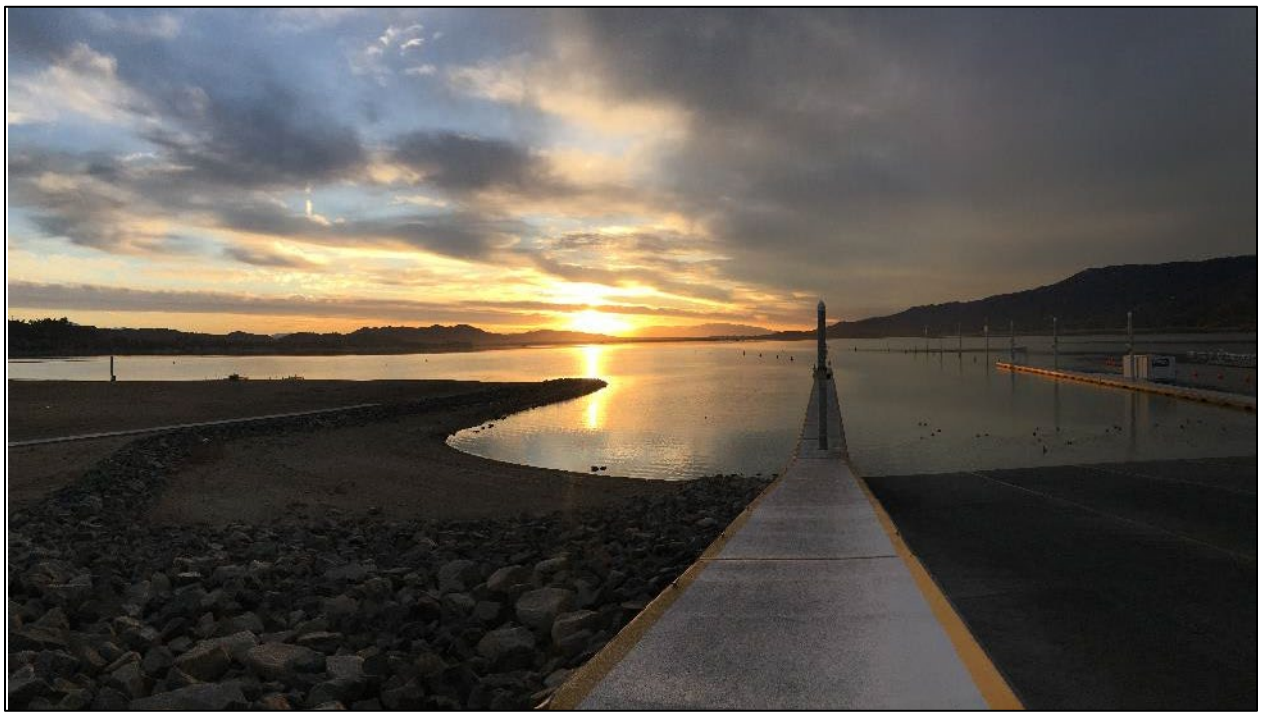
Lake Elsinore and Canyon Lake Watersheds Nutrient TMDL Monitoring 2020-2021 Annual Report – FINAL



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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
DI	Depth-integrated
DO	dissolved oxygen
EMC	event mean concentration
Epi	epilimnion
EVMWD	Elsinore Valley Municipal Water District
Forest Service	San Bernardino Nation Forest Service
FY	fiscal year
Hypo	hypolimnion
J	concentration between MDL and RL
kg	kilogram
LA	load allocation
LESJWA	Lake Elsinore and San Jacinto Watersheds Authority
MDL	Method detection limit
Mgal	million gallons of water
mg/L	milligrams per liter
NA	not applicable
ND	non-detect
NM:LE	not measured lab error
NPDES	National Pollutant Discharge Elimination System
NS	not sampled
NWS	National Weather Service
QAPP	Quality Assurance Project Plan
RCFC&WCD	Riverside County Flood Control and Water Conservation District
RL	Reporting limit
RWQCB	Regional Water Quality Control Board, Santa Ana Region
SAWPA	Santa Ana Watershed Project Authority
SM	Standard Method
Surf	Surface sample (0-2 meter composite)
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 2020-2021 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 in-lake targets and watershed load allocations have been established and incorporated in the TMDL for nutrients (total nitrogen, phosphorus, and ammonia), DO, and chlorophyll-a (Tables 1-1 and 1-2); 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 loading; 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. A draft annual report summarizing the data collected for the year and evaluating compliance with the TMDL, due August 15 of each year.

Table 1-1. Final In-Lake Numeric Compliance Targets for 2004 TMDLs (adapted from Table 5-9n in the Basin Plan, Santa Ana Water Board 2016)

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

Table 1-2. Final Watershed Loading Numeric Load Allocations from the 2004 TMDL (adapted from Table 5-9p in the Basin Plan, Santa Ana Water Board 2016)

TMDL	Final Total Phosphorus TMDL (kg/yr)[a, b]	Final Total Nitrogen TMDL (kg/yr)[a, b]
Canyon Lake	8,691	37,735
Lake Elsinore	28,584	230,025

a - Final compliance to be achieved as soon as possible, but no later than December 31, 2020
b - TMDL specified as 10-year running average. Sum all wasteload and allocation sources

Since August 2001, the Lake Elsinore and San Jacinto Watersheds 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.

1.2 Nutrient TMDL Compliance Monitoring Objectives

The primary objectives of the Nutrient TMDL Compliance Monitoring Program are to:

1. Determine in-lake concentrations of causal (total nitrogen and total phosphorus) and response (total ammonia, dissolved oxygen, and chlorophyll-a) targets outlined in the adopted 2004 Lake Elsinore and Canyon Lake Nutrient TMDL through regular monitoring of both lakes.

2. Evaluate trends in causal and response parameter concentrations toward achieving 2004 TMDL numeric targets.

3. Quantify the external pollutant loading originating from the watershed above the lakes through stormwater monitoring of the major upstream inputs to Canyon Lake.

4. Determine the total nutrient loads into Lake Elsinore and Canyon Lake from their tributaries (i.e., San Jacinto River and Salt Creek).

5. Provide water quality data from both in-lake and watershed monitoring to update loading model.

Additionally, the data generated by this monitoring program will help support the needs of other programs by tracking the trends in watershed loading and in-lake concentrations relative to BMPs or any other actions taken in the upstream watershed to reduce nutrient loads.

2.0 San Jacinto River Watershed-Wide Monitoring

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

2.1 Summary of 2020-2021 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, 2020 through June 30, 2021, 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.

Table 2-1. Summary of 2020-2021 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)	255	1.9	0.39	1,902	396
Site 4 - San Jacinto River at Goetz Road (USGS 11070365)	519	1.9	0.48	3,794	992
Site 6 - San Jacinto River at Ramona Expressway [b] (USGS 11070210)	0	Not Measured [b]	Not Measured [b]	Not Measured [b]	Not Measured [b]
Site 30 - Canyon Lake Spillway [c] (USGS 11070500)	878	1.7	0.05	5,626	175

a - Flow data after 04/27/2021 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 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 Incoming Nutrient Loads

A summary of the historical total nitrogen and total phosphorus water quality monitoring data for the period of July 1, 2011 through June 30, 2021, is presented in Tables 2-2 to and 2-3. Table 2-4 presents the 10-year running average of incoming total nitrogen and total phosphorus loads for both lakes in comparison to their TMDL load allocations. In general, the monitoring locations only flow during storm events and the storm flows account for the estimated annual load of nutrients. Lake Elsinore does meet the current 10-year running average for both total nitrogen and total phosphorus (Table 2-4). Canyon Lake meets the 10-year running average for total nitrogen but does not for total phosphorus. However, TMDL load allocation for total phosphorus in Canyon Lake does not take into account offsets for alum application. The 10-yr running average loading for Lake Elsinore was calculated from samples collected at the Canyon Lake

Spillway station. These samples represent the catchment area upstream of the Canyon Lake Spillway and correspond to 93.6% of the total area contributing runoff to Lake Elsinore. The remaining 6.4% of the Lake Elsinore catchment is in the immediate area surrounding Lake Elsinore.

Table 2-2. Summary of Historical Annual Mean Storm Concentrations Based on Monitoring Year

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
2020-2021	1.9	0.4	1.9	0.5	1.7	0.05

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 Based on Monitoring Year

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
2020-2021	255	1,902	396	519	3,794	992	878	5,626	175

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.

Table 2-4. Historical Estimated Annual Loads as a 10-Year Running Average Relative to the 2004 TMDL Wasteload and Load Allocations

Lake	Analyte	10-yr Running Average (kg/yr) [a]	TMDL Load Allocation (kg/yr) [b]	% of TMDL Load Allocation [c]
Lake Elsinore [d]	Total Nitrogen	10,109	29,953	33.8
	Total Phosphorus	1,651	6,922	23.9
Canyon Lake	Total Nitrogen	16,987	22,268	76.3
	Total Phosphorus	6,182	3,845	161

a - Sum of average 10-year annual loads from Salt Creek at Murrieta Road and San Jacinto River at Goetz Road for the monitoring period January 2012 - June 2021.
b – Load allocations taken from Resolution R8-2004-0037 (2004 TMDL) Tables 5-9p and 5-9q. Internal sediment and atmospheric deposition allocations (Table 5-9q) were subtracted from the total of all allocation sources for both TN and TP to provide a more valid comparison to incoming watershed loads.
c – the percent of TMDL load allocation for total phosphorus does not include offsets for alum application for Canyon Lake or LEAMS for Lake Elsinore.
d – watershed loading estimates for Lake Elsinore were taken from data collected at the Canyon Lake Spillway when it overflows

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 2020-2021 monitoring period included collection of samples during two storm events at the designated monitoring stations throughout the San Jacinto River Watershed. Average nutrient concentrations during these two 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 2-5 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 2-5. 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.

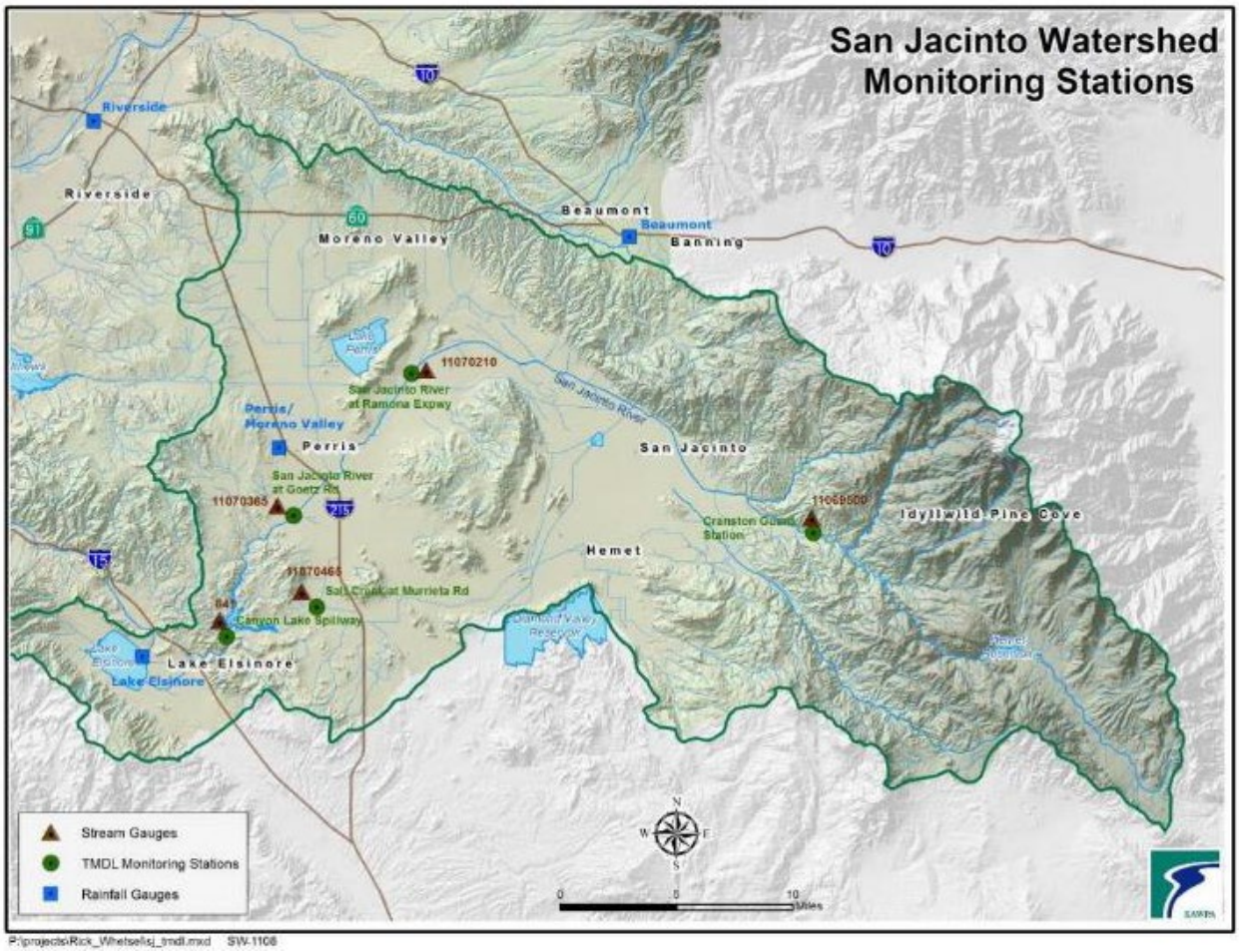


Figure 2-1. San Jacinto River Watershed Monitoring Stations

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:

https://www.evmwd.com/who-we-are/lake-levels

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 whom 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 2-5.

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 2-6 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, 2020 through June 30, 2021 is presented in Table 2-6 and visually presented in Figure 2-2 through Figure 2-6. The total monthly flows at each of the USGS stations are reported in Table 2-6. 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 April 27, 2021 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.

Table 2-6. Summary of Stream Gauge Data (July 2020 through June 2021)

July 2020-June 2021 Total Monthly Flow (cf)	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 [a] (11070210 [c])	Site 30 - Canyon Lake Spillway (11070500 [b])	Site 1 - San Jacinto River at Cranston Guard Station (11069500 [c])
July	-	-	-	64,161	613,926
August	-	-	-	-	186,192
September	-	-	-	-	127,575
October	-	-	-	234,135	1,700,937
November	-	-	-	1,628,820	808,983
December	8,480,052	11,594,070	-	3,276,153	2,217,960
January	17,561,106	43,153,551	-	39,197,889	3,398,859
February	84,096	489,987	-	15,824,214	4,464,207
March	7,968,501	14,156,487	-	54,419,688	10,871,613
April	-	-	-	2,021,184	1,697,256
May	-	-	-	708,660	454,086
June	-	-	-	-	112,509
Total Annual Flow (cf)	**34,093,755**	**69,394,095**	**-**	**117,374,904**	**26,654,103**

Notes:
a - No flows originating from the upper watershed were observed at the TMDL monitoring location just downstream of Mystic Lake.
b – USGS gauge number
cf = cubic feet

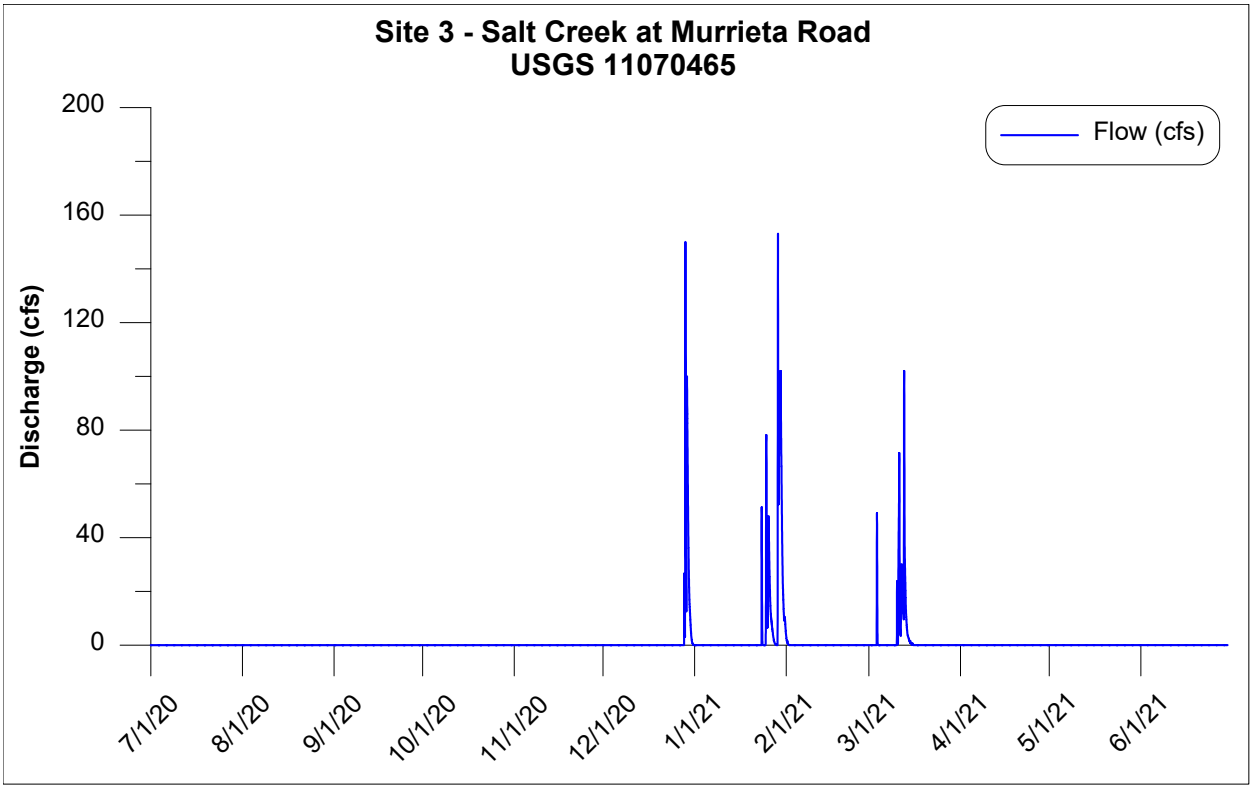


Figure 2-2. Site 3 – Salt Creek at Murrieta Road – Daily Stream Gauge Records

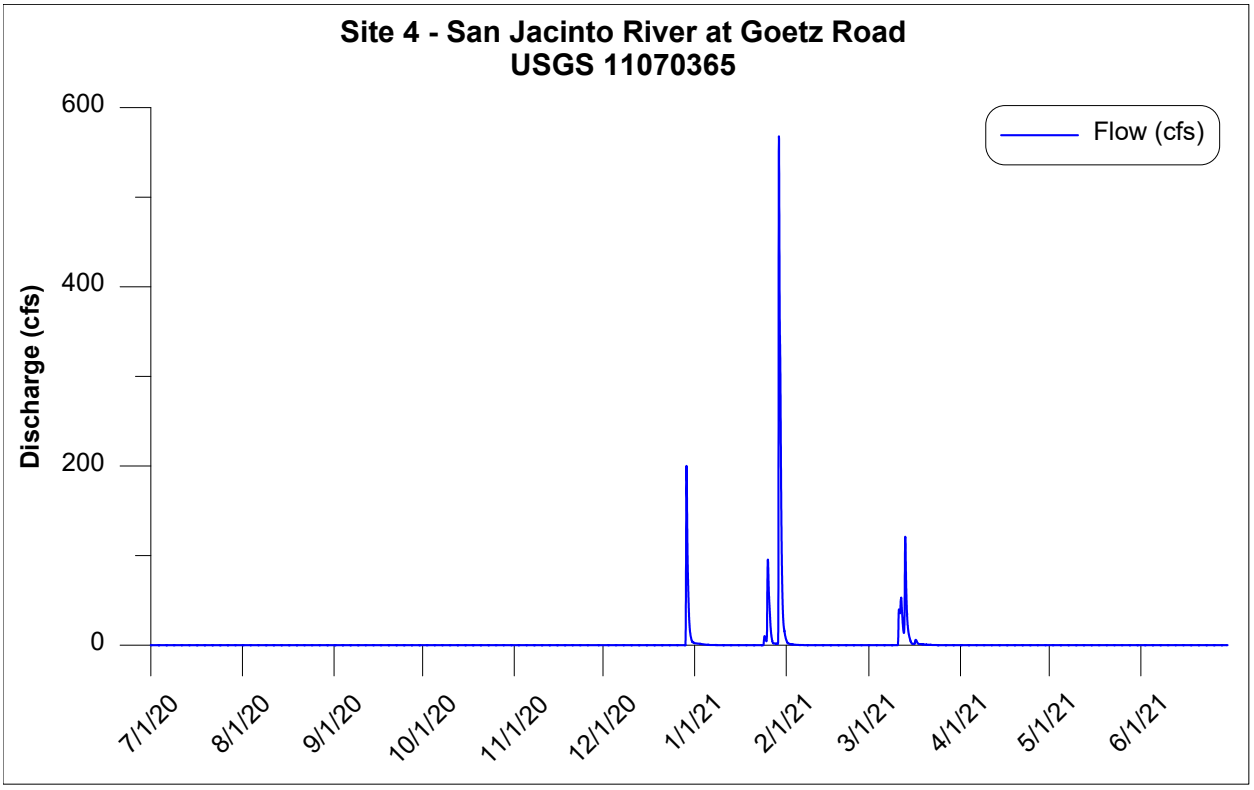


Figure 2-3. Site 4 – San Jacinto River at Goetz Road – Daily Stream Gauge Records

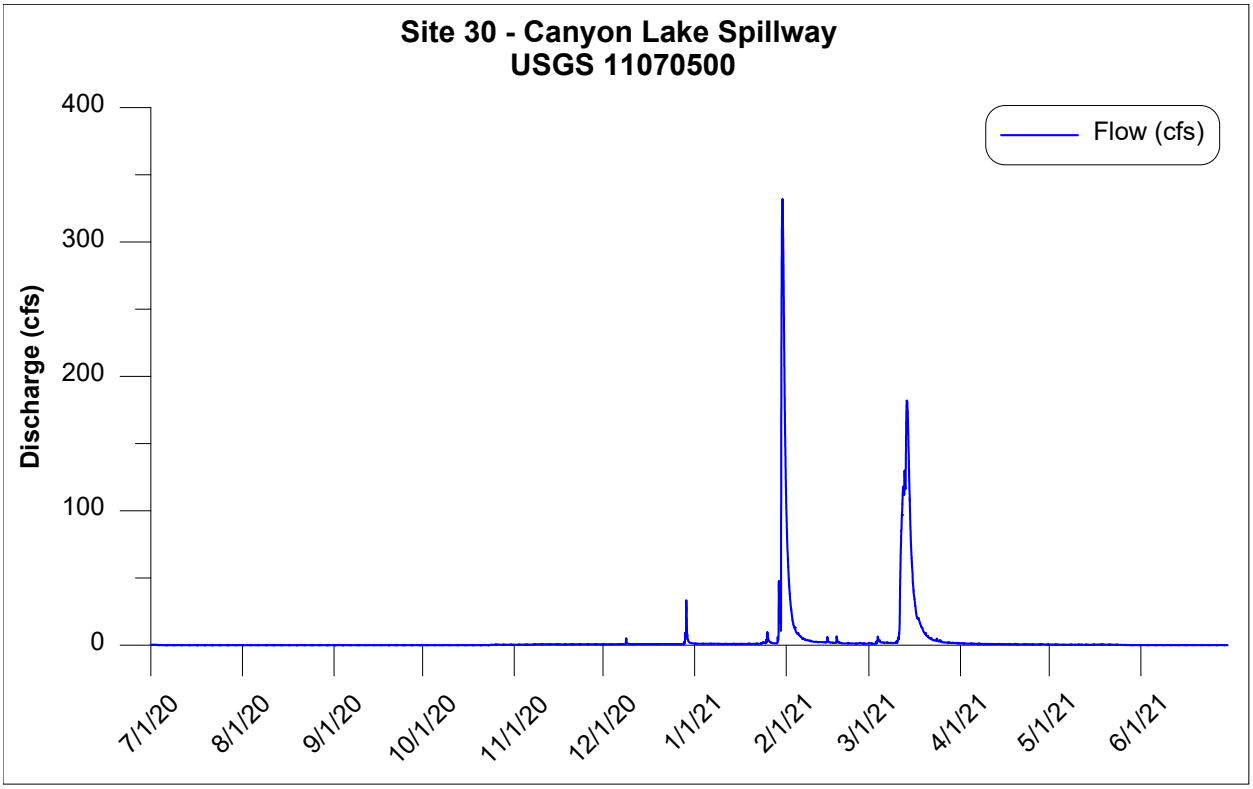


Figure 2-4. Site 30 – Canyon Lake Spillway – Daily Stream Gauge Records

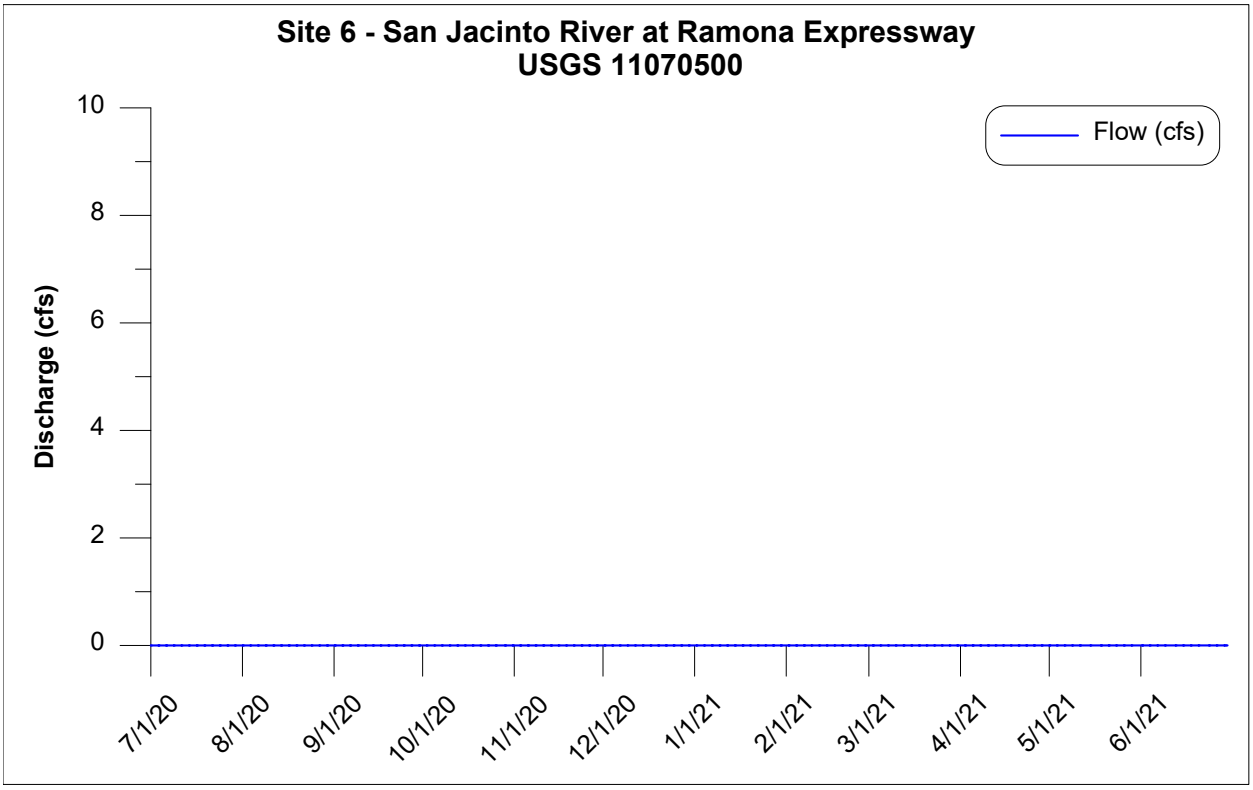


Figure 2-5. Site 6 – San Jacinto River at Ramona Expressway – Daily Stream Gauge Records

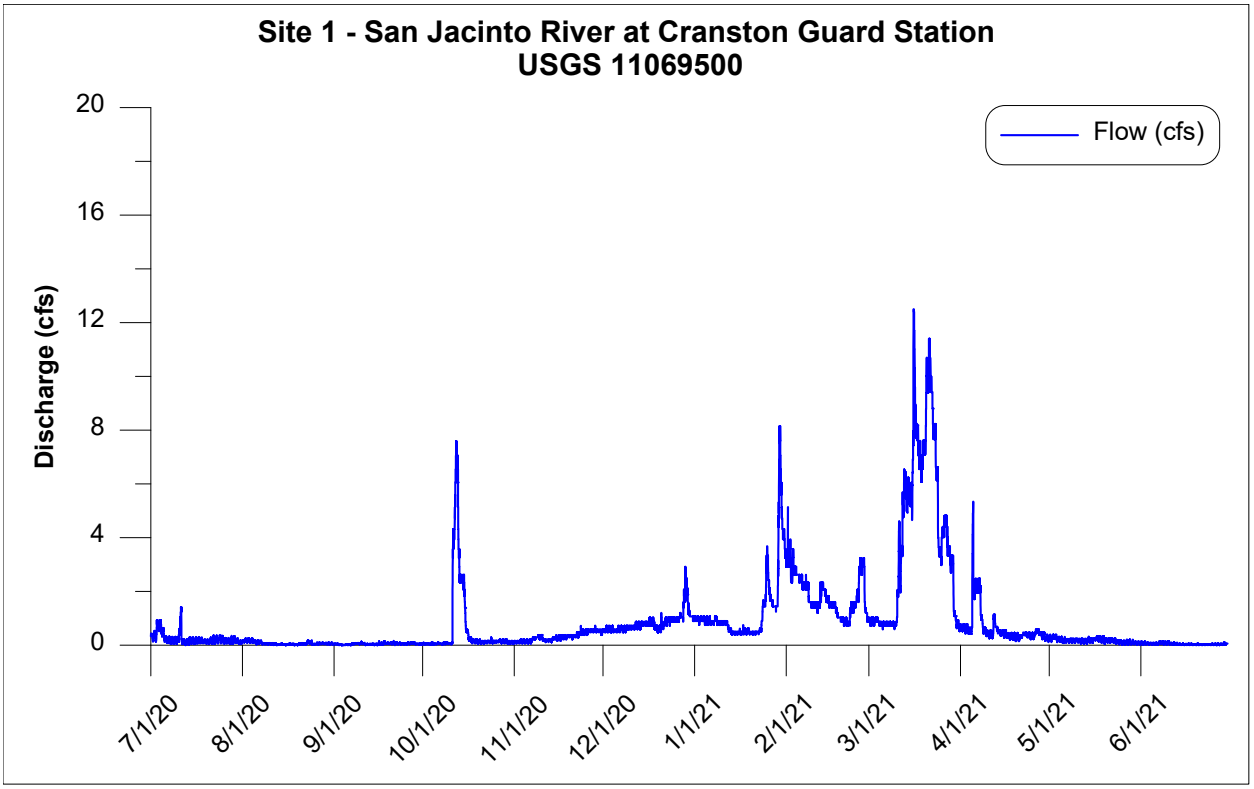


Figure 2-6. Site 1 – San Jacinto River at Cranston Guard Station – Daily Stream Gauge Records

2.6 Sampling Strategy

Phase II of the San Jacinto River Watershed Monitoring Program includes collecting water quality samples during two storm events at the designated monitoring stations throughout the San Jacinto River Watershed. Throughout the wet weather monitoring period from October 1, 2020 to May 31, 2021, 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 two 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 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 and Weck Laboratories Inc. located in Industry, California.

2.7 San Jacinto River Watershed Monitoring Events

For each station, except San Jacinto River at Ramona Expressway, water quality samples were collected during two storm events that met the mobilization criteria during the wet weather monitoring period from October 1, 2020 to May 31, 2021.

