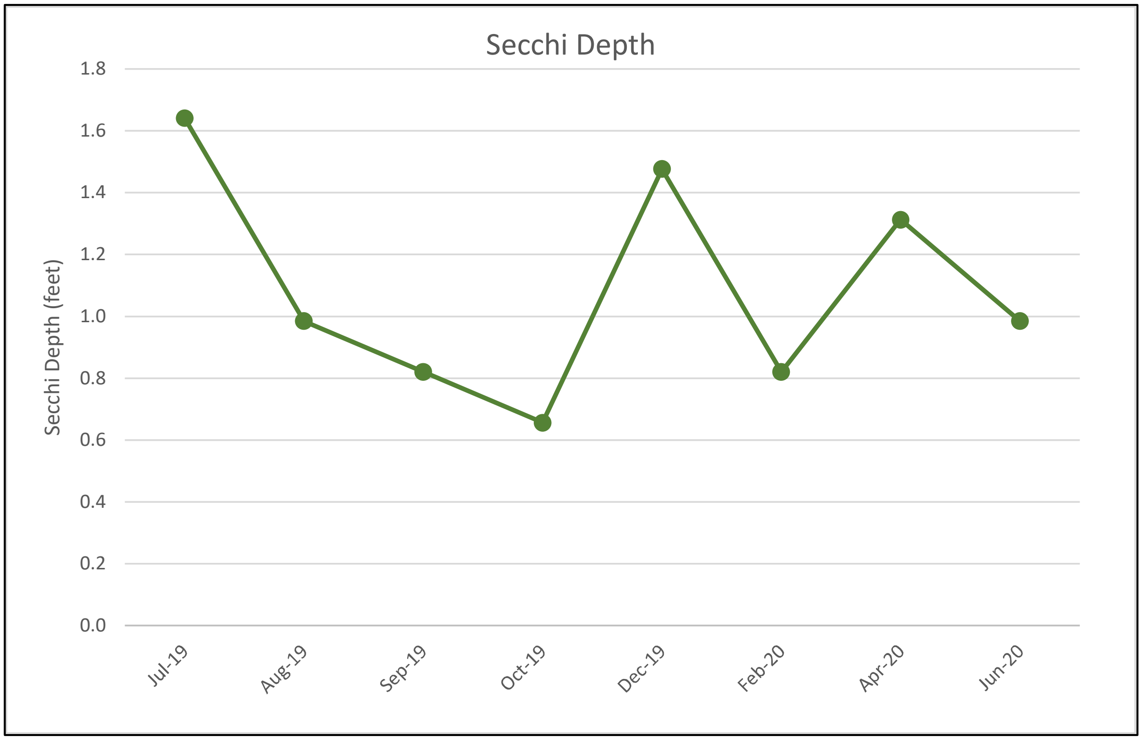


Figure 3-7. In- Situ Water Clarity Using a Secchi Disk - Lake Elsinore Site LE02

Analytical Chemistry

Monthly analytical results and annual summary chemistry concentrations at Site LE02 are presented in Tables 3-6 and 3-7, respectively. Concentrations of analytes at Site LE02 are graphically presented in Figures 3-8 through 3-10.

Total nitrogen levels were relatively flat across the summer and fall months, before decreasing sharply in February 2020, likely as a result of the winter rains (Figure 3-8). Total nitrogen values across the monitoring year ranged from 6.7 mg/L in December 2019 to 1.2 mg/L in February 2020. The annual mean concentration of total nitrogen was 4.4 mg/L (5.0 mg/L in the previous monitoring year). The total nitrogen rolling average concentration, calculated by averaging the measurement from each event with the previous seven events (i.e. one year of data), exceeded the current 2020 TMDL target of 0.75 mg/L for each event (Figure 3-9).

Total phosphorus concentrations ranged from 0.10 to 0.28 mg/L across all monitoring events. Concentrations of total phosphorus remained steady July through September 2019, but then increased in both October and December before decreasing in February 2020 (Figure 3-8). Dissolved oxygen concentrations in August 2019 indicated that the lake had stratified, due to the differences observed between average DO concentrations throughout the water column and the bottom (Figure 3-6). In September, the lake began to de-stratify and was fully de-stratified during the October and December events. This destratification may have caused the total phosphorus that had fluxed from the sediment during the stratification period, likely caused from low dissolved oxygen concentrations, to be dispersed throughout the water column, increasing the average depth-integrated water column concentration, The annual mean concentration of total phosphorus was 0.18 mg/L, similar to the 0.15 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, ranging from 0.13 to 0.18 mg/L (Figure 3-9).

Total ammonia-N concentrations ranged from <0.044 to 1.3 mg/L, with an annual mean of 0.26 mg/L. The June 2020 un-ionized ammonia concentration of 0.2 mg/L exceeded the un-ionized ammonia Criterion Continuous Concentration (CCC) objective of 0.181 mg/L (Tables 3-6 and 3.7). No other samples exceeded the un-ionized ammonia Criterion Continuous Concentration (CCC) or the Criterion Maximum Concentration (CMC) objective. A spike in total ammonia-N was observed during the December 2019 event. There are several possible explanations for this including: 1) two large back-to-back storm events dropping 1.78 inches (Nov. 27 -30) and 1.08 inches (Dec. 4 – 9) of rain which had stirred up the water column as evidenced by the substantial increase in lake turbidity (see Secchi depths for December event); 2) the December 2019 event exhibited the lowest near-bottom (1-m from bottom) DO measurement, with the exception of June 2020, which also saw an increase in ammonia-N. This low DO near the sediment can facilitate the flux of ammonia into the water column; or 3) some particles of near-bottom suspended sediment could have been accidentally collected as part of the depth-integrated sample and been analyzed along with the water sample.

Total dissolved solids (TDS) concentrations remained relatively stable between July and December 2019 (1800-2200 mg/L), with a slight dip in October, before gradually declining through April 2020 as a result of the winter storms. The reported elevated TDS concentration observed in June 2020 appears anomalous and is likely a laboratory error. This is evident as the water column mean specific conductivity in June 2020 was 3050 µS/cm. There is a known ratio of measured conductivity in water to its TDS concentration of approximately 0.67, with some slight variability in surface waters due to the composition of salts within the water. A specific conductivity of 3050 mg/L equates to a TDS of approximately 2043 mg/L. This calculated value would fall in line with other TDS values observed during the 2019-2020 monitoring year. Based on this assessment, the more accurate estimated value for TDS based on conductivity was used for summer and annual average calculations reported in Tables 3-6 and 3-7. The natural decrease of TDS in Lake Elsinore due to winter storm events is commonly observed, however, there has been a noticeable gradual decrease in TDS over the 2019-20 monitoring period compared to years prior (Appendix E).

Depth-integrated concentrations of chlorophyll-a across all eight sampling events ranged from 57 to 171 µg/L. Surface (0-2m) chlorophyll-a concentrations ranged from 37 to 165 µg/L. Surface and depth-integrated samples generally tracked with each other. Both surface and depth-integrated chlorophyll-a concentrations exhibited a general increase across the summer (approximately 60 µg/L increase for both depths) and early fall months (139 µg/L and 153 µg/L for surface and depth-integrated samples, respectively), followed by a sharp decrease in December 2019 (Figure 3-10). This was followed by a gradual increase in chlorophyll-a across the spring months. The mean chlorophyll-a concentration observed in samples collected during the summer months (June 2019 through September 2019) was 89 µg/L for depth-integrated samples and 91 µg/L for surface samples. These concentrations have declined for the previous two monitoring years, with mean summer depth-integrated concentrations of 149 and 105 µg/L, and surface concentrations of 161 and 119 µg/L for FY 2017-18 and FY 2018-19, respectively.

The current 2019-2020 FY Lake Elsinore monitoring data in the context of historical data can be found in Appendix E.

Table 3-6. Monthly Analytical Chemistry Results for Lake Elsinore in 2019-2020

Compound	Units	MDL	RL	Depth Integrated or Surface Sample	July 2019	August 2019	September 2019	October 2019	December 2019	February 2020	April 2020	June 2020	Annual Average
General Chemistry													
Total Dissolved Solids	mg/L	20-40	20-40	DI	2100	2200	2200	1800	2200	2100	1700	3500 meas.[e], 2043 estim.	2043
Sulfide	mg/L	0.10	0.10	DI	ND	ND	ND	ND	ND	ND	ND	0.40	ND
Nitrate as N	mg/L	0.16	0.20	DI	ND	ND	ND	ND	ND	0.23	ND	ND	ND
Nitrite as N	mg/L	0.091	0.10	DI	ND	ND	ND	ND	ND	ND	ND	ND	0.0
Kjeldahl Nitrogen	mg/L	0.093-0.46	0.10-0.50	DI	4.3	4.2	5.1	5.5	6.7	0.97	3.9	4.6	4.4
Total Nitrogen[a]	mg/L	NA	--	DI	4.3	4.2	5.1	5.5	6.7	1.2	3.9	4.6	4.4
Ammonia-Nitrogen	mg/L	0.044	0.10	DI	0.11	0.12	ND	0.045 J	1.3	0.073 J	ND	0.41	0.26
Unionized Ammonia[b]	mg/L	--	--	DI	0.046	0.047	ND	0.018	0.05	0.012	ND	0.20	0.047
Ortho Phosphate Phosphorus[c]	mg/L	0.016-0.050	0.050	DI	0.019 J	ND	ND	0.048 J	0.13	ND	ND	ND	0.025 J
Total Phosphorus	mg/L	0.0028-0.0049	0.010-0.020	DI	0.12	0.10	0.11	0.22	0.28 F	0.18	0.17 F	0.23	0.18
Chlorophyll-a													
Chlorophyll-a	µg/L	1.0	1.0	Surf	63.5	81.9	165	139	37.2	77.6	105	149	102
Chlorophyll-a	µg/L	1.0	1.0	DI	61.4	99.1	128	153	NM[d]	56.8	99.5	171	110

Notes:
When a concentration was non-detect, the annual average value for compliance purposes was calculated by converting non-detect (ND) values to zero. If the result of the calculated mean was non-zero but below the corresponding MDL, the average value was reported as ND.

a - Total Nitrogen = TKN+NO_2+NO_3
b - The concentration of unionized ammonia was calculated using equation by Thursby (1986), based on site specific pH and temperature recorded at each location.
c - Method SM 4500P E performed on samples collected in 2019. Analytical laboratory switched to using EPA 300.0 in 2020.
d - Sample was destroyed during laboratory preparation, no analysis was possible.
e – Measured TDS appears to be a laboratory error. Based on an average relationship between conductivity and TDS this value should be approximately 2043 mg/L The estimated value based on conductivity was used for the annual average calculation.
ND – Not detected; NA – Not Applicable/ available; NM – not measured
DI = Depth integrated; Surf = Surface 0-2m
µg/L – micrograms per liter; mg/L – milligrams per liter; MDL – method detection limit; RL – reporting limit; J - Reported value is an estimate as detection was above the MDL, but below the RL
F - Matrix Spike (MS) and/or Matrix Spike Duplicate (MSD) was outside acceptance limits (low recoveries due to suspected matrix interference). Associated laboratory control sample (LCS) recovery was within acceptance limits.

Table 3-7. Analytical Chemistry Summary for Lake Elsinore – Annual Mean Statistics (2019-2020)

Compound	Units	MDL	RL	Basin Plan or TMDL Target	Depth Integrated or Surface Sample	Min	Max	Summer Average[c]	Annual Average
General Chemistry									
Total Dissolved Solids	mg/L	20-40	20-40	2000[3]	DI	1700	2200[h]	2125	**<u>2043</u>**[h]
Sulfide	mg/L	0.10	0.10	NA	DI	ND	0.40	ND	ND
Nitrate as N	mg/L	0.16	0.20	NA	DI	ND	0.23	ND	ND
Nitrite as N	mg/L	0.091	0.10	NA	DI	ND	ND	ND	0.0
Kjeldahl Nitrogen	mg/L	0.093-0.46	0.10-0.50	NA	DI	0.97	6.7	4.3	4.4
Total Nitrogen[a]	mg/L	NA	--	0.75[b1]	DI	1.2	6.7	4.3	**<u>4.4</u>**
Ammonia-Nitrogen	mg/L	0.044	0.10	See un-ionized NH_3	DI	ND	1.3	0.143	0.26
Unionized Ammonia[d]	mg/L	--	--	CMC: 0.916-5.10 CCC: 0.181-1.63	DI	ND	0.20	0.05	0.05
Ortho Phosphate Phosphorus	mg/L	0.016-0.050	0.050	NA	DI	ND	0.13	0.06	0.025 J
Total Phosphorus	mg/L	0.0028-0.0049	0.010-0.020	0.1[b1]	DI	0.10	0.28	0.13	**<u>0.18</u>**
Chlorophyll-a									
Chlorophyll-a	µg/L	1.0	1.0	25[1c], 40[2c]	Surf	37.2	165	**<u>91</u>**	102
Chlorophyll-a	µg/L	1.0	1.0	25[1c], 40[2c]	DI	56.8	171	**<u>89</u>**	110

Notes:
When a concentration was non-detect, the annual value for compliance purposes was calculated by converting non-detect (ND) values to zero. If the result of the calculation was below the corresponding MDL, the average value was reported as ND.

a - Total Nitrogen = TKN+NO_2+NO_3
b - Annual average
c - Summer average (June 2019 – September 2019)
d - Values calculated using water column mean ammonia, temperature, salinity and pH. Calculated using equation by Thursby (1986). The range of TMDL target thresholds apply to individual samples, not applicable to annual means. See quarterly reports.
e - Measured TDS in June of 3500 mg/L appears to be a laboratory error and was estimated more accurately to be 2043 mg/L based on conductivity. The next highest TDS value of 2200 mg/L reported in multiple months (Aug., Sept., and Dec.) was thus considered the maximum value. The estimated TDS value based on conductivity in June was used for the annual average calculation.
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; ND – not detected
DI = Depth integrated; Surf = Surface 0-2m
mg/L – micrograms per liter; ug/L – milligrams per liter; MDL – method detection limit; RL – reporting limit; J –Reported value was detected above the MDL, but below the RL
<u>Bold Underline</u> - Indicates exceedance of Basin Plan/TMDL target

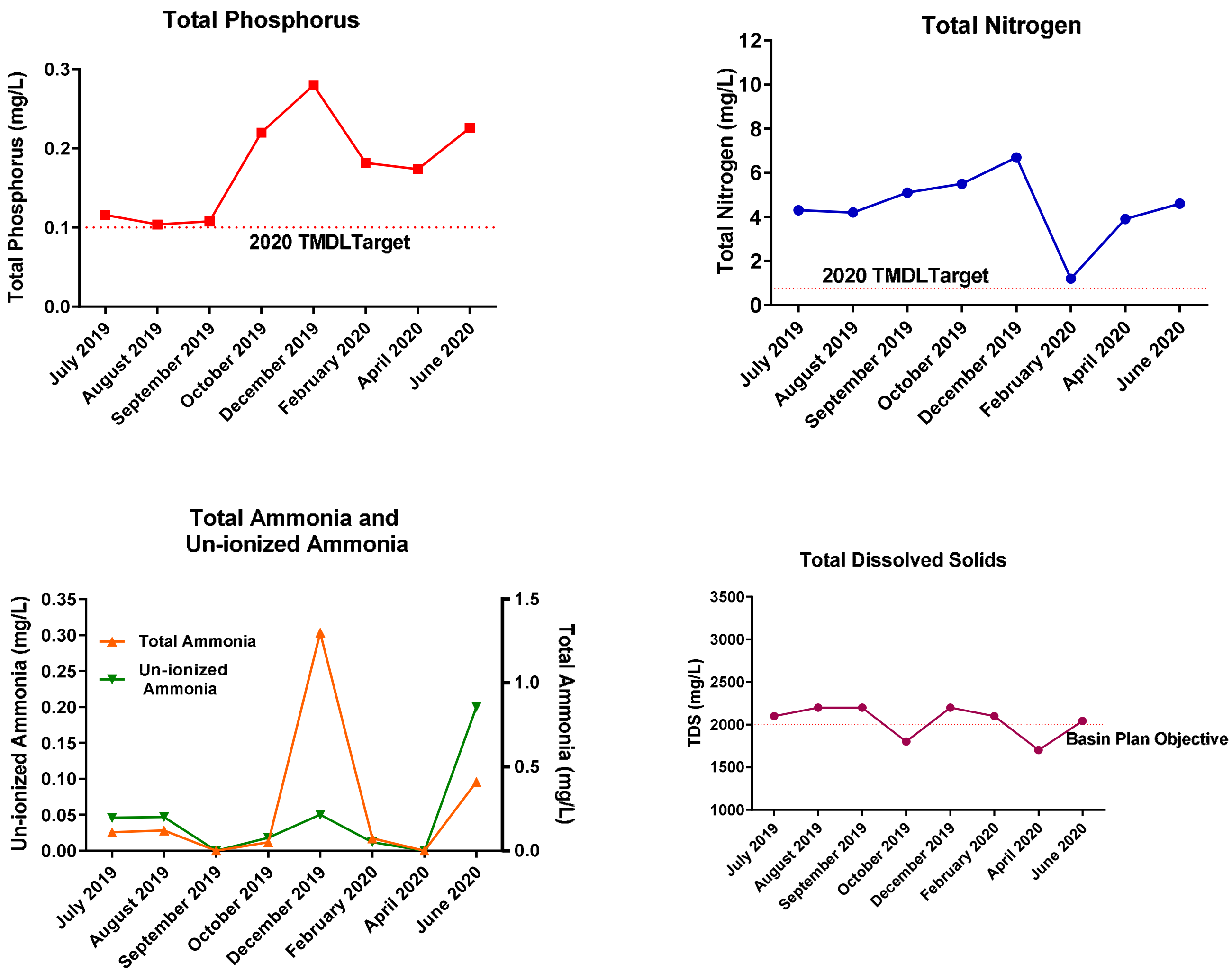
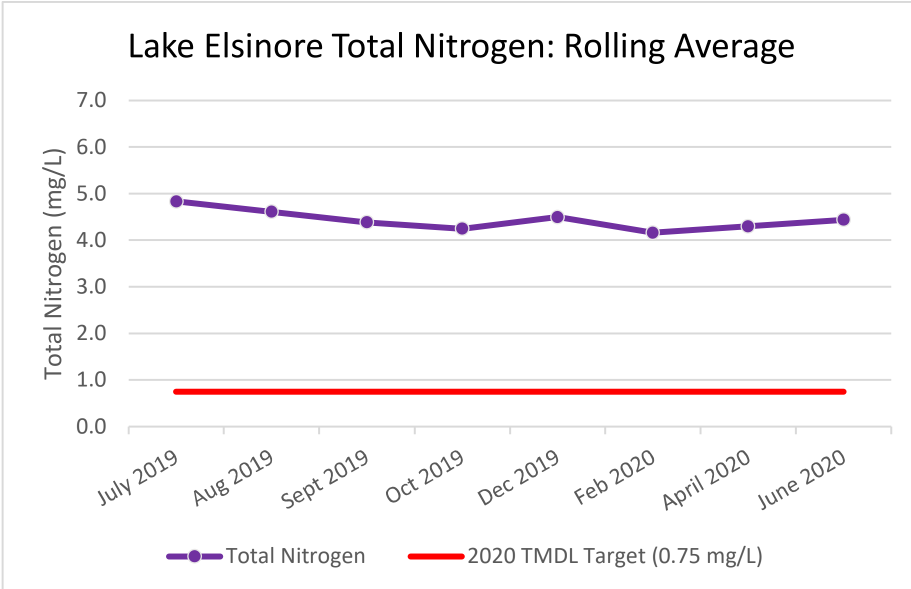


