Section 8  
Monitoring Requirements

8.1 Introduction and Background

In December 2004, the Santa Ana Water Board adopted amendments to the Basin Plan to incorporate TMDLs for nutrients in Lake Elsinore and Canyon Lake. Following adoption of the 2004 nutrient TMDLs, LESJWA developed a monitoring program to support TMDL implementation (LESJWA 2006). The Santa Ana Water Board approved the program’s monitoring plan (2006 Monitoring Plan) in March 2006 (Santa Ana Water Board 2006) and the LECL Task Force implemented the program from April 2006 through June 2012. This initial monitoring program focused on collecting data to better understand in‐lake processes, watershed nutrient sources and compliance monitoring.

The 2006 Monitoring Plan utilized the monitoring stations recommended by the 2004 nutrient TMDL: (a) Three stations in Lake Elsinore; (b) four stations in Canyon Lake; and (c) five watershed stations. In-lake sampling was performed monthly October through May, and bi-weekly June through September. Watershed sampling was conducted during three storm events per year. For both in-lake and watershed sampling, data were collected for a suite of nutrients, BOD/COD and TSS. Additionally, in-lake samples were analyzed for general water quality properties (pH, specific conductance, DO, and temperature), chlorophyll-*a*, and DOC/TOC. In-lake samples were collected as depth-integrated samples, while watershed stormwater samples were flow-weighted composites.

This initial monitoring approach continued through July 2010. Following a review of available data that indicated consistent and similar nutrient concentrations and physical water quality parameters among the three sampling sites in Lake Elsinore and two sites in the eastern arm of Canyon Lake, the 2006 Monitoring Plan was revised for the 2010-2011 sampling season. Per the approved monitoring program revisions, *in-situ* water quality parameters continued to be recorded at all original stations and watershed sampling program remained unchanged (Santa Ana Water Board 2011). However, analytical sampling was reduced to one location in Lake Elsinore (LE02; center of lake) and three locations in Canyon Lake (CL07, CL08, and CL10) and selected non-nutrient analytes were no longer analyzed (i.e. BOD, COD, TOC, DOC).

Monitoring continued under the revised program through June 2012. At that time, in agreement with the Santa Ana Water Board, while watershed monitoring would continue, in‐lake monitoring would be discontinued temporarily to redirect TMDL program funding towards nutrient reduction actions including lake stabilization, fishery management and alum application in Canyon Lake.

In April 2015, the LECL Task Force prepared a draft revised monitoring work plan to support TMDL implementation. This plan focused on a reassessment of current conditions and established a revised monitoring framework to better assess water quality trends towards meeting the existing TMDL numeric targets. Specific goals of the final work plan included (Haley & Aldrich 2016):

* Evaluate the status and trends toward achieving TMDL response targets in both lakes;
* Determine how to quantify the degree of influence from natural background sources; and
* Distinguish and quantify the external pollutant loading originating from watersheds draining to the lakes.

Watershed monitoring remained unchanged, but based on the above goals, revisions to the previous in-lake monitoring program included:

* Sampling frequency reduced to bi-monthly (every other month) for both lakes.
* Full water column profiles of physical water quality parameters (pH, DO, specific conductance, and temperature) recorded at 1-m intervals in both the morning and afternoon at each in-lake station. These two measurement times were performed to better capture the diurnal cycle of DO and pH as influenced by algal activity. These data have been used to assess both temporal and spatial variability and their comparability to data obtained from the currently installed *in-situ* data sondes operated by EVMWD.
* Acquisition of satellite imagery (30-m resolution) concurrent to in-lake sampling events to assess lake-wide estimates of chlorophyll-*a* and turbidity in both lakes.