The first monitoring event occurred January 29, 2021 through February 1, 2021. 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 158 cubic feet per second (cfs) was recorded at Salt Creek at Murrieta Road (Station ID 745), a peak flow of 568 cfs was recorded at San Jacinto River at Goetz Road (Station ID 759), and a peak flow of 332 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 0.76 to 1.08 inches of rainfall was recorded in the region during this storm (RCFCWCD 2021).

The second monitoring event occurred March 10, 2021 through March 15, 2021. 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 71 cfs was recorded at Salt Creek at Murrieta Road (Station ID 745), a peak flow of 53 cfs was recorded at San Jacinto River at Goetz Road (Station ID 759), and a peak flow of 182 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 2.07 inches of rainfall was recorded in the region during this storm (RCFCWCD 2021).

Mass loads for each chemical constituent at each location were calculated as the product of the event mean concentrations and the storm volumes for each storm event. The annual loads were calculated as the sum of the 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.

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, 2020 through June 30, 2021, is presented below. The complete set of analytical laboratory report results is included in 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 two storm events at Salt Creek at Murrieta Road (Station ID 745) during the wet weather monitoring period from October 1, 2020 to May 31, 2021.

During the storm event on January 29, 2021 through January 31, 2021, a total of 33 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 278 acre-feet or 91 million gallons (Mgal), which represents approximately 36% of the total annual flow.

During the storm event on March 10, 2021 through March 12, 2021, a total of 25 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 168 acre-feet or 55 Mgal, which represents approximately 21% of the total annual flow.

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

Figure 2-7. Storm Event at Salt Creek at Murrieta Road (January 29-31, 2021)

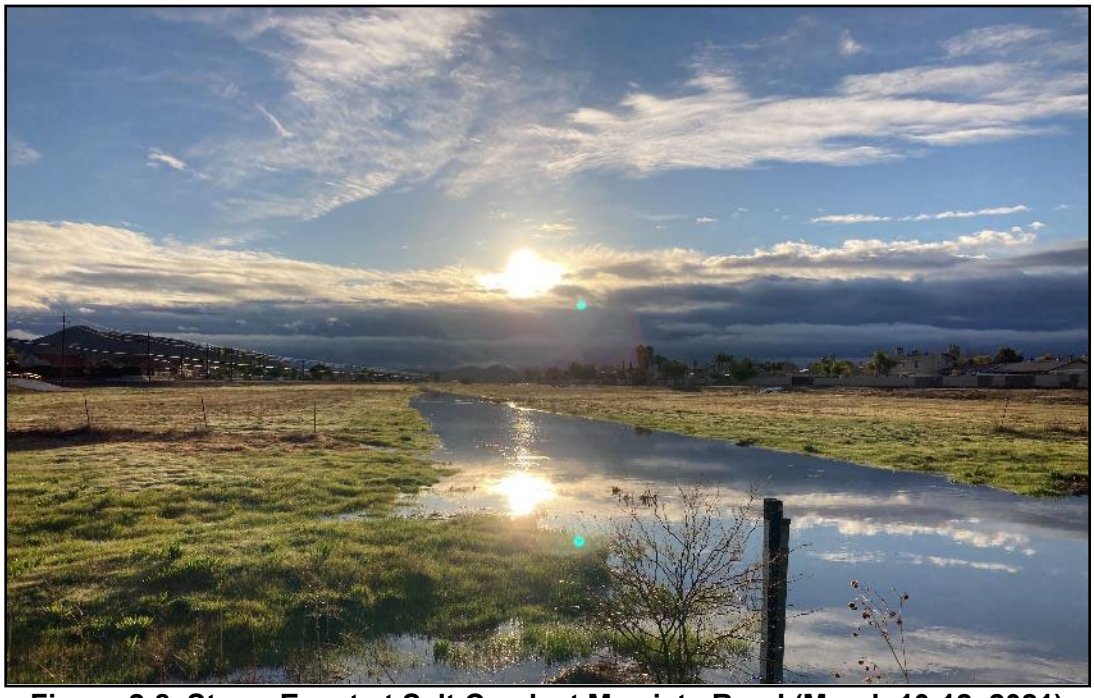


Figure 2-8. Storm Event at Salt Creek at Murrieta Road (March 10-12, 2021)

Event and annual mean concentrations for each analyte are presented in Table 2-7. Event and annual loads for each analyte are presented in Table 2-8. Concentrations for nutrients for the two storm events ranged from 1.4 to 2.4 milligrams per liter (mg/L) for total nitrogen, and 0.25 to 0.53 mg/L for total phosphorus (Table 2-7). Based on flow data provided by the nearby USGS stream gauge (Station ID 11070465), the total annual flow was estimated at 34,093,755 cubic feet (cf) or 255 Mgal for the period of July 1, 2020 through June 30, 2021. 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 estimated annual nutrient load was calculated to be 1,902 kg for total nitrogen and 396 kg for total phosphorus (Table 2-8) for the period of July 1, 2020 through June 30, 2021.

Table 2-7. Water Quality Concentrations at Salt Creek at Murrieta Road

Analyte	Units	Event 1	Event 2	Annual Mean	Annual Geomean
Ammonia-Nitrogen	mg/L	0.20	0.17	0.19	0.18
Chemical Oxygen Demand	mg/L	37.0	45.0	41.0	40.8
Kjeldahl Nitrogen	mg/L	1.80	0.92	1.36	1.29
Nitrate as N	mg/L	0.57	0.50	0.54	0.53
Nitrite as N	mg/L	ND (<0.09)	(0.019) J	0.00[a]	0.00[a]
Organic Nitrogen	mg/L	1.6	0.76	1.18	1.10
Total Nitrogen	mg/L	2.4	1.4	1.90	1.83
Total Phosphorus	mg/L	0.53	0.25	0.39	0.36
Ortho Phosphate Phosphorus	mg/L	0.21	0.16	0.19	0.18
Total Dissolved Solids	mg/L	440	240	340	325
Total Hardness	mg/L	170	89.5	130	123
Total Suspended Solids	mg/L	65.0	32.0	48.5	45.6

ND = not detected (analyte not detected at the indicated method detection limit (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 2-8. Water Quality Event and Annual Loads at Salt Creek at Murrieta Road

Analyte	Units	Load Event 1	Load Event 2	Annual Load
Ammonia-Nitrogen	kg	69	35	181
Chemical Oxygen Demand	kg	12,688	9,302	39,038
Kjeldahl Nitrogen	kg	617	190	1,373
Nitrate as N	kg	195	103	521
Nitrite as N	kg	0[a]	0[a]	0[a]
Organic Nitrogen	kg	549	157	1,196
Total Nitrogen	kg	823	289	1,902
Total Phosphorus	kg	182	52	396
Ortho Phosphate Phosphorus	kg	72	33	182
Total Dissolved Solids	kg	150,888	49,609	341,868
Total Hardness	kg	58,298	18,500	130,747
Total Suspended Solids	kg	22,290	6,615	49,071

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 2-9 and Figure 2-10. The figures were developed based on flow data provided by the nearby USGS stream gauge (Station ID 11070465).

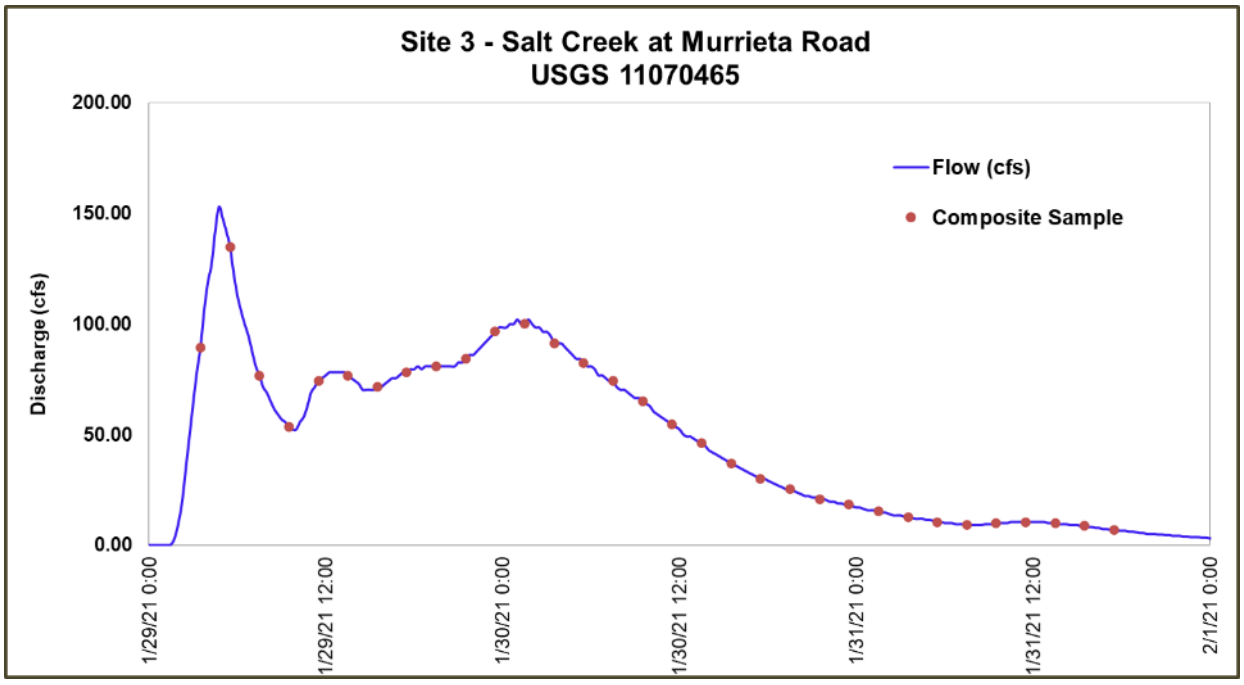


Figure 2-9. Hydrograph of First Storm Event at Salt Creek at Murrieta Road (January 29 -31, 2021)

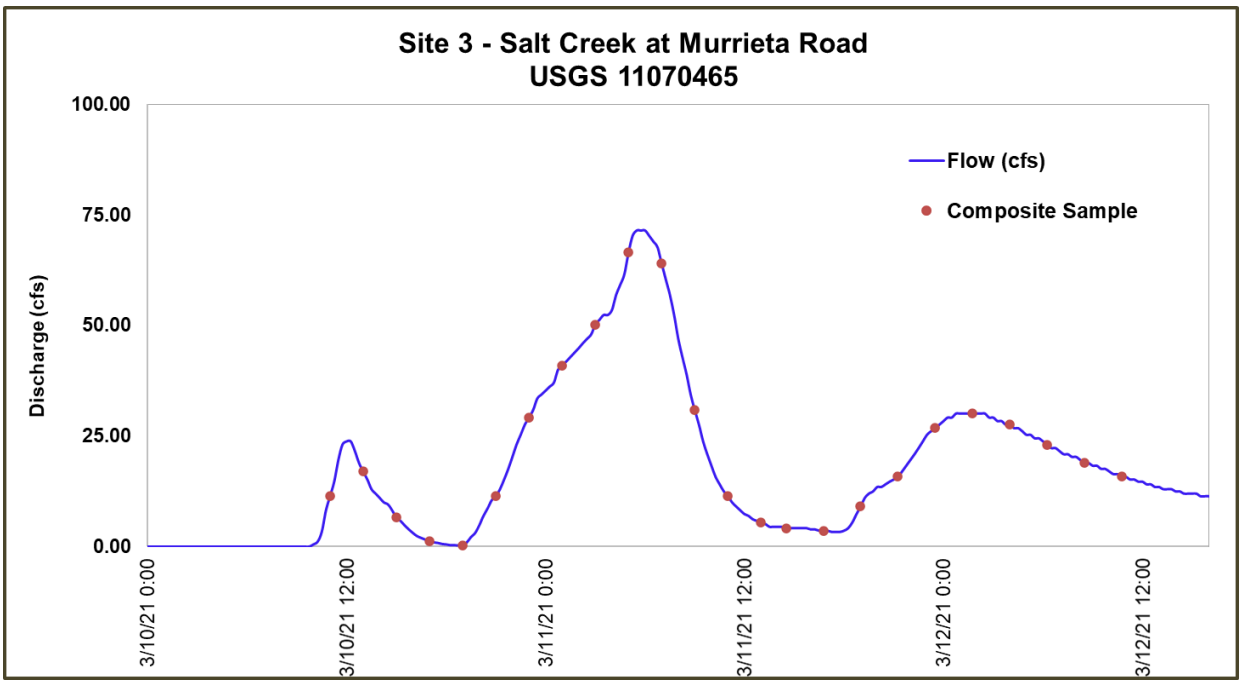


Figure 2-10. Hydrograph of Second Storm Event at Salt Creek at Murrieta Road (March 10 - 12, 2021)

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

Water quality samples were collected during two storm events at San Jacinto River at Goetz Road (Station ID 759) during the wet weather monitoring period from October 1, 2020 to May 31, 2021.

During the storm event on January 29, 2021 through January 31, 2021, a total of 29 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 817 acre-feet or 266 Mgal, which represents approximately 51% of the total annual flow.

During the storm event on March 10, 2021 through March 12, 2021, a total of 21 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 325 acre-feet or 106 Mgal, which represents approximately 20% of the total annual flow.

Photos taken during the storm events are provided in Figure 2-11 and Figure 2-12.

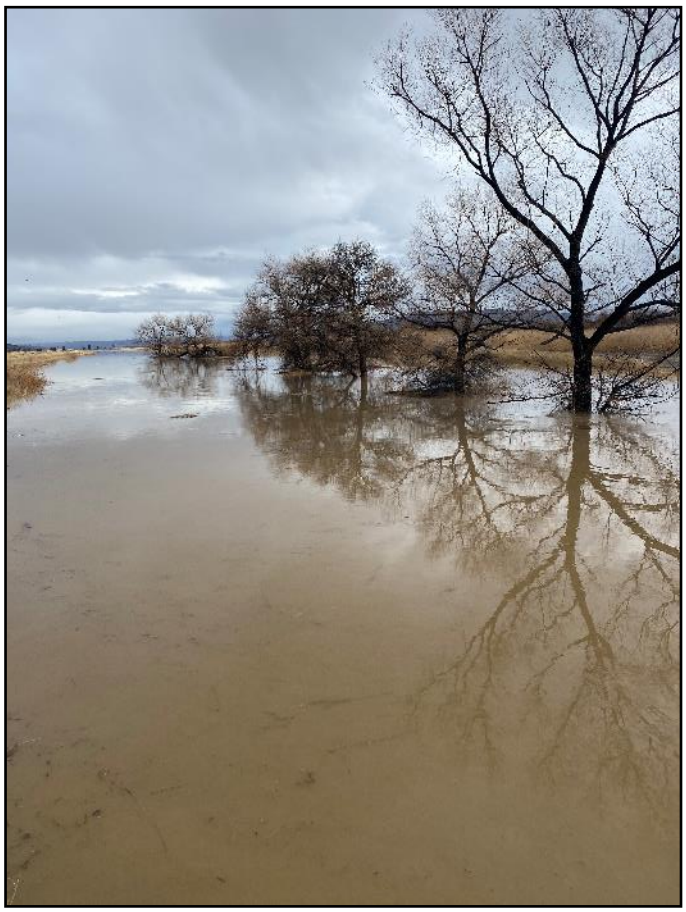


Figure 2-11. Storm Event at San Jacinto River at Goetz Road (January 29 - 31, 2021)

Figure 2-12. Storm Event at San Jacinto River at Goetz Road (March 10 - 12, 2021)

Event and annual mean concentrations for each analyte are presented in Table 2-9. Event and annual loads for each analyte are presented in Table 2-10. Concentrations for nutrients for the two storm events ranged from 1.8 to 2.0 mg/L for total nitrogen, and 0.40 to 0.56 mg/L for total phosphorus (Table 2-9). Based on flow data provided by the nearby USGS stream gauge (Station ID 11070365), the total annual flow was estimated at 69,394,095cf or 519 Mgal for the period of July 1, 2020 through June 30, 2021. 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 estimated annual nutrient load was calculated to be 3,794 kg for total nitrogen and 992 kg for total phosphorus (Table 2-10) for the period of July 1, 2020 through June 30, 2021.

Table 2-9. Water Quality Concentrations at San Jacinto River at Goetz Road

Analyte	Units	Event 1	Event 2	Annual Mean	Annual Geomean
Ammonia-Nitrogen	mg/L	(0.08) J	0.20	0.14	0.13
Chemical Oxygen Demand	mg/L	160	40	100	80.0
Kjeldahl Nitrogen	mg/L	1.4	0.93	1.17	1.14
Nitrate as N	mg/L	0.60	0.90	0.75	0.73
Nitrite as N	mg/L	ND (<0.09)	(0.039) J	0.02[a]	0.00[a]
Organic Nitrogen	mg/L	1.3	0.72	1.01	0.97
Total Nitrogen	mg/L	2.0	1.8	1.90	1.90
Total Phosphorus	mg/L	0.56	0.40	0.48	0.47
Ortho Phosphate Phosphorus	mg/L	0.17	0.22	0.20	0.19
Total Dissolved Solids	mg/L	120	170	145	143
Total Hardness	mg/L	85.0	74.3	79.7	79.5
Total Suspended Solids	mg/L	170	72	121	111

ND = not detected (analyte not detected at the indicated method detection limit (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 2-10. Water Quality Event and Annual Loads at San Jacinto River at Goetz Road

Analyte	Units	Load Event 1	Load Event 2	Annual Load
Ammonia-Nitrogen	kg	81	80	239
Chemical Oxygen Demand	kg	161,230	16,035	232,912
Kjeldahl Nitrogen	kg	1,411	373	2,432
Nitrate as N	kg	605	361	1,383
Nitrite as N	kg	0[a]	16	26
Organic Nitrogen	kg	1,310	289	2,161
Total Nitrogen	kg	2,015	722	3,794
Total Phosphorus	kg	564	160	992
Ortho Phosphate Phosphorus	kg	171	88	368
Total Dissolved Solids	kg	120,923	68,147	269,758
Total Hardness	kg	85,654	29,784	159,760
Total Suspended Solids	kg	171,307	28,862	267,502

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 2-13 and Figure 2-14. The figure was developed based on flow data provided by the nearby USGS stream gauge (Station ID 11070365).

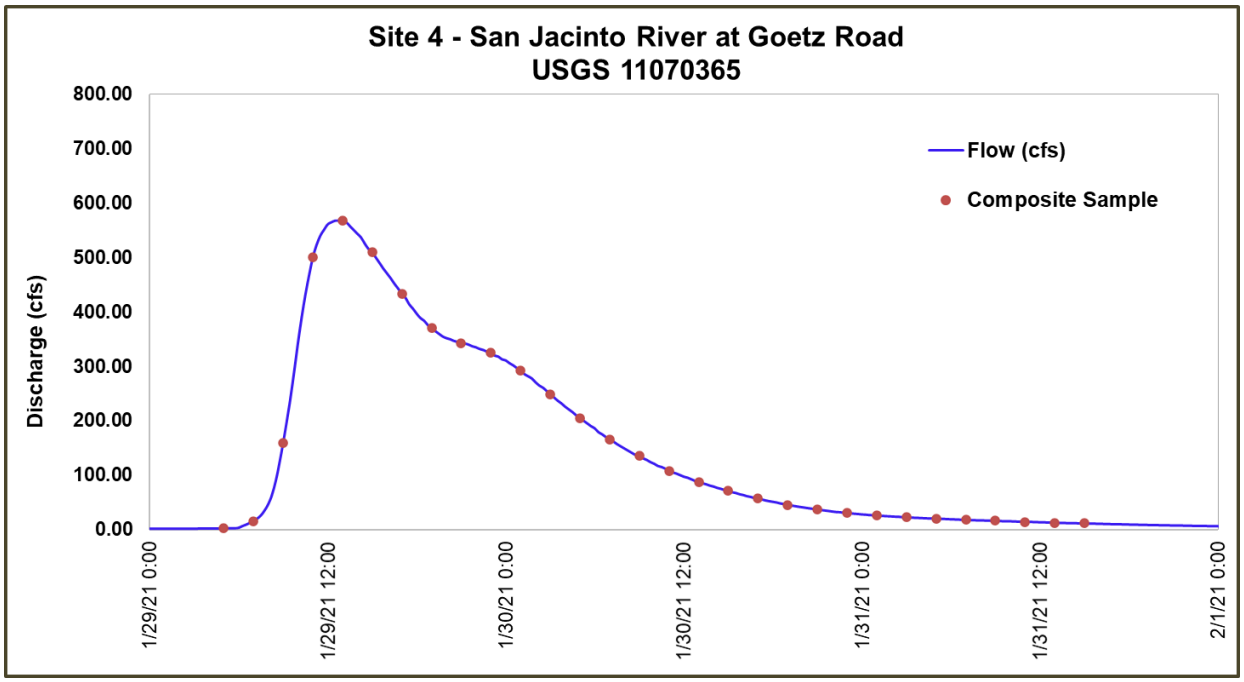


Figure 2-13. Hydrograph of First Storm Event at San Jacinto River at Goetz Road (January 29-31, 2021)

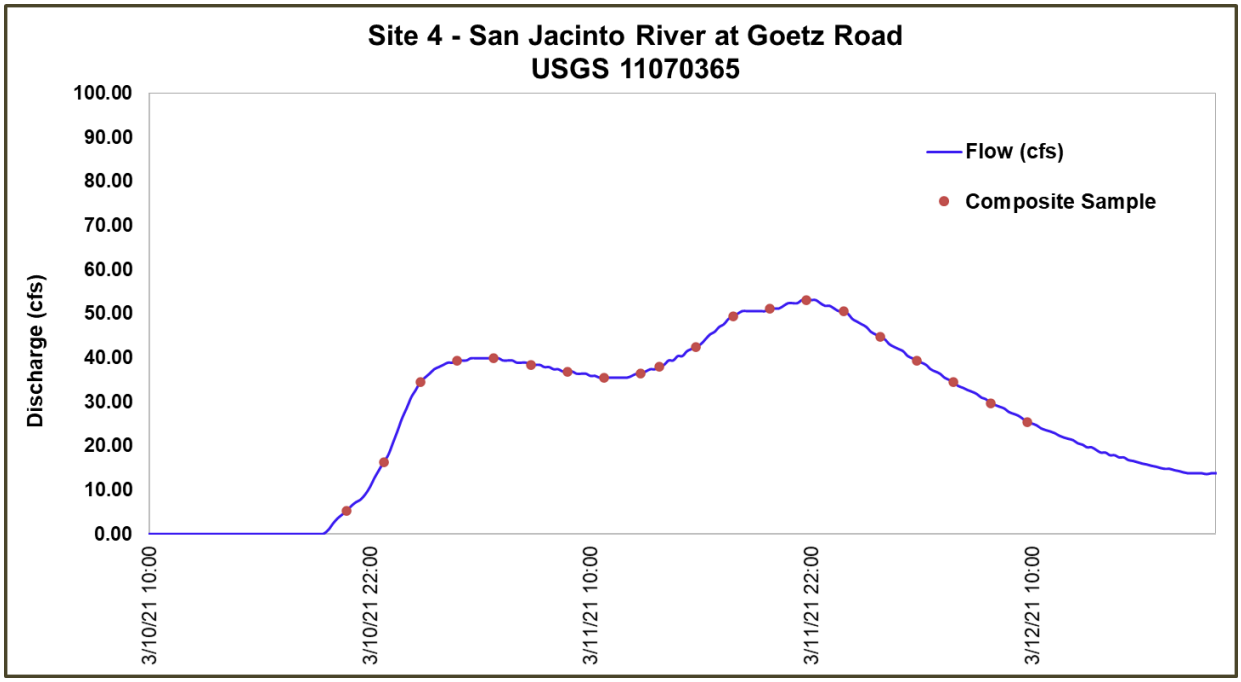


Figure 2-14. Hydrograph of Second Storm Event at San Jacinto River at Goetz Road (March 10 - 12, 2021)

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, 2020 to May 31, 2021. No flows were observed, and no samples were collected from the sampling station at San Jacinto River at Ramona Expressway (Station ID 741) during the 2020-2021 monitoring year.

2.8.4 Summary of Monitoring Data – Canyon Lake Spillway

Water quality samples were collected during two storm events at Canyon Lake Spillway (Station ID 841) during the wet weather monitoring period from October 1, 2020 to May 31, 2021.

During the storm event on January 29, 2021 through February 1, 2021, a total of 31 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 1,142 acre-feet or 372 Mgal, which represents approximately 42% of the total annual inflow to Lake Elsinore from Canyon Lake.

During the storm event on March 10, 2021 through March 15, 2021, a total of 42 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 1,192 acre-feet or 388 Mgal, which represents approximately 44% 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 2-15 and Figure 2-16.

Figure 2-15. Storm Event Sampling Below the Canyon Lake Spillway (March 10 - 15, 2021)

Figure 2-16. Canyon Lake Spillway (March 10 - 15, 2021)

Event and annual mean concentrations of each analyte are presented in Table 2-11. Event and annual loads for each analyte are presented in Table 2-12. Concentrations of nutrients for the two storm events ranged from 1.3 to 2.1 mg/L for total nitrogen, and 0.036 to 0.07 mg/L for total phosphorus (Table 2-11). Based on flow data provided by the nearby USGS stream gauge (Station ID 11070500), the total annual flow was estimated at 117,374,904 cf or 878 Mgal for the period of July 1, 2020 through June 30, 2021. 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 estimated annual nutrient load was calculated to be 5,626 kg for total nitrogen and 175 kg for total phosphorus (Table 2-12) for the period of July 1, 2020 through June 30, 2021.

Table 2-4. Water Quality Concentrations at Canyon Lake Spillway

Analyte	Units	Event 1	Event 2	Annual Mean	Annual Geomean
Ammonia-Nitrogen	mg/L	0.50	0.28	0.390	0.37
Chemical Oxygen Demand	mg/L	37.0	19.0	28.0	26.5
Kjeldahl Nitrogen	mg/L	1.7	0.9	1.30	1.24
Nitrate as N	mg/L	0.41	0.38	0.40	0.39
Nitrite as N	mg/L	ND (<0.09)	(0.023) J	0.012[a]	0.00[a]
Organic Nitrogen	mg/L	1.2	0.62	0.90	0.86
Total Nitrogen	mg/L	2.1	1.3	1.70	1.65
Total Phosphorus	mg/L	0.07	0.036	0.05	0.05
Ortho Phosphate Phosphorus	mg/L	ND (<0.030)	0.018	0.009[a]	0.00[a]
Total Dissolved Solids	mg/L	430	490	460	459
Total Hardness	mg/L	230	233	232	232
Total Suspended Solids	mg/L	2.0	ND (<5.0)	1.0	0.0

ND = not detected (analyte not detected at the indicated method detection limit (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 2-5. Water Quality Event and Annual Loads at Canyon Lake Spillway

Analyte	Units	Load Event 1	Load Event 2	Annual Load
Ammonia-Nitrogen	kg	705	412	1,289
Chemical Oxygen Demand	kg	52,138	27,946	92,508
Kjeldahl Nitrogen	kg	2,396	1,324	4,296
Nitrate as N	kg	578	559	1,312
Nitrite as N	kg	0[a]	34	39
Organic Nitrogen	kg	1,691	912	3,007
Total Nitrogen	kg	2,959	1,912	5,626
Total Phosphorus	kg	99	53	175
Ortho Phosphate Phosphorus	kg	0[a]	26	30
Total Dissolved Solids	kg	605,925	720,701	1,530,747
Total Hardness	kg	324,099	342,701	769,526
Total Suspended Solids	kg	2,818	-	3,262

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 2-17 and Figure 2-18. 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 2-19.