Figure 3-8. Lake Elsinore Analytical Chemistry – Depth-Integrated Means at Site LE02 (July 2019-June 2020)

Long term trends can be found in Appendix E



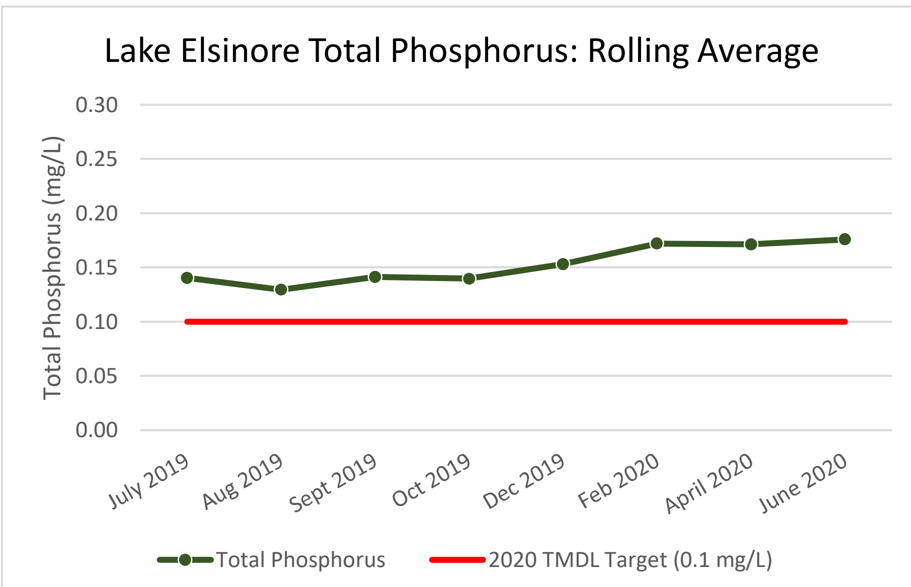


Figure 3-9. Lake Elsinore Analytical Chemistry – Total Phosphorus and Nitrogen Rolling Averages (July 2019 – June 2020)

Each data point is calculated by averaging the value of each event with the previous seven events (i.e. one year of data) to obtain a rolling average. Therefore, the graph represents data collected from August 2018 to June 2020.

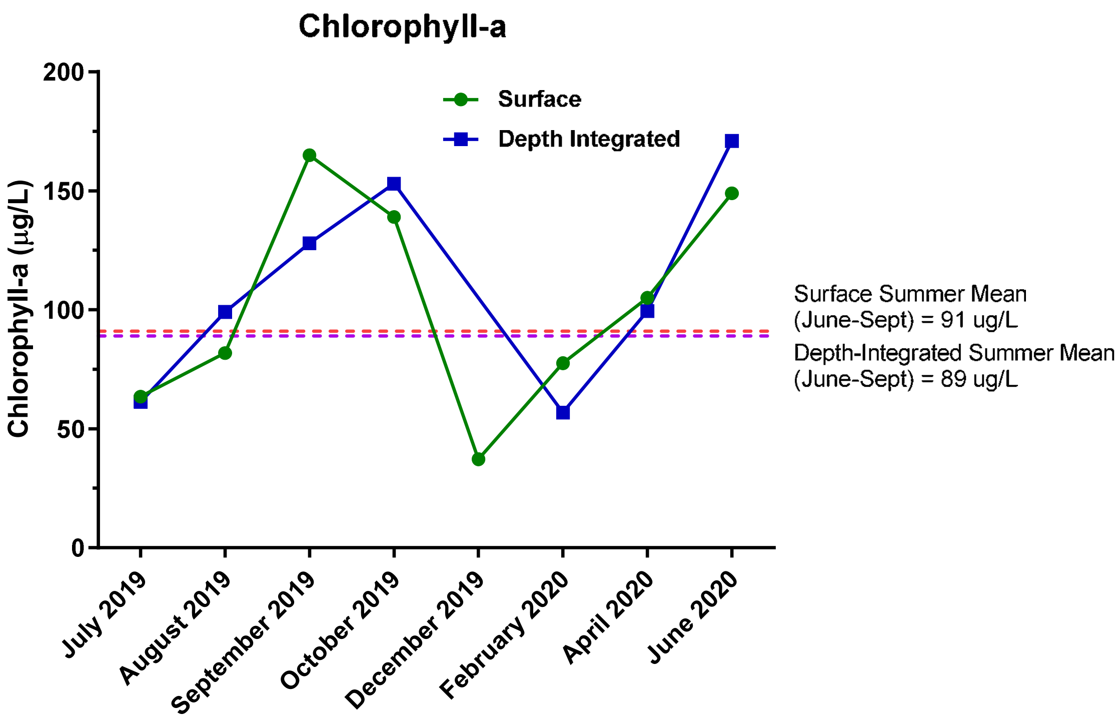


Figure 3-10. Lake Elsinore Analytical Chemistry – Depth-Integrated and Surface Chlorophyll-a at Site LE02

December 2019 depth-integrated sample missing due to lab error (see text). Long term trends can be found in Appendix E

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 in July 2015 using the four stations outlined in the approved Lake Elsinore and Canyon Lake Nutrient TMDL Monitoring Plan (LESJWA, 2006; Figure 3-11, Table 3-8). Two sites are located 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 and chlorophyll-a were collected at all four sites, 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 with the TMDL sampling in Lake Elsinore and was also coordinated with satellite overpass dates (see Section 3.4).

Table 3-8. Canyon Lake TMDL Monitoring Locations

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

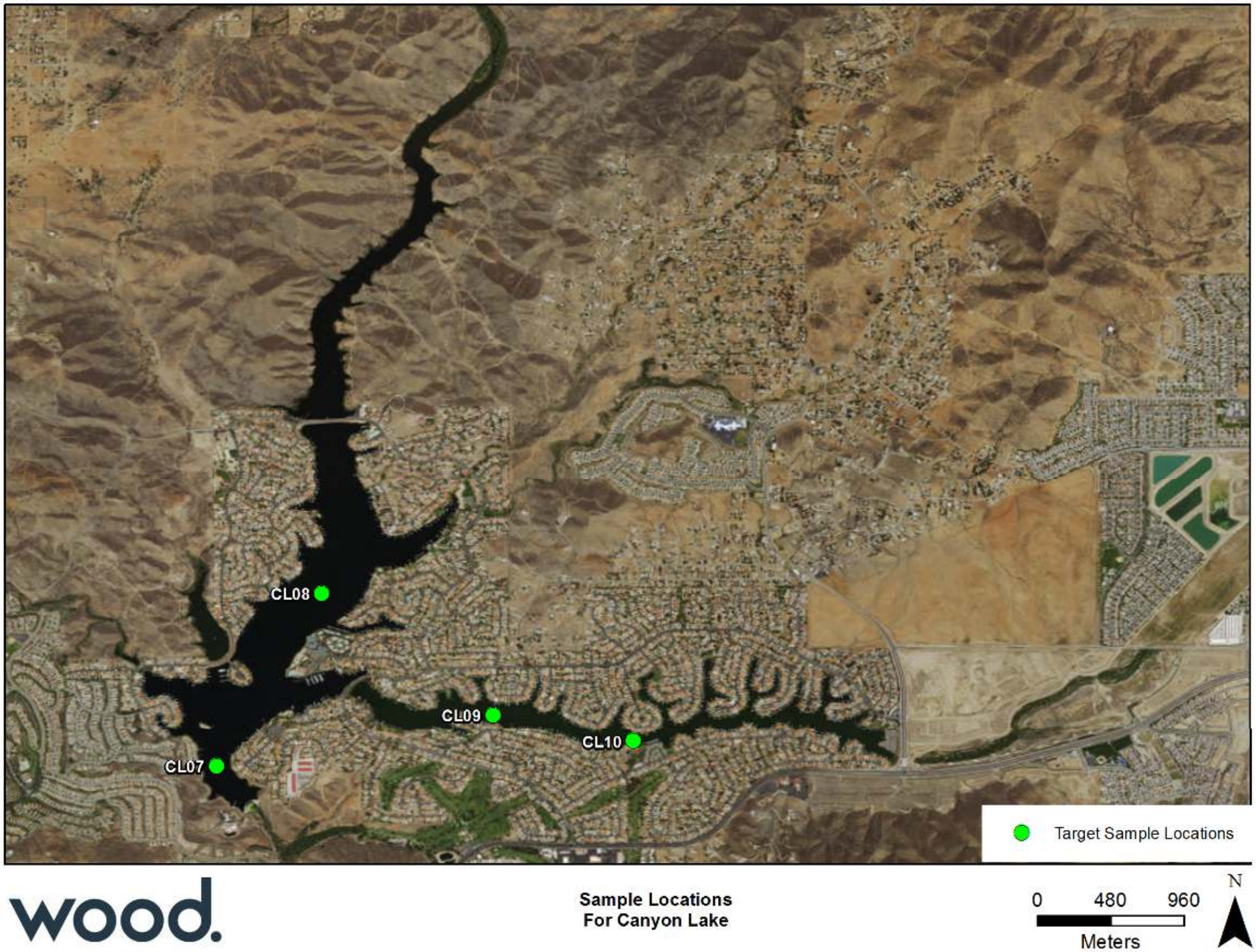


Figure 3-11. Canyon Lake Sampling Locations

3.3.2 Sampling Methods

Samples for analytical chemistry were collected in the same manner as in Lake Elsinore using a peristaltic pump. Two samples were collected for chlorophyll-a: 1) a full depth-integrated composite sample; and 2) a 0-2-m depth-integrated composite surface sample. 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, ammonia, sulfide, TDS, total suspended solids and chlorophyll-a were submitted to Babcock Laboratories Inc., located in Riverside, California (Table 3-9).

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 on Canyon Lake. During the 2019-2020 monitoring period, Canyon Lake alum applications were performed during the week of October 21, 2019 and again during the week of April 15, 2020. Pre-alum application monitoring events were performed on October 17, 2019 and April 9, 2020, 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. Satellite imagery was also used to estimate the likelihood of a harmful algae bloom.

Table 3-9. In-lake Analytical Constituents and Methods for Canyon Lake (2019-2020)

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
Total Nitrogen (TN)	Calculated	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 & EPA 300.0	Depth Integrated
Chlorophyll-a	SM 10200H	Surface (0-2m) & Depth Integrated
Total Dissolved Solids (TDS)	SM 2540 C	Depth Integrated
Total Suspended Solids (TSS)	SM 2540D	Depth Integrated
Total Aluminum	EPA 200.7	Depth Integrated
Dissolved Aluminum	EPA 200.7	Depth Integrated

Notes:
NA – not applicable

3.3.3 Water Quality Summary

A summary of the in-lake monitoring events for Canyon Lake for the period of July 1, 2019 to June 30, 2020 is presented below. A total of six events were sampled under the TMDL monitoring program, with three occurring in 2019 (August 27, October 17, December 20) and three in 2020 (February 18, April 13, and June 26). 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. The figures presented in Appendix E include historical water quality monitoring results from 2001-present.

Water Column Profiles

A summary of water column profile mean values for each site and monitoring event are presented in Tables 3-10 and 3-11. A summary of water column profile mean values for each basin (i.e., Main Lake and Eastern) are presented in Tables 3-12 and 3-13. Water column profile mean statistics for each site across the entire monitoring period are presented in Table 3-14. Mean water column values across the annual cycle are also summarized graphically in Figures 3-12 to 3-16.

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 regions exhibiting relatively stable temperatures. The thermocline portion of the water column is defined as the region between the epilimnion and hypolimnion where a marked drop in temperature per unit of depth is evident (i.e., >1.0°C over 1-m depth differential). Measurements within the thermocline were excluded from epilimnion and hypolimnion averaging. Full water column means included data recorded from all three zones, if present.

Morning and afternoon average water quality readings per sampling location were similar overall, with increases in pH (up to 0.8 SU), DO (between 0.1 and 1.4 mg/L), and temperature (not more than 0.5 degrees Celsius) consistently observed. These increases were especially prominent in summer months, while little deviation was observed during winter and spring monitoring events.

For both the Main Basin and East Basin, temperature exhibited a typical pattern with the lowest values occurring during the winter months (December and February) and highest values in summer months (August). Dissolved oxygen concentrations for both basins reflected an inverse pattern with temperature showing elevated concentrations during the winter months when averaged throughout the water column, reaching a maximum concentration in February 2020. When the thermocline developed, typically during summer and early fall period, DO concentrations within the epilimnion and hypolimnion diverged, with hypolimnion concentrations falling substantially during that timeframe to <0.5 mg/L (Figures 3-12 and 3-13). The rolling annual average DO concentration within the epilimnion was greater than the current 2015 TMDL target of 5.0 mg/L for all five events in both Basins when stratification was present (Figure 3-14). However, the rolling average DO concentration was never above the 2020 TMDL target of 5.0 mg/L in the hypolimnion. The rolling average of the full water column mean was above 5.0 mg/L for all monitoring dates (Figure 3-15).

Conductivity within the epilimnion and hypolimnion (when present) remained consistent throughout the monitoring period. Average specific conductivity throughout the entire water column in the Main Basin of Canyon Lake (mean of CL 07 & CL 08) ranged from 528-765 µS/cm, remaining consistent across the summer and fall months and decreasing after winter storms (Tables 3-12 and 3-13, Figure 3-12). Locations in the East Basin (mean of CL09 & CL10) exhibited a similar pattern with mean water column values across the monitoring year ranging from 637-1023 µS/cm. Mean values for pH were slightly higher in the Eastern Basin than the Main Basin, with values ranging from 7.81 – 8.85 and 7.37 – 8.30, respectively. Values for pH within the epilimnion and hypolimnion tended to diverge as the thermocline developed.

Secchi depths exhibited an overall decline in both basins through February 2020, with a slight delay in the East Basin relative to the Main Body of the lake (Figure 3-16).

For further comparisons regarding in-situ water quality parameters, Table 3-14 includes lake-wide averages observed during the 2018-19 monitoring year, in addition to this 2019-20 monitoring period.