The monitoring program has since been further revised by the LECL Task Force to include the following:

* Two additional annual monitoring events in Lake Elsinore, so that monthly sampling would occur during the summer period (June – September). This enhanced monitoring in Lake Elsinore was initiated given the TMDL criteria for chlorophyll-*a* are based on a summer average, as opposed to an annual average for other constituents.
* Total and dissolved aluminum analyzed at all stations in Canyon Lake to evaluate any influence from alum treatments which have been performed biannually each year beginning in 2013.
* Analysis of full constituent list at Canyon Lake Station CL09 during each sample event.
* Given a large cyanobacterial algal bloom in Lake Elsinore in summer 2016 and concern related to algal toxins statewide, cyanobacterial toxin monitoring for microcystin, cylindrospermopsin, anatoxin-a, and saxitoxin samples is collected at each Lake Elsinore and Canyon Lake station during each monitoring event.
* Increased resolution satellite imagery (10-m resolution) has been incorporated into the monitoring program. Finer satellite resolution allows for a more accurate estimation of chlorophyll-*a* and turbidity in the eastern arm of Canyon Lake, as well as providing three times the number of lake-wide data points for data analysis.

8.2 Revised TMDL Monitoring Approach

8.2.1 Overview

Under the numeric targets proposed in this TMDL revision (see Section 3), the primary objective is to establish water quality conditions that are equal to or better than what would occur in the lakes if the watershed was returned to a reference condition (i.e., pre-development). The new proposed numeric targets are based on CDFs expected in Lake Elsinore and Canyon Lake (Main Lake and East Bay) based on the reference condition. To support this approach, a revised monitoring design is proposed for implementation under the revised nutrient TMDLs to provide the data types necessary to demonstrate compliance with revised targets.

Other than several small modifications, the overall recommended monitoring design is similar to that currently being implemented by the LECL Task Force. **Table 8-1** provides a summary of elements to be included in the revised monitoring program to be formalized after the revised TMDLs are adopted. A more detailed description of the recommended program is provided below.

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| Table 8-1. Summary of Elements for Inclusion in Revised TMDL Monitoring Program | |
| Waterbody | Elements Recommended for Inclusion in Revised TMDL Monitoring Program |
| San Jacinto River Watershed | * Re-inclusion of the Cranston Guard Station * Add two new monitoring stations below reference sub-watersheds * Reduce the storm mobilization criteria for the October 1 to December 31 period from a 1.0-inch to a 0.5-inch forecast within 24-hours. The January 1 through April 30 mobilization criteria remains the same. |
| Lake Elsinore | * Discontinue the afternoon water column profile at each existing monitoring station. Analysis of water column profiles will continue to be performed once in mid to late morning during each monitoring event. * Utilize the two EVMWD multi-depth in-lake water quality sondes in combination with fixed depth DO sondes mounted just under the surface at both EVMWD sondes. These data will supplement the single point-in-time water column profiles recorded during each field monitoring event. * Incorporate Sentinel-2 satellite imagery (10-m resolution) for chlorophyll-*a* and turbidity measurements during months in which it is available (September through May), and LandSat 8 satellite imagery (30-m resolution) during all other months (June through August). |
| Canyon Lake | * Discontinue the afternoon water column profile at each existing monitoring station. Analysis of water column profiles will continue to be performed once in mid to late morning during each monitoring event. * Utilize a combination of fixed depth in-lake DO and temperature sondes to supplement single point-in-time water column profiles recorded during each field monitoring event. * Add Station CL09 to sites being monitored for full analyte list during each event. * Add total and dissolved aluminum to the analyte list for all sites to assess any influences from alum treatments in Canyon Lake. * Incorporate Sentinel-2 satellite imagery (10-m resolution) for chlorophyll-a and turbidity measurements during months in which it is available (September through May), and LandSat 8 satellite imagery (30-m resolution) during all other months (June through August) |

8.2.2 San Jacinto River Watershed Monitoring

The study design for the watershed-wide monitoring program will continue to be focused on quantifying nutrient loading into Lake Elsinore and Canyon Lake from upstream watershed sources, and adding to the historical monitoring data set to assess long-term trends. Additionally, in an effort to better understand loading from natural background sources within the San Jacinto River watershed, one historical reference site (i.e the Cranston Guard Station) and two new monitoring stations below reference sub-watersheds with little to no anthropogenic development are recommended for addition to the watershed monitoring program.