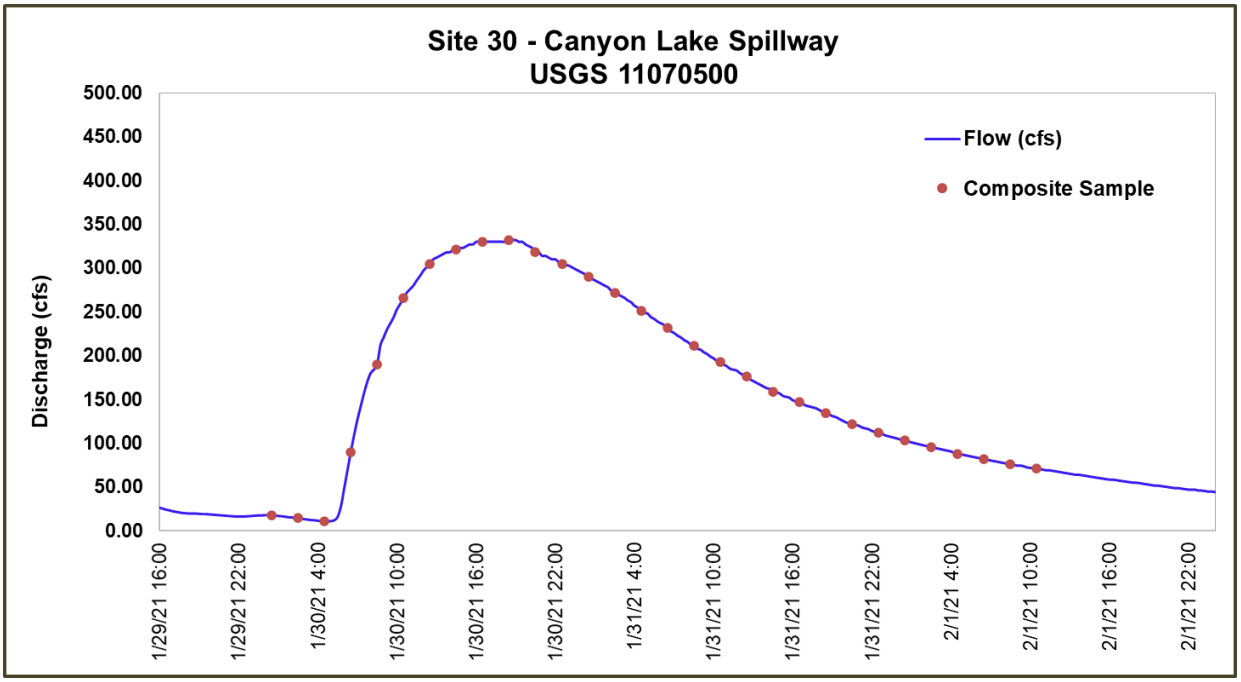


Figure 2-17. Hydrograph of First Storm Event at Canyon Lake Spillway (January 29-February 1, 2021)

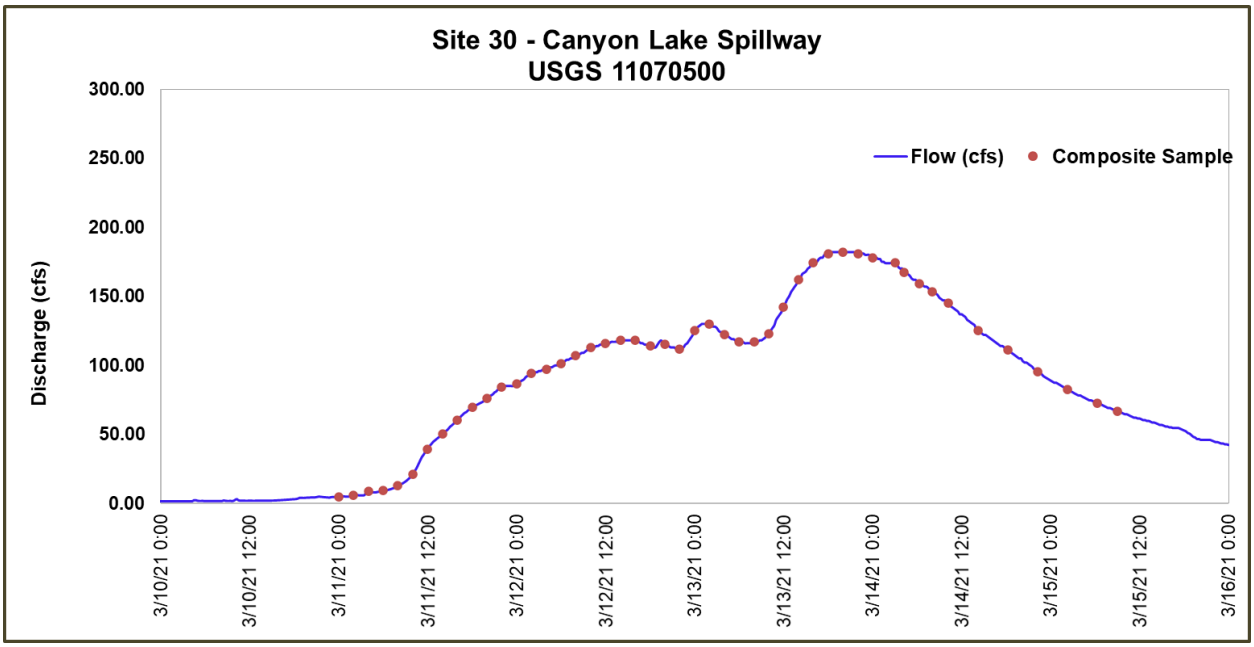


Figure 2-18. Hydrograph of Second Storm Event at Canyon Lake Spillway (March 10-15, 2021)

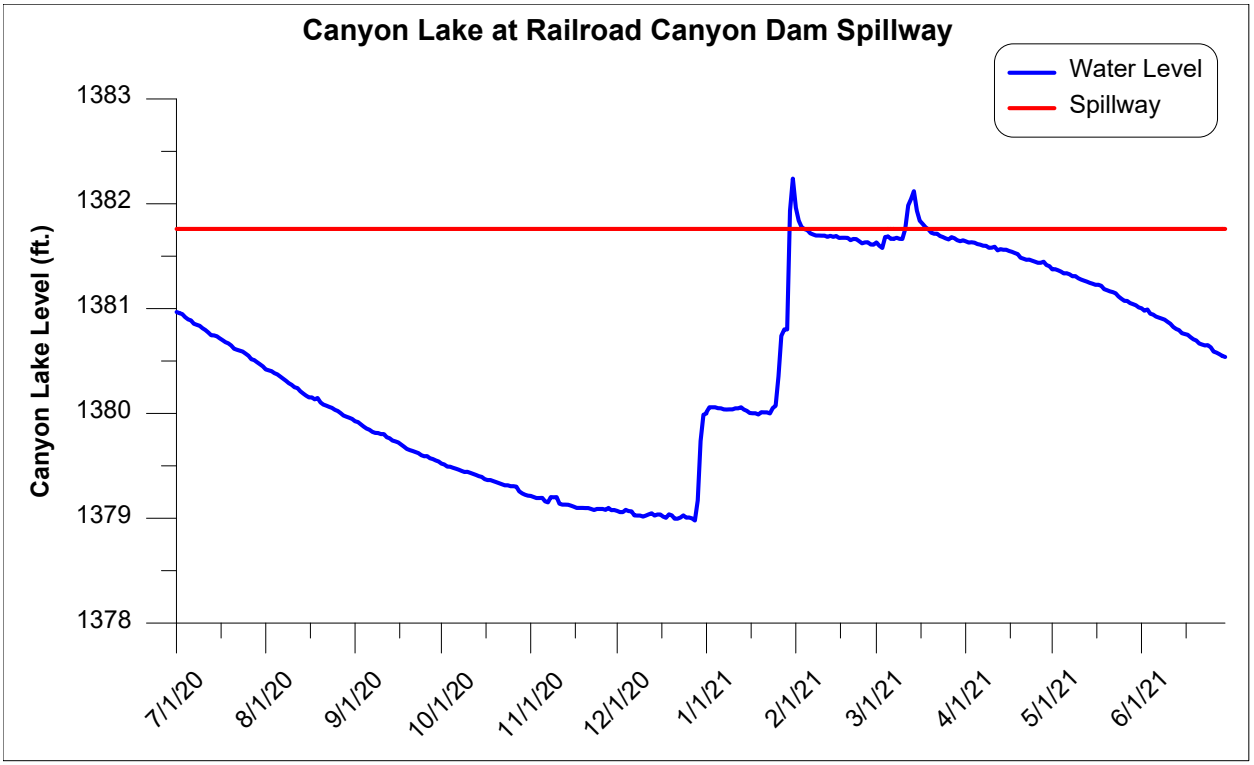


Figure 2-19. Canyon Lake Level at Railroad Canyon Dam Spillway

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 2-13.

Table 2-6. 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, 2020, through June 30, 2021, are summarized in Table 2-14.

Table 2-7. Summary Rainfall Data (July 2020 to June 2021)

Monthly Rainfall (inches)	Lake Elsinore	Perris CDF	Pigeon Pass	Hemet / San Jacinto	Winchester
Jul	0.00	0.00	0.00	0.00	0.00
Aug	0.00	0.00	0.00	0.04	0.00
Sep	0.00	0.00	0.00	0.00	0.00
Oct	0.00	0.00	0.00	0.00	0.00
Nov	0.35	0.10	0.30	0.37	0.20
Dec	1.08	0.88	1.59	1.50	1.31
Jan	1.52	1.71	2.42	2.06	1.76
Feb	0.04	0.04	0.02	0.12	0.07
Mar	1.30	1.77	2.35	1.30	1.56
Apr	0.00	0.02	0.02	0.09	0.25
May	0.00	0.00	0.02	0.01	0.00
Jun	0.01	0.00	0.09	0.02	0.16
Annual Rainfall (inches)	**4.30**	**4.53**	**6.81**	**5.50**	**5.31**

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 2020-2021 FY.

3.2 Historical In-Lake Monitoring Concentrations

A summary of the historical calendar year annual means for TMDL water quality monitoring data parameters of interest during the period of July 1, 2012 through June 30, 2021 (10-year mean), is presented in Tables 3-1 and 3-2 for Lake Elsinore and Tables 3-3 and 3-4 for Canyon Lake.

Table 3-1. Summary of Historical TMDL Data for Lake Elsinore Based on Calendar Year

Parameter	2020 TMDL Target	Calendar Year	Number of Samples Collected	Annual Average	Units	2011-2020 Ten Year Average (Percent of Annual Means Not Meeting TMDL Target)	2012-2021 Ten Year Average[a] (Percent of Annual Means Not Meeting TMDL Target)
Total Phosphorus	<0.1 mg/L (Annual Average)	2011	14	**0.294**	mg/L	0.246 (100%)	0.242 (100%)
		2012	9	**0.162**			
		2013	NA	NA			
		2014	NA	NA			
		2015	3	**0.383**			
		2016	8	**0.416**			
		2017	8	**0.181**			
		2018	8	**0.162**			
		2019	8	**0.154**			
		2020	8	**0.219**			
		2021	3	**0.260**			
Total Nitrogen	<0.75 mg/L (Annual Average)	2011	14	**3.88**	mg/L	4.91 (100%)	4.87 (100%)
		2012	9	**3.32**			
		2013	NA	NA			
		2014	NA	NA			
		2015	3	**6.10**			
		2016	8	**7.28**			
		2017	8	**4.68**			
		2018	8	**5.56**			
		2019	8	**4.50**			
		2020	8	**3.99**			
		2021	3	**3.53**			
Total Ammonia	CMC: 0.447-2.45; CCC: 0.112-0.856	2011	15	0.049	mg/L	0.143 (2004- CMC: 0%; CCC: 50%)	0.158 (2004- CMC: 0%; CCC: 50%)
	CMC: 0.749-2.52; CCC: 0.192-0.880	2012	9	**0.096**			
	NA	2013	NA	NA			
	NA	2014	NA	NA			
	CMC: 1.28-1.69; CCC: 0.273-0.473	2015	3	**0.357**			
	CMC: 0.671-1.91; CCC: 0.150-0.683	2016	8	**0.176**			
	CMC: 0.832-2.65; CCC: 0.186-0.450	2017	8	0.124			
	CMC: 1.14-2.20; CCC: 0.283-0.524	2018	8	0.097			
	CMC: 0.940-5.10; CCC: 0.201-1.63	2019	8	**0.300**			
	CMC: 0.916-2.81; CCC: 0.170-0.791	2020	8	**0.312**			
	CMC: 1.56-2.7; CCC: 0.327-0.935	2021	3	0.170			

Table 3-2. Summary of Historical TMDL Data for Lake Elsinore Based on Calendar Year

Parameter	2020 TMDL Target	Calendar Year	Number of Samples Collected	Annual Average	Units	2011-2020 Ten Year Average (Percent of Annual Means Not Meeting TMDL Target)	2012-2021 Ten Year Average[a] (Percent of Annual Means Not Meeting TMDL Target)
Depth-Integrated Chlorophyll-a (Summer)	≤ 25 mg/L (Summer Average)	2011	8	**169**	µg/L	186 (100%)	184 (100%)
		2012	2	**200**			
		2013	NA	NA			
		2014	NA	NA			
		2015	1	**326**			
		2016	4	**258**			
		2017	4	**148**			
		2018	4	**87**			
		2019	4	**89**			
		2020	2	**212**			
		2021	1	**150**			
Dissolved Oxygen (1-m from lake bottom)	>5 mg/L 1-m from lake bottom	2011	15	**3.4**	mg/L	3.7 (100%)	3.7 (100%)
		2012	8	**4.8**			
		2013	NA	NA			
		2014	NA	NA			
		2015	3	**2.9**			
		2016	8	**4.2**			
		2017	8	**4.9**			
		2018	8	**3.2**			
		2019	8	**3.3**			
		2020	8	**2.8**			
		2021	3	**3.4**			

Table 3-3. Summary of Historical TMDL Data for Canyon Lake Based on Calendar Year

Parameter	2020 TMDL Target	Calendar Year	Number of Sampling Events	Annual Average	Units	2011-2020 Ten Year Average (Percent of Annual Means Not Meeting TMDL Target)	2012-2021 Ten Year Average[a] (Percent of Annual Means Not Meeting TMDL Target)
Total Phosphorus	<0.1 mg/L (Annual Average)	2011	15	**0.846**	mg/L	0.242 (70%)	0.168 (70%)
		2012	8	**0.346**			
		2013	2	**0.266**			
		2014	15	**0.246**			
		2015	7	0.084			
		2016	7	0.085			
		2017	6	**0.237**			
		2018	6	0.038			
		2019	6	**0.144**			
		2020	6	**0.133**			
		2021	3	**0.102**			
Total Nitrogen	<0.75 mg/L (Annual Average)	2011	15	**1.64**	mg/L	1.60 (80%)	1.59 (80%)
		2012	8	**2.43**			
		2013	NA	NA			
		2014	NA	NA			
		2015	3	**1.50**			
		2016	7	**1.47**			
		2017	6	**1.30**			
		2018	6	**1.37**			
		2019	6	**1.50**			
		2020	6	**1.62**			
		2021	3	**1.54**			
Total Ammonia	2004- CMC: 0.58-5.73; CCC: 0.11-1.79	2011	14	**0.672**	mg/L	0.422 (CMC: 12.5%; CCC: 37.5%)	0.413 (CMC: 0%; CCC: 25%)
	2004- CMC: 1.12-11.10; CCC: 0.19-2.99	2012	8	0.168			
	NA	2013	NA	NA			
	NA	2014	NA	NA			
	2004- CMC: 2.97-28.7; CCC: 0.718-5.31	2015	3	0.455			
	2004- CMC: 1.98-21.2; CCC: 0.486-3.17	2016	7	0.236			
	2004- CMC: 3.13-23.4; CCC: 0.515-3.69	2017	6	0.297			
	2004- CMC: 4.06-23.8; CCC: 1.24-3.33	2018	6	0.346			
	2004- CMC: 3.56-29.5; CCC: 0.680-5.39	2019	6	0.471			
	2004- CMC: 1.88-25.8; CCC: 0.378-5.03	2020	6	**0.733**			
	2004- CMC: 2.60-19.9; CCC: 0.904-4.36	2021	3	0.598			

Table 3-4. Summary of Historical TMDL Data for Canyon Lake Based on Calendar Year

Parameter	2020 TMDL Target	Calendar Year	Number of Sampling Events	Annual Average	Units	2011-2020 Ten Year Average (Percent of Annual Means Not Meeting TMDL Target)	2012-2021 Ten Year Average[a] (Percent of Annual Means Not Meeting TMDL Target)
Depth-Integrated Chlorophyll-a	< 25 µg/L (Annual Average)	2011	15	**59.1**	µg/L	44.3 (80%)	40.5 (70%)
		2012	8	**76.3**			
		2013	2	**59.6**			
		2014	15	**56.4**			
		2015	3	**60.2**			
		2016	7	**29.7**			
		2017	6	**29.4**			
		2018	6	**27.9**			
		2019	6	21.6			
		2020	6	22.7			
		2021	3	21.1			
Dissolved Oxygen (Hypolimnion)	>5 mg/L Hypolimnion (Daily Average)	2011	11	**0.3**	mg/L	0.9 (100%)	0.9 (100%)
		2012	6	0.8			
		2013	NA	NA			
		2014	NA	NA			
		2015	3	**4.0**			
		2016	7	**1.3**			
		2017	5	**0.3**			
		2018	5	**0.4**			
		2019	4	**0.2**			
		2020	3	**0.0**			
		2021	2	**0.3**			

3.3 Lake Elsinore Monitoring

3.3.1 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 3-5). Analytical chemistry samples and in-situ water column profile readings were collected at Site LE02, while only in-situ water column 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 3-6. 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).

Table 3-5. Lake Elsinore TMDL Monitoring Locations

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

Table 3-6. 2020-2021 In-lake Analytical Constituents and Methods for Lake Elsinore

Parameter	Analysis Method	Sampling Method
Analytical Chemistry		
Nitrite Nitrogen (NO_2-N)	EPA 353.2	Depth Integrated
Nitrate Nitrogen (NO_3-N)	EPA 353.2	Depth Integrated
Total Kjeldahl Nitrogen (TKN)	EPA 351.2	Depth Integrated
Total Nitrogen (TN)[1]	Calculated	Depth Integrated
Ammonia Nitrogen (NH4-N)	EPA 350.1	Depth Integrated
Sulfide	SM 4500S2 D	Depth Integrated
Total Phosphorus (TP)	EPA 365.3	Depth Integrated
Soluble Reactive Phosphorus (SRP / Ortho-P)	EPA 365.3, EPA 353.2	Depth Integrated
Chlorophyll-a	SM 10200H	Surface (0-2m) & Depth Integrated
Total Dissolved Solids (TDS)	SM 2540 C	Depth Integrated

US EPA - United States Environmental Protection Agency; m- meter; SM- standard method[1] Total Nitrogen calculated as TKN+NO_2+NO_3

Figure 3-1. Lake Elsinore Sampling Locations

3.3.2 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 Weck Laboratories Inc., located in City of Industry, 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 in-situ 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 at the water surface. 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.

3.3.3 Water Quality Summary

A summary of the in-lake monitoring events for Lake Elsinore for the period of July 1, 2020 to June 30, 2021 is presented below. A total of eight Lake Elsinore events were sampled during this period under the TMDL monitoring program, with five occurring in 2020 (July 28, August 13, September 14, October 5 and December 9) and three in 2021 (February 17, April 8 and June 2). Complete monthly water column profiles can be found in Appendix B. Detailed analytical chemistry in-lake lab reports for each event are contained in Appendix C. Satellite imagery reports for each event are provided in Appendix D. Current data in the context of historical water quality monitoring results from 2002-present are presented in Appendix E.

A summary of mean water column profile values for each site and monitoring event are presented in Tables 3-7 and 3-8. Water column mean profile statistics for each site across the entire monitoring period are presented in Table 3-9. Mean values for water column measurements for each site, as well as the lake-wide mean are also summarized graphically in Figures 3-3 through 3-8. The measurements during the morning and afternoon of any given monitoring event were averaged prior to summarizing in the tables and figures below.

Table 3-7. In-Situ Water Quality Parameter Measurements in Lake Elsinore – 2020 Monthly Means for Each Site (July – Dec 2020)

Site	Measure	Jul-20		Aug-20		Sep-20		Oct-20		Dec-20	
		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)	26.7	26.2	27.3	26.8	25.3	25.1	24.8	24.5	13.1	12.9
	Cond (µS/cm)	3143	3143	3197	3196	3315	3315	3360	3358	3466	3478
	pH	*9.17*	*9.08*	*8.83*	*8.73*	*8.55*	8.50	*8.82*	*8.74*	*8.67*	*8.63*
	DO (mg/L)	5.0	**2.2**	2.7	**0.3**	1.9	**0.9**	3.4	**1.4**	5.9	**4.9**
LE02	Temp (°C)	26.6	26.3	27.2	26.7	25.4	25.2	24.8	24.6	13.1	13.0
	Cond (µS/cm)	3145	3144	3198	3195	3314	3315	3358	3358	3484	3486
	pH	*9.19*	*9.12*	*8.84*	*8.74*	*8.56*	*8.47*	*8.76*	*8.70*	*8.69*	*8.67*
	DO (mg/L)	4.4	**2.6**	2.5	**0.1**	2.0	**0.3**	2.4	**0.8**	5.3	**4.7**
LE03	Temp (°C)	26.8	26.2	27.4	26.8	25.5	25.3	25.1	24.8	13.3	13.2
	Cond (µS/cm)	3145	3146	3199	3197	3314	3314	3357	3358	3472	3471
	pH	*9.13*	*9.01*	*8.76*	*8.73*	*8.59*	*8.53*	*8.81*	*8.74*	*8.74*	*8.72*
	DO (mg/L)	2.8	**0.2**	1.7	**0.1**	3.3	**1.7**	3.5	**2.0**	6.1	5.5
Lake-wide Average	Temp (°C)	26.7	26.2	27.3	26.8	25.4	25.2	24.9	24.6	13.2	13.0
	Cond (µS/cm)	3144	3144	3198	3196	3314	3314	3358	3358	3474	3478
	pH	*9.16*	*9.07*	*8.81*	*8.73*	*8.56*	8.50	*8.79*	*8.73*	*8.70*	*8.67*
	DO (mg/L)	4.1	**1.6**	2.3	**0.2**	2.4	**1.0**	3.1	**1.4**	5.7	5.0

Notes:
°C = degrees Celsius; µS/cm = microSiemens per centimeter; m= meter; mg/L = milligrams per liter
2020 TMDL target for Dissolved Oxygen (DO) is no less than 5 mg/L in bottom 1m of sampling site
Bold Underline - Indicates exceedance of 2020 TMDL target
Italicize – Indicates exceedance of Basin Plan WQO

Table 3-8. In-Situ Water Quality Parameter Measurements in Lake Elsinore – 2021 Monthly Means for Each Site (February – June 2021)

Site	Measure	Feb-21		Apr-21		Jun-21		2020-2021 FY Mean	
		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)	13.2	13.1	18.2	18.0	23.5	22.6	21.5	21.1
	Cond (µS/cm)	3319	3318	3308	3308	3462	3463	3321	3322
	pH	*8.70*	*8.65*	*8.93*	*8.89*	*8.91*	*8.79*	*8.82*	*8.75*
	DO (mg/L)	9.0	8.6	7.7	6.5	7.5	**3.5**	5.4	**3.5**
LE02	Temp (°C)	12.9	12.9	17.8	15.9	23.6	22.2	21.4	20.8
	Cond (µS/cm)	3322	3324	3303	3300	3462	3459	3323	3322
	pH	*8.59*	*8.57*	*8.87*	*8.61*	*8.90*	*8.75*	*8.80*	*8.70*
	DO (mg/L)	8.0	7.9	6.3	**0.2**	7.1	**2.1**	4.7	**2.3**
LE03	Temp (°C)	13.1	13.0	18.2	17.4	23.6	22.7	21.6	21.2
	Cond (µS/cm)	3322	3324	3301	3303	3458	3456	3321	3321
	pH	*8.63*	*8.59*	*8.89*	*8.78*	*8.93*	*8.85*	*8.81*	*8.74*
	DO (mg/L)	8.4	7.8	6.6	**3.2**	8.6	**4.9**	5.1	**3.2**
Lake-wide Mean	Temp (°C)	13.1	13.0	18.1	17.1	23.5	22.5	21.5	21.0
	Cond (µS/cm)	3321	3322	3304	3304	3461	3459	3322	3322
	pH	*8.64*	*8.60*	*8.90*	*8.76*	*8.91*	*8.80*	*8.81*	*8.73*
	DO (mg/L)	8.5	8.1	6.9	**3.3**	7.7	**3.5**	5.1	**3.0**

Notes:
°C = degrees Celsius; µS/cm = microSiemens per centimeter; m= meter; mg/L = milligrams per liter
2020 TMDL target for Dissolved Oxygen (DO) is no less than 5 mg/L in bottom 1m of sampling site
Bold Underline - Indicates exceedance of 2020 TMDL target
Italicize – Indicates exceedance of Basin Plan WQO

Regular differences in morning and afternoon water column mean measurements were noted across all monitoring events, with consistent increases in pH (up to 0.1 standard units (SU)), DO (up to 3.3 mg/L), and temperature (up to 1.3 °C increase), while specific conductivity remained stable. These increases were more 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). Historical Lake Elsinore data shows that the average lake-wide annual temperature during this monitoring year was the highest observed over the last 19 years of record when including data from complete monitoring years July to June (i.e., temperature data available for each month of the monitoring year[2]). Lake water temperature correlated well with ambient air temperature, as the annual mean of daily high air temperature exhibited a good relationship with annual mean lake surface water temperature (Figure 3-2). Generally, the greatest DO concentrations throughout the water column (both water column mean and 1-meter from bottom) were observed in February at all three sites. One exception to this was the highest water column mean for LE03 observed in June 2021. Concentrations of DO near the bottom, while lower, generally tracked with the overall water column mean for all three sites. While all three sites exhibited a divergence in water column mean and 1-meter from bottom DO beginning in April 2021, the 1-m from the bottom DO reading dropped dramatically at Site LE02. Site LE02 is located in the deepest portion of the lake and would be expected to have a larger hypolimnion with low DO than other portions of the lake. These diverging measurements indicate that the lake was starting to stratify, further supported by the concurrent increased temperatures recorded during the April and June 2021 events and historical trends that demonstrate stratification in portions of the lake beginning during this period. The 12-month rolling DO concentration 1-m above the lake bottom at Site LE02 remained below the 2020 TMDL target of 5.0 mg/L for the entire monitoring year, ranging from 2.1 to 3.5 mg/L. (Figure 3-3).

[2] 2004-05, 2005-06 and 2008-09 monitoring years each had several months of missing temperature data and were not included in this retrospective analysis. No temperature profile data was collected across the July 2012 to June 2015 monitoring years.

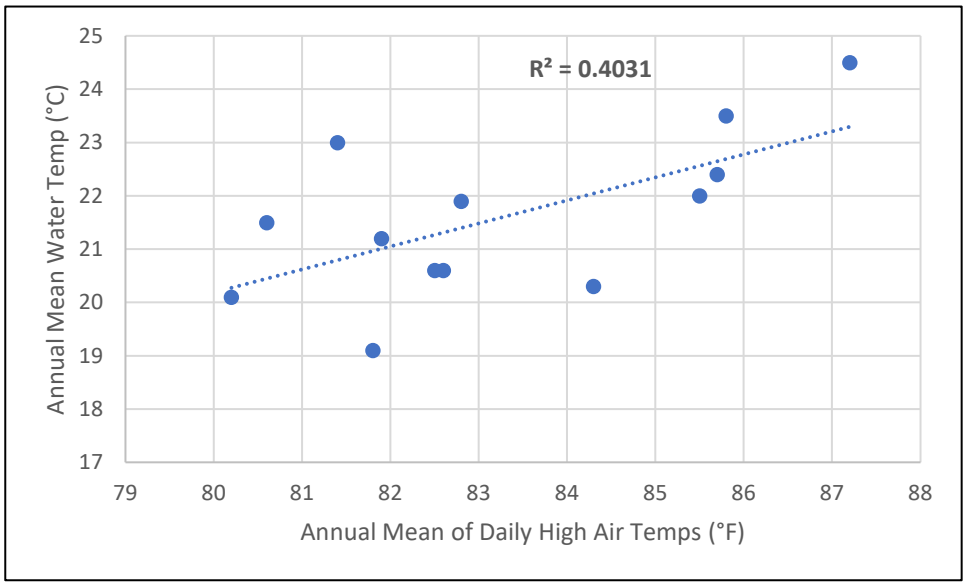


Figure 3-2. Relationship of Annual Mean Surface Water Temperature and Annual Mean Daily High Air Temperatures in Lake Elsinore
(for years with complete monthly water temperatures (2006-2011, 2015-2021))

Conductivity exhibited a gradual increased from July through December 2020, from approximately 3144 to 3474 microSiemens per centimeter (µS/cm). The conductivity dropped slightly between December 2020 and February 2021, as a series of storms moved through the region. Conductivity then remained steady before an increase in June 2021 to near its highest level of the monitoring year.

Relative to the previous 2 monitoring years (2018-2019 and 2019-2020), the 2020-2021 pH values exhibited a much different annual pattern. The pH measurements from previous 2 years remained relatively steady across the monitoring year and within a relatively narrow band. During the 2020-2021 monitoring year, a notable drop of 1.0 SU was observed during the 2nd and 3rd field events (August and September), followed by a gradual increase. A similar drop was observed in August of the 2017-2018 monitoring year. There is no obvious reason for the decrease in pH across these two monitoring events but could be partially due to the algal composition of the lake as a result of the known close relationship between the processes involved in algal photosynthesis and pH levels particularly in lakes with high algal biomass.

Water clarity measured using a Secchi disk increased gradually at LE02 across the summer, fall and early winter months, from 0.8 feet (ft) in July to 1.1 ft in February (Figure 3-8). This pattern is somewhat different from previous monitoring years which generally exhibit a decrease in water clarity across the summer and fall months. A decrease in clarity was then observed between February and June. The first overflow of the Canyon Lake spillway was February 1, with the majority of the precipitation in this monitoring year falling between January and March. While not a tight relationship, the Secchi depths observed generally exhibited an inverse relationship with

algal density (i.e., chlorophyll-a concentrations) at Site LE02. 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 3-9 includes lake-wide averages observed for the current 2020-21 monitoring year, as well as the prior 2018-19 and 2019-20 monitoring years.

Table 3-9. In-Situ Water Quality Parameter Measurements in Lake Elsinore – 2020-2021 Annual Mean Statistics for Each Site

		Measure	LE01	LE02	LE03	Lake-wide Average (July 2020-June 2021)	Lake-wide Average (July 2019-June 2020)	Lake-wide Average (July 2018-June 2019)
Water Column Mean	Min	Temp (°C)	13.1	12.9	13.1	13.0	12.0	11.4
		Cond (µS/cm)	3143	3145	3145	3144	2880	3329
		pH	*8.55*	*8.56*	*8.59*	*8.56*	*8.97*	*8.76*
		DO (mg/L)	1.9	2.0	1.7	1.9	2.8	3.9
	Max	Temp (°C)	27.3	27.2	27.4	27.3	27.4	28.3
		Cond (µS/cm)	3466	3484	3472	3474	3895	5224
		pH	*9.17*	*9.19*	*9.13*	*9.16*	*9.28*	*9.10*
		DO (mg/L)	9.0	8.0	8.6	8.5	11.6	10.4
	Average	Temp (°C)	21.5	21.4	21.6	21.5	20.5	20.9
		Cond (µS/cm)	3321	3323	3321	3322	3562	4473
		pH	*8.82*	*8.80*	*8.81*	*8.81*	*9.15*	*8.93*
		DO (mg/L)	5.4	4.7	5.1	5.1	5.9	6.6
1m from Bottom	Min	Temp (°C)	12.9	12.9	13.0	12.9	11.6	11.2
		Cond (µS/cm)	3143	3144	3146	3144	3007	3330
		pH	8.50	8.47	*8.53*	8.50	*8.85*	*8.70*
		DO (mg/L)	0.3	0.1	0.1	0.2	0.1	1.3
	Max	Temp (°C)	26.8	26.7	26.8	26.8	27.2	27.7
		Cond (µS/cm)	3478	3486	3471	3478	3896	5232
		pH	*9.08*	*9.12*	*9.01*	*9.07*	*9.23*	*9.03*
		DO (mg/L)	8.6	7.9	7.8	8.1	8.3	8.8
	Average	Temp (°C)	21.1	20.8	21.2	21.0	20.1	20.5
		Cond (µS/cm)	3322	3322	3321	3322	3578	4478
		pH	*8.75*	*8.70*	*8.74*	*8.73*	*9.07*	*8.88*
		DO (mg/L)	**3.5**	**2.3**	**3.2**	**3.0**	**3.7**	**4.5**

Notes:
°C = degrees Celsius; µS/cm = microSiemens per centimeter; m= meter; mg/L = milligrams per liter
2020 TMDL target for Dissolved Oxygen (DO) is no less than 5 mg/L in bottom 1m of sampling site
Bold Underline - Indicates exceedance of 2020 TMDL target
Italicize – Indicates exceedance of Basin Plan WQO

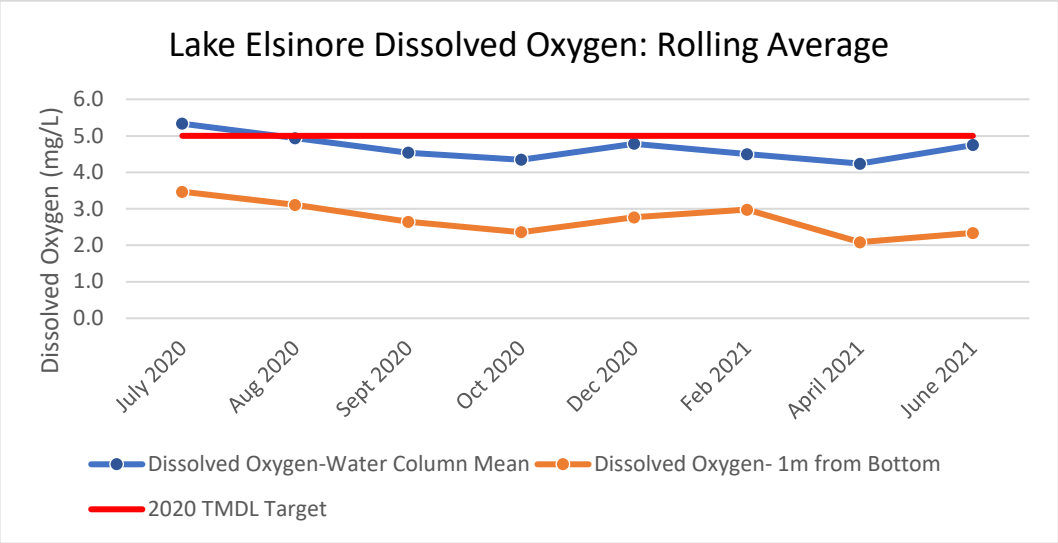


Figure 3-3. Water Column Mean Dissolved Oxygen (DO) Rolling Average – Lake Elsinore for Site LE02

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 2019 to June 2021.