Table 3-10. In-Situ Water Quality Parameter Measurements for Canyon Lake - Monthly Means for Each Site (August – December 2019)

Basin	Site	Measure	Aug-19			Oct-19			Dec-19		
			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)	20.3	28.2	13.9	18.0	20.7	14.1	12.5	--	--
		Cond (µS/cm)	668	723	623	729	782	661	758	--	--
		pH	7.67	8.52	7.24	7.34	7.82	6.80	7.42	--	--
		DO (mg/L)	2.7	7.4	0.2	2.9	5.6	0.2	4.4	--	--
	CL08	Temp (°C)	24.8	28.2	16.1	20.5	--	--	12.4	--	--
		Cond (µS/cm)	694	718	635	772	--	--	747	--	--
		pH	7.97	8.53	7.10	7.71	--	--	7.40	--	--
		DO (mg/L)	4.4	7.5	0.3	4.5	--	--	5.2	--	--
East Basin	CL09	Temp (°C)	25.2	--	--	20.3	--	--	11.8	--	--
		Cond (µS/cm)	889	--	--	997	--	--	979	--	--
		pH	8.01	--	--	7.85	--	--	7.67	--	--
		DO (mg/L)	4.8	--	--	5.1	--	--	5.1	--	--
	CL10	Temp (°C)	28.2	--	--	21.0	--	--	12.0	--	--
		Cond (µS/cm)	921	--	--	1049	--	--	944	--	--
		pH	8.63	--	--	8.21	--	--	8.26	--	--
		DO (mg/L)	7.7	--	--	9.4	--	--	8.2	--	--
Lake-wide Average		Temp (°C)	24.6	28.2	15.0	19.9	20.7	14.1	12.2	--	--
		Cond (µS/cm)	793	720	629	887	782	661	857	--	--
		pH	8.07	8.53	7.17	7.78	7.82	6.80	7.69	--	--
		DO (mg/L)	4.9	7.5	0.2	5.5	5.6	0.2	5.7	--	--

-- = not applicable due to lack of thermocline
Epi = epilimnion; Hypo = hypolimnion

Table 3-11. In-Situ Water Quality Parameter Measurements for Canyon Lake - Monthly Means for Each Site (Feb – June 2020)

Basin	Site	Measure	Feb-20			Apr-20			Jun-20		
			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)	12.1	--	--	14.8	--	--	19.4	26.6	14.7
		Cond (µS/cm)	713	--	--	544	--	--	640	571	672
		pH	8.12	--	--	7.73	--	--	8.14	9.60	7.41
		DO (mg/L)	7.2	--	--	3.1	--	--	3.6	11.6	0.0
	CL08	Temp (°C)	12.5	--	--	15.0	--	--	22.3	27.3	15.1
		Cond (µS/cm)	715	--	--	512	--	--	616	563	670
		pH	8.32	--	--	7.58	--	--	8.46	9.67	7.37
		DO (mg/L)	9.1	--	--	3.9	--	--	5.1	12.6	0.0
East Basin	CL09	Temp (°C)	12.7	--	--	14.0	--	--	22.5	26.6	13.9
		Cond (µS/cm)	901	--	--	662	--	--	776	648	1023
		pH	8.19	--	--	7.95	--	--	8.46	9.39	7.28
		DO (mg/L)	6.8	--	--	5.2	--	--	4.5	8.8	0.0
	CL10	Temp (°C)	13.9	--	--	15.0	--	--	26.4	--	--
		Cond (µS/cm)	894	--	--	612	--	--	685	--	--
		pH	8.84	--	--	7.95	--	--	9.24	--	--
		DO (mg/L)	11.4	--	--	6.2	--	--	8.8	--	--
Lake-wide Average		Temp (°C)	12.8	--	--	14.7	--	--	22.6	26.8	14.6
		Cond (µS/cm)	806	--	--	583	--	--	679	594	788
		pH	8.37	--	--	7.80	--	--	8.57	9.55	7.35
		DO (mg/L)	8.7	--	--	4.6	--	--	5.5	11.0	0.0

-- = not applicable due to lack of thermocline
Epi = epilimnion; Hypo = hypolimnion

Table 3-12. In-Situ Water Quality Parameter Measurements for Canyon Lake - Monthly Means for Each Basin (Aug – Dec 2019)

Basin	Measure	Aug-19			Oct-19			Dec-19		
		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)	22.6	28.2	15.0	19.3	20.7	14.1	12.5	--	--
	Cond (µS/cm)	681	720	629	750	782	661	753	--	--
	pH	7.82	8.53	7.17	7.52	7.82	6.80	7.41	--	--
	DO (mg/L)	3.5	7.5	0.2	3.7	5.6	0.2	4.8	--	--
East	Temp (°C)	26.7	--	--	20.6	--	--	11.9	--	--
	Cond (µS/cm)	905	--	--	1023	--	--	962	--	--
	pH	8.32	--	--	8.03	--	--	7.97	--	--
	DO (mg/L)	6.2	--	--	7.3	--	--	6.6	--	--
Lake-wide Average	Temp (°C)	24.6	28.2	15.0	19.9	20.7	14.1	12.2	--	--
	Cond (µS/cm)	793	720	629	887	782	661	857	--	--
	pH	8.07	8.53	7.17	7.78	7.82	6.80	7.69	--	--
	DO (mg/L)	4.9	7.5	0.2	5.5	5.6	0.2	5.7	--	--

-- = not applicable due to lack of thermocline
Epi = epilimnion; Hypo = hypolimnion

Table 3-13. In-Situ Water Quality Parameter Measurements for Canyon Lake - Monthly Means for Each Basin (Feb – June 2020)

Basin	Measure	Feb-20			Apr-20			Jun-20		
		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)	12.3	--	--	14.9	--	--	20.8	26.9	14.9
	Cond (µS/cm)	714	--	--	528	--	--	628	567	671
	pH	8.22	--	--	7.65	--	--	8.30	9.63	7.39
	DO (mg/L)	8.2	--	--	3.5	--	--	4.4	12.1	0.0
East	Temp (°C)	13.3	--	--	14.5	--	--	24.5	26.6	13.9
	Cond (µS/cm)	898	--	--	637	--	--	730	648	1023
	pH	8.52	--	--	7.95	--	--	8.85	9.39	7.28
	DO (mg/L)	9.1	--	--	5.7	--	--	6.6	8.8	0.0
Lake-wide Average	Temp (°C)	12.8	--	--	14.7	--	--	22.6	26.8	14.4
	Cond (µS/cm)	806	--	--	583	--	--	679	607	847
	pH	8.37	--	--	7.80	--	--	8.57	9.51	7.33
	DO (mg/L)	8.7	--	--	4.6	--	--	5.5	10.5	0.0

-- = not applicable due to lack of thermocline
Epi = epilimnion; Hypo = hypolimnion

Table 3-14. In-Situ Water Quality Parameter Measurements for Canyon Lake - Annual Mean Statistics for Each Site (Aug 2019 – June 2020)

		Measure	CL07	CL08	Main Basin	CL09	CL10	East Basin	Lake-wide Average (July 2019-June 2020)	Lake-wide Average (July 2018-June 2019)
Water Column Mean	Min	Temp (°C)	12.1	12.4	12.3	11.8	12.0	11.9	12.1	11.6
		Cond (µS/cm)	544	512	528	662	612	637	583	519
		pH	7.34	7.40	7.37	7.67	7.95	7.81	7.59	7.40
		DO (mg/L)	2.7	3.9	3.3	4.5	6.2	5.3	4.3	3.1
	Max	Temp (°C)	20.3	24.8	22.6	25.2	28.2	26.7	24.6	26.7
		Cond (µS/cm)	758	772	765	997	1049	1023	894	1069
		pH	8.14	8.46	8.30	8.46	9.24	8.85	8.57	8.20
		DO (mg/L)	7.2	9.1	8.2	6.8	11.4	9.1	8.7	8.3
	Average	Temp (°C)	16.2	17.9	17.0	17.8	19.4	18.6	17.8	18.6
		Cond (µS/cm)	676	676	676	867	851	859	767	839
		pH	7.74	7.90	7.82	8.02	8.52	8.27	8.05	7.85
		DO (mg/L)	4.0	5.4	4.7	5.2	8.6	6.9	5.8	5.5
Epilimnion	Min	Temp (°C)	20.7	27.3	24.0	26.6	--	26.6	24.9	20.2
		Cond (µS/cm)	571	563	567	648	--	648	594	594
		pH	7.82	8.53	8.18	9.39	--	9.39	8.58	8.40
		DO (mg/L)	5.6	7.5	6.6	8.8	--	8.8	7.3	6.7
	Max	Temp (°C)	28.2	28.2	28.2	26.6	--	26.6	27.7	28.1
		Cond (µS/cm)	782	718	750	648	--	648	716	920
		pH	9.60	9.67	9.63	9.39	--	9.39	9.55	8.91
		DO (mg/L)	11.6	12.6	12.1	8.8	--	8.8	11.0	9.1
	Average	Temp (°C)	25.2	27.8	26.5	26.6	--	26.6	26.5	24.6
		Cond (µS/cm)	692	640	666	648	--	648	660	734
		pH	8.65	9.10	8.88	9.39	--	9.39	9.05	8.60
		DO (mg/L)	8.2	10.1	9.1	8.8	--	8.8	9.0	7.8
Hypolimnion	Min	Temp (°C)	13.9	15.1	14.5	13.9	--	13.9	14.3	12.5
		Cond (µS/cm)	623	635	629	1023	--	1023	760	657
		pH	6.80	7.10	6.95	7.28	--	7.28	7.06	7.06
		DO (mg/L)	0.0	0.0	0.0	0.0	--	0.0	0.0	0.2
	Max	Temp (°C)	14.7	16.1	15.4	13.9	--	13.9	14.9	17.2
		Cond (µS/cm)	672	670	671	1023	--	1023	788	888
		pH	7.41	7.37	7.39	7.28	--	7.28	7.35	7.21
		DO (mg/L)	0.2	0.3	0.2	0.0	--	0.0	0.2	0.3
	Average	Temp (°C)	14.2	15.6	14.9	13.9	--	13.9	14.6	14.4
		Cond (µS/cm)	652	652	652	1023	--	1023	776	744
		pH	7.15	7.23	7.19	7.28	--	7.28	7.22	7.14
		DO (mg/L)	0.1	0.1	0.1	0.0	--	0.0	0.1	0.2

-- = not applicable due to lack of thermocline
Values reported for epilimnion and hypolimnion are the arithmetic mean of measurements collected across all months sampled in which stratification was present.
Main Basin = mean of Sites CL07 and CL08
East Basin = mean of Sites CL09 and CL10

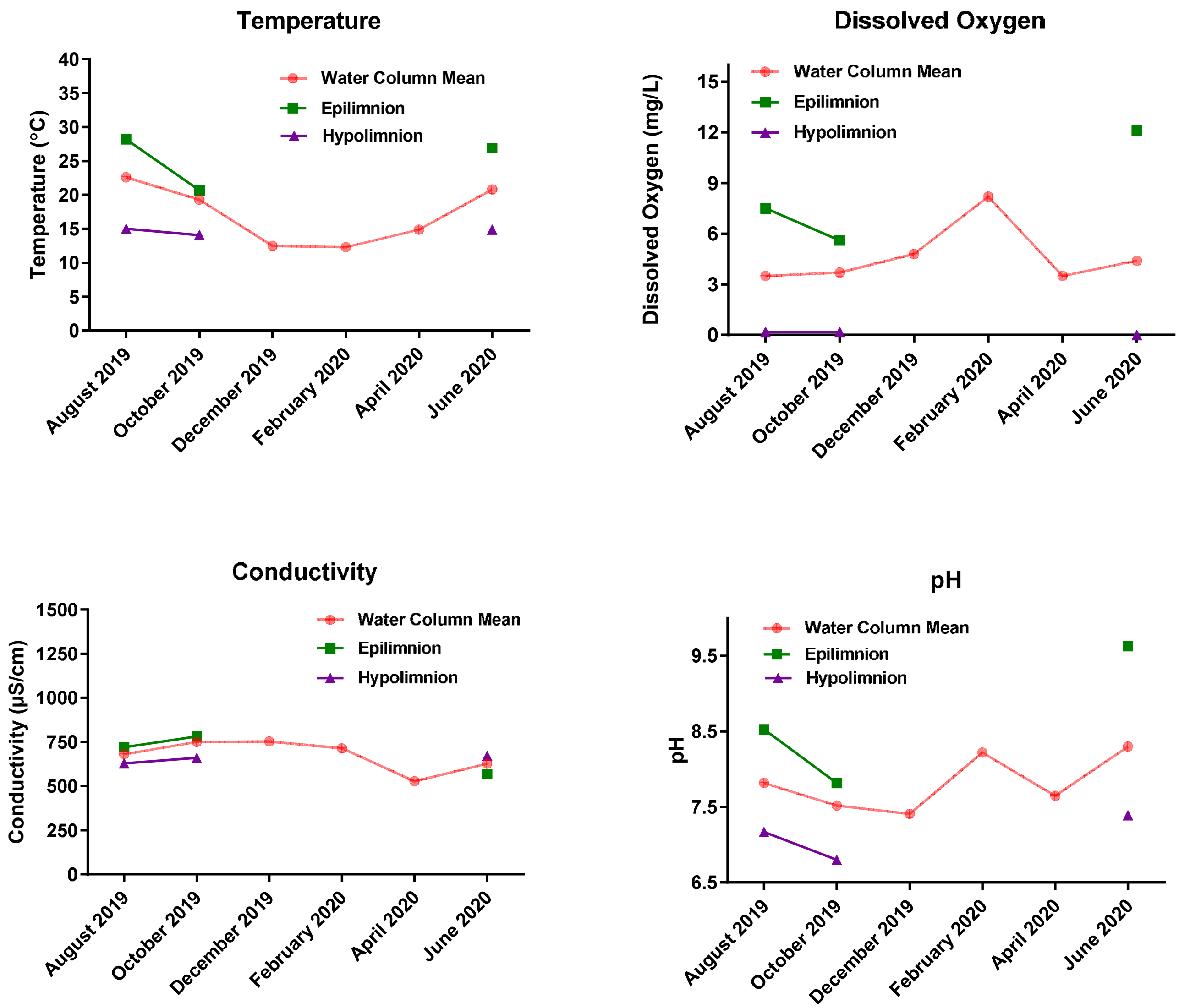


Figure 3-12. Mean In-Situ Physical Water Quality Parameters – Canyon Lake Main Basin

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

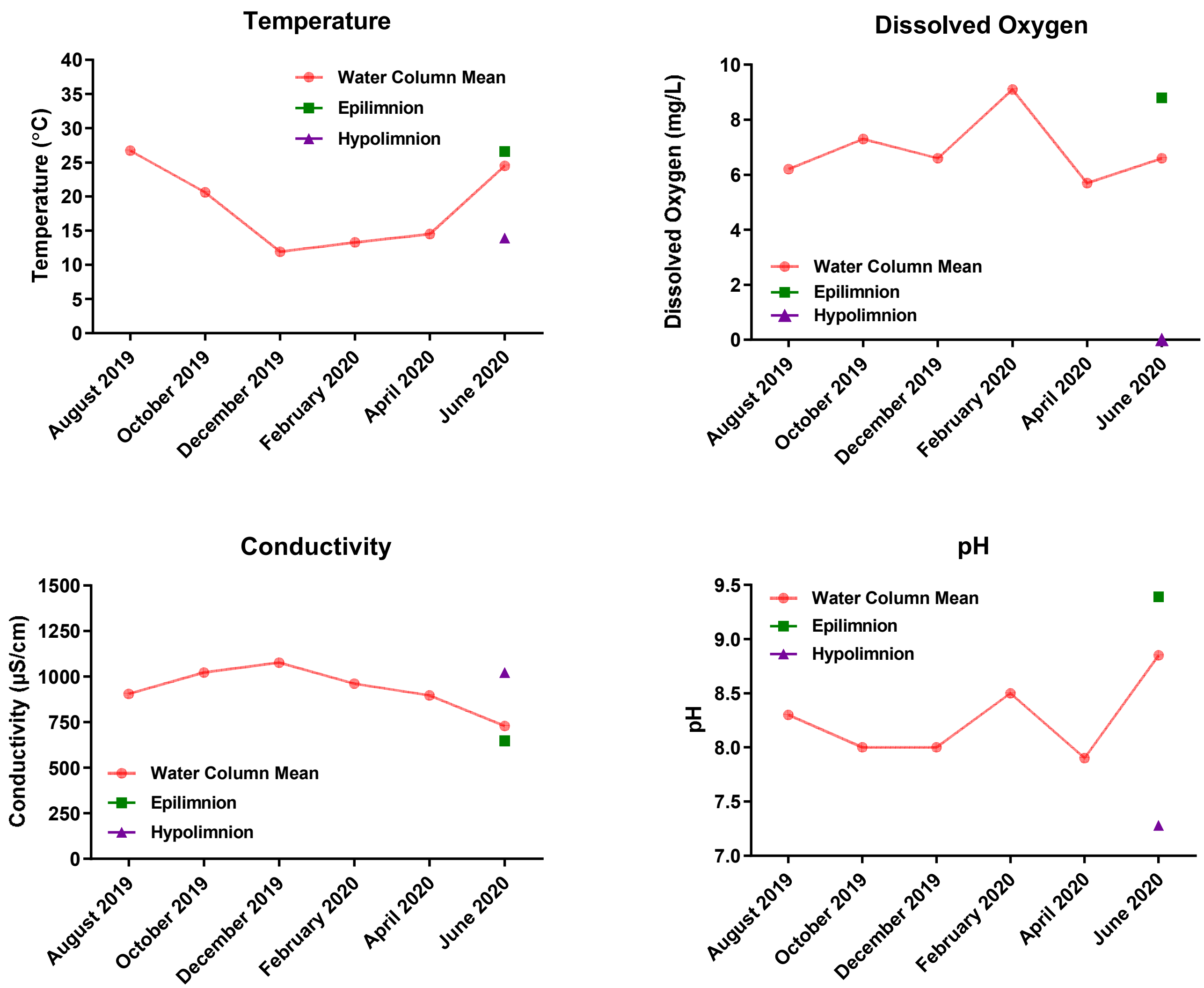


Figure 3-13. Mean In-Situ Physical Water Quality Parameters - Canyon Lake East Basin

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

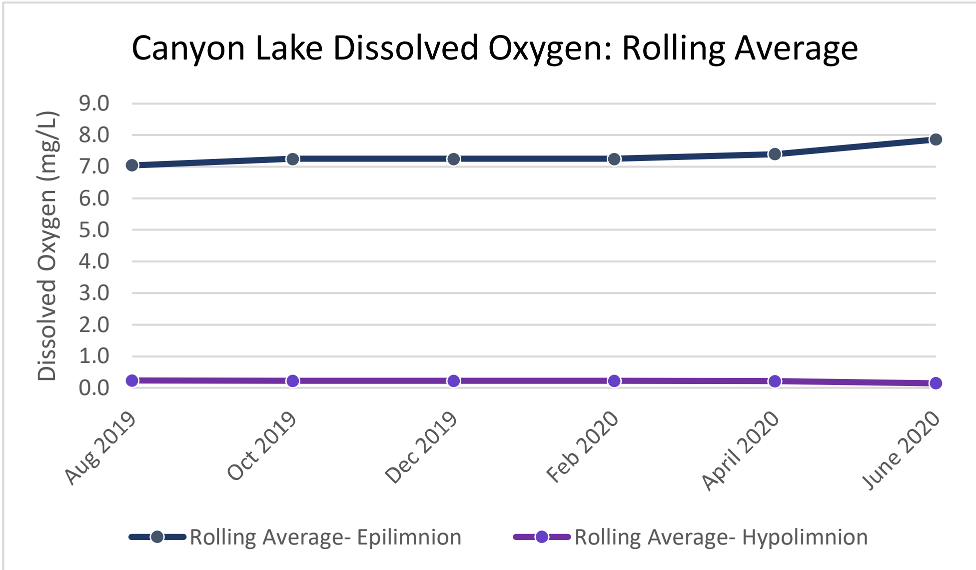


Figure 3-14. Rolling Average Concentrations of Dissolved Oxygen in the Epilimnion and Hypolimnion of Canyon Lake

Means are calculated by averaging the values from all 4 sites of each event with the previous five event values (i.e. one year of data) to obtain a rolling average. Therefore, the graph represents data collected from July 2018 to June 2020. Events in which a thermocline was not present were not included in rolling average.