Stormwater runoff will continue to be sampled during three storm events per year during the wet season at all stations when flow is present. Storm mobilization criteria will be revised to be a 0.5-inch forecast within 24-hours through the entire wet season of October 1 through April 30. amples will not be collected during dry weather; however, total annual flows measured at the collocated USGS stream gauges will be used to calculate total watershed loading.

Sample Locations

Currently, four historical sampling stations are located throughout the San Jacinto River watershed, Lake Elsinore, and Canyon Lake area (**Table 8-2**). The sampling locations were carefully selected to reflect various types of land use and have been monitored since 2006. Three of the four sites were selected because they are indicative of inputs to Canyon Lake originating from the mainstem of the San Jacinto River, Salt Creek, and the watershed above Mystic Lake. The fourth site, located below the Canyon Lake Dam, is indicative of loads entering Lake Elsinore from Canyon Lake and the upstream watershed when Canyon Lake overflows. Many of the sampling stations are located in close proximity to stream gauge stations installed by the USGS or the RCFC&WCD. The stream gauges provide a general estimate of the total flow in the channel at a location close to each autosampler.

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| Table 8-2. Watershed-wide Monitoring Stations | | |
| Location Number and Description | Historical Database Station Number | Lat / Long |
| Salt Creek at Murrieta Rd | 745 | 33.693842°, -117.206041° |
| San Jacinto River at Goetz Rd | 759 | 33.751257°, -117.223632° |
| San Jacinto River at Ramona Expressway | 741 | 33.840382°, -117.135548° |
| Canyon Lake Spillway | 841 | 33.674240°, -117.272059° |
| Cranston Guard Station Reference | 792 | 33.736812°, -116.826491° |
| Candidate Reference Station 11 | -- | 33.677998°, -117.414117° |
| Candidate Reference Station 13 | -- | 33.890439°, -117.070250° |
| Candidate Reference Station 15 | -- | 33.761685°, -116.882620° |
| Candidate Reference Station 16 | -- | 33.862848°, -117.025500° |

The San Jacinto River at Ramona Expressway sampling location is downgradient of Mystic Lake, an area of land subsidence. Flow has not been observed at this location since a strong El Nino event in the mid-1990s; however, because of the active subsidence, this monitoring station is not expected to flow except under extremely high rainfall conditions.

The Cranston Guard Station (reference location last monitored in the 2014-2015 fiscal year), is recommended for addition back into the monitoring program. Table 8-2 provides several candidate reference stations under consideration for estimation of the natural loading to the lakes. As part of the implementation of the revised TMDLs, two of these candidate locations will be selected for inclusion in the watershed monitoring program.

Sample Collection

Flow-weighted composite samples will be collected either manually by compositing discrete grab samples, or by using automatic sampling equipment (e.g., ISCO™ autosamplers equipped with flow meters). Samples will be collected on both the rising limb (increasing flow) and the falling limb (decreasing flow) of the hydrograph. Eight to twelve discrete samples will be collected for compositing if collected manually (consistent with previous direction from the Santa Ana Water Board). Flow will be estimated based on data from USGS stream gauges collocated on the same streams near the sampling stations (if possible). The flow-weighted composite samples for analysis will be created post-storm by combining aliquots of each discrete sample collected across the hydrograph based on flow data from USGS gauges.

Sample Analytes

**Table 8-3** summarizes sample analytes and their associated laboratory methods. *In-situ* water quality measurements (pH, temperature and turbidity) will be conducted using handheld portable meters at multiple points throughout each storm event.

| Table 8-3. Watershed Analytical Constituents and Methods | |
| --- | --- |
| Parameter | Analysis |
| Turbidity | Field Meter |
| Water Temperature | Field Meter |
| pH | Field Meter |
| Total Organic Nitrogen (Org-N) | Calculated |
| Nitrite Nitrogen (NO2-N) | SM4500-NO2 B |
| Nitrate Nitrogen (NO3-N) | EPA 300.0 |
| Ammonia Nitrogen (NH4-N) | SM4500-NH3 H |
| Total Kjeldahl Nitrogen (TKN) | EPA 351.3 |
| Total Phosphorus (TP) | SM4500-P E |
| Soluble Reactive Phosphorus (SRP / Ortho-P) | SM4500-P E |
| Total Suspended Solids (TSS) | SM2540C |
| Chemical Oxygen Demand (COD)\* | SM5220D |
| Biochemical Oxygen Demand (BOD)\* | SM5210B |
| Total Dissolved Solids (TDS) | EPA 160.1 |
| Total Hardness as Calcium Carbonate (CaCO3) | SM 2340C |
| \*Analyses to be performed on the first discrete sample only. | |