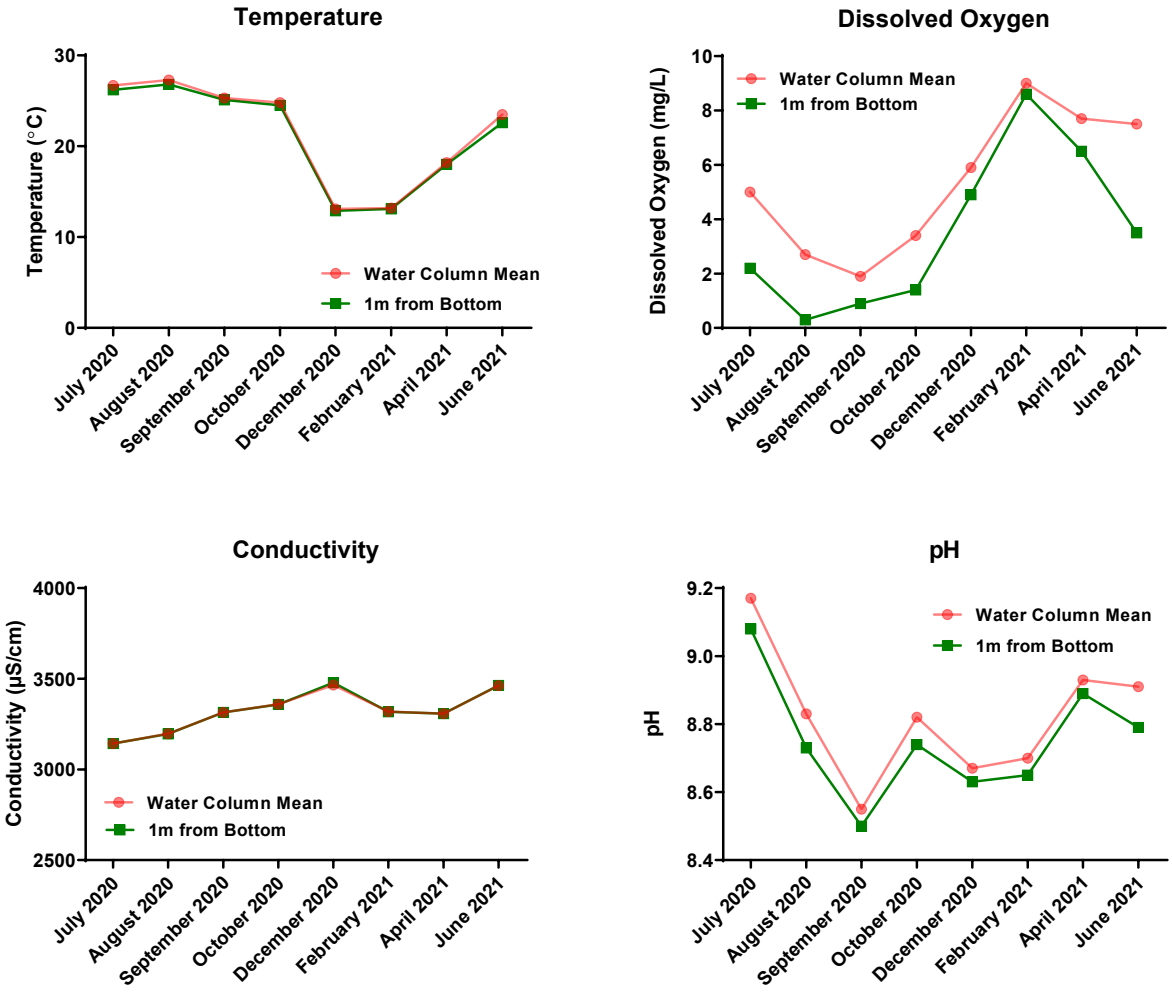


Figure 3-4. In-Situ Physical Water Quality Parameters - Lake Elsinore - Site LE01

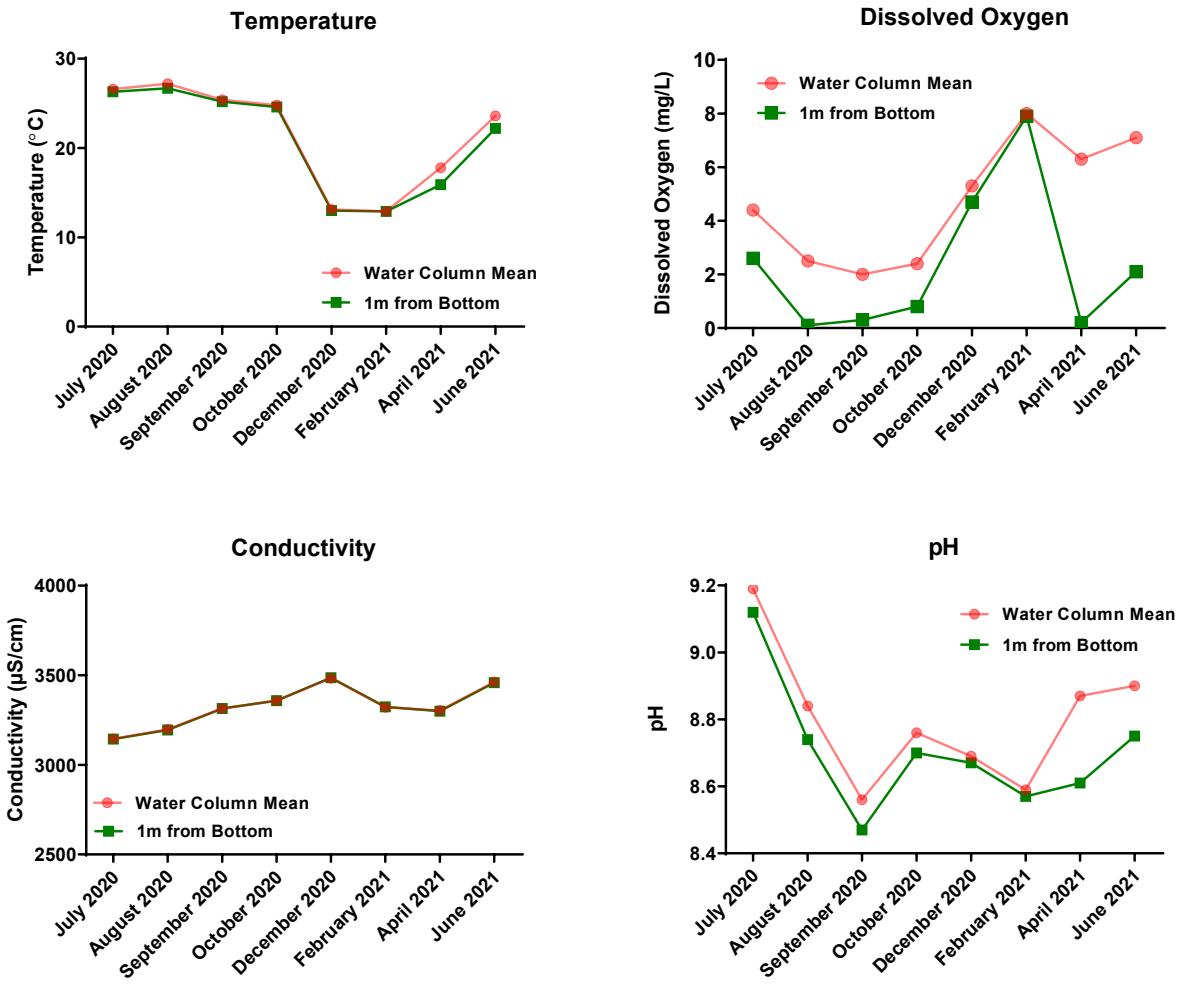


Figure 3-5. In- Situ Physical Water Quality Parameters - Lake Elsinore Site LE02

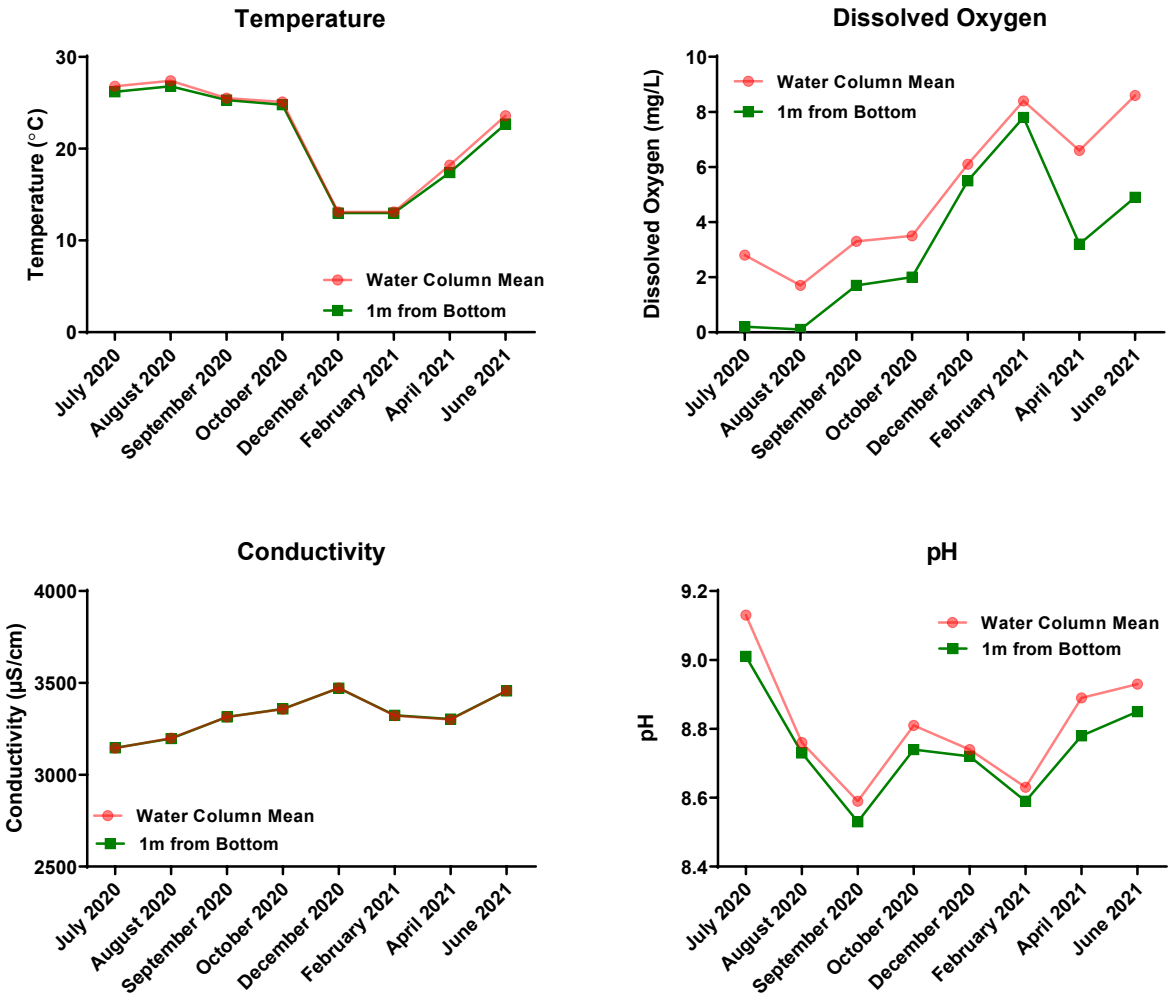


Figure 3-6. In- Situ Physical Water Quality Parameters - Lake Elsinore Site LE03

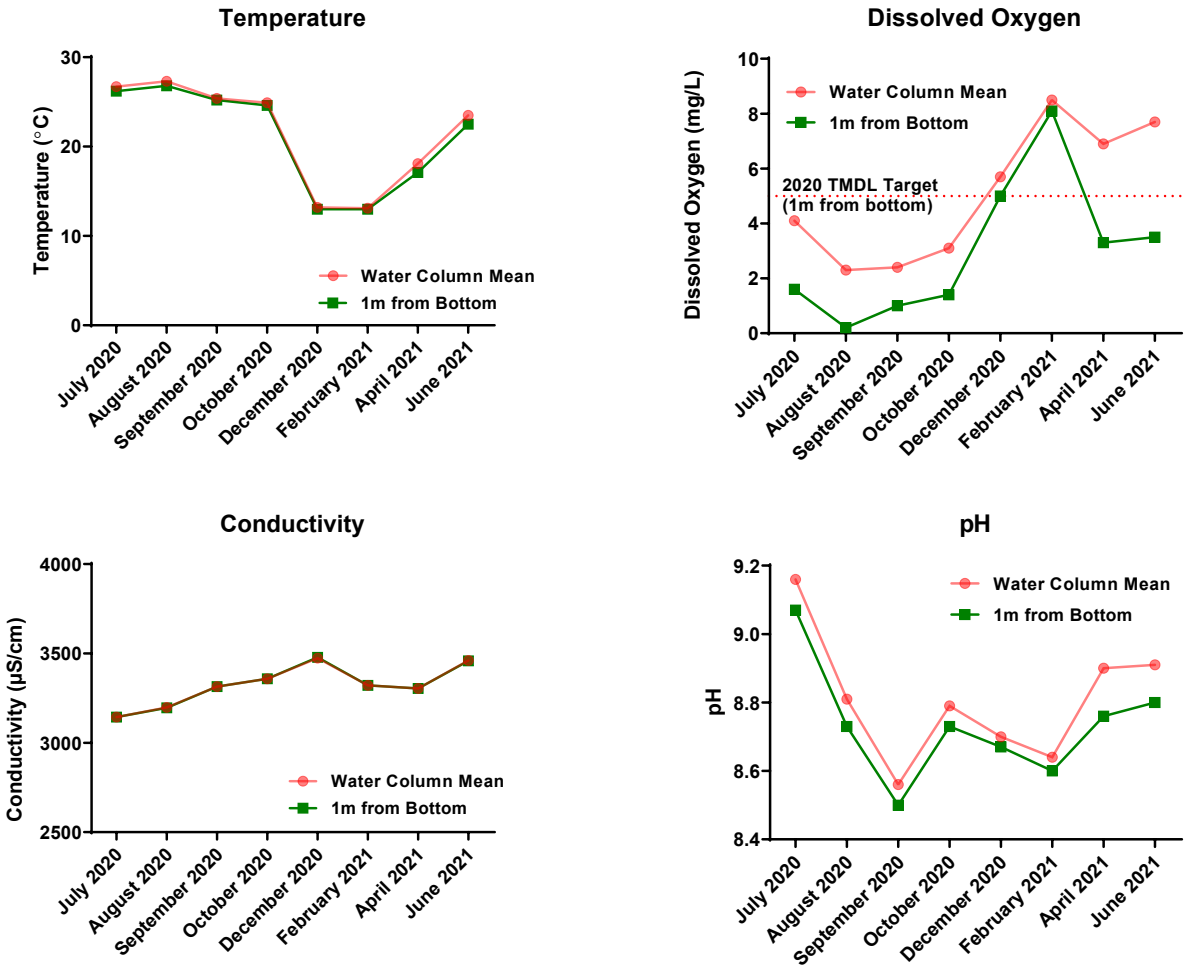


Figure 3-7. Monthly Lake-wide Mean of In-Situ Physical Water Quality Parameters – Mean of All Three Stations

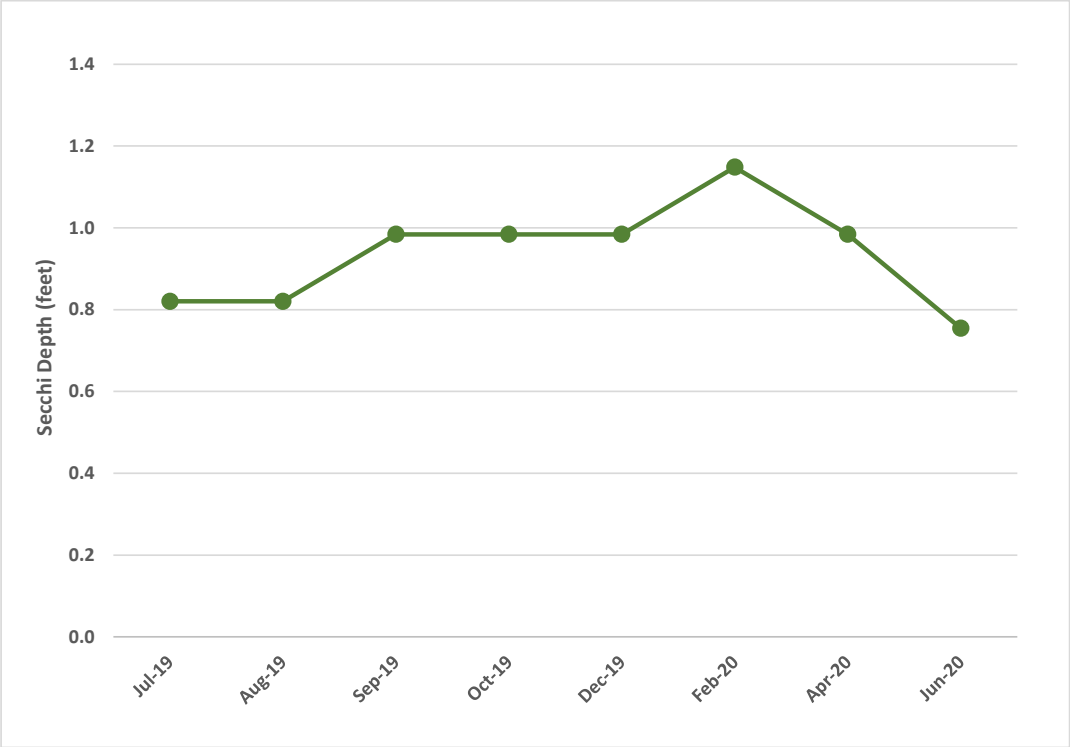


Figure 3-8. In- Situ Water Clarity Using a Secchi Disk - Lake Elsinore Site LE02

Analytical Chemistry

Monthly analytical results and annual summary chemistry concentrations at Site LE02 are presented in Tables 3-10 and 3-11, respectively. Concentrations of analytes at Site LE02 are graphically presented in Figures 3-9 through 3-11.

Total nitrogen concentrations were steady across the summer, fall and winter months, before decreasing in April 2021 (Figure 3-9), likely as a result of the largest precipitation events coming after the February collection event and the overflow of the Canyon Lake spillway. Total nitrogen values across the monitoring year ranged from 4.6 mg/L in July and September 2020 dropping to 2.6 mg/L in April 2021. The annual mean concentration of total nitrogen was 4.1 mg/L (4.4 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 3-10).

Total phosphorus concentrations ranged from 0.13 to 0.28 mg/L across all monitoring events. The lowest total phosphorus concentration was observed in July 2019 (0.13 mg/L). The remainder of the monitoring events exhibited higher concentrations of total phosphorus, all within a narrow range (0.25 – 0.28 mg/L; Figure 3-9). Dissolved oxygen concentrations in July and August 2020 indicated that the lake was stratified during both events and didn't de-stratify until

sometime between the October and December 2020 monitoring events. Typically, total phosphorus concentrations exhibit an increase following destratification as phosphorus that had fluxed from the sediment during the stratification period as a result of low dissolved oxygen concentration near the sediment surface, is dispersed throughout the water column. So, the jump in total phosphorus from July to August 2020, and the lack of increase in depth-integrated total phosphorus when the lake did de-stratify is not clear but could be related to a range of factors including greater vertical mixing with bottom waters and physical disturbance of the sediments. All QA data associated with the July 2020 total phosphorus laboratory data meets acceptability criteria and does not explain an anomalously low value for July. The annual mean concentration of total phosphorus was 0.24 mg/L, up from the 0.18 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 (Figure 3-10).

Total ammonia-N concentrations while quite variable, exhibited an increase during the first two monitoring events followed by a general downward trend through the remainder of the monitoring year, with an annual mean of 0.31 mg/L. Total ammonia concentrations of 0.40 and 0.69 mg/L in August and September 2020 exceeded their corresponding Criterion Continuous Concentration (CCC) objectives (Table 3-10). No other samples exceeded the total ammonia CCC or the Criterion Maximum Concentration (CMC) objective. The initial increase in total ammonia-N during the first two monitoring events is likely the result of the lake stratification and low DO near the bottom, as these two months showed the strongest differentiation in DO concentrations between the water column and 1-m from the bottom. This low DO near the sediment can facilitate the flux of ammonia.

Total dissolved solids (TDS) concentrations showed a slight increase from July to October (1800 to 2000 mg/L) and then remained stable through the remainder of the monitoring year until a slight increase again in June 2021. This pattern follows that observed for specific conductivity (Figure 3-7). The typical decrease of TDS in Lake Elsinore due to winter storm events was not observed this year, likely due to the reduced precipitation totals of this past winter, and the paucity of water coming over the Canyon Lake spillway.

Depth-integrated concentrations of chlorophyll-a across all eight sampling events ranged from 61 to 252 µg/L. Surface (0-2m) chlorophyll-a concentrations ranged from 55 to 200 µg/L. Surface and depth-integrated samples generally tracked with each other. Chlorophyll-a concentrations exhibited a general decrease across the summer and early fall months (Figure 3-11). This is unusual for this lake which typically exhibits an increase in chlorophyll-a during these months until winter storms bring rain to the area. This was followed by an increase in chlorophyll-a concentration from 61 to 150 µg/L between April and June 2021. The mean chlorophyll-a concentration observed in samples collected during the summer months (June 2020 through September 2020) was 212 µg/L for depth-integrated samples and 179 µg/L for surface samples. The August (depth-integrated) and September (depth-integrated and surface) chlorophyll-a samples for Lake Elsinore were not analyzed due to a laboratory error. The chlorophyll was extracted from the glass-fiber filters, but the vials holding the extract material were dropped and broken, unable to be recovered.

Table 3-10. Monthly Analytical Chemistry Results for Lake Elsinore in 2020-2021

Compound	Units	MDL	RL	Depth Integrated or Surface Sample	July 2020	August 2020	September 2020	October 2020	December 2020	February 2021	April 2021	June 2021	Annual Average
General Chemistry													
Total Dissolved Solids	mg/L	4.0	10	DI	*1800*	*1800*	*1900*	*2000*	*2000*	*2000*	*2000*	***2100***	*1950*
Sulfide	mg/L	0.05	0.1	DI	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)
Nitrate as N	mg/L	0.04	0.2	DI	ND (<0.04)	ND (<0.04)	ND (<0.04)	ND (<0.04)	0.23	0.09 J	ND (<0.04)	ND (<0.04)	ND (<0.04)
Nitrite as N	mg/L	0.042	0.1	DI	ND (<0.042)	ND (<0.042)	ND (<0.042)	0.11	ND (<0.042)	0.11	ND (<0.042)	ND (<0.042)	ND (<0.042)
Total Kjeldahl Nitrogen	mg/L	0.018-0.072	0.1-0.4	DI	4.6	4.5	4.6	4.4	3.8	3.7	2.6	4.1	4.0
Total Nitrogen[a]	mg/L	NA	--	DI	4.6	4.5	4.6	4.5	4.0	3.9	2.6	4.1	4.1
Ammonia-Nitrogen	mg/L	0.012-0.047	0.1	DI	ND (<0.012)	**0.40***	**0.69***	0.31	0.61	0.18	0.23	0.099 J	0.31
Unionized Ammonia[b]	mg/L	NA	--	DI	0.0	0.12	0.12	0.075	0.061	0.015	0.045	0.027	0.058
Ortho Phosphate Phosphorus	mg/L	0.003	0.01	DI	0.003 J	0.007 J	ND (<0.003)	0.009 J	0.052	0.028	0.039	0.012	0.019
Total Phosphorus	mg/L	0.00083-0.0067	0.01	DI	0.13	0.25	0.26	0.26	0.27	0.26	0.24	0.28	0.24
Chlorophyll-a													
Chlorophyll-a	µg/L	NA	1.0	Surf	188	200[c]	NM:LE	160	96	55	56	180	134
Chlorophyll-a	µg/L	NA	1.0	DI	252	NM:LE	NM:LE	170	96	70	61	150	133

Notes:
When a concentration was non-detect (ND), the annual mean value for compliance purposes was calculated by converting ND values to zero. If the result of the calculated mean was non-zero, but below the corresponding MDL, the mean 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 – Sample measured out of holding time
ND – Not detected; NA – Not Applicable/ available; NM:LE – Not measured due to laboratory error
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
Bold Underline - Indicates exceedance of 2020 TMDL Objective
Italicize – Indicates exceedance of Basin Plan Water Quality Objective
* Exceeds 2004 TMDL Permit NH3 CCC; ** Exceeds 2004 TMDL Permit NH3 CMC

Table 3-11. Analytical Chemistry Summary for Lake Elsinore – Annual Mean Statistics (2020-2021)

Compound	Units	MDL	RL	Basin Plan WQO or TMDL Target	Depth Integrated or Surface Sample	Min	Max	Summer Average[c]	Annual Average
General Chemistry									
Total Dissolved Solids	mg/L	4.0	10	2000 [2]	DI	*1800*	*2100*	*2250*	*1950*
Sulfide	mg/L	0.05	0.1	NA	DI	ND (<0.05)	ND (<0.05)	0.10	ND (<0.05)
Nitrate as N	mg/L	0.04	0.2	NA	DI	ND (<0.04)	0.23	ND (<0.04)	ND (<0.04)
Nitrite as N	mg/L	0.042	0.1	NA	DI	ND (<0.042)	0.11	ND (<0.042)	ND (<0.042)
Total Kjeldahl Nitrogen	mg/L	0.018-0.072	0.1-0.4	NA	DI	2.6	4.6	4.6	4.0
Total Nitrogen[a]	mg/L	NA	--	0.75[b1]	DI	2.6	4.6	4.6	**4.1**
Ammonia-Nitrogen	mg/L	0.012-0.047	0.1	2004 - CMC: 0.98-2.8[1]; CCC: 0.17-0.94[1]	DI	ND (<0.012)	0.69	0.38	0.31
Unionized Ammonia[d]	mg/L	NA	--	NA	DI	0.0	0.12	0.11	0.058
Ortho Phosphate Phosphorus	mg/L	0.003	0.01	NA	DI	ND (<0.003)	0.052	ND (<0.003)	0.019
Total Phosphorus	mg/L	0.00083-0.0067	0.01	0.1[b1]	DI	0.13	0.28	0.22	**0.24**
Chlorophyll-a									
Chlorophyll-a	µg/L	NA	1.0	25[c1]	Surf	55	200[e]	**179**	134
Chlorophyll-a	µg/L	NA	1.0	25[c1]	DI	61	252	**212**	133

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 2020 – September 2020)
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.
e - Measured outside of holding time
1 – 2020 TMDL Target, based on Table 5-9n of 2004 TMDL
2 – Santa Ana Region Basin Plan Water Quality 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
Bold Underline - Indicates exceedance of 2020 TMDL target
Italicize – Indicates exceedance of Basin Plan Water Quality Objective
* Exceeds 2004 TMDL Permit NH3 CCC; ** Exceeds 2004 TMDL Permit NH3 CMC

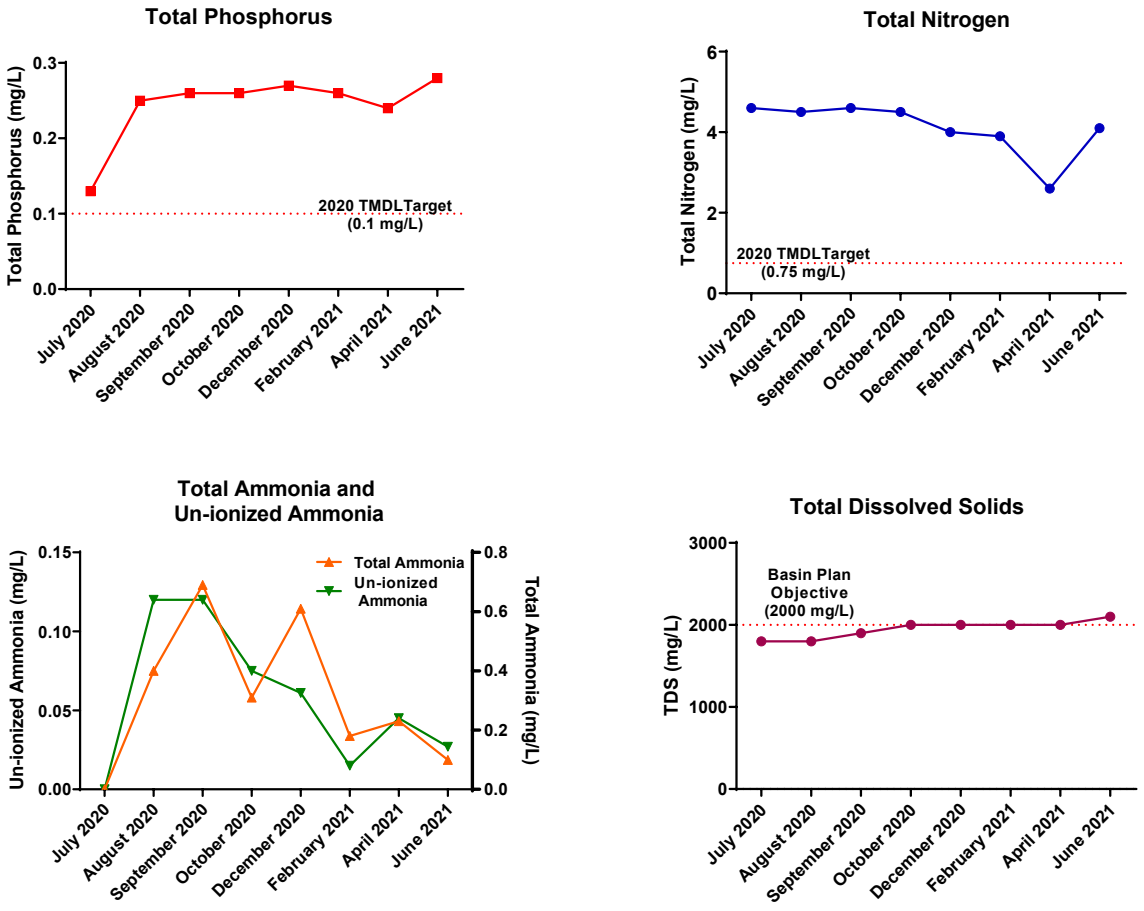
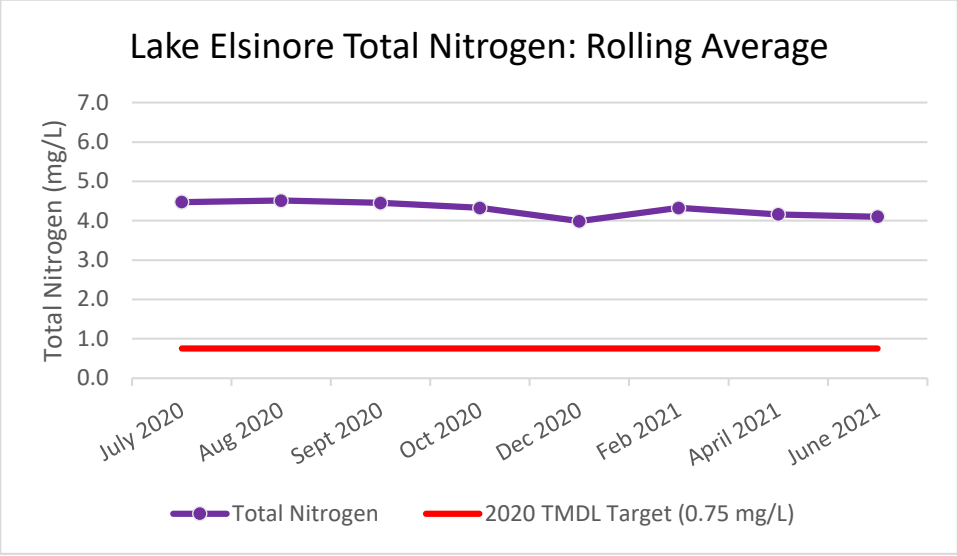


Figure 3-9. Lake Elsinore Analytical Chemistry – Depth-Integrated Means at Site LE02 (July 2020-June 2021)

Long term trends can be found in Appendix E



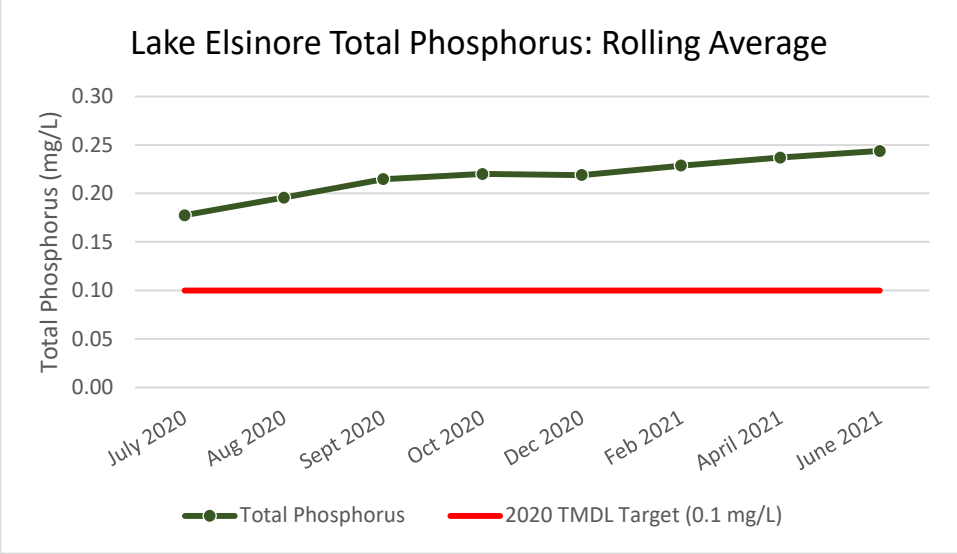


Figure 3-10. Lake Elsinore Analytical Chemistry – Total Nitrogen and Phosphorus Rolling Averages (July 2020 – June 2021)

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 2019 to June 2021.