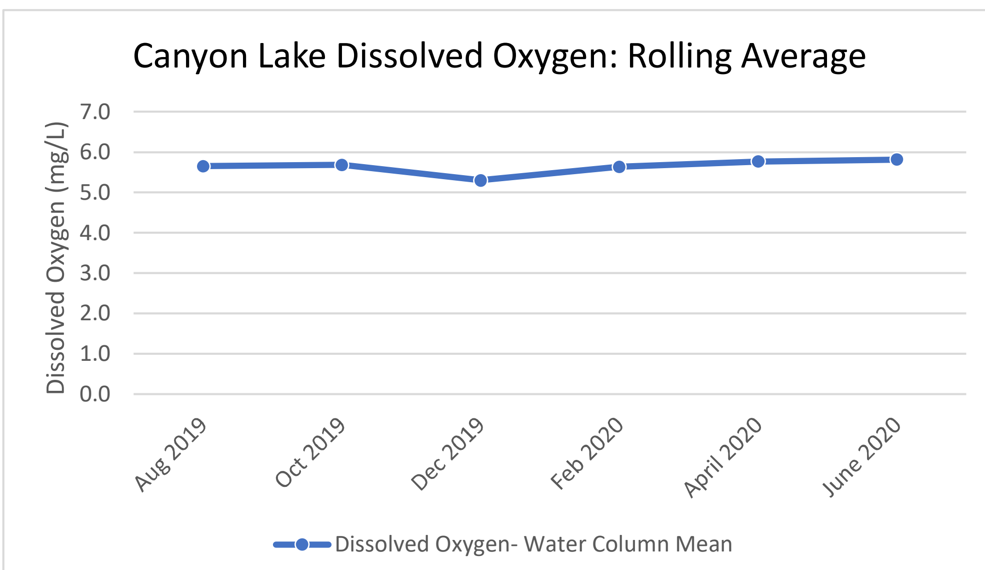


Figure 3-15. Rolling Average Concentration of Dissolved Oxygen Across the Full Vertical Water Column in Canyon Lake

Each data point is calculated by averaging the values from all 4 sites of each event with the previous five event values (i.e. one year of data) to obtain a rolling average. Therefore, the graph represents data collected from July 2018 to June 2020.

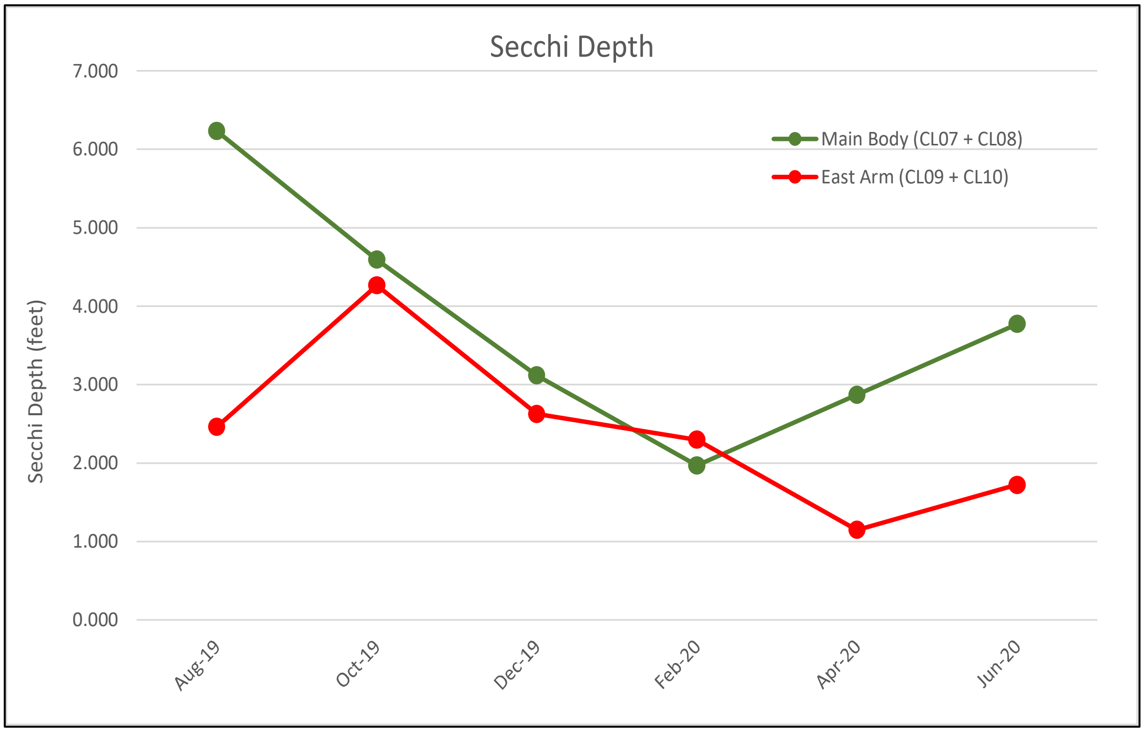


Figure 3-16. In-Situ Water Clarity Using a Secchi Disk– Main and East Basins

Analytical Chemistry

Summaries of analytical chemistry concentrations for each monitoring event in Canyon Lake are presented in Tables 3-15 and 3-16. A summary of analytical chemistry mean statistics for each site across the entire monitoring period are presented in Tables 3-17 through 3-19. Concentrations of analytes are presented graphically in Figures 3-17 and 3-18. The data displayed in these figures shows mean concentrations for the two locations in the Main Basin and the two locations in the East Basin during each sampling event.

Total nitrogen concentrations in the Main Basin (at sites CL07 and CL08) ranged from 0.71 to 2.7 mg/L across the six sampling events, with an annual mean of 1.3 mg/L (down from the 2018-19 annual mean of 1.5 mg/L). Total nitrogen concentrations at the two East Basin sites ranged from 0.87 to 2.9 mg/L across the six sampling events, with the annual mean of 1.7 mg/L (up from the 2018-19 annual mean of 1.4 mg/L). The rolling average for total nitrogen ranged from 1.36 to 1.54 mg/L, exceeding the current 2020 TMDL target of 0.75 mg/L during all events (Figure 3-19).

Total phosphorus concentrations among the two locations in the Main Basin across the monitoring year ranged from 0.02 to 0.24 mg/L, with an annual mean of 0.12 mg/L (similar to the 2018-19 annual mean of 0.10 mg/L). Total phosphorus concentrations in the East Basin ranged from 0.04 to 0.45 mg/L, with an annual mean of 0.14 mg/L (similar to the 2018-19 annual mean of 0.13 mg/L). The rolling average for total phosphorus across all sites was ranged from 0.13 to 0.14 mg/L (Figure 3-19).

Total ammonia concentrations observed in the East Basin exhibited a high point in August 2019, a large decrease and then a gradual rise in values throughout the remainder monitoring period. Values in the East Basin ranged from non-detect (<0.044) to 1.9 mg/L among the two East Basin sites, with an annual mean of 0.38 mg/L. Similar to the previous monitoring year, an increase in total ammonia was noted in the Main Basin in October 2019 up to 1.7 mg/L at Site CL07 which could be related to a turnover (de-stratification) of the lake. Total ammonia concentrations in the Main Basin ranged from 0.14 to 1.7 mg/L among the two Main Basin sites, with an annual mean of 0.58 mg/L. No individual samples at any of the sites exceeded calculated un-ionized ammonia CMC or CCC values for the protection of aquatic life.

Total dissolved solids concentrations for both basins followed a very similar pattern to the previous monitoring year. The Main Basin exhibited a slight increasing trend in TDS from August to December 2020, while the East Basin exhibited a slight decreasing trend. However, TDS in both basins showed a marked decline in February and April as a result of the winter rainfall. The average TDS concentration in the Main Basin ranged from 430 mg/L in December 2019 to 320 mg/L in April 2020. Similarly, the average concentrations of TDS in the East Basin ranged from 580 mg/L in August 2019 to 370 mg/L in April 2020. None of the TDS concentrations exceeded the Basin Plan water quality objective of 700 mg/L during any monitoring event.

Depth-integrated samples in both basins exhibited a steady decline in chlorophyll-a concentrations through April 2020, then increased slightly in June 2020. Depth-integrated concentrations in the Main Basin (mean of Sites CL07 and CL08) across all six sampling events ranged from 4.3 to 38 µg/L, with a mean of 22 µg/L (Figure 3-18). This mean concentration is greater than the 2018-19 annual mean of 13 mg/L in the Main Basin). Depth-integrated concentrations of chlorophyll-a in the East Basin (Sites CL09 and CL10) across all events ranged from 8.9 to 65 µg/L, with a mean of 27 µg/L (also greater than the 2018-19 annual mean of 16 mg/L in the East Basin). The lake-wide chlorophyll-a depth-integrated rolling average remained below the 2020 TMDL target of 25 µg/L for the entire monitoring year (Figure 3-19).

Concentrations of total aluminum ranged from ND (< 16 µg/L) to 720 µg/L in the Main Basin and ND (< 16 µg/L) to 1000 µg/L in the East Basin among all sampling locations and dates. Generally, concentrations of total aluminum were consistently low across the monitoring period (<180 µg/L). However, an increase in April was observed in both basins in April 2020, ranging from 210 to 1000 µg/L. Similar to the previous monitoring year, this was following a substantial period of storms. A large portion of the earth's crust is composed of aluminum, so this increase after large storms might be expected. Dissolved aluminum was not detected at concentrations greater than the MDL in any sample (16-33 mg/L), with the exception of August 2019 (CL10 at 47 µg/L) and all sites in June 2020 (18 to 41 µg/L). Detected concentrations of dissolved aluminum were all below the RL of 100 µg/L.

The current 2019-2020 FY Canyon Lake monitoring data in the context of historical data can be found in Appendix E.

Table 3-15. Analytical Chemistry Results for Canyon Lake - Monthly Depth-Integrated Results (Aug – Dec 2019)

Compound	Units	MDL	RL	Depth Integrated or Surface Sample	August 2019				October 2019				December 2019			
					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																
Total Dissolved Solids	mg/L	10	10	DI	370	420	560	600	380	420	560	590	440	420	540	540
Total Suspended Solids	mg/L	2	2	DI	2	4	8	9	4	ND	10	12	4	6	8	12
Sulfide	mg/L	0.10	0.10	DI	3.4	1.3	10	ND	6.7	ND	ND	ND	ND	ND	0.2	ND
Nitrate as N	mg/L	0.16	0.20	DI	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrite as N	mg/L	0.091	0.10	DI	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Kjeldahl Nitrogen	mg/L	0.093-0.37	0.10-0.40	DI	2.1	0.97	2.9	1.2	2.7	0.71	1.2	1.1	1.2	1.2	1.5	1.7
Total Nitrogen[a]	mg/L	NA	--	DI	2.1	0.97	2.9	1.2	2.7	0.71	1.2	1.1	1.2	1.2	1.5	1.7
Ammonia-Nitrogen	mg/L	0.044	0.10	DI	1.3	0.18	1.9	ND	1.7	0.57	ND	ND	0.34	0.31	0.24	0.085 J
Unionized Ammonia[b]	mg/L	NA	--	DI	0.020	0.0075	0.11	ND	0.011	0.011	ND	ND	0.0012	0.0011	0.0010	0.0018
Ortho Phosphate Phosphorus[c]	mg/L	0.016-0.050	0.050	DI	0.23	0.016 J	0.025 J	ND	0.23	ND	ND	0.027 J	0.018 J	0.019 J	0.052	0.021 J
Total Phosphorus	mg/L	0.0028-0.0049	0.010-0.020	DI	0.24	0.044	0.085	0.039 F	0.24	0.024	0.043	0.062	0.047	0.054	0.095	0.086
Total Aluminum	µg/L	16-33	100-200	DI	ND	34 J	75 J	230	ND	36 J	120	280	81 J	87 J	120	180
Dissolved Aluminum	µg/L	16-33	100	DI	ND	ND	ND	47 J	ND	ND	ND	ND	ND	ND	ND	ND
Chlorophyll-a																
Chlorophyll-a	µg/L	1.0	1.0	Surf	6.7	6.7	13.8	19.9	14.5	13.5	31.8	40.3	16.4	29.7	23.7	46.7
Chlorophyll-a	µg/L	1.0	1.0	DI	33.3	36.3	64.5	19.5	33.7	14.7	17.9	27.9	20.7	21.9	19.0	55.4

Notes:
When a concentration was non-detect, the annual average value for compliance purposes was calculated by converting non-detect (ND) values to zero. If the result of the calculated mean was non-zero but below the corresponding MDL, the average value was reported as ND.

a - Total Nitrogen = TKN+NO_2+NO_3
b - The concentration of unionized ammonia was calculated using equation by Thursby (1986), based on site specific pH and temperature recorded at each location.
c - Method SM 4500P E performed on samples collected in 2019. Analytical laboratory switched to using EPA 300.0 in 2020.
ND – Not detected; NA – Not applicable; DI = Depth integrated; Surf = Surface 0-2m
µg/L – micrograms per liter; mg/L – milligrams per liter; MDL – method detection limit; RL – reporting limit; F - Matrix Spike (MS) and/or Matrix Spike Duplicate (MSD) was outside acceptance limits (low recoveries due to suspected matrix interference). Associated laboratory control sample (LCS) recovery was within acceptance limits.
; J- Reported value was detected above the Method Detection Limit (MDL), but below the Reporting Limit (RL)

Table 3-16. Analytical Chemistry Results for Canyon Lake- Monthly Depth-Integrated Results (Feb – June 2020)

Compound	Units	MDL	RL	Depth Integrated or Surface Sample	February 2020				April 2020				June 2020			
					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																
Total Dissolved Solids	mg/L	10	10	DI	390	390	510	510	330	310	380	360	350	340	450	310
Total Suspended Solids	mg/L	2	2	DI	6	8	5	10	4	6	16	13	4	4	5	15
Sulfide	mg/L	0.10	0.10	DI	ND	ND	1.3	ND	ND	ND	0.50	ND	3.3	3.0	ND	0.80
Nitrate as N	mg/L	0.16	0.20	DI	ND	ND	ND	ND	ND	ND	0.19 J	0.27	ND	ND	ND	ND
Nitrite as N	mg/L	0.091	0.10	DI	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Kjeldahl Nitrogen	mg/L	0.093-0.37	0.10-0.40	DI	0.93	1.1	0.86	1.4	1.1	0.93	1.6	1.3	1.7	1.1	2.5	2.2
Total Nitrogen[a]	mg/L	NA	--	DI	0.93	1.1	0.86	1.4	1.1	0.93	1.8	1.6	1.7	1.1	2.5	2.2
Ammonia-Nitrogen	mg/L	0.044	0.10	DI	0.25	0.14	0.86	0.067 J	0.35	0.24	0.40	0.073 J	1.3	0.29	0.75	0.22
Unionized Ammonia[b]	mg/L	NA	--	DI	0.0067	0.0065	0.027	0.0087	0.0050	0.0028	0.0069	0.0016	0.070	0.033	0.10	0.12
Ortho Phosphate Phosphorus[c]	mg/L	0.016-0.050	0.050	DI	ND	ND	0.19	ND	0.21	0.17	0.43	0.44	0.10	ND	ND	ND
Total Phosphorus	mg/L	0.0028-0.0049	0.010-0.020	DI	0.064	0.056	0.20	0.076	0.21	0.22	0.45	0.43	0.16	0.077	0.053	0.057
Total Aluminum	µg/L	16-33	100-200	DI	68 J	71 J	ND	71 J	210	720	960	1000	41 J	42 J	100	110
Dissolved Aluminum	µg/L	16-33	100	DI	ND	ND	ND	ND	ND	ND	ND	ND	27 J	18 J	41 J	38 J
Chlorophyll-a																
Chlorophyll-a	µg/L	1.0	1.0	Surf	40.6	30.7	9.58	17.1	6.65	5.53	28.5	17.6	23.4	16.1	31.3	59.4
Chlorophyll-a	µg/L	1.0	1.0	DI	17.5	25.3	13.2	16.7	4.64	4.33	9.00	8.85	15.7	38.0	19.9	47.0