8.2.3 Lake Elsinore Monitoring

Three historical stations will be monitored during each field event: LE01, LE02, and LE03 (**Table 8-4**). Lake Elsinore will be monitored monthly during the summer period (June through September) and bi-monthly (every-other month) during the remainder of the annual cycle (October through May) (**Table 8-5**). Analytical chemistry samples will be collected at one station (Station LE02) for the constituents listed in **Table 8-6**; sampling is coordinated to occur on the same day as the satellite imagery (See Section 8.2.5). Sample collection efforts include:

* Depth-integrated samples will be prepared by either combining discrete grab samples collected using a Van Dorn bottle at each 1-m depth interval throughout the water column, including the surface, or using a peristaltic pump and lowering/raising the inlet tube through the water column at a uniform speed.
* Two discrete chlorophyll-*a* samples will be collected at Station LE02: (1) a surface-to-bottom depth integrated sample; and (2) a 0 to 2-m depth integrated surface sample. The   
  0 to 2-m depth integrated sample provides a better estimation of chlorophyll-*a* for comparison to satellite imagery. Both chlorophyll-*a* sample types will be collected in the same manner as analytical chemistry samples using peristaltic pump.

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| Table 8-4. Lake Elsinore Monitoring Stations | | |
| Location Description | Historical Database Station Number | Latitude / Longitude |
| North-northeast side of lake | LE01 | 33.668978°, -117.364185° |
| Mid-lake | LE02 | 33.663344°, -117.354213° |
| South-southwest side of lake | LE03 | 33.654939°, -117.341653° |

| Table 8-5. Summary of Lake Elsinore TMDL Monitoring Activities (Y = Yes; N = No) | | | | |
| --- | --- | --- | --- | --- |
| Sample Period | Location | Analytical Samples1 | Chlorophyll-a2 | Field Water Quality Measurements3 |
| Monthly (June – September);  Bimonthly4 (October – May) | LE01 | N | N | Y |
| LE02 | Y | Y | Y |
| LE03 | N | N | Y |
| Continuous | *In-Situ* Sondes | N | N | Y5 |
| 1 Includes depth-integrated samples for all constituents listed in Table 8-6.  2 Chlorophyll-*a*: Two samples: (1) surface-to-bottom depth integrated sample; and (2) a 0 to 2-m depth integrated surface sample.  3 Includes depth profile field measurements for pH, DO, temperature, and conductivity; water clarity measured using a Secchi disk.  4 Bi-monthly is sampling every other month from October to May. Monthly sampling to occur over summer months only (June-September).  5 Two stations located near the center of Lake Elsinore are monitored by EVMWD for DO, conductivity, pH, and temperature at 1-m intervals using permanently installed *in-situ* YSI™ data sondes. | | | | |