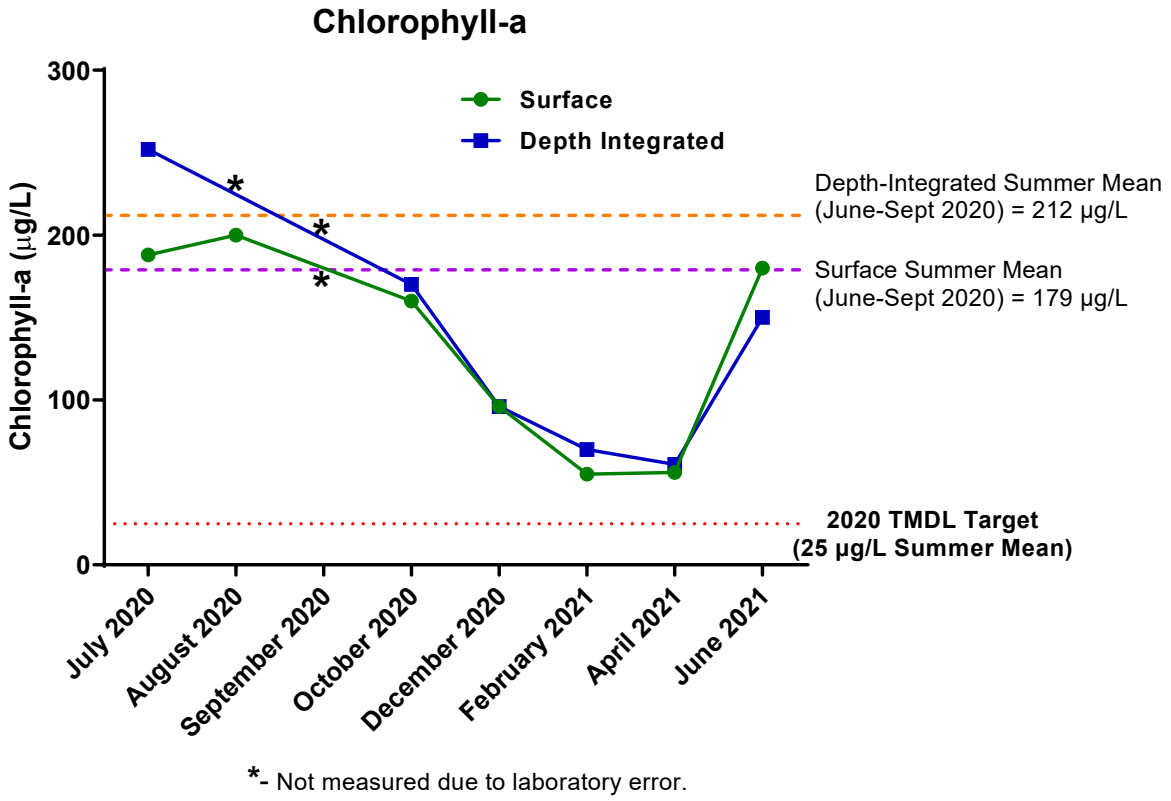


Figure 3-11. Lake Elsinore Analytical Chemistry – Depth-Integrated and Surface Chlorophyll-a at Site LE02

August (Depth-integrated) and September (Depth-integrated & Surface) samples not analyzed due to lab error (see text). Long term trends can be found in Appendix E

3.4 Canyon Lake Monitoring

3.4.1 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 and resumed in July 2015 using the four stations outlined in the approved Lake Elsinore and Canyon Lake Nutrient TMDL Monitoring Plan (LESJWA, 2006; Figure 3-12, Table 3-12). 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 column 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 3-12. 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°

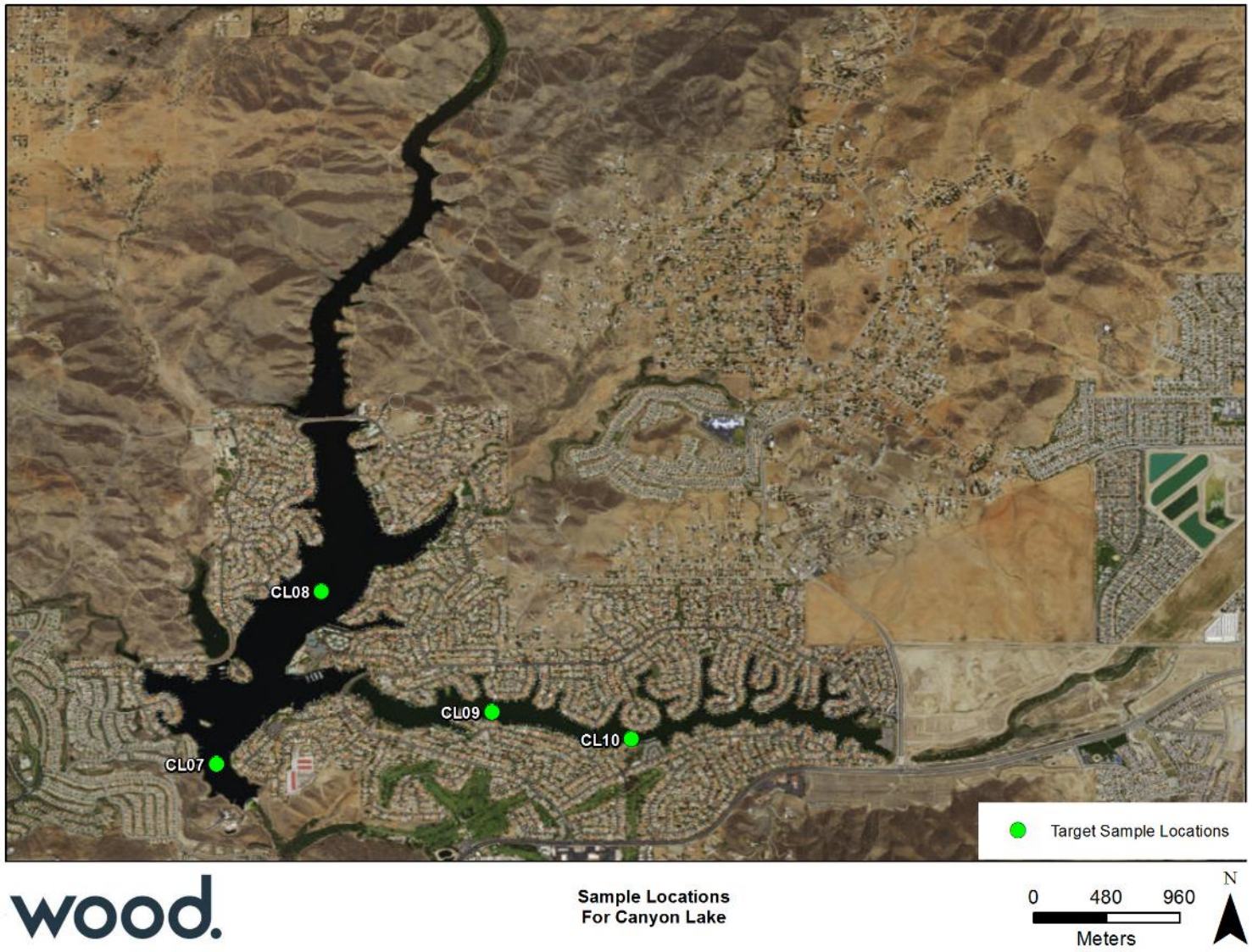


Figure 3-12. Canyon Lake Sampling Locations

3.4.2 Sampling Methods

Samples for analytical chemistry were collected in the same manner as in Lake Elsinore using a peristaltic pump to collect depth-integrated composite samples. 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 Weck Laboratories Inc., located in City of Industry, California (Table 3-13).

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 2020-2021 monitoring period, Canyon Lake alum applications were performed during the week of October 12, 2020. Pre-alum application monitoring events were performed on October 5, 2020, with the subsequent respective bi-monthly TMDL event on December 9, 2020 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 in-situ 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 at the water surface in Canyon Lake. Satellite imagery was also used to estimate the likelihood of a harmful algae bloom.

Table 3-13. In-lake Analytical Constituents and Methods for Canyon Lake (2020-2021)

Parameter	Analysis SOP #	Sampling Method
Analytical Chemistry		
Nitrite Nitrogen (NO_2-N)	EPA 353.2	Depth Integrated
Nitrate Nitrogen (NO_3-N)	EPA 353.2	Depth Integrated
Total Kjeldahl Nitrogen (TKN)	EPA 351.2	Depth Integrated
Total Nitrogen (TN)	Calculated	Depth Integrated
Ammonia Nitrogen (NH4-N)	EPA 350.1	Depth Integrated
Sulfide	SM 4500S2 D	Depth Integrated
Total Phosphorus (TP)	EPA 365.3	Depth Integrated
Soluble Reactive Phosphorus (SRP / Ortho-P)	EPA 365.3	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:
US EPA - United States Environmental Protection Agency; m- meter; SM- standard method

3.4.3 Water Quality Summary

A summary of the in-lake monitoring events for Canyon Lake for the period of July 1, 2020 to June 30, 2021 is presented below. A total of six events were sampled under the TMDL monitoring program, with three occurring in 2020 (August 13, October 5 and December 9) and three in 2021 (February 17, April 8 and June 2). Complete monthly water column profiles can be found 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. Current data in the context of historical water quality monitoring results from 2002-present are presented in Appendix E.

Water Column Profiles

A summary of water column profile mean values for each site and monitoring event are presented in Tables 3-14 and 3-15. A summary of water column profile mean values for each basin (i.e., Main Lake and Eastern) are presented in Tables 3-16 and 3-17. Water column profile mean statistics for each site across the entire monitoring period are presented in Table 3-18. Mean water column values across the annual cycle are also summarized graphically in Figures 3-13 to 3-17.

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.

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). Over the past 14 years of available records when including data from complete monitoring years July to June (i.e., temperature data available for each month of the monitoring year[3]), Canyon Lake data shows that a different pattern than that of Lake Elsinore. The highest lake-wide mean temperature was observed in the 2011-12 and 2016-17 monitoring years (19.7°C), compared to 18.9°C for the current year. Dissolved oxygen concentrations for both basins reflected an inverse pattern with temperature, exhibiting elevated concentrations during the winter months when averaged throughout the water column, reaching a maximum concentration in February 2021. When the thermocline develops in the lake, typically beginning in late spring through early fall period as the surface water heats up, DO concentrations within the epilimnion and hypolimnion diverge, with hypolimnion concentrations falling substantially during that timeframe. This same pattern was observed this monitoring year with the lake exhibiting stratification in August and October 2020, being de-stratified in December and February, and becoming stratified again in April 2021 (Figures 3-13 and 3-14). The rolling 12-month DO concentration was never above 5.0 mg/L in the hypolimnion (Figure 3-15). The rolling average of the full water column mean was above 5.0 mg/L for all monitoring dates (Figure 3-16).

Conductivity within the epilimnion and hypolimnion (when present) and the water column in general exhibited a gradual increase over the monitoring period. Average specific conductivity throughout the entire water column in the Main Basin of Canyon Lake (mean of CL07 & CL08) rose from 677 to 868 µS/cm (Tables 3-16 and 3-17, Figure 3-13). Locations in the East Basin (mean of CL09 & CL10) exhibited a similar increase across the monitoring year from 804 to 1051 µS/cm. Mean values for pH were slightly higher in the Eastern Basin than the Main Basin, with values ranging from 7.57 – 8.58 and 7.33 – 7.94, respectively. Values for pH within the epilimnion and hypolimnion tended to diverge as the thermocline developed, with pH values remaining higher in the epilimnion.

Secchi depths remained stable and relatively similar for both portions of the lake through December 2020. The Main Body then exhibited a notable increase in secchi depth (increased water clarity) in February and April 2021. This same increase was observed in the East Basin but was delayed by one monitoring event (Figure 3-17). There appears to be an inverse relationship with chlorophyll-a in the Main Basin, however this is not the case with the East Bain.

[3] Temperature data was not available prior to the 2007-08 monitoring year. No temperature profile data was collected across the July 2012 to June 2015 monitoring years.

For further comparisons regarding in-situ water quality parameters, Table 3-18 includes lake-wide averages observed for the current 2020-21 monitoring year, as well as the prior 2018-19 and 2019-20 monitoring years.

Table 3-14. In-Situ Water Quality Parameter Measurements for Canyon Lake - Monthly Means for Each Site (August – December 2020)

Basin	Site	Measure	Aug-20			Oct-20			Dec-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)	20.6	28.4	14.7	20.1	25.3	15.1	13.9	--	--
		Cond (µS/cm)	681	657	703	738	744	745	729	--	--
		pH	7.77	*9.19*	6.97	7.65	*8.55*	7.04	7.30	--	--
		DO (mg/L)	2.8	8.8	**0.0**	3.1	8.0	**0.0**	2.4	--	--
	CL08	Temp (°C)	23.6	28.3	15.5	23.9	25.3	17.9	13.8	--	--
		Cond (µS/cm)	673	658	697	736	741	723	723	--	--
		pH	8.02	*8.99*	6.99	8.01	8.44	7.07	7.36	--	--
		DO (mg/L)	3.7	7.8	**0.0**	4.9	7.4	**0.1**	3.6	--	--
East Basin	CL09	Temp (°C)	24.5	28.3	15.6	23.4	25.3	17.8	12.9	--	--
		Cond (µS/cm)	833	739	1055	922	863	1099	847	--	--
		pH	8.23	*9.20*	6.84	8.01	*8.60*	6.89	7.43	--	--
		DO (mg/L)	4.9	9.1	**0.1**	4.9	7.7	**0.1**	3.3	--	--
	CL10	Temp (°C)	28.2	--	--	25.5	--	--	12.9	--	--
		Cond (µS/cm)	775	--	--	898	--	--	857	--	--
		pH	*8.92*	--	--	*8.62*	--	--	7.71	--	--
		DO (mg/L)	8.2	--	--	8.1	--	--	6.1	--	--
Lake-wide Average		Temp (°C)	24.2	28.3	15.3	23.2	25.3	16.9	13.4	--	--
		Cond (µS/cm)	740	685	818	823	782	855	789	--	--
		pH	8.23	*9.13*	6.93	8.07	*8.53*	7.00	7.45	--	--
		DO (mg/L)	4.9	8.6	**0.0**	5.2	7.7	**0.1**	3.8	--	--

Notes:
Epi = epilimnion; Hypo = hypolimnion; **--** not applicable due to lack of thermocline
2020 TMDL target for Dissolved Oxygen (DO) is no less than 5 mg/L in the hypolimnion
Bold Underline - Indicates exceedance of 2020 TMDL target
Italicize – Indicates exceedance of Basin Plan WQO

Table 3-15. In-Situ Water Quality Parameter Measurements for Canyon Lake - Monthly Means for Each Site (February – June 2021)

Basin	Site	Measure	Feb-21			Apr-21			Jun-21		
			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)	12.5	--	--	15.5	20.0	13.5	18.9	25.5	14.1
		Cond (µS/cm)	790	--	--	793	779	801	867	873	863
		pH	7.50	--	--	7.59	8.19	7.32	7.75	*8.65*	7.22
		DO (mg/L)	4.5	--	--	3.8	10.0	**0.6**	3.5	10.9	**0.0**
	CL08	Temp (°C)	12.9	--	--	17.2	20.7	14.4	21.9	25.5	15.6
		Cond (µS/cm)	767	--	--	784	776	792	869	869	864
		pH	7.58	--	--	7.76	8.18	7.39	8.11	*8.70*	7.28
		DO (mg/L)	5.2	--	--	5.9	10.1	**1.6**	6.0	11.6	**0.1**
East Basin	CL09	Temp (°C)	12.7	--	--	17.4	20.7	13.3	22.6	25.5	15.1
		Cond (µS/cm)	909	--	--	953	910	1000	1045	1027	1100
		pH	8.24	--	--	7.74	8.41	7.15	7.86	8.25	7.10
		DO (mg/L)	7.8	--	--	4.8	11.1	**0.2**	4.6	8.1	**0.1**
	CL10	Temp (°C)	13.3	--	--	20.5	--	--	25.7	--	--
		Cond (µS/cm)	900	--	--	984	--	--	1058	--	--
		pH	*8.61*	--	--	8.01	--	--	8.25	--	--
		DO (mg/L)	11.9	--	--	7.6	--	--	8.5	--	--
Lake-wide Average		Temp (°C)	12.9	--	--	17.6	20.4	13.7	22.3	25.5	14.9
		Cond (µS/cm)	842	--	--	878	821	864	960	923	942
		pH	7.98	--	--	7.77	8.26	7.29	7.99	*8.53*	7.20
		DO (mg/L)	7.4	--	--	5.5	10.4	**0.8**	5.7	10.2	**0.0**

Notes:
Epi = epilimnion; Hypo = hypolimnion; **--** not applicable due to lack of thermocline
2020 TMDL target for Dissolved Oxygen (DO) is no less than 5 mg/L in the hypolimnion
Bold Underline - Indicates exceedance of 2020 TMDL target
Italicize – Indicates exceedance of Basin Plan WQO

Table 3-16. In-Situ Water Quality Parameter Measurements for Canyon Lake - Monthly Means for Each Basin (August – December 2020)

Basin	Measure	Aug-20			Oct-20			Dec-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)	22.1	28.3	15.1	22.0	25.3	16.5	13.8	--	--
	Cond (µS/cm)	677	657	700	737	742	734	726	--	--
	pH	7.89	*9.09*	6.98	7.83	8.49	7.05	7.33	--	--
	DO (mg/L)	3.2	8.3	**0.0**	4.0	7.7	**0.0**	3.0	--	--
East	Temp (°C)	26.3	28.3	15.6	24.4	25.3	17.8	12.9	--	--
	Cond (µS/cm)	804	739	1055	910	863	1099	852	--	--
	pH	*8.57*	*9.20*	6.84	8.31	*8.60*	6.89	7.57	--	--
	DO (mg/L)	6.5	9.1	**0.1**	6.5	7.7	**0.1**	4.7	--	--
Lake-wide Average	Temp (°C)	24.2	28.3	15.3	23.2	25.3	17.1	13.4	--	--
	Cond (µS/cm)	740	698	878	823	803	916	789	--	--
	pH	8.23	*9.14*	6.91	8.07	*8.55*	6.97	7.45	--	--
	DO (mg/L)	4.9	8.7	**0.1**	5.2	7.7	**0.1**	3.8	--	--

Notes:
Epi = epilimnion; Hypo = hypolimnion; -- not applicable due to lack of thermocline
2020 TMDL target for Dissolved Oxygen (DO) is no less than 5 mg/L in the hypolimnion
Bold Underline - Indicates exceedance of 2020 TMDL target
Italicize – Indicates exceedance of Basin Plan WQO

Table 3-17. In-Situ Water Quality Parameter Measurements for Canyon Lake - Monthly Means for Each Basin (February – June 2021)

Basin	Measure	Feb-21			Apr-21			Jun-21		
		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)	12.7	--	--	16.3	20.3	13.9	20.4	25.5	14.9
	Cond (µS/cm)	779	--	--	789	777	797	868	871	863
	pH	7.54	--	--	7.67	8.18	7.35	7.93	*8.68*	7.25
	DO (mg/L)	4.9	--	--	4.8	10.0	**1.1**	4.8	11.2	**0.0**
East	Temp (°C)	13.0	--	--	18.9	20.7	13.3	24.1	25.5	15.1
	Cond (µS/cm)	905	--	--	968	910	1000	1051	1027	1100
	pH	8.43	--	--	7.87	8.41	7.15	8.05	8.25	7.10
	DO (mg/L)	9.9	--	--	6.2	11.1	**0.2**	6.6	8.1	**0.1**
Lake-wide Average	Temp (°C)	12.9	--	--	17.6	20.5	13.6	22.3	25.5	15.0
	Cond (µS/cm)	842	--	--	878	844	898	960	949	981
	pH	7.98	--	--	7.77	8.30	7.25	7.99	8.46	7.17
	DO (mg/L)	7.4	--	--	5.5	10.5	**0.6**	5.7	9.7	**0.1**

Notes:
Epi = epilimnion; Hypo = hypolimnion; -- not applicable due to lack of thermocline
2020 TMDL target for Dissolved Oxygen (DO) is no less than 5 mg/L in the hypolimnion
Bold Underline - Indicates exceedance of 2020 TMDL target
Italicize – Indicates exceedance of Basin Plan WQO

Table 3-18. In-Situ Water Quality Parameter Measurements for Canyon Lake - Annual Mean Statistics for Each Site (August 2020 – June 2021) and Comparison to Previous Monitoring Events

		Measure	CL07	CL08	Main Basin	CL09	CL10	East Basin	Lake-wide Average (July 2020-June 2021)	Lake-wide Average (July 2019-June 2020)	Lake-wide Average (July 2018-June 2019)
Water Column Mean	Min	Temp (°C)	12.5	12.9	12.7	12.7	12.9	12.8	12.8	12.1	11.6
		Cond (µS/cm)	681	673	677	833	775	804	740	583	519
		pH	7.30	7.36	7.33	7.43	7.71	7.57	7.45	7.59	7.40
		DO (mg/L)	2.4	3.6	3.0	3.3	6.1	4.7	3.8	4.3	3.1
	Max	Temp (°C)	20.6	23.9	22.2	24.5	28.2	26.3	24.3	24.6	26.7
		Cond (µS/cm)	867	869	868	1045	1058	1051	960	894	1069
		pH	7.77	8.11	7.94	8.24	*8.92*	*8.58*	8.26	*8.57*	8.20
		DO (mg/L)	4.5	6.0	5.3	7.8	11.9	9.9	7.6	8.7	8.3
	Average	Temp (°C)	16.9	18.9	17.9	18.9	21.0	19.9	18.9	17.8	18.6
		Cond (µS/cm)	766	758	762	918	912	915	839	767	839
		pH	7.59	7.80	7.70	7.92	8.35	8.13	7.92	8.05	7.85
		DO (mg/L)	3.3	4.9	4.1	5.0	8.4	6.7	5.4	5.8	5.5
Epilimnion	Min	Temp (°C)	20.0	20.7	20.3	20.7	--	20.7	20.4	24.9	20.2
		Cond (µS/cm)	657	658	657	739	--	739	685	594	594
		pH	8.19	8.18	8.18	8.25	--	8.25	8.21	*8.58*	8.40
		DO (mg/L)	8.0	7.4	7.7	7.7	--	7.7	7.7	7.3	6.7
	Max	Temp (°C)	28.4	28.3	28.3	28.3	--	28.3	28.3	27.7	28.1
		Cond (µS/cm)	873	869	871	1027	--	1027	923	716	920
		pH	*9.19*	*8.99*	*9.09*	*9.20*	--	*9.20*	*9.13*	*9.55*	*8.91*
		DO (mg/L)	10.9	11.6	11.2	11.1	--	11.1	11.2	11.0	9.1
	Average	Temp (°C)	24.8	24.9	24.9	24.9	--	24.9	24.9	26.5	24.6
		Cond (µS/cm)	763	761	762	885	--	885	803	660	734
		pH	*8.64*	*8.58*	*8.61*	*8.62*	--	*8.62*	*8.61*	*9.05*	*8.60*
		DO (mg/L)	9.4	9.2	9.3	9.0	--	9.0	9.2	9.0	7.8
Hypolimnion	Min	Temp (°C)	13.5	14.4	13.9	13.3	--	13.3	13.7	14.3	12.5
		Cond (µS/cm)	703	697	700	1000	--	1000	800	760	657
		pH	6.97	6.99	6.98	6.84	--	6.84	6.93	7.06	7.06
		DO (mg/L)	0.0	0.0	0.0	0.1	--	0.1	0.0	0.0	0.2
	Max	Temp (°C)	15.1	17.9	16.5	17.8	--	17.8	16.9	14.9	17.2
		Cond (µS/cm)	863	864	863	1100	--	1100	942	788	888
		pH	7.32	7.39	7.35	7.15	--	7.15	7.29	7.35	7.21
		DO (mg/L)	0.6	1.6	1.1	0.2	--	0.2	0.8	0.2	0.3
	Average	Temp (°C)	14.3	15.8	15.1	15.4	--	15.4	15.2	14.6	14.4
		Cond (µS/cm)	778	769	773	1063	--	1063	870	776	744
		pH	7.14	7.18	7.16	6.99	--	6.99	7.10	7.22	7.14
		DO (mg/L)	**0.2**	**0.4**	**0.3**	**0.1**	--	**0.1**	**0.2**	**0.1**	**0.2**

Notes:
-- not applicable due to lack of thermoclineValues 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
2020 TMDL target for Dissolved Oxygen (DO) is no less than 5 mg/L in the hypolimnion
Bold Underline - Indicates exceedance of 2020 TMDL target
Italicize – Indicates exceedance of Basin Plan WQO

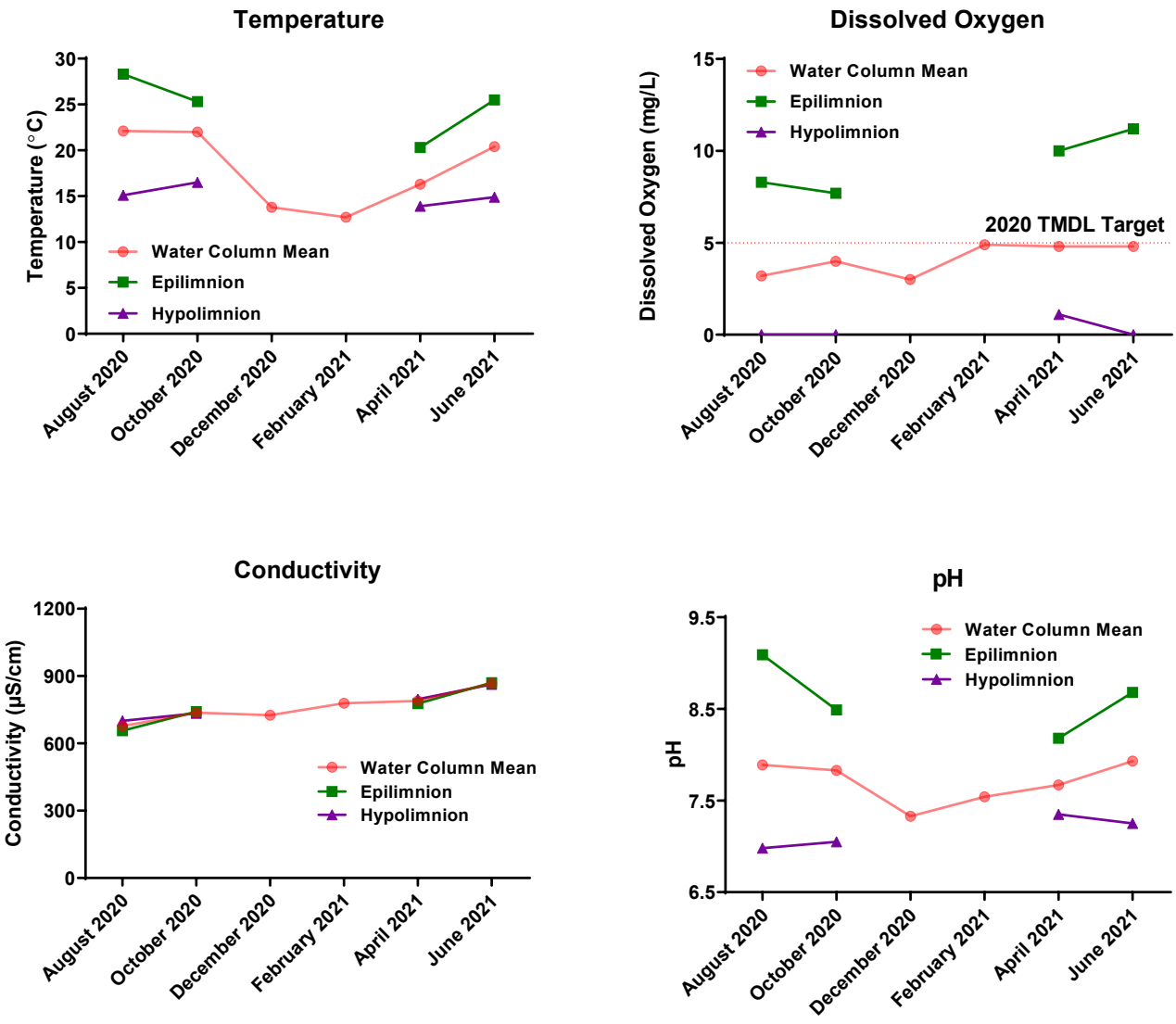


Figure 3-13. Mean In-Situ Physical Water Quality Parameters – Canyon Lake Main Basin

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

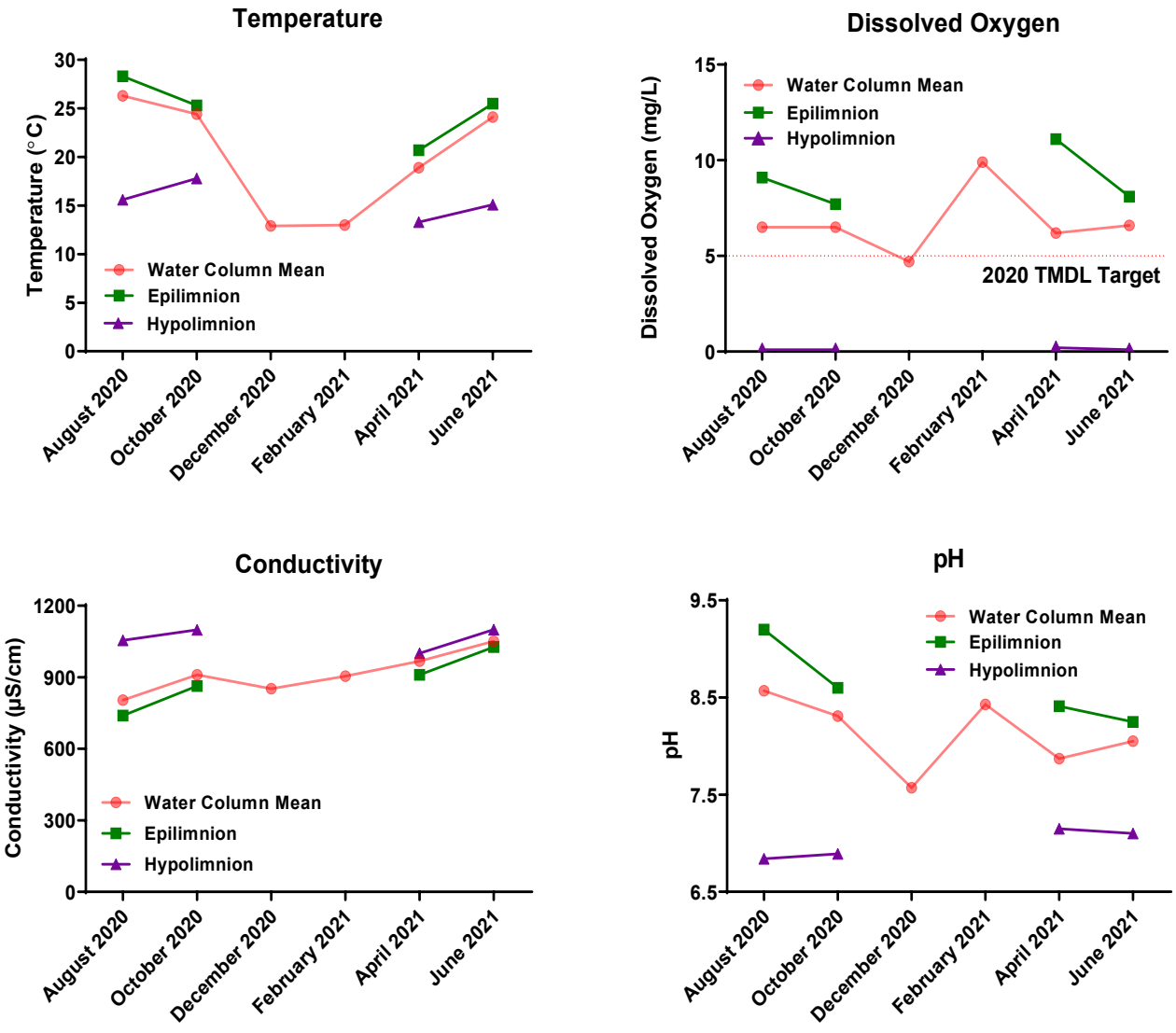


Figure 3-14. Mean In-Situ Physical Water Quality Parameters - Canyon Lake East Basin

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

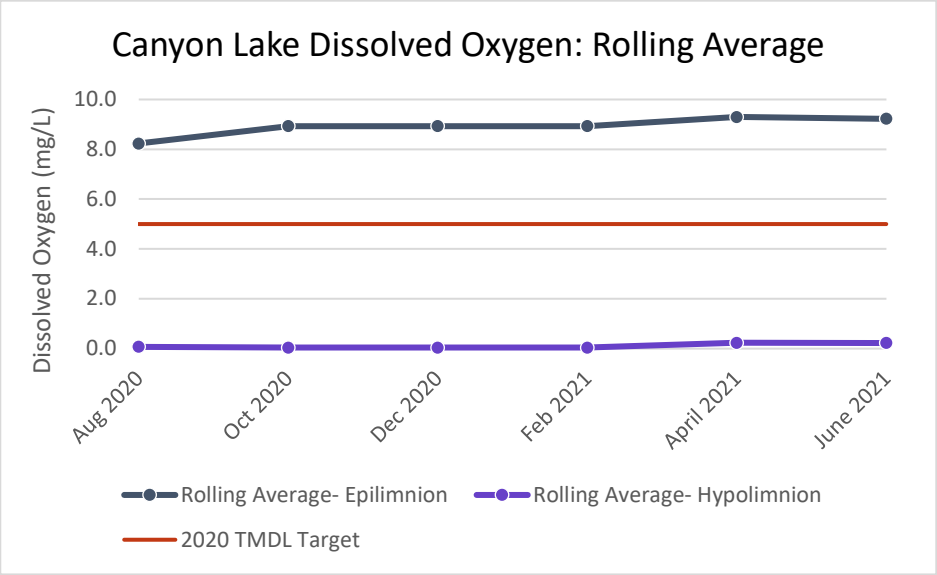


Figure 3-15. Rolling Average Concentrations of Dissolved Oxygen in the Epilimnion and Hypolimnion of Canyon Lake

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 August 2019 to June 2021. Events in which a thermocline was not present were not included in rolling average.