Notes:
When a concentration was non-detect, the annual average value for compliance purposes was calculated by converting non-detect (ND) values to zero. If the result of the calculated mean was non-zero but below the corresponding MDL, the average value was reported as ND.

a - Total Nitrogen = $TKN+NO_2+NO_3$
b - The concentration of unionized ammonia was calculated using equation by Thursby (1986), based on site specific pH and temperature recorded at each location.
c - Method SM 4500P E performed on samples collected in 2019. Analytical laboratory switched to using EPA 300.0 in 2020.
ND – Not detected; NA – Not applicable; DI = Depth integrated; Surf = Surface 0-2m
µg/L – micrograms per liter; mg/L – milligrams per liter; MDL – method detection limit; RL – reporting limit; F- MS and/or MSD Recovery is outside acceptance limits; 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 - Annual Mean Statistics for Each Site in the Main Basin

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														
Total Dissolved Solids	mg/L	10	10	700 [3]	DI	330	440	377	310	420	383	310	440	380
Total Suspended Solids	mg/L	2	2	NA	DI	2	6	4	ND	8	5	ND	8	4
Sulfide	mg/L	0.10	0.10	NA	DI	ND	6.7	2.2	ND	3.0	0.72	ND	6.7	1.5
Nitrate as N	mg/L	0.16	0.20	NA	DI	ND	ND	0.0	ND	ND	0.0	ND	ND	0.0
Nitrite as N	mg/L	0.091	0.10	NA	DI	ND	ND	0.0	ND	ND	0.0	ND	ND	0.0
Kjeldahl Nitrogen	mg/L	0.093-0.37	0.10-0.40	NA	DI	0.93	2.7	1.6	0.71	1.2	1.0	0.71	2.7	1.3
Total Nitrogen[a]	mg/L	NA	--	0.75[b1]	DI	0.93	2.7	1.6	0.71	1.2	1.0	0.71	2.7	1.3
Ammonia-Nitrogen	mg/L	0.044	0.10	See un-ionized NH3	DI	0.25	1.7	0.87	0.14	0.57	0.29	0.14	1.7	0.58
Unionized Ammonia[d]	mg/L	NA	--	CMC: 3.53-30.5 CCC: 0.72-5.48	DI	0.0012	0.070	0.019	0.0011	0.033	0.010	0.0011	0.070	0.015
Ortho Phosphate Phosphorus[c]	mg/L	0.016-0.050	0.05	NA	DI	ND	0.23	0.13	ND	0.17	0.034	ND	0.23	0.083
Total Phosphorus	mg/L	0.0028-0.0049	0.010-0.020	0.1[b1]	DI	0.047	0.24	0.16	0.024	0.22	0.080	0.024	0.24	0.12
Total Aluminum	µg/L	16-33	100-200	NA	DI	ND	210	67	34	720	165	ND	720	116
Dissolved Aluminum	µg/L	16-33	100	NA	DI	ND	27	ND	ND	18	ND	ND	27	ND
Chlorophyll-a														
Chlorophyll-a	µg/L	1.0	1.0	25[1], 40[2]	Surf	6.7	41	18	5.5	31	17	5.5	41	18
Chlorophyll-a	µg/L	1.0	1.0	25[1], 40[2]	DI	4.6	34	21	4.3	38	23	4.3	38	22

Notes:

When a concentration was non-detect, the annual average value for compliance purposes was calculated by converting non-detect (ND) values to zero. If the result of the calculated mean was non-zero but below the corresponding MDL, the average value was reported as ND.

a - Total Nitrogen = TKN+NO_2+NO_3
b - Annual average
c - Method SM 4500P E performed on samples collected in 2019. Analytical laboratory switched to using EPA 300.0 in 2020.
d - The concentration of unionized ammonia was calculated using equation by Thursby (1986), based on site specific pH and temperature recorded at each location. The range of TMDL target thresholds apply to individual samples, not applicable to annual means. See quarterly reports.
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; ND – Not detected; DI = Depth integrated; Surf = Surface 0-2m
µg/L – micrograms per liter; mg/L – milligrams per liter; MDL – method detection limit; RL – reporting limit

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

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														
Total Dissolved Solids	mg/L	10	10	700 [3]	DI	380	560	500	310	600	485	310	600	493
Total Suspended Solids	mg/L	2	2	NA	DI	5	16	9	9	15	12	5	16	10
Sulfide	mg/L	0.10	0.10	NA	DI	ND	10	2.0	ND	0.80	0.13	ND	10	1.1
Nitrate as N	mg/L	0.16	0.20	NA	DI	ND	0.19	ND	ND	0.27	ND	ND	0.27	ND
Nitrite as N	mg/L	0.091	0.10	NA	DI	ND	ND	0.0	ND	ND	0.0	ND	ND	0.0
Kjeldahl Nitrogen	mg/L	0.093-0.37	0.10-0.40	NA	DI	0.86	2.9	1.8	1.1	2.2	1.5	0.86	2.9	1.6
Total Nitrogen[a]	mg/L	NA	--	0.75[b1]	DI	0.86	2.9	1.8	1.1	2.2	1.5	0.86	2.9	1.7
Ammonia-Nitrogen	mg/L	0.044	0.10	See un-ionized NH3	DI	ND	1.9	0.69	ND	0.22	0.074	ND	1.9	0.38
Unionized Ammonia[d]	mg/L	NA	--	CMC: 0.842-27.5 CCC: 0.154-5.21	DI	ND	0.11	0.041	ND	0.12	0.022	ND	0.12	0.032
Ortho Phosphate Phosphorus[c]	mg/L	0.016-0.050	0.05	NA	DI	ND	0.43	0.14	ND	0.44	0.081	ND	0.44	0.11
Total Phosphorus	mg/L	0.0028-0.0049	0.010-0.020	0.1[b1]	DI	0.043	0.45	0.15	0.039	0.43	0.13	0.039	0.45	0.14
Total Aluminum	µg/L	16-33	100-200	NA	DI	ND	960	229	71	1000	312	ND	1000	271
Dissolved Aluminum	µg/L	16-33	100	NA	DI	ND	41	ND	ND	47	ND	ND	47	ND
Chlorophyll-a														
Chlorophyll-a	µg/L	1.0	1.0	25[1], 40[2]	Surf	9.6	32	23	17	59	34	9.6	59	28
Chlorophyll-a	µg/L	1.0	1.0	25[1], 40[2]	DI	9.0	65	24	8.9	55	29	8.9	65	27

Notes:
When a concentration was non-detect, the annual average value for compliance purposes was calculated by converting non-detect (ND) values to zero. If the result of the calculated mean was non-zero but below the corresponding MDL, the average value was reported as ND.

a - Total Nitrogen = TKN+NO_2+NO_3
b - Annual average
c - Method SM 4500P E performed on samples collected in 2019. Analytical laboratory switched to using EPA 300.0 in 2020.
d - The concentration of unionized ammonia was calculated using equation by Thursby (1986), based on site specific pH and temperature recorded at each location. The range of TMDL target thresholds apply to individual samples, not applicable to annual means. See quarterly reports.
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; ND – Not detected; DI = Depth integrated; Surf = Surface 0-2m
µg/L – micrograms per liter; mg/L – milligrams per liter; MDL – method detection limit; RL – reporting limit

Table 3-19. Analytical Chemistry Results for Canyon Lake- Annual Mean Statistics for Both Main and East Basins

Compound	Units	MDL	RL	Basin Plan or TMDL Target	Depth Integrated or Surface Sample	Main Basin			East Basin			Lake-wide Average		
						Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
General Chemistry														
Total Dissolved Solids	mg/L	10	10	700 [3]	DI	310	440	380	310	600	493	310	600	436
Total Suspended Solids	mg/L	2	2	NA	DI	ND	8	4	5	16	10	ND	16	7
Sulfide	mg/L	0.10	0.10	NA	DI	ND	6.7	1.5	ND	10	1.1	ND	10	1.3
Nitrate as N	mg/L	0.16	0.20	NA	DI	ND	ND	0.0	ND	0.27	ND	ND	0.27	ND
Nitrite as N	mg/L	0.091	0.10	NA	DI	ND	ND	0.0	ND	ND	0.00	ND	ND	0.00
Kjeldahl Nitrogen	mg/L	0.093-0.37	0.10-0.40	NA	DI	0.71	2.7	1.3	0.86	2.9	1.6	0.71	2.9	1.5
Total Nitrogen[a]	mg/L	NA	--	0.75[b1]	DI	0.71	2.7	1.3	0.86	2.9	1.7	0.71	2.9	1.5
Ammonia-Nitrogen	mg/L	0.044	0.10	NA	DI	0.14	1.7	0.58	ND	1.9	0.38	ND	1.9	0.48
Unionized Ammonia[d]	mg/L	NA	--	CMC: 0.842-29.5 CCC: 0.154-5.39	DI	0.0011	0.070	0.015	ND	0.12	0.032	ND	0.12	0.023
Ortho Phosphate Phosphorus[c]	mg/L	0.016-0.050	0.050	NA	DI	ND	0.23	0.083	ND	0.44	0.11	ND	0.44	0.10
Total Phosphorus	mg/L	0.0028-0.0049	0.010-0.020	0.1[b1]	DI	0.024	0.24	0.12	0.039	0.45	0.14	0.024	0.45	0.13
Total Aluminum	µg/L	16-33	100-200	NA	DI	ND	720	116	ND	1000	271	ND	1000	193
Dissolved Aluminum	µg/L	16-33	100	NA	DI	ND	27	ND	ND	47	ND	ND	47	ND
Chlorophyll-a														
Chlorophyll-a	µg/L	1.0	1.0	25[1], 40[2]	Surf	5.5	41	18	9.6	59	28	5.5	59	23
Chlorophyll-a	µg/L	1.0	1.0	25[1], 40[2]	DI	4.3	38	22	8.9	65	27	4.3	65	24

Notes:
When a concentration was non-detect, the annual average value for compliance purposes was calculated by converting non-detect (ND) values to zero. If the result of the calculated mean was non-zero but below the corresponding MDL, the average value was reported as ND.

a - Total Nitrogen = TKN+NO_2+NO_3
b - Annual average
c - Method SM 4500P E performed on samples collected in 2019. Analytical laboratory switched to using EPA 300.0 in 2020.
d - The concentration of unionized ammonia was calculated using equation by Thursby (1986), based on site specific pH and temperature recorded at each location. The range of TMDL target thresholds apply to individual samples, not applicable to annual means. See quarterly reports.
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; ND – Not detected; DI = Depth integrated; Surf = Surface 0-2m
µg/L – micrograms per liter; mg/L – milligrams per liter; MDL – method detection limit; RL – reporting limit

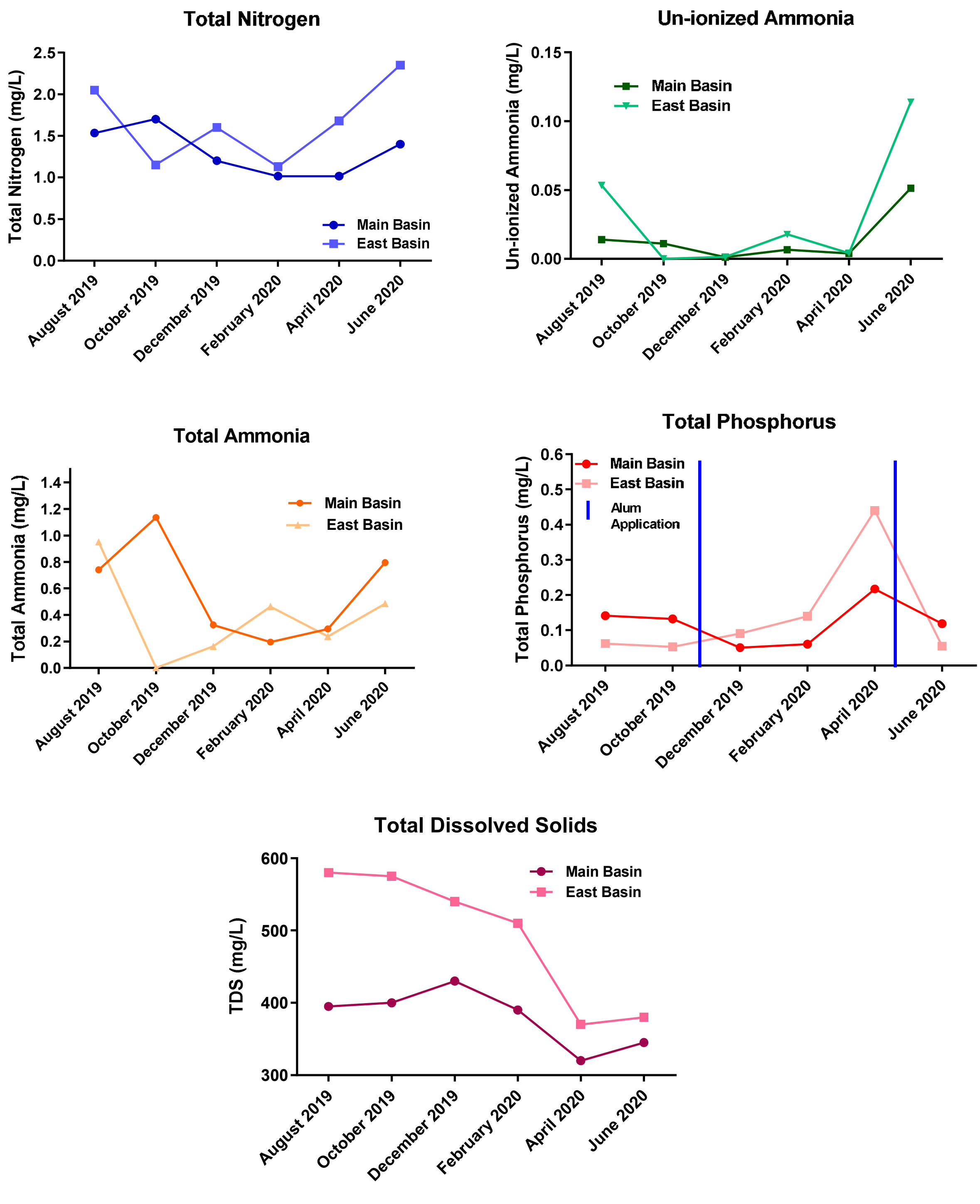


Figure 3-17. Canyon Lake Analytical Chemistry – Depth-Integrated Means

Main Basin values represent the mean of Sites CL07 & CL08, East Basin values represent the mean of Sites CL09 & CL10
Long term trends can be found in Appendix E