| Table 8-6. In-Lake Analytical Constituents and Methods | | |
| --- | --- | --- |
| Parameter | Analysis Method | Sampling Method |
| Water Temperature | Field | Point Measure |
| Specific Conductivity | Field | Portable Meter |
| pH | Field | Portable Meter |
| Dissolved Oxygen | Field | Portable Meter |
| Turbidity | Field | Secchi disk |
| Total Hardness as CaCO3 | SM 2340 C | Depth Integrated1 |
| Total Alkalinity as CaCO3 | SM 2320 B | Depth Integrated1 |
| Nitrite Nitrogen (NO2-N) | SM4500-NO2 B | Depth Integrated1 |
| Nitrate Nitrogen (NO3-N) | EPA 300.0 | Depth Integrated1 |
| Total Kjeldahl Nitrogen (TKN) | EPA 351.3 | Depth Integrated1 |
| Ammonia Nitrogen (NH4-N) | SM4500-NH3 H | Depth Integrated1 |
| Sulfide | SM 4500S2 D | Depth Integrated1 |
| Total Phosphorus (TP) | SM4500-P E & EPA 365.1 | Depth Integrated1 |
| Soluble Reactive Phosphorus (SRP / Ortho-P) | SM4500-P E | Depth Integrated1 |
| Chlorophyll-a | SM 10200H | Surface & Depth Integrated2 |
| Total Dissolved Solids (TDS) | SM 2540 C | Depth Integrated1 |
| Total Suspended Solids (TSS) | SM 2540D | Depth Integrated1 |
| Total Aluminum | EPA 200.7 | Depth Integrated1 |
| Dissolved Aluminum | EPA 200.7 | Depth Integrated1 |
| 1 Depth integrated samples are a composite of the entire water column.  2 Two samples collected for chlorophyll-a: (1) Depth integrated - surface to bottom depth integrated sample; and (2) Surface - 0 to 2 m depth integrated surface sample. | | |

* *In-situ* monitoring using pre-calibrated hand-held YSI™ field meters or equivalent will be performed during each sampling event at all three stations (LE01, LE02, and LE03) for pH, DO, temperature, and specific conductivity measurements. During each field visit, a surface to bottom depth profile at each station will be recorded at 1-m depth intervals.
* Surface and 1-m depth profiles will be assessed immediately adjacent to each of the centrally-located EVMWD multi-depth in-lake sondes (“EVMWD sondes”, Lakeshore and Grand Avenue) for comparative purposes. Data from the two EVMWD sondes will be supplemented with DO sondes mounted to the in-lake sonde buoys at a fixed depth just beneath the surface to capture the DO concentration within the surface layer (this data currently lacking from EVMWD sondes). Data from these two sources supplements the manual water column profile measurements taken during each field sampling event. Given the continuous high-resolution dataset provided by the data sondes, these measures will provide a more accurate assessment of water quality conditions over time relative to single point-in-time measures, and will thus be used as the primary method to assess TMDL compliance for DO. Data from the hand-held meters recorded immediately adjacent to each sonde during monitoring events will be used to validate the in-lake sonde data.
* To the extent possible, sample collection and field measurements will be conducted prior to noon during each field event to avoid collecting suspended sediments potentially stirred up from the bottom of the lake by frequent afternoon winds.
* If the EPA promulgates 304(a) criteria for cyanotoxins, or the State Water Board or Santa Ana Water Board approve a water quality standard for cyanotoxins, then this constituent will be added to the analyte list for each monitoring event.

8.2.4 Canyon Lake Monitoring

Four historical stations will be monitored during each field event: Sites CL07, CL08, CL09, and CL10 (**Table 8-7**). Canyon Lake sampling will be conducted bi-monthly and coordinated to occur on the same day as satellite imagery as described in Section 8.2.5 below (**Table 8-8**). Analytical chemistry samples will be collected at all stations for the constituents listed above in Table 8-6. Sample collection efforts include:

* Depth-integrated samples are prepared by either combining discrete grab samples collected using a Van Dorn bottle at each 1-m depth interval throughout the water column, including the surface, or using a peristaltic pump and lowering/raising the inlet tube through the water column at a uniform speed.
* Two discrete chlorophyll-*a* samples will be collected at each station: (1) a surface-to-bottom depth integrated sample; and (2) a 0 to 2-m depth integrated surface sample. The   
  0 to 2-m depth integrated sample provides a better estimation of chlorophyll-*a* for comparison to satellite imagery. Both chlorophyll-*a* sample types will be collected in the same manner as analytical chemistry samples using a peristaltic pump.
* *In-situ* monitoring using pre-calibrated hand-held YSI™ field meters or equivalent will be performed once during each sampling event at all four stations (CL07, CL08, CL09, and CL10) for pH, DO, temperature, and specific conductivity measurements. A complete depth profile at each station will be recorded for each parameter at 1-m intervals.
* Two fixed depth DO sondes will be placed year-round at Sites CL07, CL08, and CL09 at depths corresponding with the upper epilimnion and at the median boundary depth between epilimnion and thermocline.[[1]](#footnote-1) Temperature-only loggers will be deployed at 1-m intervals encompassing the range of depths at which the epilimnion/thermocline boundary (ETB) is located based on prior monitoring data. All sondes will be programmed to record data at 2-hour intervals. Data from these sondes will supplement the bi-monthly water column profiles, and will provide a higher resolution, continuous data set for DO and temperature. Given the continuous data provided by the DO data sondes, these measures will provide a more accurate assessment of water quality conditions over time relative to single point-in-time measures, and will thus be used as the primary method to assess TMDL compliance for DO. Data from the hand-held meters recorded immediately adjacent to each sonde array during bi-monthly monitoring events will be used to validate the in-lake sonde data.
* To the extent possible, water samples will be collected and field measurements made prior to noon during each sampling event.
* If the EPA promulgates 304(a) criteria, for cyanotoxins or the State Water Board or Santa Ana Water Board approve a water quality standard for cyanotoxins, then this constituent will be added to the analyte list for each monitoring event.

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| Table 8-7. Canyon Lake Monitoring Stations | | |
| Location Description | Historical Database Station Number | Latitude / Longitude |
| Main Body near Dam | CL07 | 33.678027°, -117.275135° |
| Main Body North Lake | CL08 | 33.688211°, -117.268944° |
| Eastern Arm near Roadrunner Park | CL09 | 33.681100°, -117.258892° |
| Eastern Arm near Indian Beach Park | CL10 | 33.679495°, -117.250669° |

| Table 8-8. Summary of Canyon Lake TMDL Monitoring Activities (Y = Yes; N = No) | | | | |
| --- | --- | --- | --- | --- |
| Sample Period | Location | Analytical Samples Collected1 | Chlorophyll-a2 | Field Water Quality Measurements3 |
| Bi-monthly4 | CL07 | Y | Y | Y |
| CL08 | Y | Y | Y |
| CL09 | Y | Y | Y |
| CL10 | Y | Y | Y |
| Continuous | *In-Situ* Sondes | N | N | Y5 |
| 1 Includes depth-integrated samples for all constituents listed in Table 8-6.  2 Chlorophyll-*a*: Two samples: (1) surface-to-bottom depth integrated sample; and (2) a 0 to 2-m depth integrated surface sample.  3 Includes depth profile field measurements for pH, DO, temperature, and conductivity; water clarity measured using a Secchi disk.  4 Bi-monthly is sampling every other month.  5 In-lake continuous data sondes at Canyon Lake will only measure DO and temperature. | | | | |

8.2.5 Satellite Imagery

Satellite imagery was added to the existing TMDL monitoring program to provide a more spatially comprehensive assessment of chlorophyll-*a* concentrations in Lake Elsinore and Canyon Lake on the day of each sampling event. A combination of LandSat 7/8 (30-m pixel resolution) and Sentinel 2 (10-m pixel resolution) satellite imagery will continue to be used under the revised program, dependent upon the time of year. During the summer months (June – September), images from the Sentinel 2A satellite experience an interference referred to as a sunglint. The sunglint results from the geometry angle of the imagery when the satellite faces the sun during recording of the image, causing a direct reflection of sunlight from the water surface to the satellite (i.e., sunglint), thereby causing image quality issues. As a result of this, LandSat 7/8 satellite imagery will be utilized during summer months, and Sentinel 2 imagery during all other months of the year. Maps depicting lake-wide chlorophyll-*a* and turbidity will be generated for each monitoring event.

1. Epilimnion = upper portion of the water column in which the water temperature is nearly uniform; Thermocline = portion of the water column between the epilimnion and hypolimnion in which there is a marked drop in temperature per unit of depth; Hypolimnion = lower portion of the water column in which the temperature from its upper limit to the bottom is nearly uniform. [↑](#footnote-ref-1)