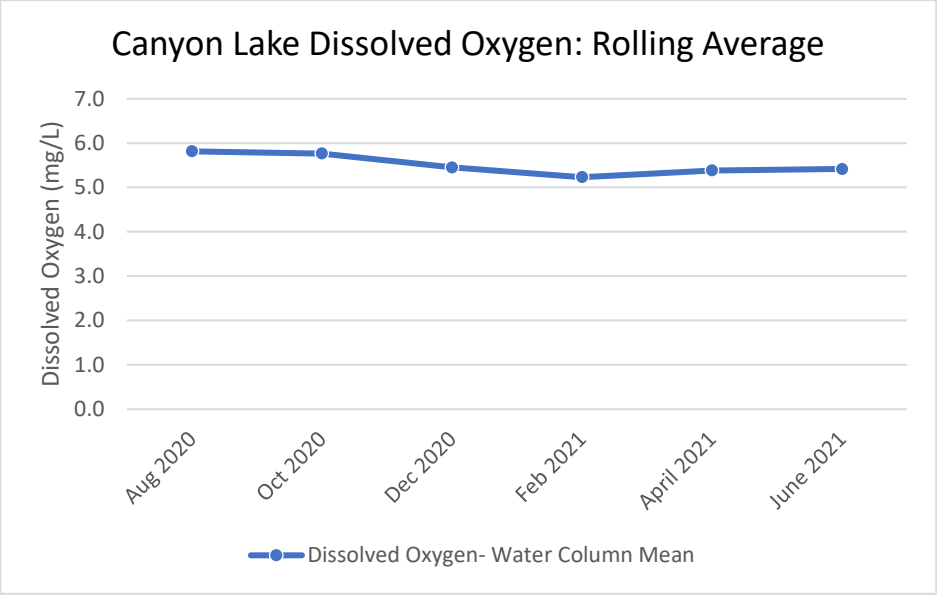


Figure 3-16. Rolling Average Concentration of Dissolved Oxygen Across the Full Vertical Water Column in Canyon Lake

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 August 2019 to June 2021.

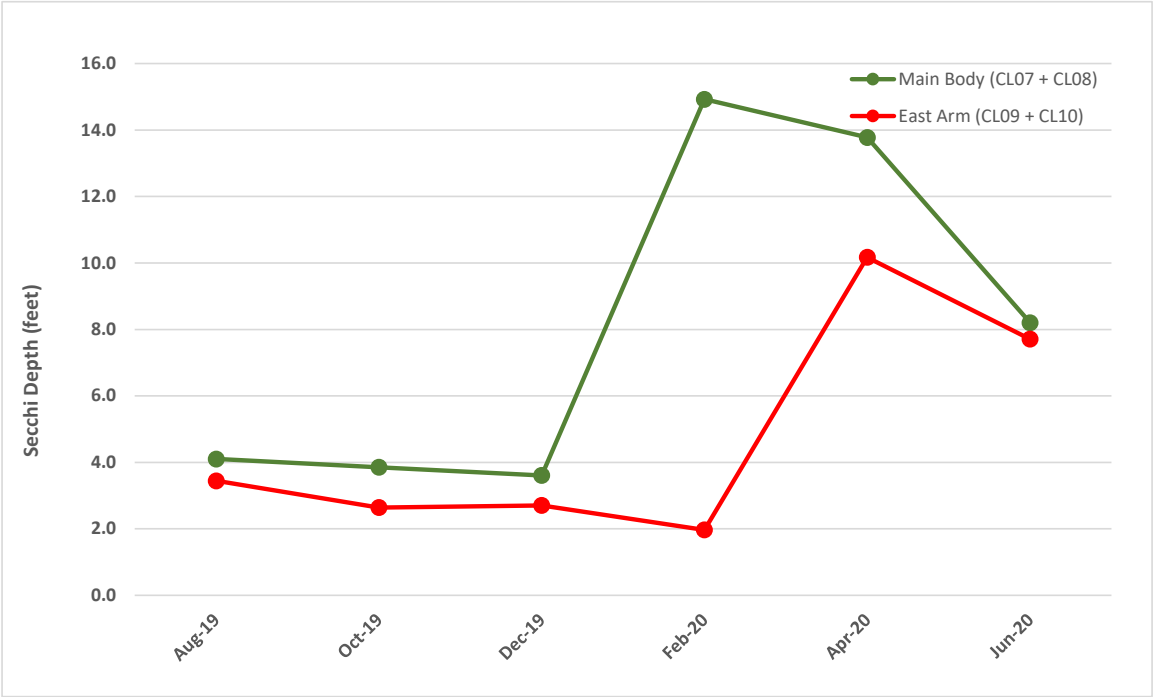


Figure 3-17. In-Situ Water Clarity Using a Secchi Disk– Main and East Basins

Analytical Chemistry

Summaries of analytical chemistry concentrations for each monitoring event in Canyon Lake are presented in Tables 3-19 and 3-20. A summary of analytical chemistry mean statistics for each site across the entire monitoring period are presented in Tables 3-21 through 3-23. Concentrations of analytes are presented graphically in Figures 3-18 and 3-19.

Depth-integrated (water column average) concentrations of total nitrogen in the Main Basin (at sites CL07 and CL08) ranged from 1.1 to 2.6 mg/L across the six sampling events, with an annual mean of 1.6 mg/L (up from the 2019-20 annual mean of 1.3 mg/L). Total nitrogen concentrations at the two East Basin sites ranged from 0.77 to 3.2 mg/L across the six sampling events, with the annual mean of 1.7 mg/L (the same as the 2019-20 annual mean). The total nitrogen concentrations in both basins exhibited a decreasing trend across the monitoring year. However, the rolling average for total nitrogen ranging from 1.51 to 1.75 mg/L including both of both basins, showed an increasing trend, with all points exceeding the current 2020 TMDL target of 0.75 mg/L (Figure 3-20).

Depth-integrated concentrations of total phosphorus in the Main Basin exhibited a sharp decline from August to December, and then a slight gradual increase across the remainder of the monitoring year. Total phosphorus concentrations ranged from 0.036 to 0.27 mg/L, with an annual mean of 0.096 mg/L (a decrease from the 2019-20 annual mean of 0.12 mg/L). Total phosphorus

concentrations in the East Basin remained steady from August to December, and then exhibited a gradual increase from December to April, before decreasing in June 2021. Total phosphorus concentrations in the East Basin ranged from 0.046 to 0.24 mg/L, with an annual mean of 0.099 mg/L (a decrease from the 2019-20 annual mean of 0.14 mg/L). The rolling average for total phosphorus across all sites in the East Basin ranged from 0.10 to 0.14 mg/L, with a decrease towards the end of the monitoring year (Figure 3-20). The 2020-2021 alum application in Canyon Lake occurred during the week of October 12, 2021, with pre-alum application TMDL monitoring occurring on October 5. While a decline was observed in total phosphorus in the Main Body of Canyon Lake across the three monitoring events spanning August and December 2020, this cannot be solely linked to the alum application, as the total phosphorus had begun its decline between August and October prior to the alum application. The decline in total phosphorus continued after the alum application at the same rate as that observed prior to the alum application. While the October 2021 alum application did not appear to have a direct correlation to the drop in total phosphorus concentration between August and December 2020, the regular application of alum since September 2013 has served to reduce the annual mean water column total phosphorus concentration in Canyon Lake in comparison to those measured prior to the alum applications (Appendix E).

Depth-integrated concentrations of total ammonia observed in the Main Basin were at their highest during the first monitoring event of the year (August 2020) at 1.5 mg/L, and then displayed a consistent decrease through February 2021, before increasing in April and June 2021. This pattern is likely tied to the annual stratification cycle of the lake and was similar to that exhibited by total phosphorus in the Main Basin. The Main Basin exhibits a stable stratification beginning in early spring (April) through early Fall (October). During this time low dissolved oxygen in the hypolimnion facilitates the release of phosphorus and ammonia from the sediments. Total ammonia concentrations in the Main Basin ranged from 0.45 to 2.1 mg/L among the two Main Basin sites, with an annual mean of 0.97 mg/L. Total ammonia values in the East Basin ranged from non-detect (<0.012) to 2.3 mg/L among the two sites, with an annual mean of 0.69 mg/L. Concentrations in the East Basin were a bit variable, with an initial increase in total ammonia, followed by a decline over the next two events, and then fluctuating concentrations during the last two events of the monitoring year. Two individual samples, both at Site CL09 (August and October) exceeded the calculated total ammonia CCC value for the protection of aquatic life. No samples exceeded the total ammonia CMC value.

Total dissolved solids concentrations for both basins displayed an increasing trend across monitoring year, which unlike previous years, appeared to be unimpacted by the storm season rain events. The average TDS concentration in the Main Basin ranged from 390 mg/L to 520 mg/L. The average concentrations of TDS in the East Basin ranged from 400 mg/L to 620 mg/L. None of the TDS concentrations exceeded the Basin Plan water quality objective of 700 mg/L.

Following a small increase in chlorophyll-a depth-integrated concentrations in the Main Basin between August and October, a steady decline was observed through February 2021, before a small increase in April and a larger increase in June. Depth-integrated concentrations in the Main Basin (mean of Sites CL07 and CL08) across all six sampling events ranged from 1.6 to 36 µg/L, with a mean of 17 µg/L (Figure 3-19). Depth-integrated concentrations of chlorophyll-a in the East Basin (Sites CL09 and CL10) decreased across the first three events (from 45 to 21 µg/L), and

then exhibited a large spike in February 2021 up to 55 µg/L, followed by a large decrease in April, The overall annual mean for the East Basin was 31 µg/L. While the exact reason for this large increase in chlorophyll-a in February is unclear, with the February in-lake monitoring event occurring on February 17, this spike in chlorophyll-a could be due to runoff from the large storm event occurring on January 29 - February 1, 2021, causing a short-term algal bloom. This proposition is backed by the large decrease in chlorophyll-a observed in the subsequent April 2021 monitoring event, dropping to a concentration similar to that observed in the Main Body. 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 3-20).

Concentrations of total and dissolved aluminum are measured in Canyon Lake to assess any potential long-term influence that the alum additions may have on water column aluminum concentrations relative to existing water quality objectives. Concentrations of total aluminum ranged from 35 to 64 µg/L in the Main Basin and 63 to 270 µg/L in the East Basin among all sampling locations and dates. Only one alum application event was performed this monitoring year during the week of October 12-16, 2020. Concentrations of total aluminum did increase slightly following this application event; however, concentrations were consistently lower overall than the previous monitoring year. All total aluminum concentrations measured were well below CCC and CMC values of 1000 and 2300 ug/L total aluminum respectively, based on the US EPA's Final Aquatic Life Ambient Water Quality Criteria for Aluminum (US EPA, 2018) when using the annual average lake-wide measured pH, and default total organic carbon and hardness values. Dissolved aluminum concentrations ranged from ND to 34 µg/L in the Main Basin and ND to 93 µg/L in the East Basin. It does not appear that the regular additions of alum to Canyon Lake are causing an increase in aluminum concentration that would produce acute or chronic effects on resident aquatic life.

Table 3-19. Analytical Chemistry Results for Canyon Lake - Monthly Depth-Integrated Results (Aug – Dec 2020)

Compound	Units	MDL	RL	Depth Integrated or Surface Sample	August 2020				October 2020				December 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	4.0	10	DI	390	390	460	440	490	390	400	500	440	440	520	530
Total Suspended Solids	mg/L	NA	5	DI	4 J	4 J	6	9	ND (<5)	ND (<5)	6	8	ND (<5)	ND (<5)	6	8
Sulfide	mg/L	0.05-0.2	0.1-0.4	DI	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	8.0	4.8	8.8	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)
Nitrate as N	mg/L	0.04	0.2	DI	ND (<0.04)	ND (<0.04)	ND (<0.04)	ND (<0.04)	0.041 J	ND (<0.04)	0.056 J	0.044 J	ND (<0.04)	ND (<0.04)	0.052 J	0.071 J
Nitrite as N	mg/L	0.042	0.1	DI	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)
Total Kjeldahl Nitrogen	mg/L	0.018-0.065	0.1	DI	2.6	1.7	2.4	0.97	2.4	1.1	3.1	0.98	1.4	1.3	1.7	1.6
Total Nitrogen[a]	mg/L	NA	--	DI	2.6	1.7	2.4	0.97	2.4	1.1	3.2	1.0	1.4	1.3	1.8	1.8
Ammonia-Nitrogen	mg/L	0.012-0.047	0.1	DI	2.1	0.95	**1.5***	ND (<0.012)	1.9	0.45	**2.3***	ND (<0.012)	0.87	0.80	0.95	0.82
Unionized Ammonia[b]	mg/L	NA	--	DI	0.045	0.041	0.14	0	0.030	0.019	0.10	0	0.0040	0.0042	0.0058	0.0078
Ortho Phosphate Phosphorus	mg/L	0.003	0.01	DI	0.23	0.089	0.012	ND (<0.003)	0.16	0.007 J	0.007 J	0.005 J	0.022	0.069	0.058	0.026
Total Phosphorus	mg/L	0.00083-0.0067	0.01	DI	0.27	0.14	0.077	0.046	0.20	0.052	0.061	0.061	0.039	0.036	0.066	0.072
Total Aluminum	µg/L	1.4-41	20-50	DI	35	39	100	130	36	40	70	160	41	64	140	270
Dissolved Aluminum	µg/L	1.4-41	20-50	DI	26	34	71	93	27	32	53	69	13 J	16 J	19 J	21
Chlorophyll-a																
Chlorophyll-a	µg/L	NA	1.0	Surf (0-2m)	9.5	11	17	NM:LE	30	30	24	25	12	19	25	35
Chlorophyll-a	µg/L	NA	1.0	DI	18	28	68	23[c]	36	30	26	25	11	18	25	17

Notes:
When a concentration was non-detect (ND), the annual mean value for compliance purposes was calculated by converting ND values to zero. If the result of the calculated mean was non-zero, but below the corresponding MDL, the mean 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 – Sample measured out of holding time
ND – Not detected; NA – Not Applicable/ available; NM:LE – Not measured due to laboratory error
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 detection was above the MDL, but below the RL
Bold Underline - Indicates exceedance of 2020 TMDL Objective
Italicize – Indicates exceedance of Basin Plan Water Quality Objective
* Exceeds 2004 TMDL Permit NH3 CCC; ** Exceeds 2004 TMDL Permit NH3 CMC

Table 3-20. Analytical Chemistry Results for Canyon Lake- Monthly Depth-Integrated Results (Feb – June 2021)

Compound	Units	MDL	RL	Depth Integrated or Surface Sample	February 2021				April 2021				June 2021			
					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	4.0	10	DI	480	470	580	560	490	480	600	600	520	520	620	620
Total Suspended Solids	mg/L	NA	5	DI	0.5 J	0.1 J	10	14	ND (<5)	ND (<5)	ND (<5)	ND (<5)	ND (<5)	ND (<5)	ND (<5)	ND (<5)
Sulfide	mg/L	0.05-0.2	0.1-0.4	DI	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)
Nitrate as N	mg/L	0.04	0.2	DI	0.38	0.40	0.12 J	0.088 J	0.21	0.24	0.12 J	0.20	ND (<0.04)	ND (<0.04)	ND (<0.04)	ND (<0.04)
Nitrite as N	mg/L	0.042	0.1	DI	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)
Total Kjeldahl Nitrogen	mg/L	0.018-0.065	0.1	DI	1.5	1.3	1.6	1.5	1.2	1.0	2.0	0.91	1.8	1.2	2.0	0.77
Total Nitrogen[a]	mg/L	NA	--	DI	1.9	1.7	1.7	1.6	1.4	1.2	2.1	1.1	1.8	1.2	2.0	0.77
Ammonia-Nitrogen	mg/L	0.012-0.047	0.1	DI	0.58	0.51	0.40	0.11	0.76	0.48	1.4	0.27	1.1	1.1	0.47	ND (<0.047)
Unionized Ammonia[b]	mg/L	NA	--	DI	0.0040	0.0043	0.015	0.0095	0.0076	0.0074	0.019	0.0064	0.020	0.055	0.014	0
Ortho Phosphate Phosphorus	mg/L	0.003	0.01	DI	0.15	0.032	0.034	0.004 J	0.051	0.039	0.19	0.064	0.075	0.019	0.10	0.003 J
Total Phosphorus	mg/L	0.00083-0.0067	0.01	DI	0.051	0.056	0.12	0.12	0.072	0.070	0.24	0.099	0.11	0.056	0.17	0.054
Total Aluminum	µg/L	1.4-41	20-50	DI	53	52	180	210	50	52	63	65	45 J	45 J	68	100
Dissolved Aluminum	µg/L	1.4-41	20-50	DI	ND (<1.4)	2.8	ND (<1.4)	3.4 J	ND (<41)	ND (<41)	ND (<41)	ND (<41)	ND (<41)	ND (<41)	ND (<41)	ND (<41)
Chlorophyll-a																
Chlorophyll-a	µg/L	NA	1.0	Surf (0-2m)	3.2	3.7	40	70	4.3	4.8	10	5.9	6.7	15	6.9	9.6
Chlorophyll-a	µg/L	NA	1.0	DI	1.6	3.2	43	67	3.2	3.4	7.5	5.8	26	28	54	9.9

Notes:
When a concentration was non-detect (ND), the annual mean value for compliance purposes was calculated by converting ND values to zero. If the result of the calculated mean was non-zero, but below the corresponding MDL, the mean 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 – Sample measured out of holding time
ND – Not detected; NA – Not Applicable/ available
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 detection was above the MDL, but below the RL
Bold Underline - Indicates exceedance of 2020 TMDL target
Italicize – Indicates exceedance of Basin Plan Water Quality Objective

Table 3-21. Analytical Chemistry Results for Canyon Lake - Annual Mean Statistics for Each Site in the Main Basin

Compound	Units	MDL	RL	Basin Plan WQO or TMDL Target	Depth Integrated or Surface Sample	CL07			CL08			Main Basin		
						Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
General Chemistry														
Total Dissolved Solids	mg/L	4.0	10	700[2]	DI	390	520	468	390	520	448	390	520	458
Total Suspended Solids	mg/L	NA	5	NA	DI	ND (<5)	4 J	0.75 J	<5	4 J	0.68 J	<5	4 J	0.72 J
Sulfide	mg/L	0.05-0.2	0.1-0.4	NA	DI	ND (<0.05)	8.0	1.3	ND (<0.05)	4.8	0.80	ND (<0.05)	8.0	1.1
Nitrate as N	mg/L	0.04	0.2	NA	DI	ND (<0.04)	0.38	0.11 J	ND (<0.04)	0.40	0.11 J	ND (<0.04)	0.40	0.11 J
Nitrite as N	mg/L	0.042	0.1	NA	DI	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)
Total Kjeldahl Nitrogen	mg/L	0.018-0.065	0.1	NA	DI	1.2	2.6	1.8	1.0	1.7	1.3	1.0	2.6	1.5
Total Nitrogen[a]	mg/L	NA	--	0.75[b1]	DI	1.4	2.6	**1.9**	1.1	1.7	**1.4**	1.1	2.6	**1.6**
Ammonia-Nitrogen	mg/L	0.012-0.047	0.1	2004- CMC: 1.4-27[1]; CCC: 0.22-5.1[1]	DI	0.58	2.1	1.2	0.45	1.1	0.72	0.45	2.1	1.0
Unionized Ammonia[c]	mg/L	NA	--	NA	DI	0.0040	0.045	0.018	0.0042	0.055	0.022	0.0040	0.055	0.020
Ortho Phosphate Phosphorus	mg/L	0.003	0.01	NA	DI	0.022	0.23	0.11	0.007 J	0.089	0.043	0.007 J	0.23	0.079
Total Phosphorus	mg/L	0.00083-0.0067	0.01	0.1[b1]	DI	0.039	0.27	**0.12**	0.036	0.14	0.068	0.036	0.27	0.096
Total Aluminum	µg/L	1.4-41	20-50	NA	DI	35	53	43	39	64	49	35	64	46
Dissolved Aluminum	µg/L	1.4-41	20-50	NA	DI	ND (<1.4-41)	27	11	ND (<1.4-41)	34	14	ND (<1.4-41)	34	13
Chlorophyll-a														
Chlorophyll-a	µg/L	NA	1.0	25[b1]	Surf (0-2m)	3.2	30	11	3.7	30	14	3.2	30	12
Chlorophyll-a	µg/L	NA	1.0	25[b1]	DI	1.6	36	16	3.2	30	18	1.6	36	17

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 - 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.
1 – 2020 TMDL Target, based on Table 5-9n of 2004 TMDL
2 – 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
Bold Underline - Indicates exceedance of 2020 TMDL target
Italicize – Indicates exceedance of Basin Plan Water Quality Objective

Table 3-22. Analytical Chemistry Results for Canyon Lake - Annual Mean Statistics for Each Site in the East Basin

Compound	Units	MDL	RL	Basin Plan WQO or TMDL Target	Depth Integrated or Surface Sample	CL09			CL10			East Basin		
						Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
General Chemistry														
Total Dissolved Solids	mg/L	4.0	10	700[2]	DI	400	620	530	440	620	542	400	620	536
Total Suspended Solids	mg/L	NA	5	NA	DI	<5	10	4.7 J	<5	14	6.5	<5	14	5.6
Sulfide	mg/L	0.05-0.2	0.1-0.4	NA	DI	ND (<0.05)	8.8	1.5	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	8.8	0.73
Nitrate as N	mg/L	0.04	0.2	NA	DI	ND (<0.04)	0.12	0.058	ND (<0.04)	0.20	0.067	ND (<0.04)	0.20	0.063
Nitrite as N	mg/L	0.042	0.1	NA	DI	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)
Total Kjeldahl Nitrogen	mg/L	0.018-0.065	0.1	NA	DI	1.6	3.1	2.1	0.77	1.6	1.1	0.77	3.1	1.6
Total Nitrogen[a]	mg/L	NA	--	0.75[b1]	DI	1.7	3.2	**2.2**	0.77	1.8	**1.2**	0.77	3.2	**1.7**
Ammonia-Nitrogen	mg/L	0.012-0.047	0.1	2004- CMC: 1.4-27[1]; CCC: 0.22-5.1[1]	DI	0.40	2.3	1.2	ND (<0.012)	0.82	0.20	ND (<0.012)	2.3	0.69
Unionized Ammonia[c]	mg/L	NA	--	NA	DI	0.0058	0.14	0.049	0	0.0095	0.0040	0	0.14	0.026
Ortho Phosphate Phosphorus	mg/L	0.003	0.01	NA	DI	0.0070	0.19	0.067	<0.003	0.064	0.017	<0.003	0.19	0.042
Total Phosphorus	mg/L	0.00083-0.0067	0.01	0.1[b1]	DI	0.061	0.24	**0.12**	0.046	0.12	0.075	0.046	0.24	0.099
Total Aluminum	µg/L	1.4-41	20-50	NA	DI	63	180	104	65	270	156	63	270	130
Dissolved Aluminum	µg/L	1.4-41	20-50	NA	DI	ND (<1.4-41)	71	24	ND (<1.4-41)	93	31	ND (<1.4-41)	93	27
Chlorophyll-a														
Chlorophyll-a	µg/L	NA	1.0	25[b1]	Surf (0-2m)	6.9	40	20	5.9	70	**29**	5.9	70	**25**
Chlorophyll-a	µg/L	NA	1.0	25[b1]	DI	7.5	68	**37**	5.8	67	**25**	5.8	68	**31**

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 - 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.
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 Water Quality 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
Bold Underline - Indicates exceedance of 2020 TMDL target
Italicize – Indicates exceedance of Basin Plan Water Quality Objective

Table 3-23. Analytical Chemistry Results for Canyon Lake - Annual Mean Statistics for Both Main and East Basins

Compound	Units	MDL	RL	Basin Plan WQO 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	4.0	10	700[2]	DI	390	520	458	400	620	536	390	620	497
Total Suspended Solids	mg/L	NA	5	NA	DI	ND (<5)	4 J	0.72 J	ND (<5)	14	5.6	ND (<5)	14	3.2 J
Sulfide	mg/L	0.05-0.2	0.1-0.4	NA	DI	ND (<0.05)	8.0	1.1	ND (<0.05)	8.8	0.73	ND (<0.05)	8.8	0.90
Nitrate as N	mg/L	0.04	0.2	NA	DI	ND (<0.04)	0.40	0.11 J	ND (<0.04)	0.20	0.063 J	ND (<0.04)	0.40	0.084
Nitrite as N	mg/L	0.042	0.1	NA	DI	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)	ND (<0.042)
Total Kjeldahl Nitrogen	mg/L	0.018-0.065	0.1	NA	DI	1.0	2.6	1.5	0.77	3.1	1.6	0.77	3.1	1.6
Total Nitrogen[a]	mg/L	NA	--	0.75[b1]	DI	1.1	2.6	**1.6**	0.77	3.2	**1.7**	0.77	3.2	**1.7**
Ammonia-Nitrogen	mg/L	0.012-0.047	0.1	2004- CMC: 1.4-27[1]; CCC: 0.22-5.1[1]	DI	0.45	2.1	0.97	ND (<0.012)	2.3	0.69	ND (<0.012)	2.3	0.83
Unionized Ammonia[c]	mg/L	NA	--	NA	DI	0.0040	0.055	0.020	0.0	0.14	0.026	0.0	0.14	0.023
Ortho Phosphate Phosphorus	mg/L	0.003	0.01	NA	DI	0.01	0.23	0.079	ND (<0.003)	0.19	0.042	0.0	0.23	0.060
Total Phosphorus	mg/L	0.00083-0.0067	0.01	0.1[b1]	DI	0.036	0.27	0.096	0.046	0.24	0.099	0.036	0.27	0.097
Total Aluminum	µg/L	1.4-41	20-50	NA	DI	35	64	46	63	270	130	35	270	88
Dissolved Aluminum	µg/L	1.4-41	20-50	NA	DI	ND (<1.4)	34	13	ND (<1.4)	93	27	ND (<1.4)	93	20
Chlorophyll-a														
Chlorophyll-a	µg/L	NA	1.0	25[b1]	Surf (0-2m)	3.2	30	12	5.9	70	25	3.2	70	19
Chlorophyll-a	µg/L	NA	1.0	25[b1]	DI	1.6	36	17	5.8	68	**31**	1.6	68	24

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 - 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.
1 – 2020 TMDL Target, based on Table 5-9n of 2004 TMDL
2 – Santa Ana Region Basin Plan Water Quality 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
Bold Underline - Indicates exceedance of 2020 TMDL target
Italicize – Indicates exceedance of Basin Plan Water Quality Objective