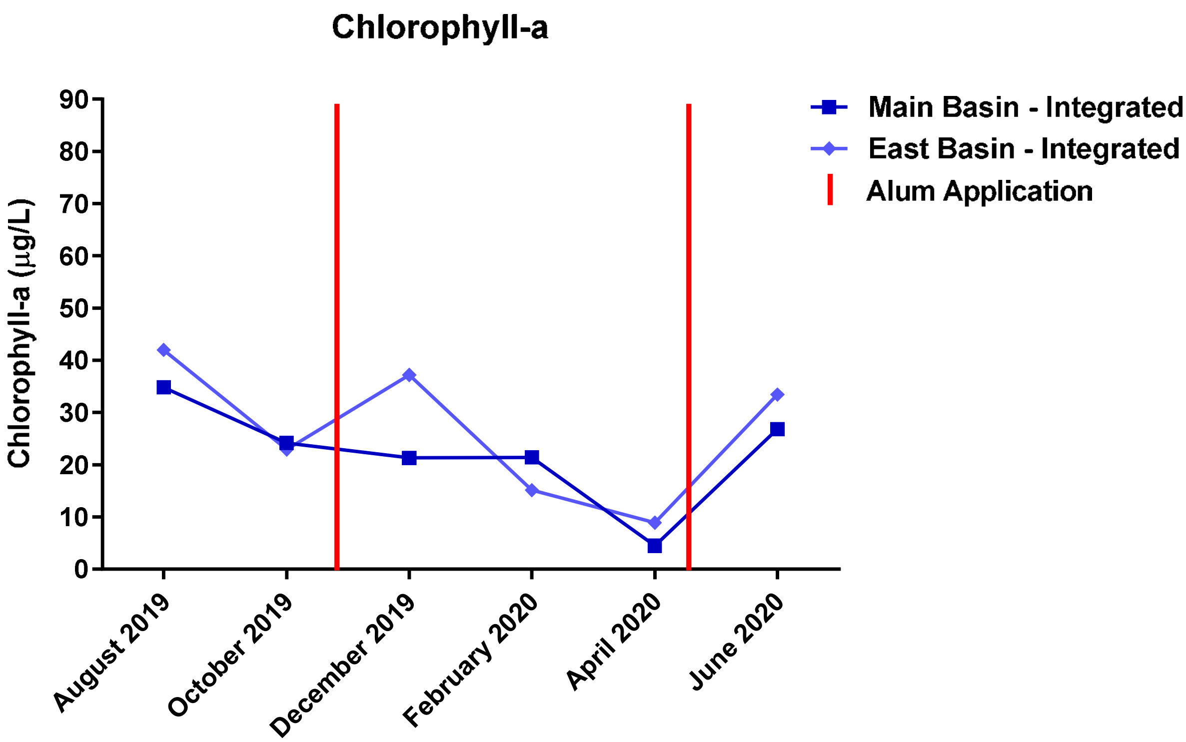
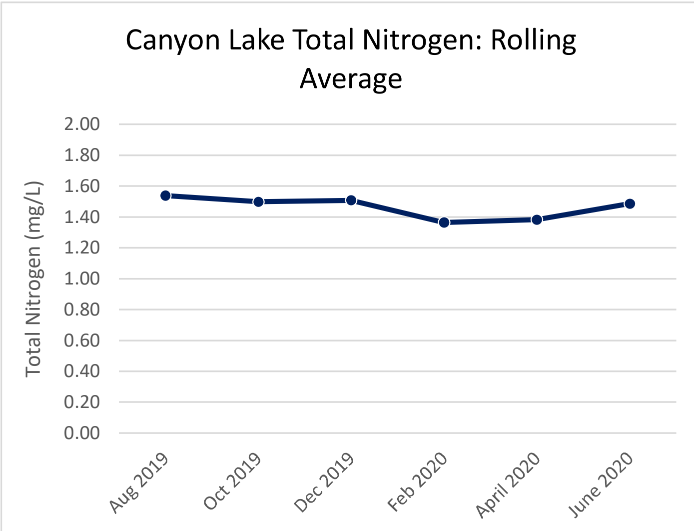
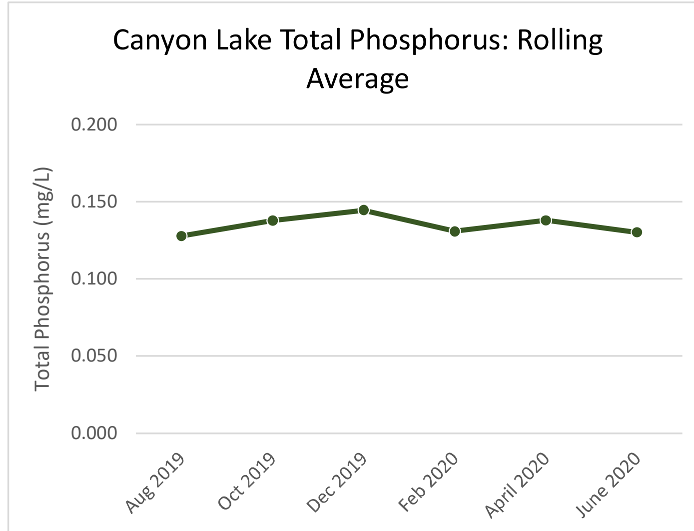


Figure 3-18. Canyon Lake Analytical Chemistry – Depth-Integrated Chlorophyll-a

Main Basin values represent the mean of Sites CL07 & CL08, East Basin values represent the mean of Sites CL09 & CL10
Long term trends can be found in Appendix E





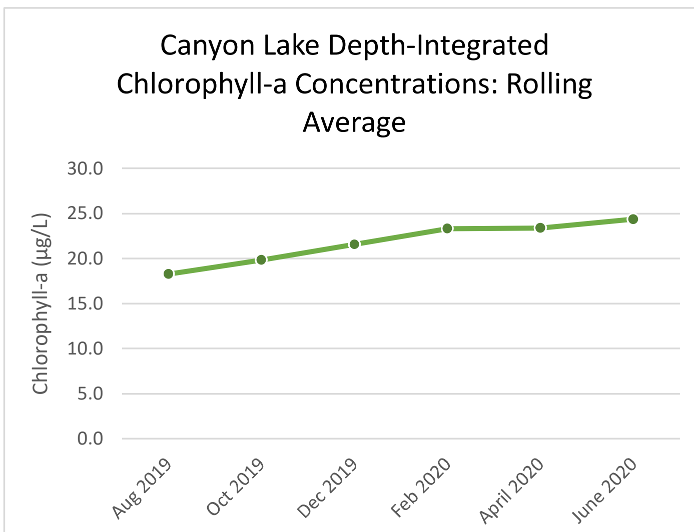


Figure 3-19. Canyon Lake Analytical Chemistry- Rolling Averages

Each data point is calculated by averaging the value from each event across all sites with the previous five events across all sites (i.e. one year of data) to obtain a rolling average. Therefore, each graph represents data collected from October 2018 to June 2020.

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 and Sentinel-2 satellite imagery to estimate chlorophyll-a and turbidity concentrations in Lake Elsinore and Canyon Lake. Using 30-m (LandSat) or 10-m (Sentinel-2) pixel resolution, this effort produced maps of the lakes 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 lakes 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 3-feet of the water column depending on water clarity, and therefore cannot completely replace manual sampling where depth-integrated values are required. The satellite images are also able to provide a sense of the relative variability in algae concentrations across the lake that are rather dramatic and missed by measuring values from only a few discrete locations.

As part of the TMDL compliance monitoring, satellite imagery depicting surficial 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 3-20 through 3-23. Significant spatial variability in chlorophyll-a is evident, providing a more complete assessment of algal density conditions across each lake.

To quantify the data presented in the satellite images, cumulative frequency distribution plots showing lake-wide chlorophyll-a concentrations based on individual pixels from the satellite measurements are provided in Figures 3-24 and 3-25. Satellite derived mean and median values along with measured chlorophyll-a concentrations in the surface composite (0-2m) are provided for each date showing these single data points relative to concentrations throughout the entire lake. Mean and median lake-wide values were derived from satellite imagery data treating each pixel as a unique individual data point. Additionally, the Lake Elsinore lake-wide mean chlorophyll-a concentration was also calculated using the mean of a sub-set of satellite data pixels within the lake (e.g., 100-m radius around the in-lake sampling points). This serves to minimize the known risk of edge-interference (mixing of land and water pixels) near the lake borders or shallow-water interference (satellite detecting bottom sediments) that can artificially inflate satellite derived lake-wide mean chlorophyll-a and turbidity concentrations.

The satellite images for Lake Elsinore show a generalized lake wide chlorophyll-a concentration increase from July through October 2019, followed by a decrease in December after the first rains of the season, an increase February 2020, and then a decrease through June 2020. The pattern observed using satellite imagery was consistent with measured chlorophyll-a values between July 2018 and February 2019 but diverged thereafter with measured chlorophyll-a values continuing to increase from February to June 2019.

Chlorophyll-a concentrations in Canyon Lake derived from satellite imagery remained relatively consistently low throughout the monitoring period, with a slight increase in chlorophyll-a in June 2020. Measured concentrations of chlorophyll-a are also relatively low (< 40 mg/L) but appear to exhibit greater concentrations and more variability than that resolved using satellite imagery. Satellite imagery did show some periods of elevated chlorophyll-a in April and June 2020 of the East Basin though it should be noted that there may be some edge-interference effects as a result of land and water pixels mixing near the edges of the narrow channel. This “edge effect” is somewhat diminished during non-summer months when Sentinel-2 satellite data is used[2], which

[2] The Sentinel-2 satellite data 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.

generates a smaller pixel size (10-m) than the LandSat satellite (30-m) used during summer months (June – Sept) reducing the possibility of mixing land and water in a single pixel.

It was evident that some of the chlorophyll-a concentrations generated from the satellite images for both lakes did not consistently match with analytically measured values from in-lake water samples collected. In Lake Elsinore this was possibly due to the very high chlorophyll-a concentrations observed in this water body. During the initial satellite validation performed over the 2015-2016 sampling season, it was determined that satellite derived chlorophyll-a estimates tended to diverge from known in-lake concentrations when in-lake concentrations were above approximately 100 µg/L. Discussions and sharing of this data with EOMaps (the satellite data vendor) will continue to enhance model predictions and assess whether there may be other confounding factors (including turbidity) that are not accurately accounted for in this lake. It is also possible, that the discrepancy in satellite chlorophyll-a concentrations relative to in-lake concentrations is due to a difference in the depth being analyzed. In-lake "surface" analytical samples are collected as a composite of the top 2 meters of the water column, while the satellite imagery analyzes approximately one-half of that depth, or the top 1 meter of the water column. It is well known that some algae, particularly blue-green algae (cyanobacteria), can regulate their buoyancy and exhibit a diurnal pattern of rising to the surface during the day and sinking down in the water column at night. This would serve to concentrate the algae right at the surface during the day where the satellite imagery collects its data (i.e. top 3-feet), while the in-lake analytical sample is a composite of surface water (where the algae density is highest) and less concentrated deeper water, serving to somewhat dilute the in-lake analytical sample relative to what the satellite measures. Additionally, cyanobacterial algal blooms are known to have patchy distributions, which can result in high spatial variability in algal concentrations. Given that the resolution of a single satellite pixel varied between 10-m (Sentinel-2) and 30-m (LandSat), and that the estimated satellite chlorophyll-a concentration is a composite of the area within a pixel, this can lead to a potential discrepancy when compared to an in-lake grab sample collected at a single point. Chlorophyll-a concentration satellite estimates in Canyon Lake were more in-line with analytical measurements overall.

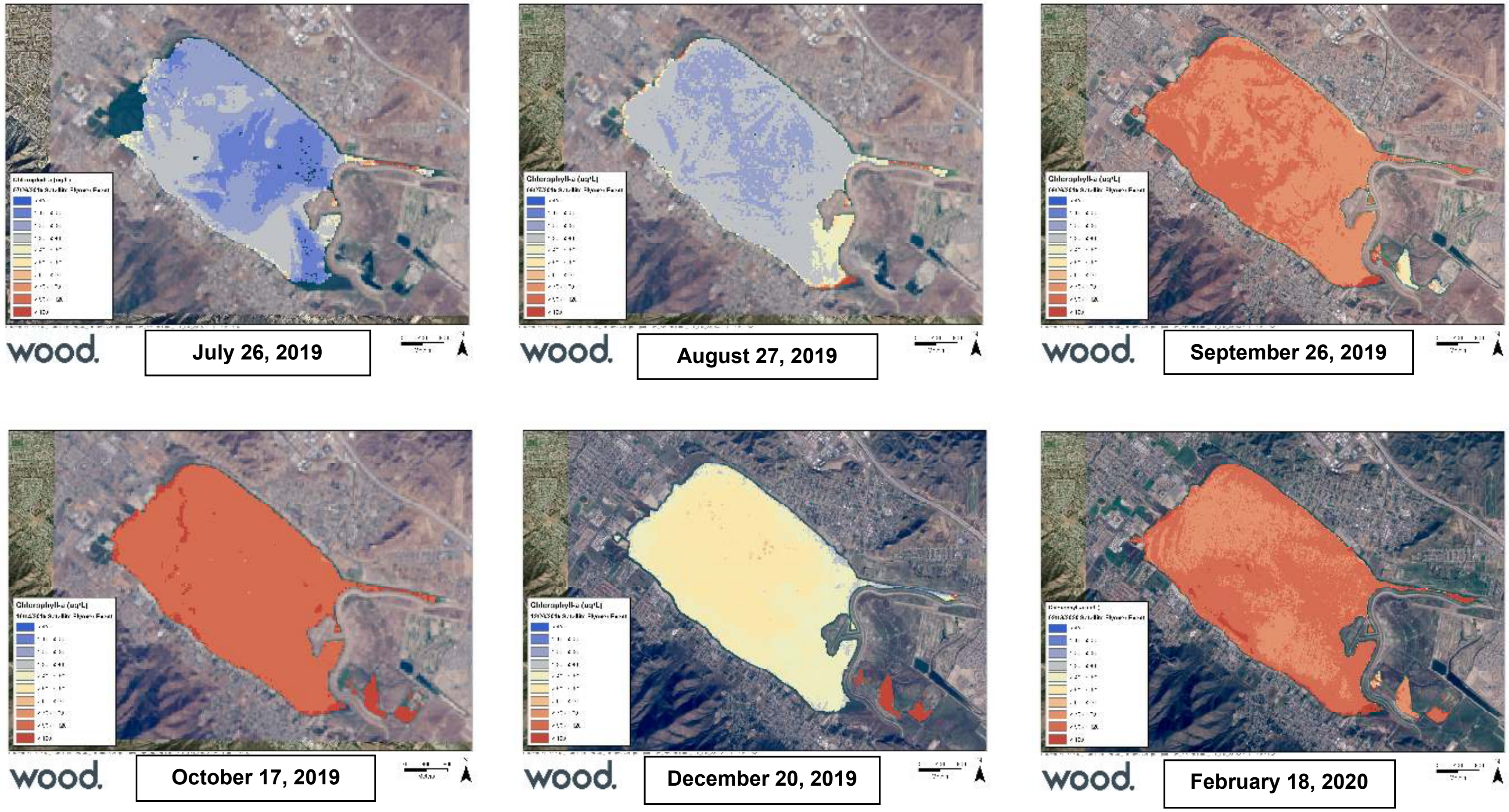


Figure 3-20. Satellite Imagery of Chlorophyll-a Concentrations in Lake Elsinore

(Data gaps in July is due to sunglint)

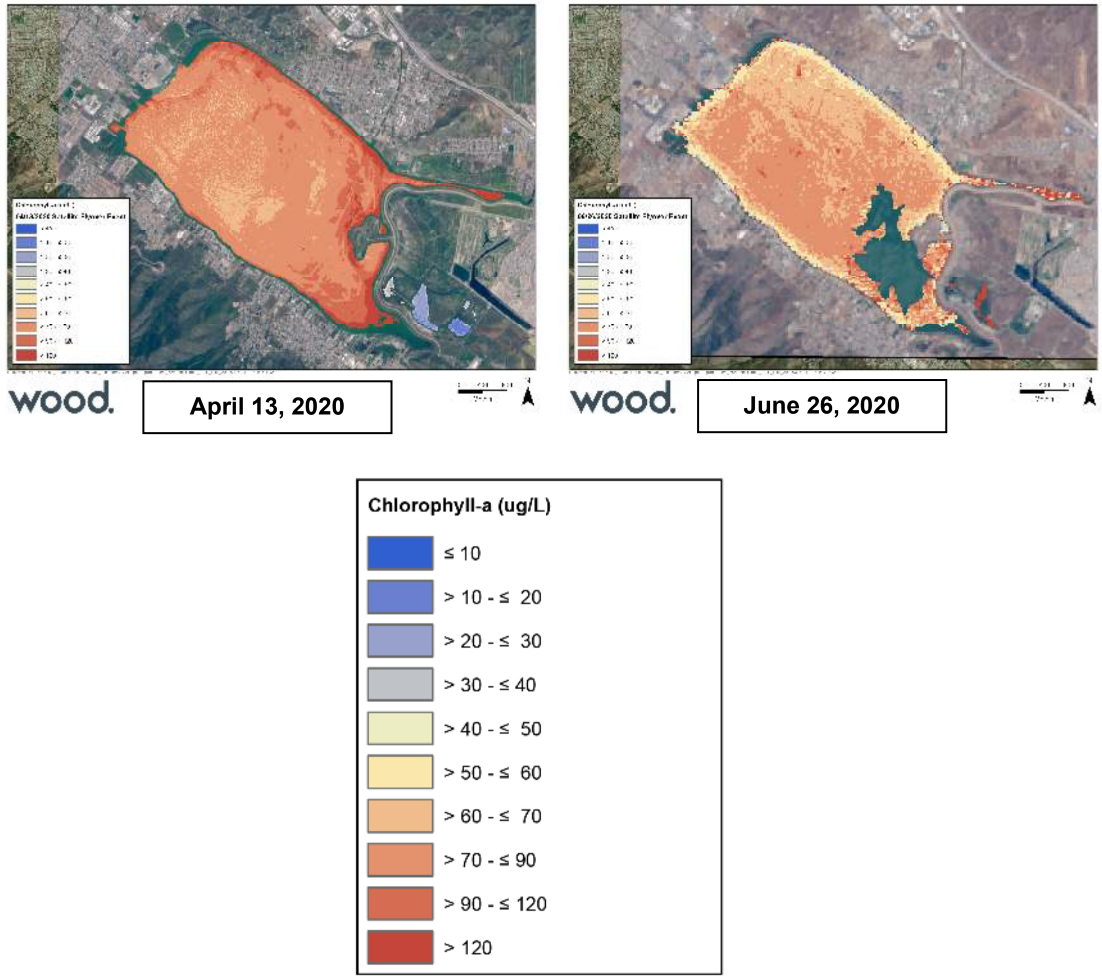


Figure 3-20 (cont.). Satellite Imagery of Chlorophyll-a Concentrations in Lake Elsinore

(Data gaps in June are due to surface reflection.)