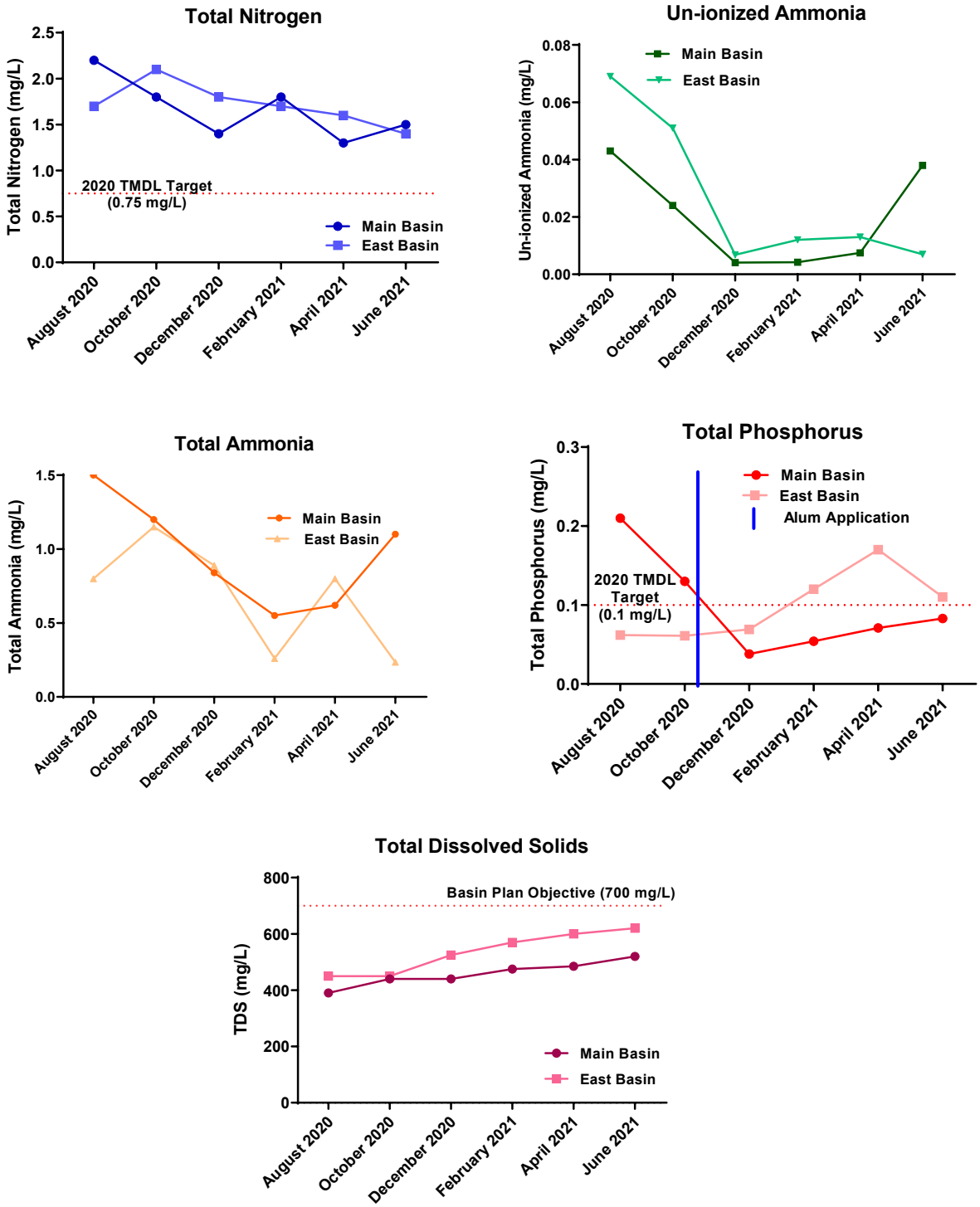


Figure 3-18. Canyon Lake Analytical Chemistry – Depth-Integrated Means

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

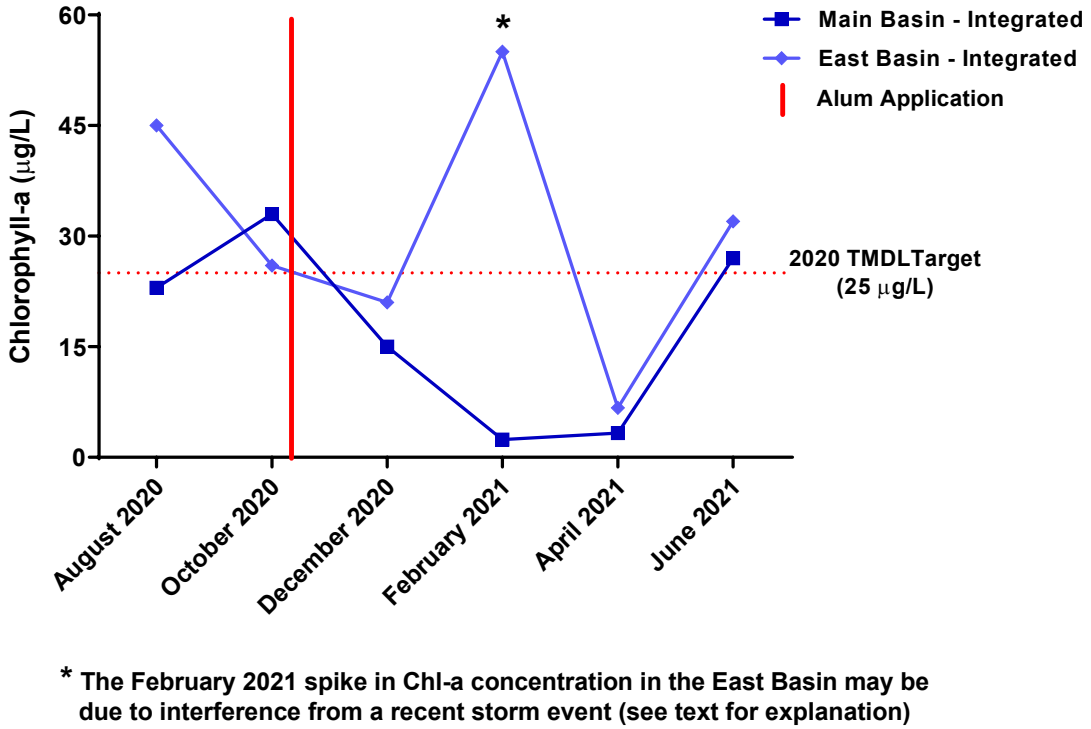


Figure 3-19. Canyon Lake Analytical Chemistry – Depth-Integrated Chlorophyll-a

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

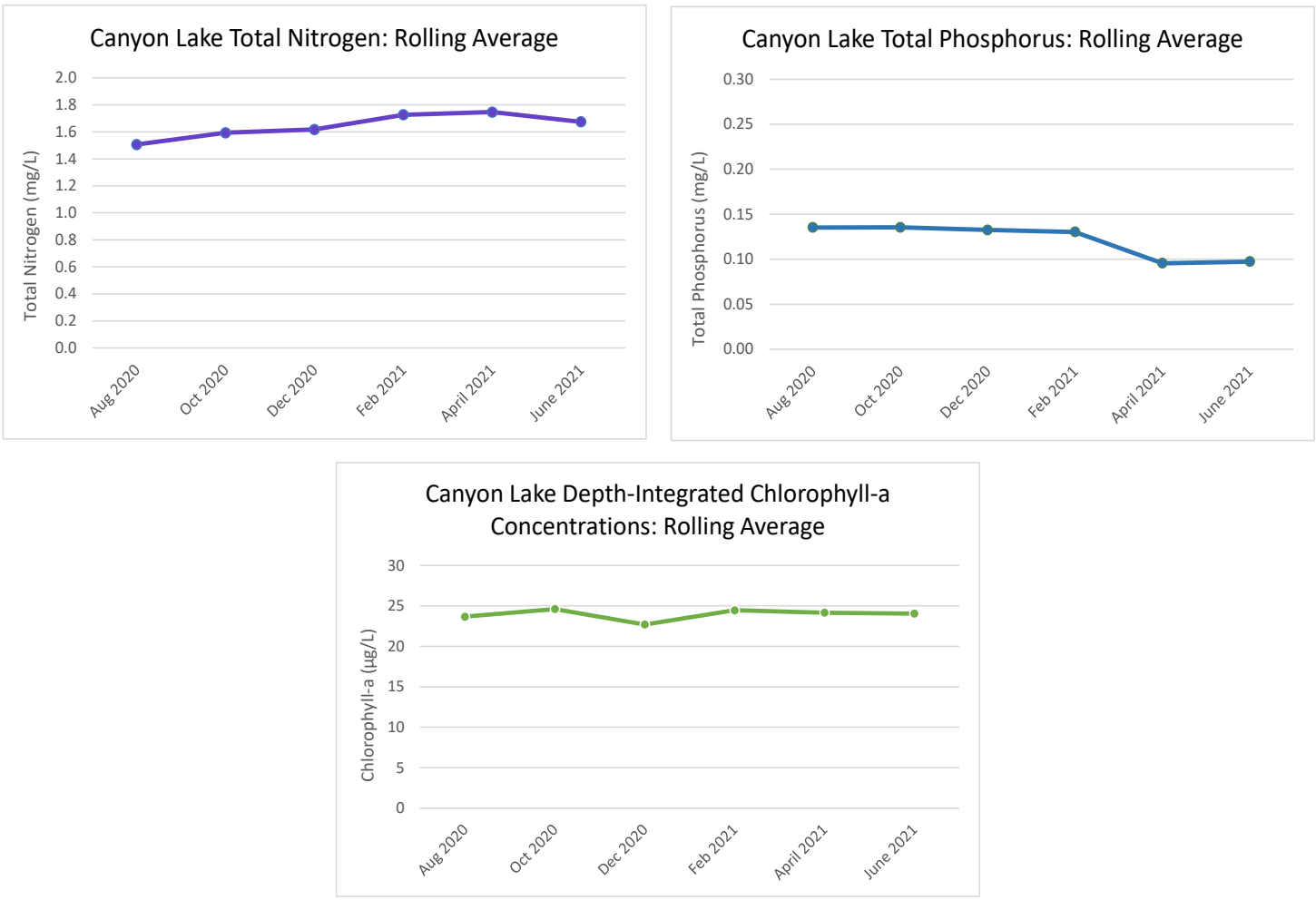


Figure 3-20. Canyon Lake Analytical Chemistry- Rolling Averages

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

3.5 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. The satellite images are also able to provide a sense of the relative variability in algae concentrations

across the lake that can be rather dramatic and missed by measuring individual values from only a few discrete locations. 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.

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 3-21 through 3-24. 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 3-25 and 3-26. Satellite derived mean and median concentrations along with measured in-lake chlorophyll-a concentrations in the surface composite (0-2m) sample are provided for each date showing how these single samples compare 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.

The satellite images for Lake Elsinore show an initial increase in lake wide chlorophyll-a concentration from July to August 2020, but then a gradual decrease in chlorophyll-a through April 2021, followed by an increase in June 2021. These generalizations are validated when using satellite pixel data to calculate lake-wide mean and median chlorophyll-a concentrations. The general lake-wide pattern observed using satellite imagery was consistent with measured month-to-month surface chlorophyll-a values at Site LE02.

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 October 2020 in the Main Basin, as well as February and April for the East Basin. Measured in-lake concentrations of chlorophyll-a in the Main Basin were relatively low and generally matched those observed in the satellite images (< 36 mg/L). Edge-interference effects can occur as a result of land and water pixels mixing near the edges of the narrow East Basin channel. This "edge effect" is somewhat diminished during non-summer months when Sentinel-2 satellite data is used[4], which 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. However, the elevated chlorophyll-a satellite images were captured during the non-summer months indicating that the elevated chlorophyll-a observed in the satellite imagery is less-likely to be an edge interference effect. Overall satellite estimates of chlorophyll-a data generally tracked with Canyon Lake in-lake analytical surface sample data. As mentioned in the analytical chemistry section for Canyon Lake (Section 3.3.3), there is the possibility that the elevated chlorophyll-a seen in February 2021 for the East Basin could be the result of water quality interference caused by the recent storm event prior to sampling.

[4] 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.

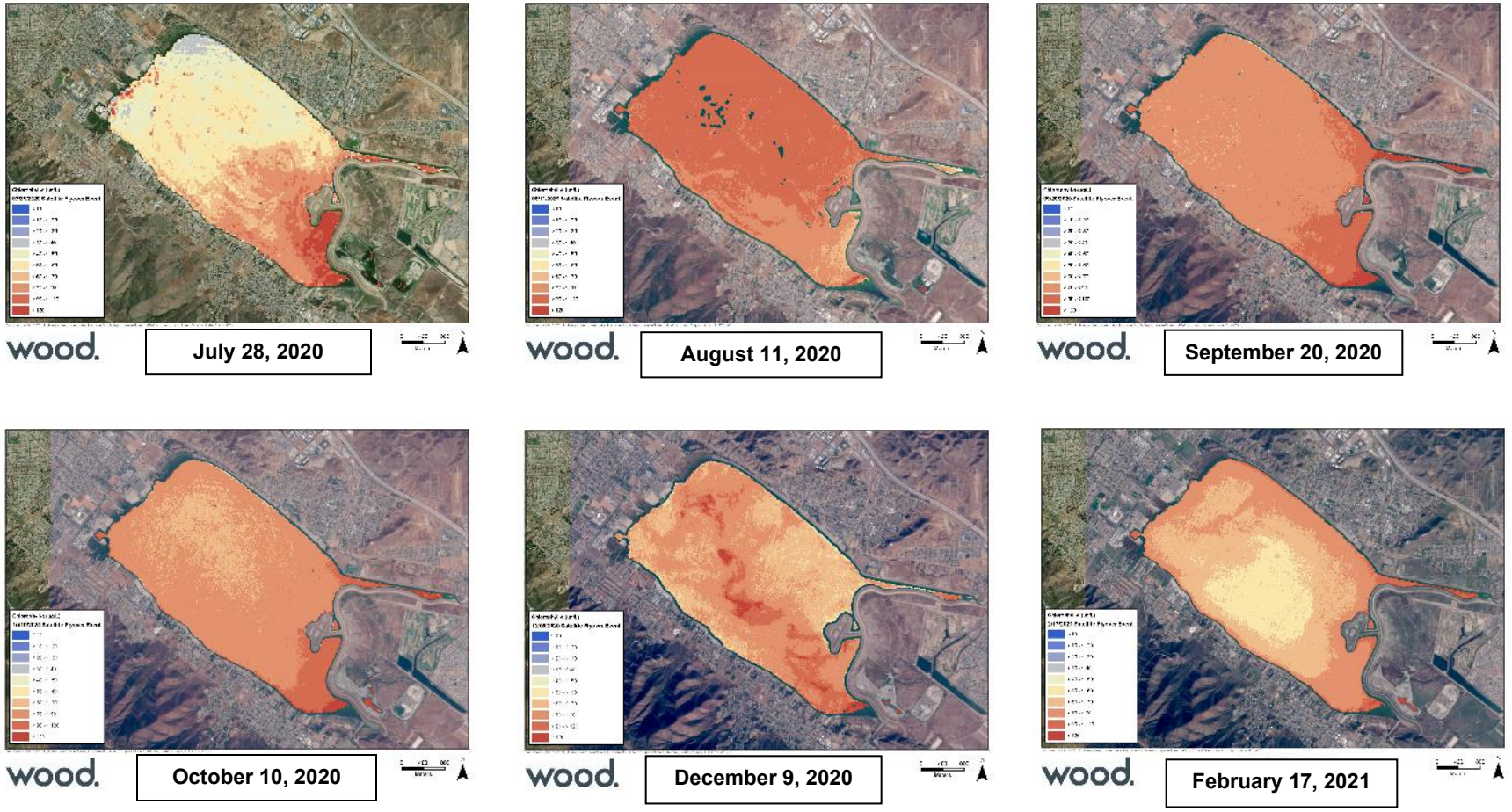


Figure 3-21. Satellite Imagery of Chlorophyll-a Concentrations in Lake Elsinore

(Data gaps in August are due to sunglint)

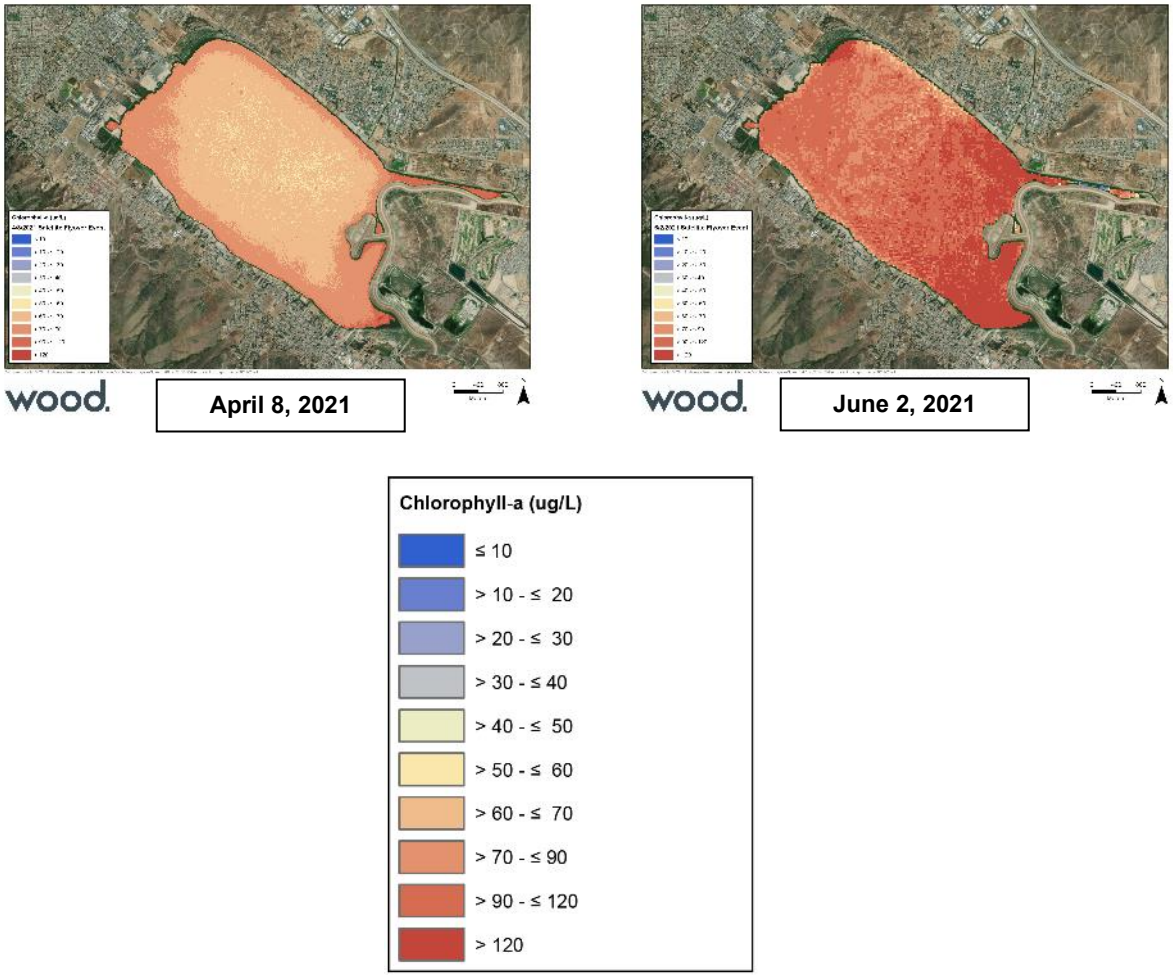


Figure 3-21 (cont.). Satellite Imagery of Chlorophyll-a Concentrations in Lake Elsinore

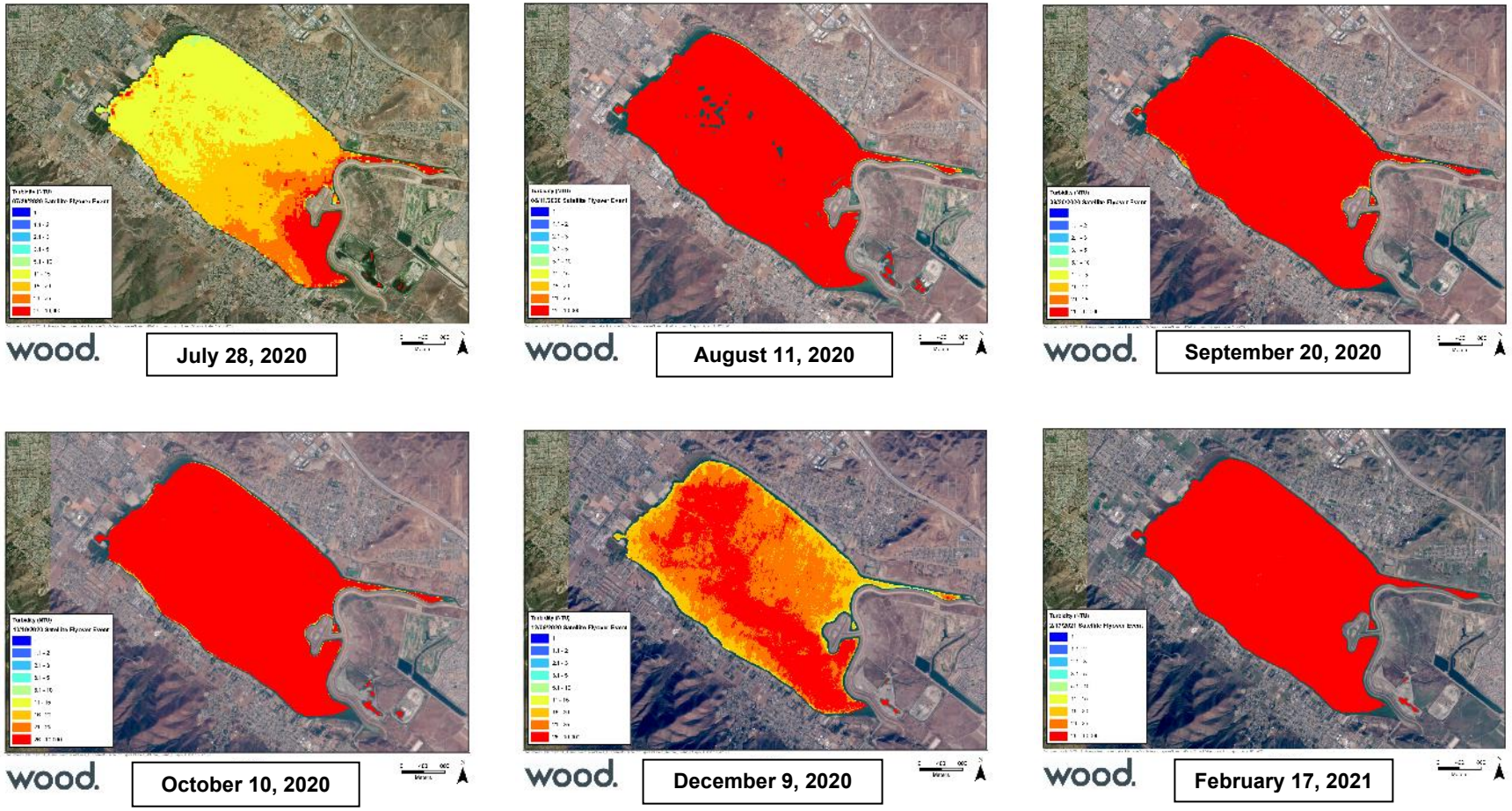


Figure 3-22. Satellite Imagery of Turbidity Concentrations in Lake Elsinore

(Data gaps in August are due to sunglint)

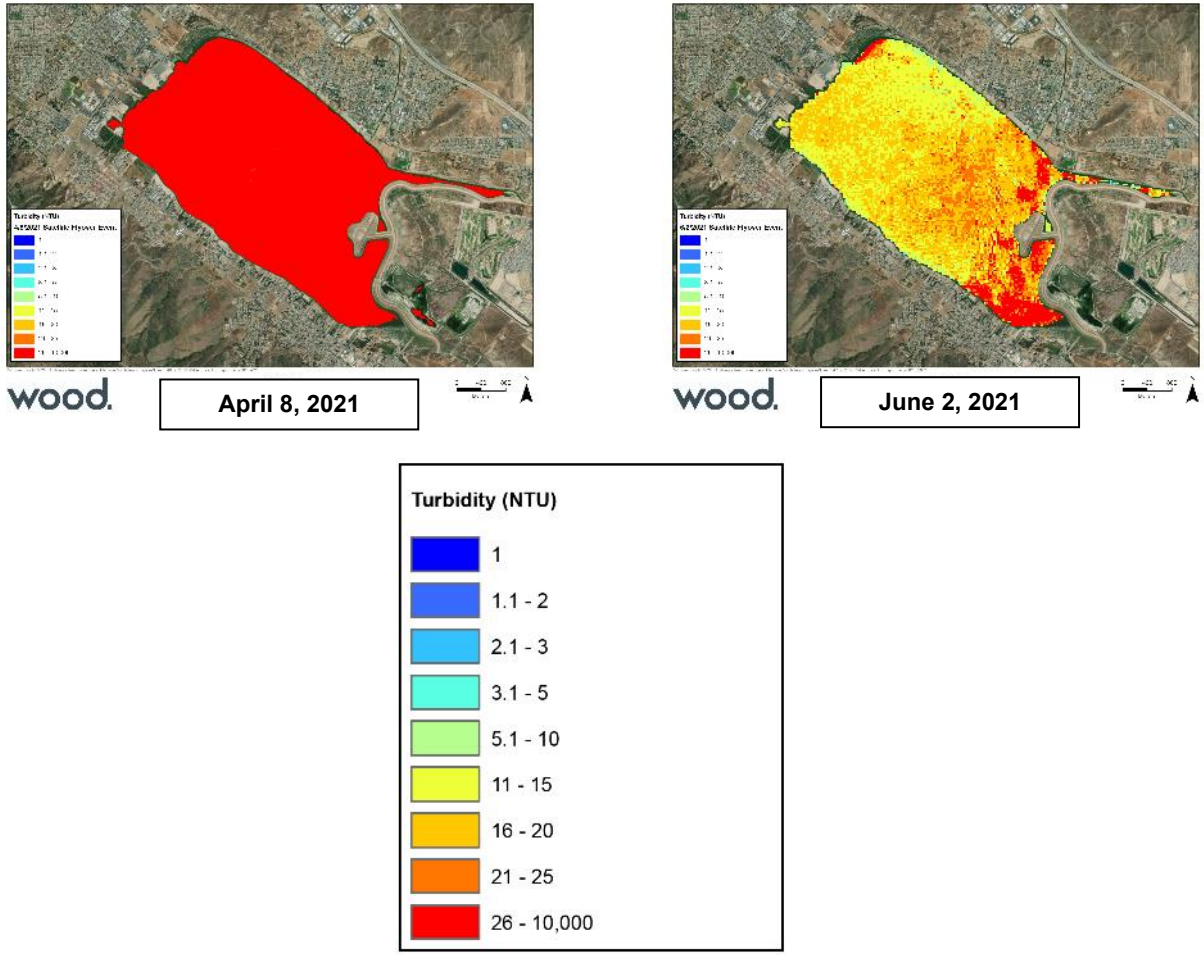


Figure 3-22 (cont.). Satellite Imagery of Turbidity Concentrations in Lake Elsinore

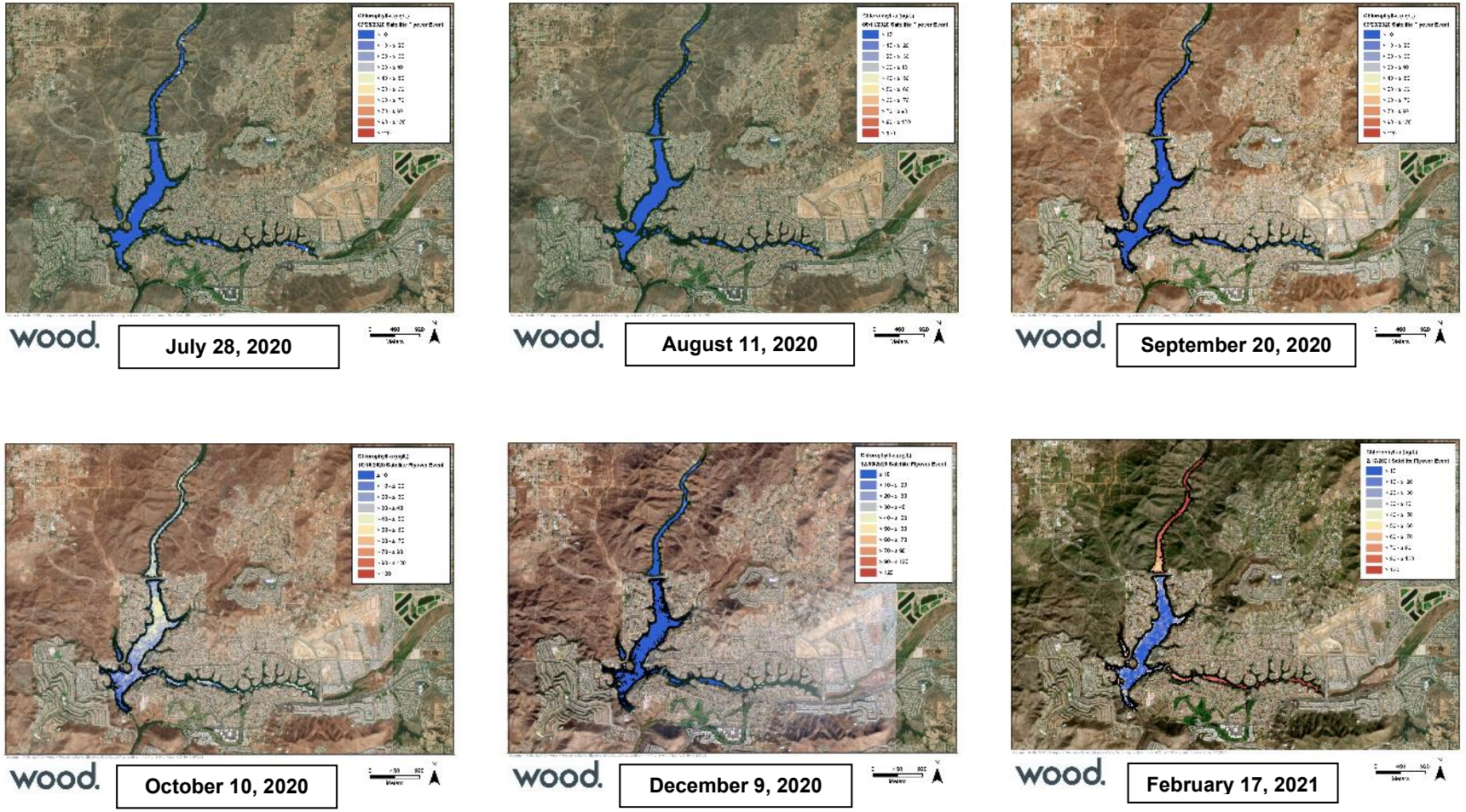


Figure 3-23. Satellite Imagery of Chlorophyll-a Concentrations in Canyon Lake

(Data gaps in December 2020 are caused by sunglint)