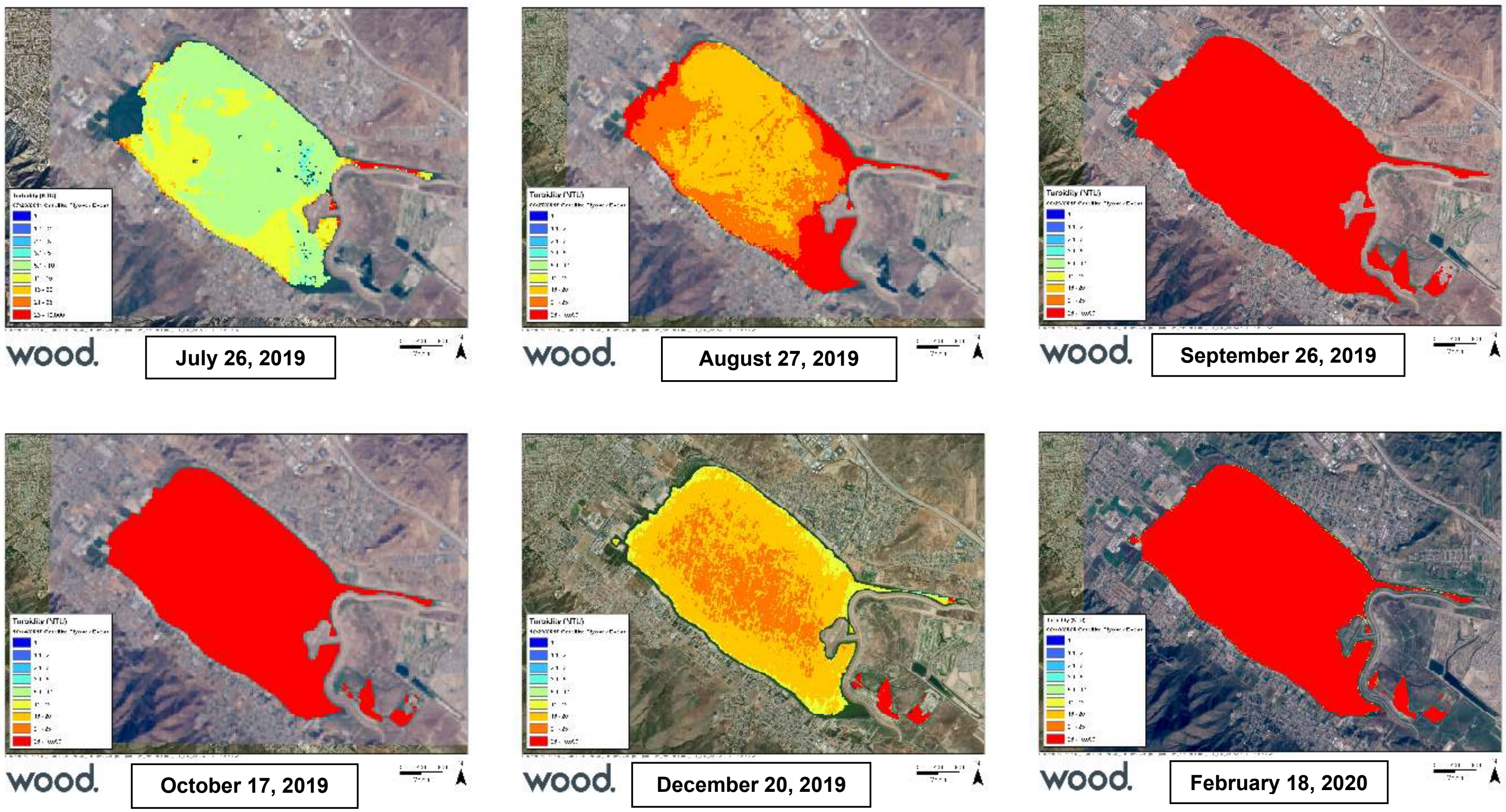


Figure 3-21. Satellite Imagery of Turbidity Concentrations in Lake Elsinore

(Data gaps in July is due to sunglint)

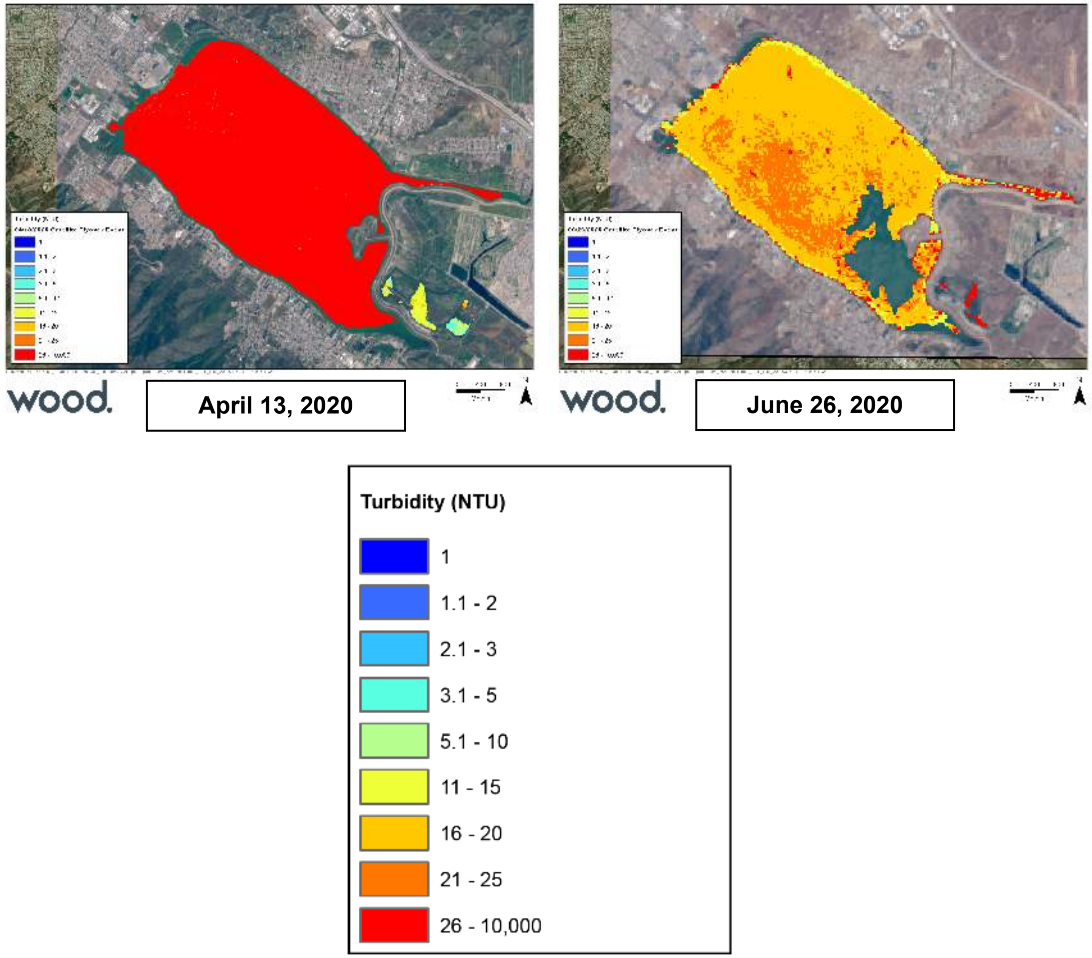


Figure 3-21 (cont.). Satellite Imagery of Turbidity Concentrations in Lake Elsinore

(Data gaps in June 2020 are due to sunglint)

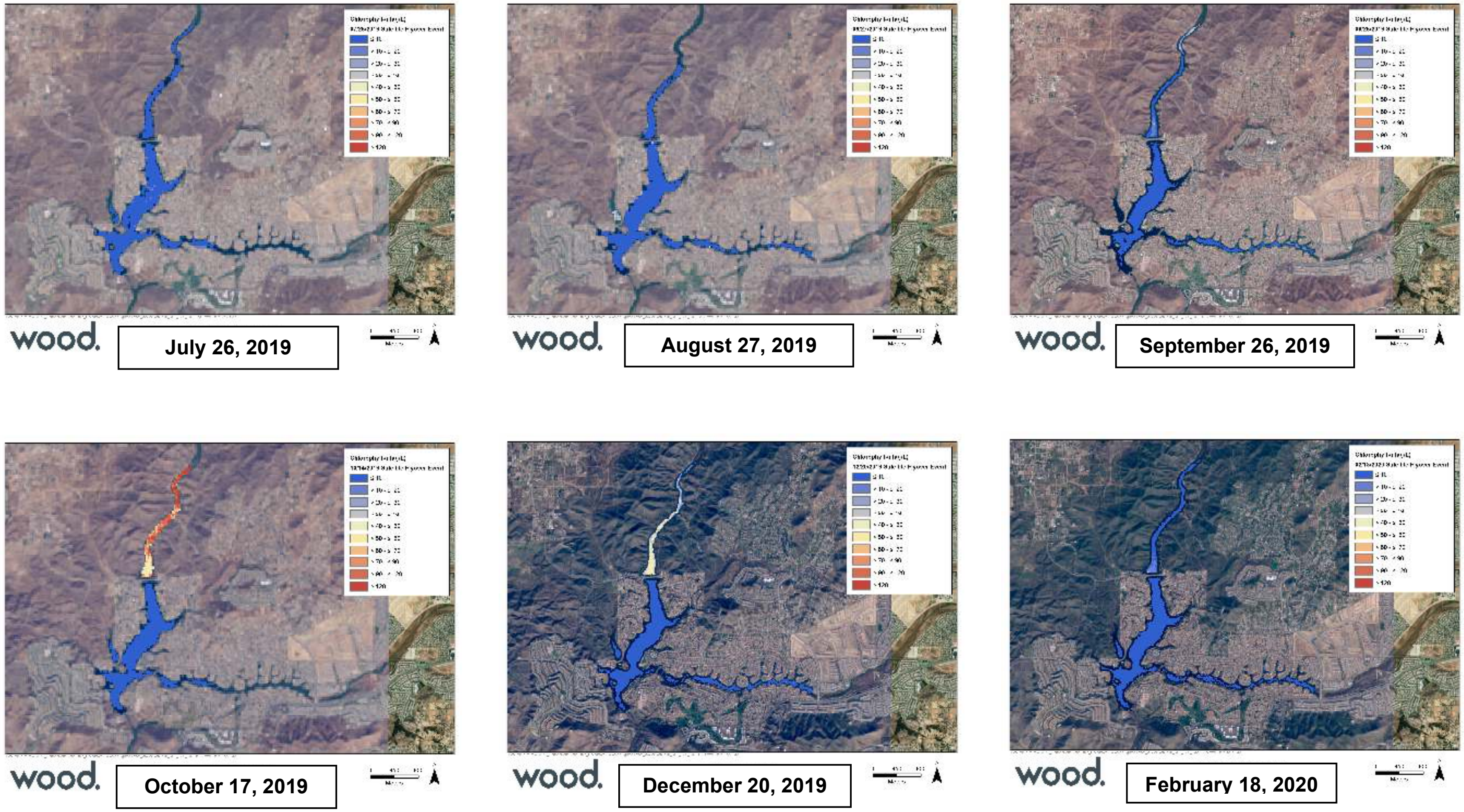


Figure 3-22. Satellite Imagery of Chlorophyll-a Concentrations in Canyon Lake

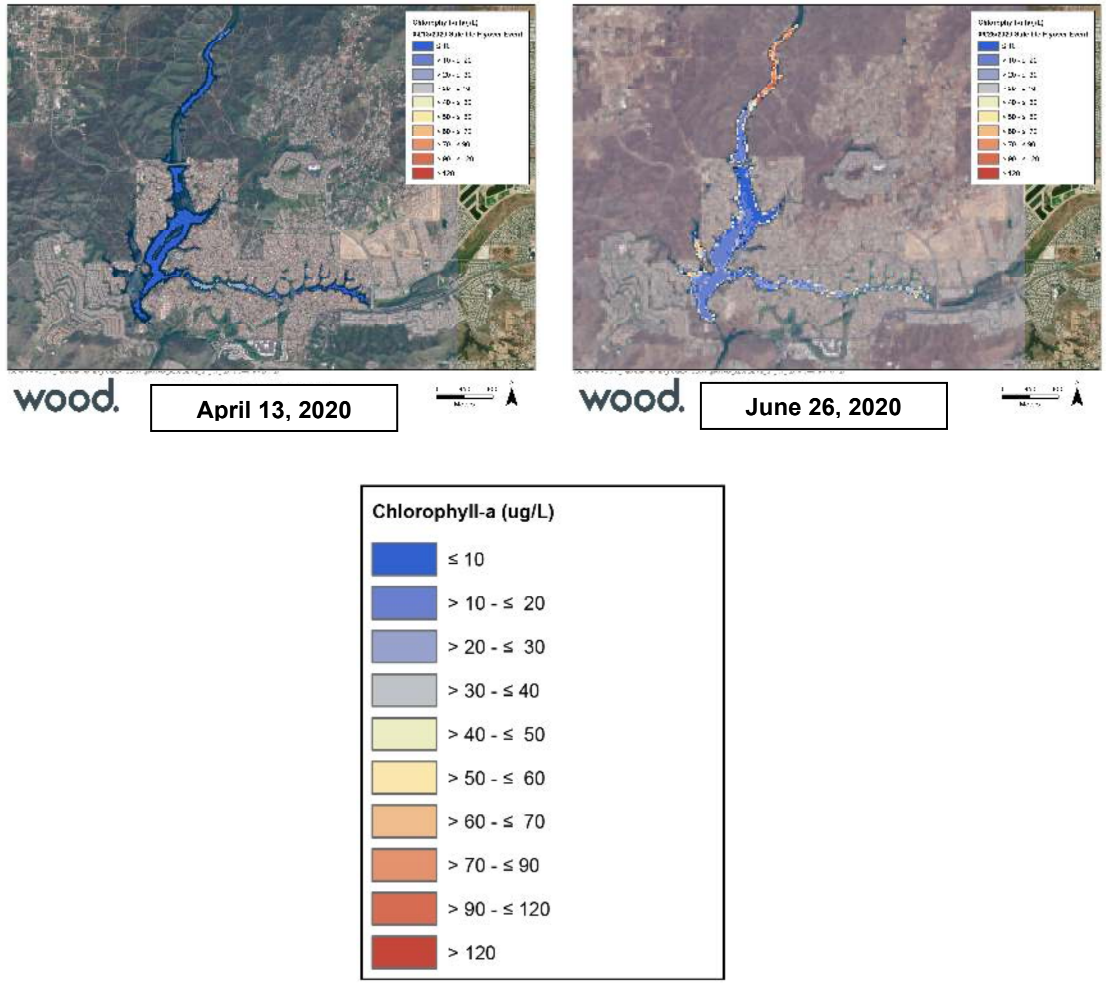


Figure 3-22 (cont.). Satellite Imagery of Chlorophyll-a Concentrations in Canyon Lake

(Data gaps in April 2020 were caused by sunglint)

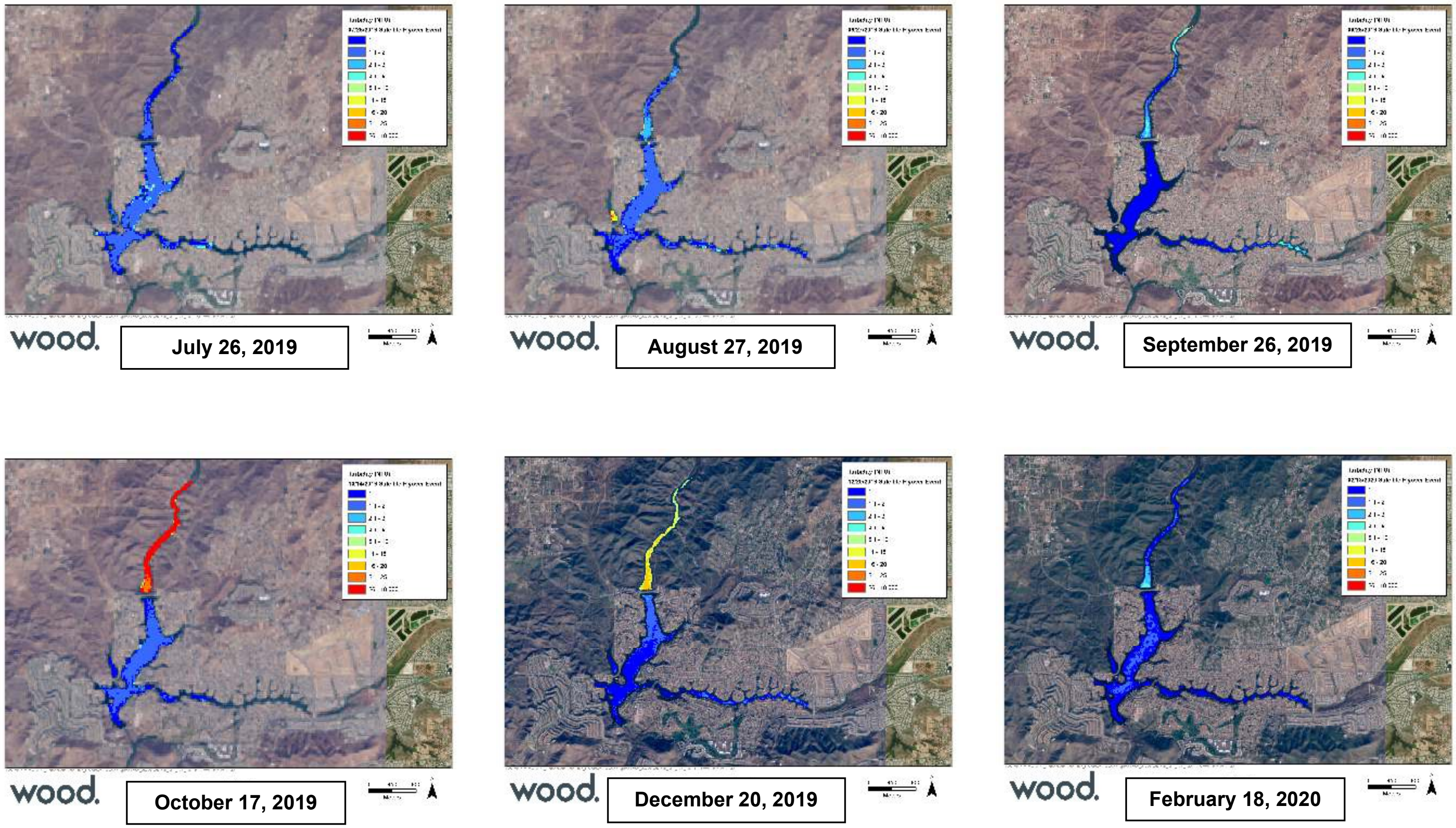


Figure 3-23. Satellite Imagery of Turbidity Measurements Canyon Lake

(High cirrus cloud interference caused data gaps in July 2019, and decreased clarity in June 2020.)

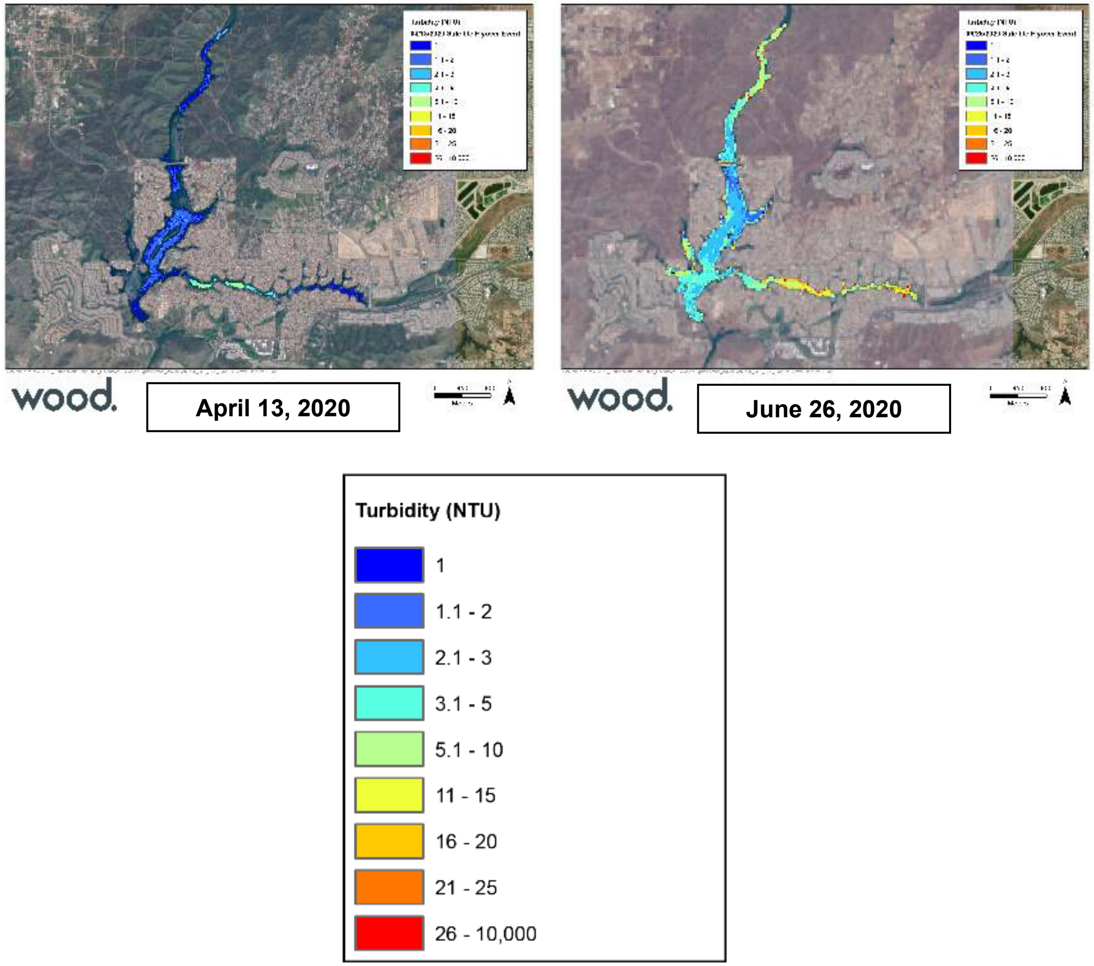


Figure 3-23 (cont.). Satellite Imagery of Turbidity Measurements Canyon Lake

(Sunglint interference caused data gaps in April 2020)

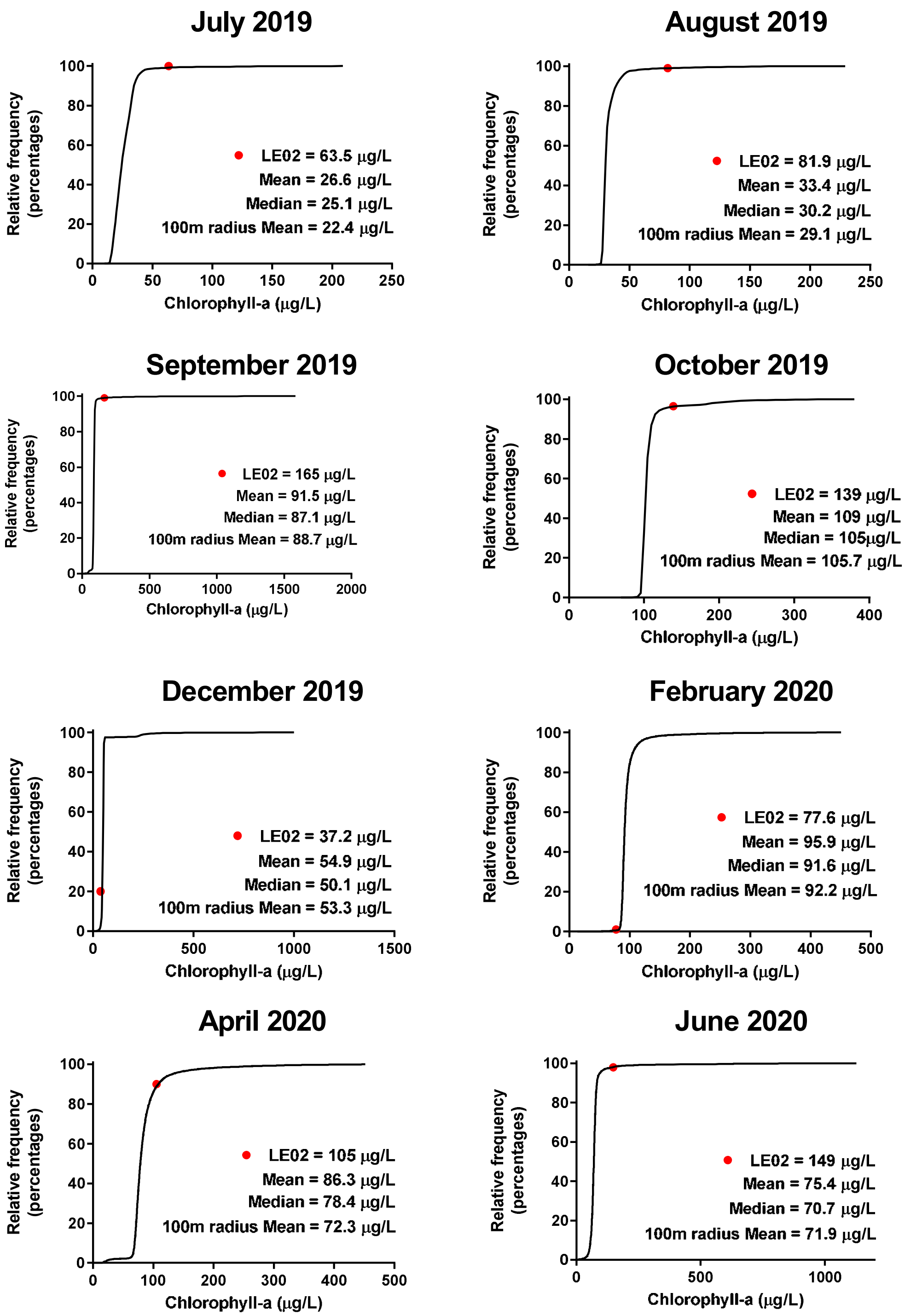


Figure 3-24. Cumulative Distribution of Satellite Derived Chlorophyll-a Concentrations in Lake Elsinore Relative to Measured Chlorophyll-a in Field Collected Samples

Colored dots represent the in-lake surface (0-2m) analytical measured concentration for each event

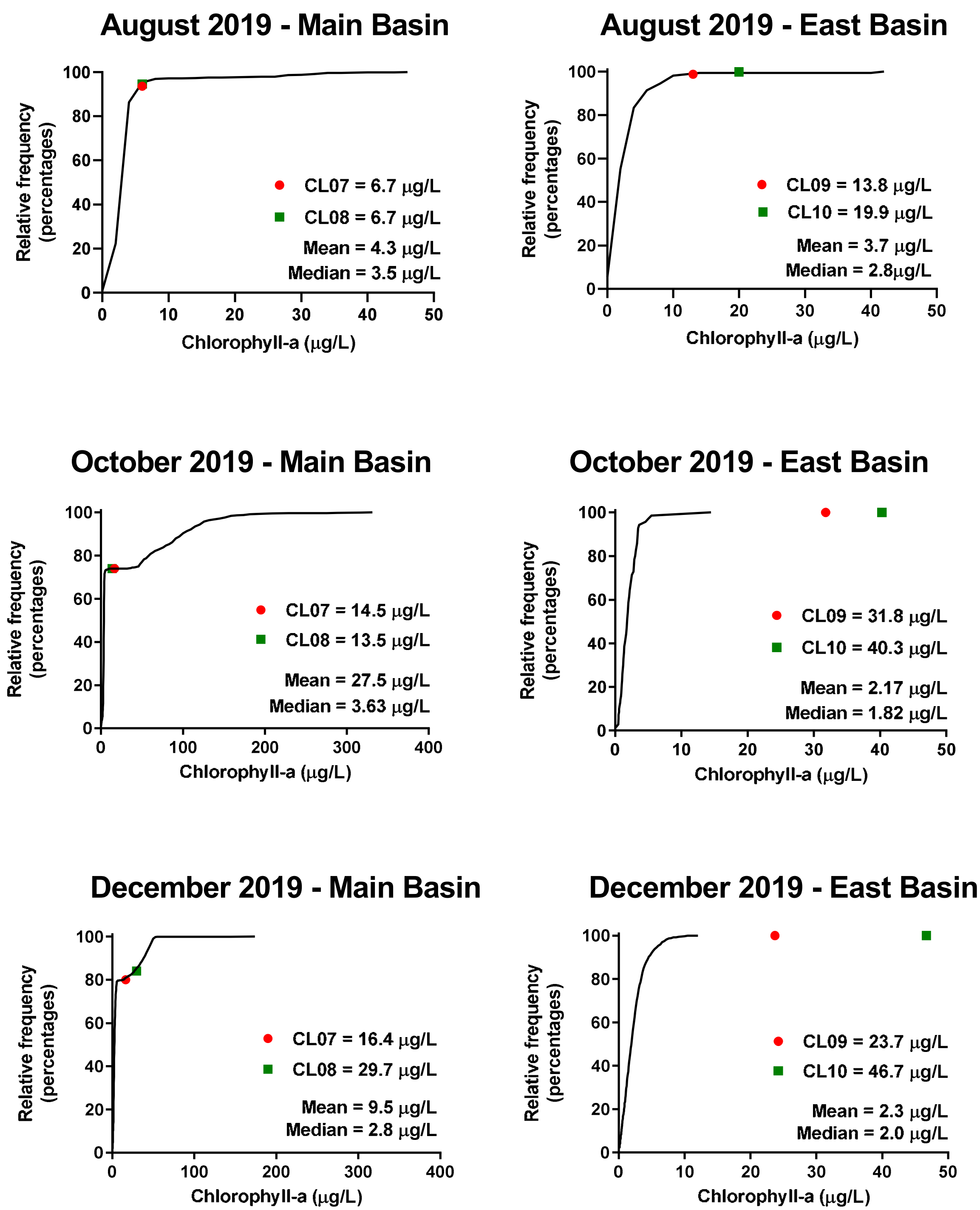


Figure 3-25. Cumulative Distribution of Satellite Derived Chlorophyll-a Concentrations in Canyon Lake Relative to Measured Chlorophyll-a in Field Collected Samples

Colored dots represent the in-lake surface (0-2m) analytical measured concentration for each event

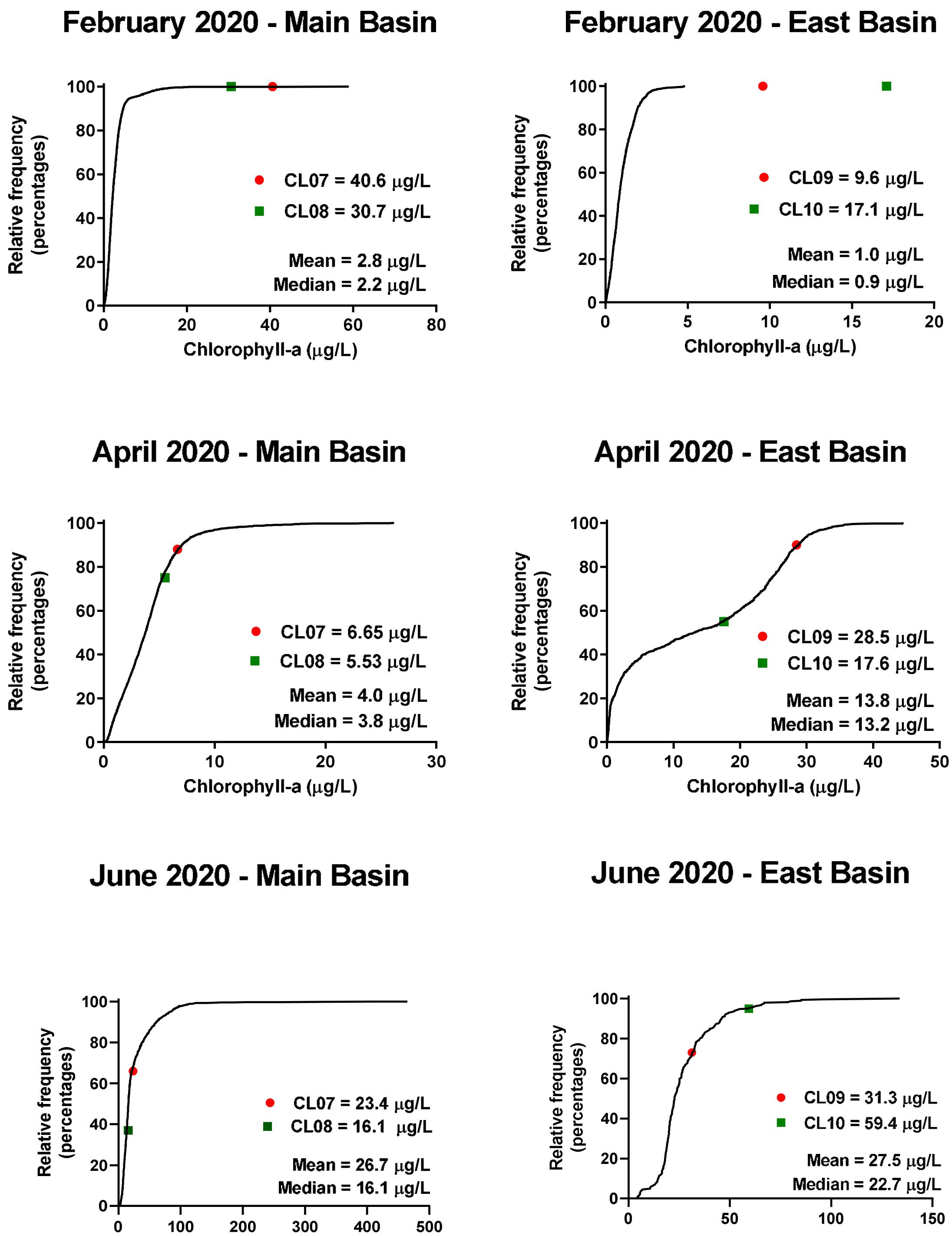


Figure 3-25. (cont). Cumulative Distribution of Satellite Derived Chlorophyll-a Concentrations in Canyon Lake Relative to Measured Chlorophyll-a in Field Collected Samples

Colored dots represent the in-lake surface (0-2m) analytical measured concentration for each event

4.0 References

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