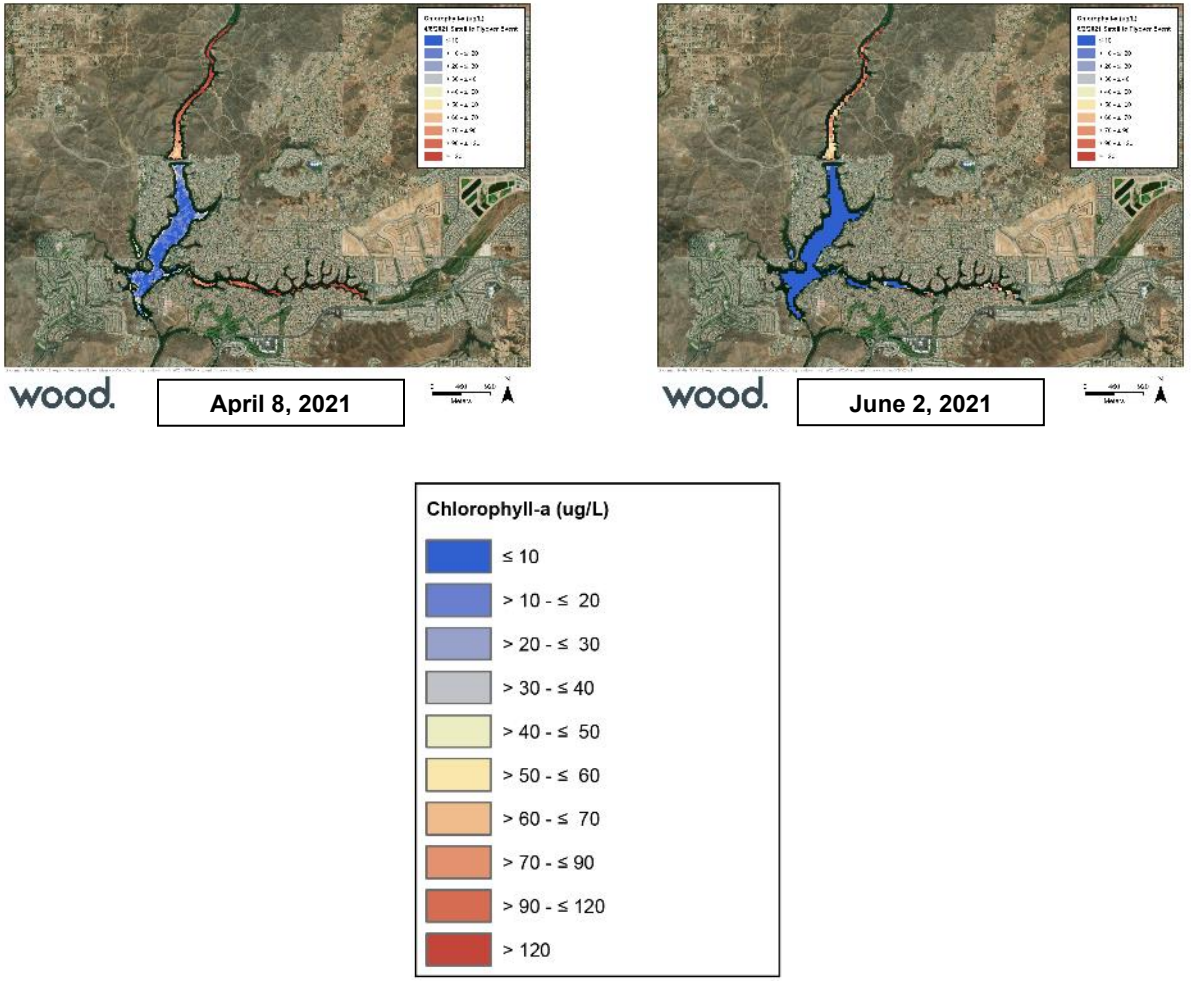


Figure 3-23 (cont.). Satellite Imagery of Chlorophyll-a Concentrations in Canyon Lake

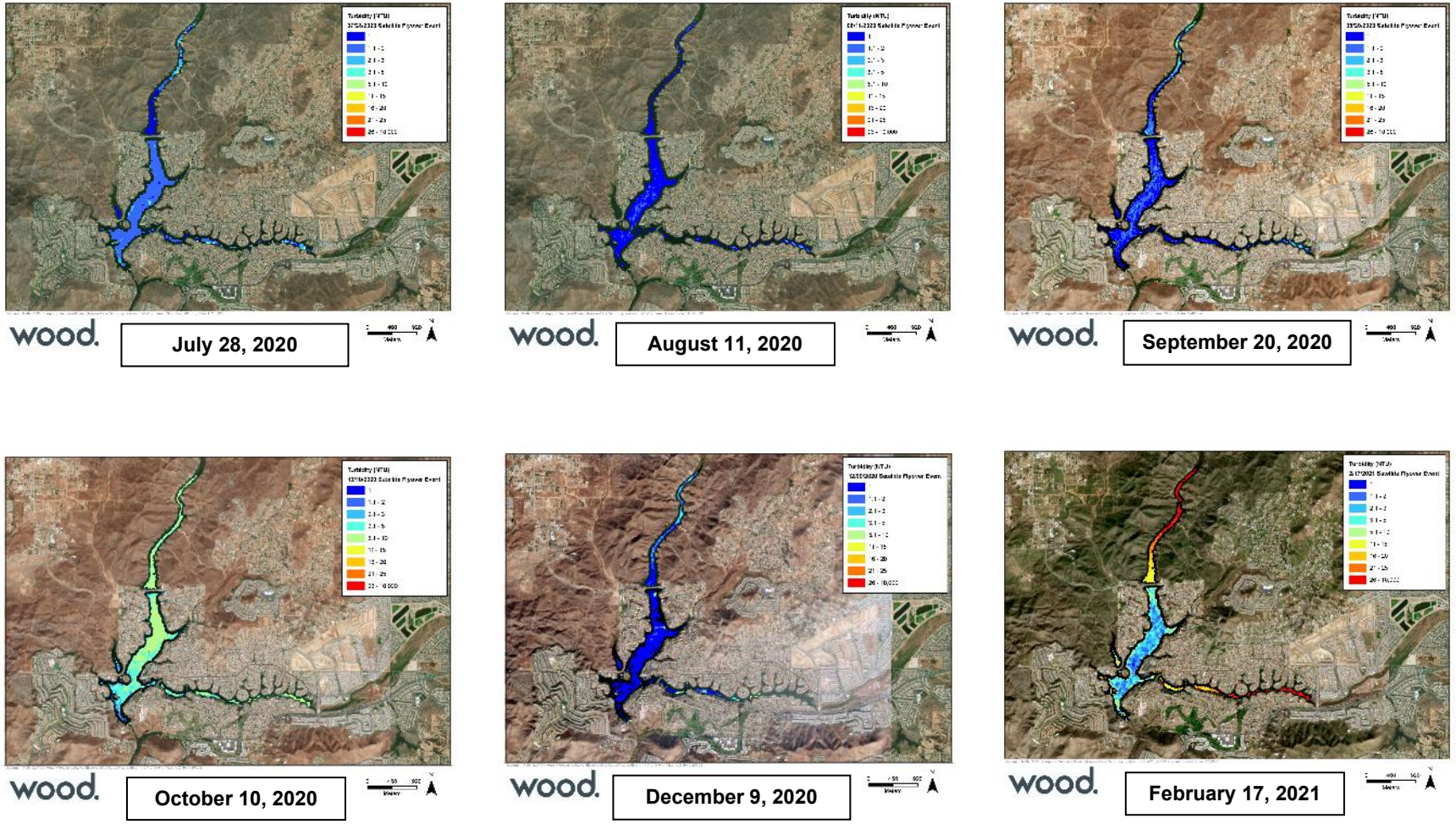


Figure 3-24. Satellite Imagery of Turbidity Measurements Canyon Lake

(Data gaps in December 2020 are caused by sunglint.)

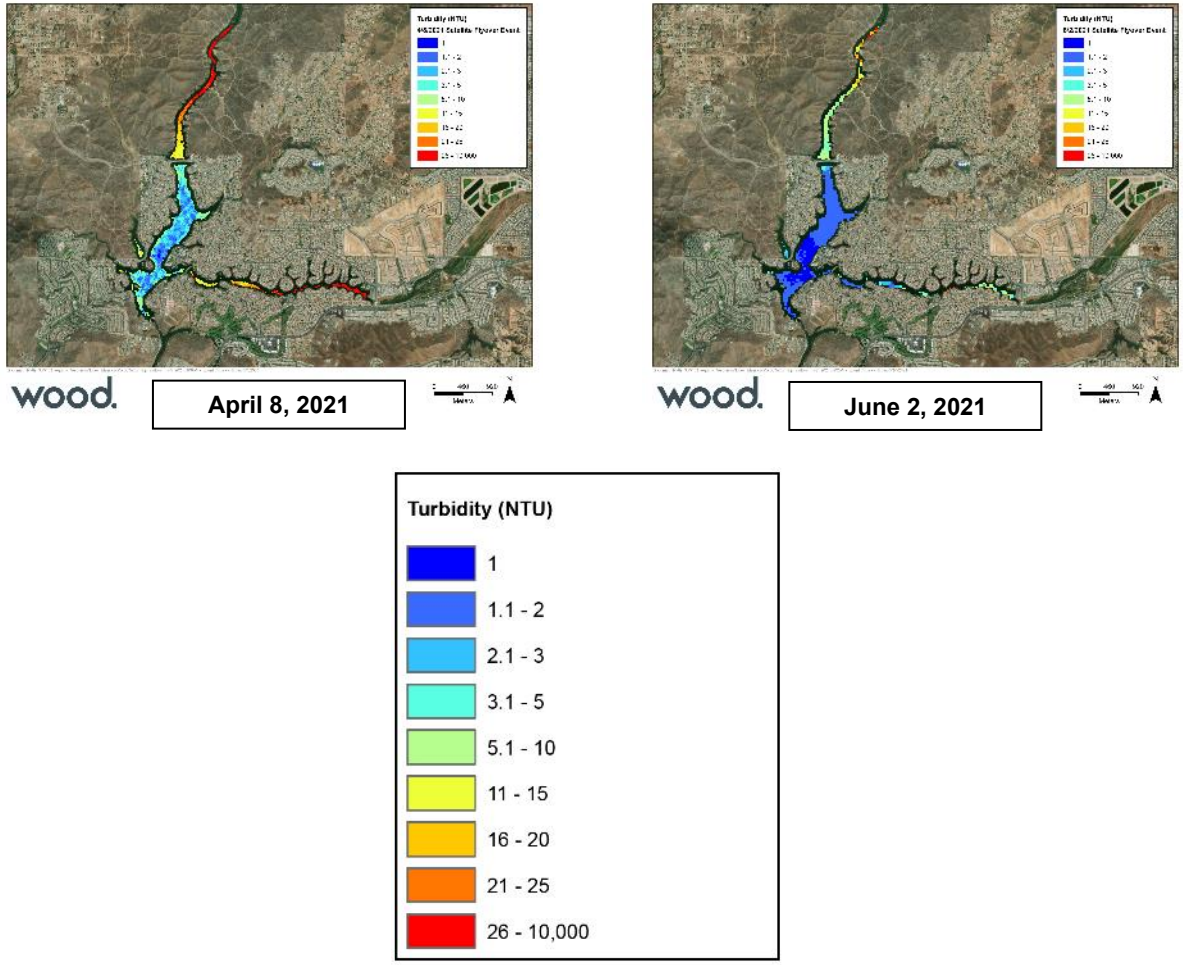


Figure 3-24 (cont.). Satellite Imagery of Turbidity Measurements Canyon Lake

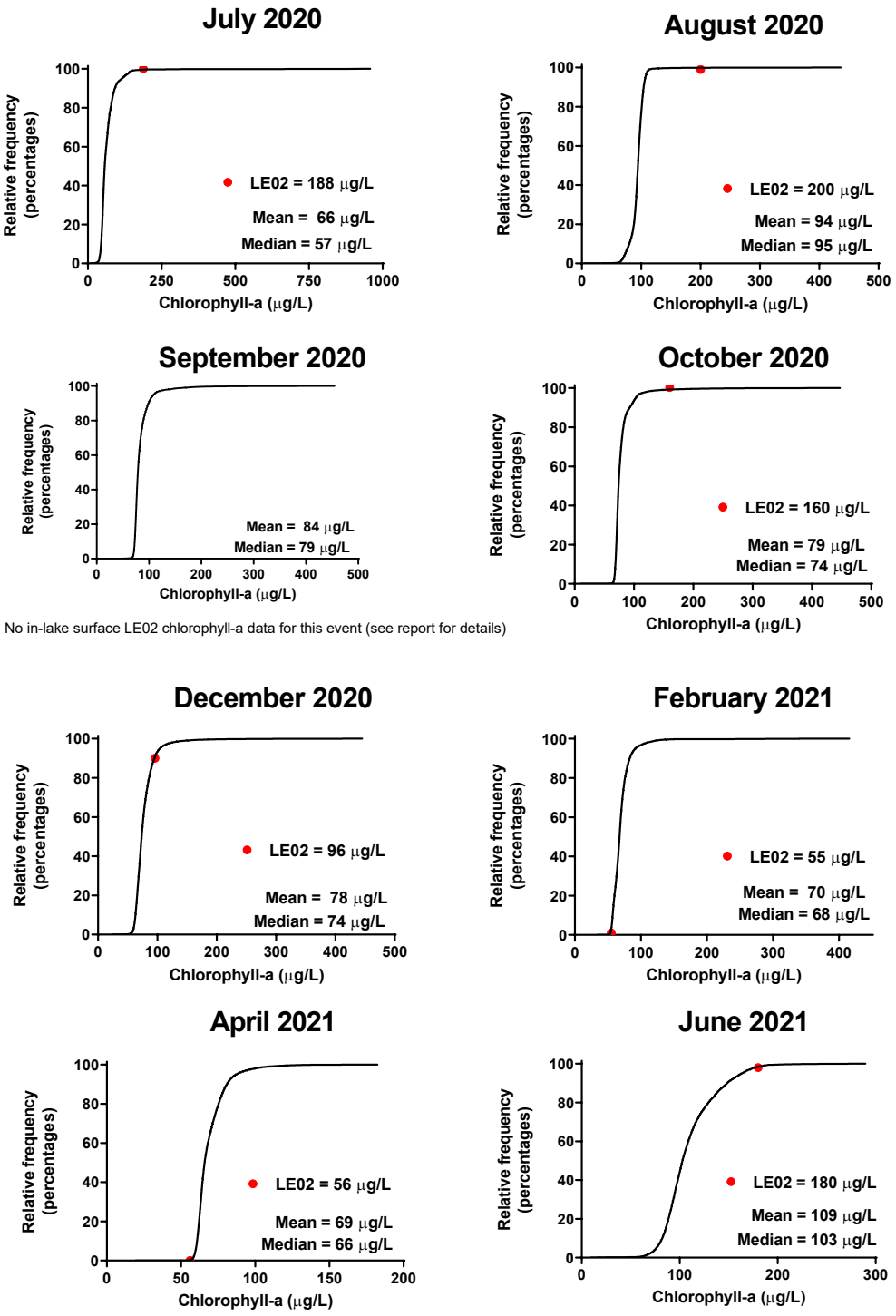


Figure 3-25. Cumulative Distribution of Satellite Derived Chlorophyll-a Concentrations in Lake Elsinore Relative to Measured Chlorophyll-a in Field Collected Samples
Colored dots represent the in-lake surface (0-2m) analytical measured concentration for each event

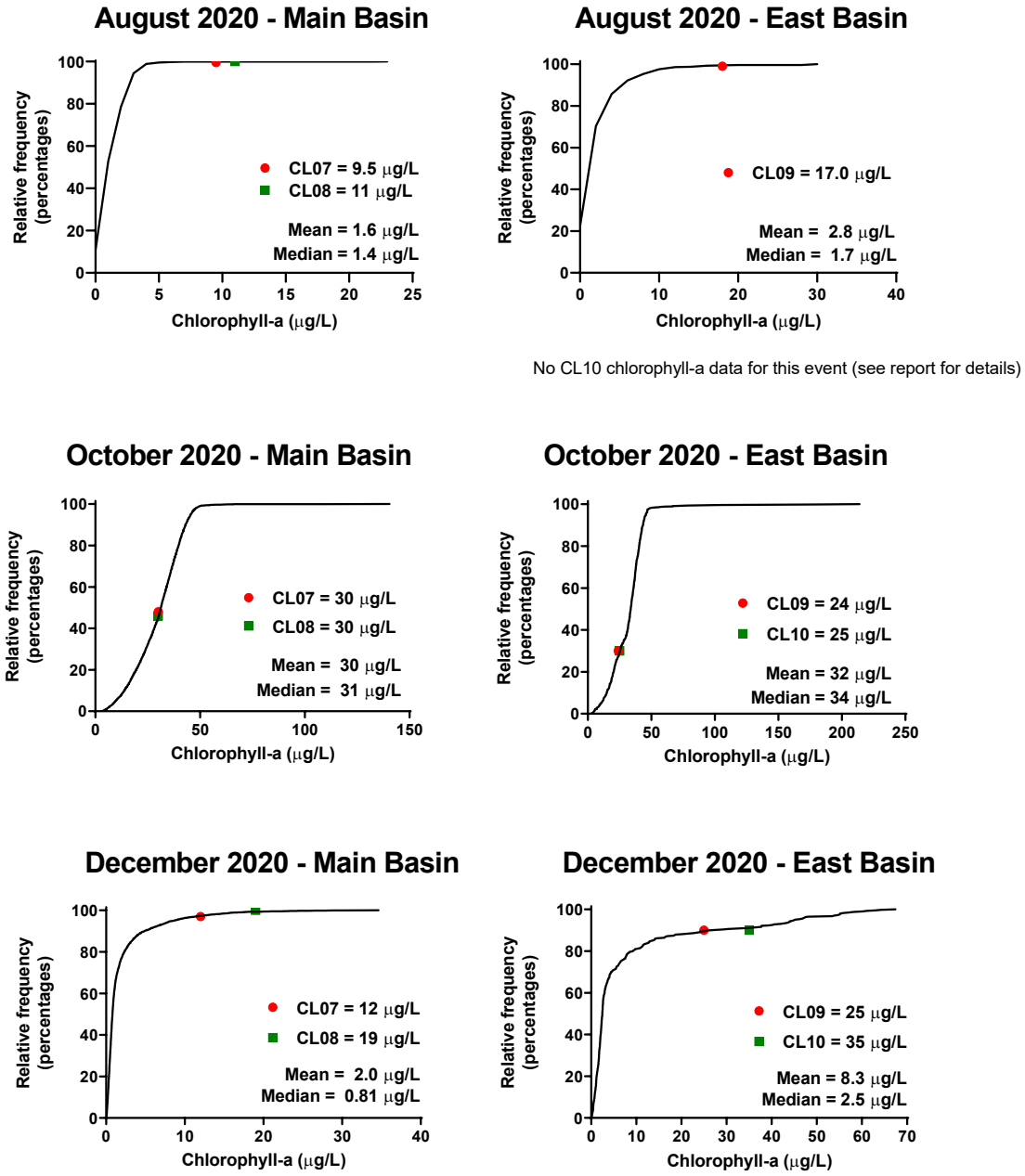


Figure 3-26. Cumulative Distribution of Satellite Derived Chlorophyll-a Concentrations in Canyon Lake Relative to Measured Chlorophyll-a in Field Collected Samples
Colored dots represent the in-lake surface (0-2m) analytical measured concentration for each event

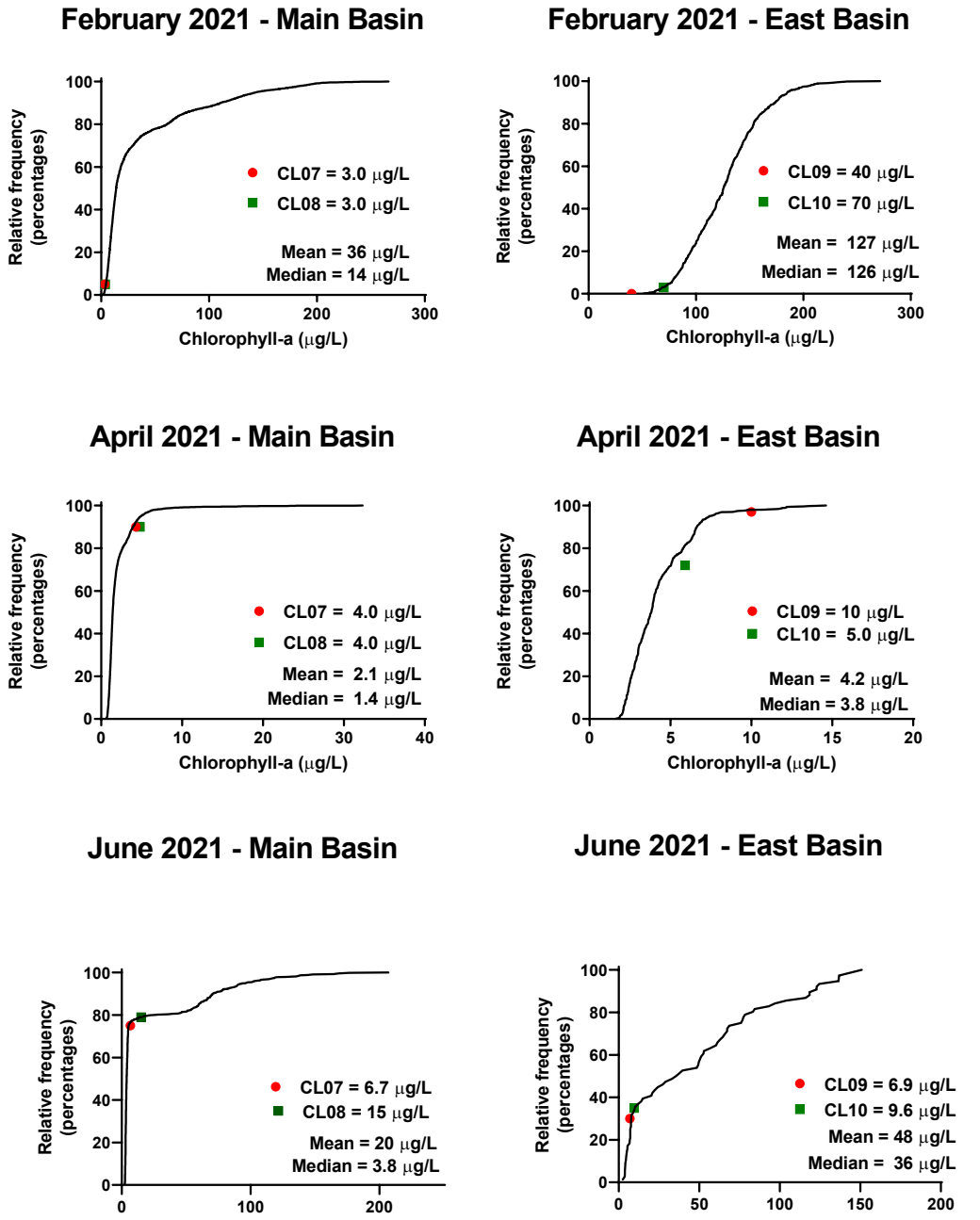


Figure 3-26. (cont). Cumulative Distribution of Satellite Derived Chlorophyll-a Concentrations in Canyon Lake Relative to Measured Chlorophyll-a in Field Collected Samples

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

4.0 Conclusions

Sampling was conducted during the July 2020 to June 2021 monitoring year according to the Lake Elsinore and Canyon Lake Nutrient Monitoring Work Plan (Haley & Aldrich 2016) and companion Quality Assurance Project Plan (Amec Foster Wheeler 2016) in order to fulfill the requirements outlined in RWQCB Resolution No. R8-2004-0037. A total of 8 monitoring events were conducting in Lake Elsinore (monthly June to September, bi-monthly otherwise) and 6 monitoring events in Canyon Lake (bi-monthly). A total of two storm events met mobilization criteria for watershed stormwater sampling, occurring on January 29, 2021, and March 10, 2021.

The following summarizes the data collected during the 2020-2021 monitoring year, noting any exceedances of TMDL targets, and any relevant observations pertaining to results obtained.

4.1 Watershed Monitoring

A summary of watershed water quality monitoring data for each of the four monitoring locations for the monitoring period of July 1, 2020 through June 30, 2021 is provided below.

1. Concentrations of nutrients for the two storm events monitored at Salt Creek at Murrieta Road (Station ID 745) ranged from 1.4 to 2.4 mg/L for total nitrogen, and 0.25 to 0.53 mg/L for total phosphorus. Based on flow data provided by the nearby USGS stream gauge (Station ID 11070465), the total annual flow was estimated at 34,093,755 cubic feet. The estimated annual nutrient load was calculated to be 1,902 kg for total nitrogen and 396 kg for total phosphorus.

2. Concentrations of nutrients for the two storm events monitored at San Jacinto River at Goetz Road (Station ID 759) ranged from 1.8 to 2.0 mg/L for total nitrogen, and 0.40 to 0.56 mg/L for total phosphorus. Based on flow data provided by the nearby USGS stream gauge (Station ID 11070365), the total annual flow was estimated at 69,394,095 cf. The estimated annual nutrient load was calculated to be 3,794 kg for total nitrogen and 992 kg for total phosphorus.

3. Concentrations of nutrients for the two storm events monitored at Canyon Lake Spillway (Station ID 841) ranged from 1.3 to 2.1 mg/L for total nitrogen, and 0.036 to 0.07 mg/L for total phosphorus. Based on flow data provided by the nearby USGS stream gauge (Station ID 11070500), the total annual flow was estimated at 117,374,904 cf. The estimated annual nutrient load was calculated to be 5,626 kg for total nitrogen and 175 kg for total phosphorus.

4. No flows were observed at San Jacinto River at Ramona Expressway (Station ID 741) during the 2020-2021 monitoring year.

4.2 In-Lake Monitoring

4.2.1 Lake Elsinore

1. The Lake Elsinore annual monitoring year mean for total nitrogen and total phosphorus, at 4.1 mg/L and 0.24 mg/L respectively, exceeded their associated 2020 TMDL limits. While the total nitrogen concentration dropped from the previous monitoring year (4.4 mg/L), total phosphorus exhibited an increase (0.18 mg/L in 2019-2020).

2. The annual mean for total ammonia was 0.31 mg/L, up slightly from the previous monitoring year (0.26 mg/L). All total ammonia concentrations were below CMC and CCC thresholds, with the exception of samples collected in August and September 2020 (0.40 and 0.69 mg/L total ammonia, respectively), which exceeded their corresponding CCC objective. The 2019-2020 monitoring year had one exceedance of the CCC objective.

3. The DO concentration in Lake Elsinore as a 12-month rolling average remained below the 2020 TMDL target (>5.0 mg/L 1-m above the lake bottom) for the entire monitoring year. Similar results were observed during the 2019-2020 monitoring year.

4. The mean chlorophyll-a concentration observed in samples collected during the summer TMDL compliance period (June 2020 through September 2020) was 212 µg/L for depth-integrated samples and 179 µg/L for surface samples. These concentrations exceed the 2020 TMDL target of 25 µg/L chlorophyll-a. The summer 2020 chlorophyll-a values were higher than those observed during the previous summer of 2019 (89 µg/L for depth integrated samples and 91 µg/L for surface samples).

4.2.2 Canyon Lake

1. The Canyon Lake annual monitoring year mean for total nitrogen and total phosphorus was 1.65 mg/L and 0.098 mg/L, respectively. Total nitrogen exceeded the 0.75 mg/L 2020 TMDL limit, but total phosphorus was under its 0.1 mg/L 2020 TMDL limit. The total nitrogen concentration increased slightly from the previous monitoring year (1.5 mg/L), while total phosphorus exhibited an decrease (0.13 mg/L in 2019-2020).

2. The annual lake wide mean for total ammonia was 0.083 mg/L. This value is substantially less than the previous monitoring year which had a mean total ammonia of 0.48 mg/L. Two samples at Site CL09 (August and October) exceeded the total ammonia CCC threshold value for the protection of aquatic life. No samples exceeded the total ammonia CMC value. Interestingly, in both this and the previous monitoring year the annual mean total ammonia concentration was somewhat higher in the Main Basin than the East Basin (0.97 vs. 0.69 mg/L in 2020-2021, and 0.58 vs. 0.38 mg/L in 2019-2020). This is likely due to the lower dissolved oxygen near the sediment surface in the Main Basin as a result of stronger stratification, thereby allowing more ammonia to flux out of the sediment.

3. The DO concentration in the hypolimnion (when the lake was stratified) ranged from 0.1 to 0.8 mg/L. The rolling 12-month mean DO concentration was never above the 2020 TMDL target of >5.0 mg/L in the hypolimnion. The magnitude of stratification in Canyon Lake, particularly in the Main Basin, as well as its duration limits the ability of the lake to meet the 2020 TMDL target for DO. The lake is stratified during large portions of the year, during which there is almost no mixing between the upper epilimnion and lower hypolimnion. During this time, the DO in the hypolimnion declines substantially as sediment processes deplete the oxygen.

4. The mean annual lake-wide depth-integrated chlorophyll-a concentration observed was 24 µg/L for depth-integrated samples and 19 µg/L for surface samples. Both of these concentrations are below the 2020 TMDL target of 25 µg/L. The was a spike in chlorophyll-a in February 2021 in the East Basin up to 55 µg/L. It is likely that the large storm event occurring on January 29 - February 1, 2021 was related to this increase in chlorophyll-a, either by causing an interference in the analysis for chlorophyll-a, or by runoff from the storm causing a short-term algal bloom. Interference is less likely as the satellite imagery also shows an increase in chlorophyll-a during the February 2021 event. The satellite imagery utilizes a specific, narrow wavelength of light reflected by chlorophyll-a to estimate chlorophyll-a concentrations. Hence, if detected by the satellite, it is highly likely that chlorophyll-a was present at the elevated concentration.

   The Menifee Lake Country Club golf course is approximately 4 miles upstream of the East Basin of Canyon Lake within the Salt Creek. There is the potential that fertilizers were either overapplied or applied shortly before the January 29 - February 1, 2021 storm event and were washed into the Canyon Lake East Basin. This application of golf course fertilizer prior to the storm event was unable to be confirmed. Wood has reached out to the Menifee Lake Country Club to obtain a fertilizer schedule, but as of the date of this report, no schedule has been obtained.

5. The highest total aluminum concentration was measured at 270 µg/L at Site CL10 in the East Basin. This was measured in the monitoring first event after the alum application during the week of October 12-16, 2020. Even this highest concentration observed was well below the conservative CCC of 1000 ug/L total aluminum. It appears that alum is having the desired effect of lowering total phosphorus and chlorophyll-a (both of which were below their respective 2020 TMDL target concentrations), while not posing an aquatic life health risk by remaining well below the CCC and CMC thresholds.

5.0 References

Amec Foster Wheeler. 2016. Quality Assurance Project Plan for Lake Elsinore, Canyon Lake, and San Jacinto River Watershed TMDL Monitoring Program. May 2016.

Amec Foster Wheeler. 2017. Lake Elsinore and Canyon Lake Watersheds Nutrient TMDL Monitoring, 2016-2017 Annual Report. Prepared for the Lake Elsinore & San Jacinto Watersheds Project Authority, August 2017.

Haley & Aldrich, Inc. 2016. Lake Elsinore and Canyon Lake Nutrient TMDL Compliance Monitoring Work Plan for Lake Elsinore and San Jacinto Watershed Authority. Riverside, CA. April 2016.

Lake Elsinore and San Jacinto Watersheds Authority (LESJWA). 2006. Lake Elsinore and Canyon Lake Nutrient TMDL Monitoring Plan. CA Regional Water Quality Control Board, Santa Ana Region. February.

Montgomery Watson and Elsinore Valley Municipal Water District (MWH/ EVMWD). 2009. Canyon Lake Bacteria Characterization Study. Technical Memorandum prepared for the Lake Elsinore and Canyon Lake TMDL Task Force. December 1, 2009

Riverside County Flood Control and Water Conservation District (RCFCWCD). 2021. Hydrologic Data Collection, Rain Fall Reports.

Santa Ana Regional Water Quality Control Board. 2007. Resolution Amending the Water Quality Control Plan for the Santa Ana River Basin to Incorporate Nutrient Total Maximum Daily Loads (TMDLs) for Lake Elsinore and Canyon Lake, No. R8-2004-0037.

Santa Ana Regional Water Quality Control Board. 2007. Resolution Approving Plans and Schedules Submitted by the Canyon Lake/Lake Elsinore TMDL Task Force and Individual Discharger Groups Pursuant to the Lake Elsinore and Canyon Lake Nutrient Total Maximum Daily Loads Specified in the Water Quality Control Plan for the Santa Ana River Basin. Resolution R8-2007-0083.

Thursby, C.B. 1986. Memorandum to David J. Hansen, U.S. EPA, Narragansett, Rhode Island.

United States Environmental Protection Agency (US EPA). 2018. 2018 Final Aquatic Life Ambient Water Quality Criteria for Aluminum. EPA-822-R-18-001. U.S. EPA Office of Water. December 2018. EPA-822-R-18-001

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