U.S. Environmental Protection Agency

Los Angeles Area Lakes TMDLs
March 2012

Section 11 Santa Fe Dam Park Lake TMDLs

11 Santa Fe Dam Park Lake TMDLs

Santa Fe Dam Park Lake (#CAL4053100020000303202907) is listed as impaired by copper, lead, and pH SWRCB, 2010). This section of the TMDL report describes the pH impairment and the TMDLs developed to maintain existing water quality (Section 11.2). Nutrient TMDLs are identified here based on existing conditions since nitrogen and phosphorus levels are achieving the chlorophyll *a* target level. Comparison of metals data to their associated hardness-dependent water quality objectives indicates that copper and lead are currently achieving numeric targets at Santa Fe Dam Park Lake; therefore, TMDLs are not included for these pollutants. Analyses are presented below for lead (Section 11.3) and copper (Section 11.4).

11.1 Environmental Setting

Santa Fe Dam Park Lake is located in the San Gabriel River Basin (HUC 18070106) in the Santa Fe Flood Control Basin (Figure 11-1; Figure 11-2). This waterbody was constructed in 1978 by the US Army Corps of Engineers. According to the Los Angeles County Department of Public Works (personal communication Arthur Gotingco, July 13, 2009, County of Los Angeles Dept. of Public Works) and the superintendent of Santa Fe Dam Park Lake, no flood waters are diverted to the park lake (flood water that is diverted from the San Gabriel River enters the spreading grounds and does not reach the lake). In addition, there is no outlet from the lake (personal communication, Chris Graham, County of Los Angeles, March 31, 2010). The park lake is 70.6 ac (surface area based on Southern California Association of Governments [SCAG] 2005 land use) with an average depth of six feet and a total volume of 423.6 ac-ft (volume calculated from depth reported by the lake superintendent and surface area estimated from land use data). Restrooms on the park grounds are connected to the city sewer system. Recreation within Santa Fe Dam Park Lake includes swimming and fishing. The California Fish and Game periodically stock trout. Bird feeding may be another recreational activity at Santa Fe Dam Park Lake; however, it has not been observed during recent fieldwork. There is no known current use of algaecide in this lake. However, lake managers have indicated that the lake has been treated in the past to control nutrients. Additional characteristics of the watershed are summarized below.

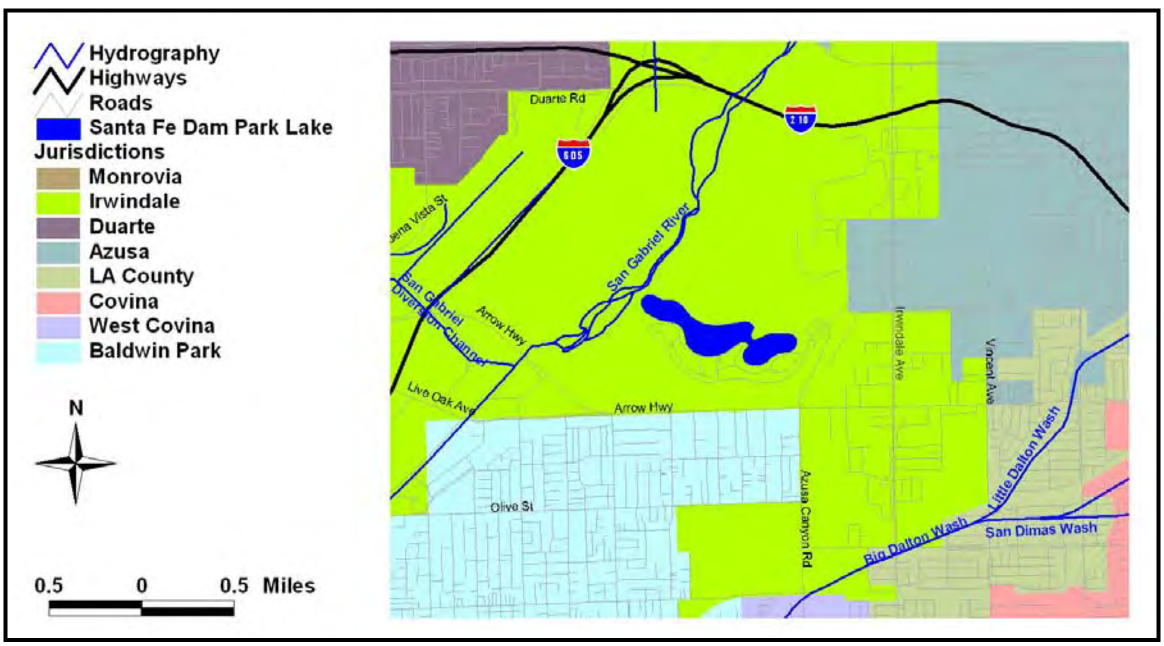

Figure 11-1. **Location of Santa Fe Dam Park Lake**

Figure 11-2. **View of Santa Fe Dam Park Lake**

11.1.1 Elevation, Storm Drain Networks, and Subwatershed Boundaries

The county of Los Angeles subwatershed coverage was sub-delineated based on aerial imagery and a digital elevation model to isolate the drainage area to this lake. Figure 11-3 shows the elevation data for this subwatershed and the resulting 362-acre drainage area (140 meters to 165 meters above sea level). The subwatershed is not drained by a storm drain system, so all loads generated by upland areas will be assigned load allocations except wasteload allocations for the supplemental water additions.

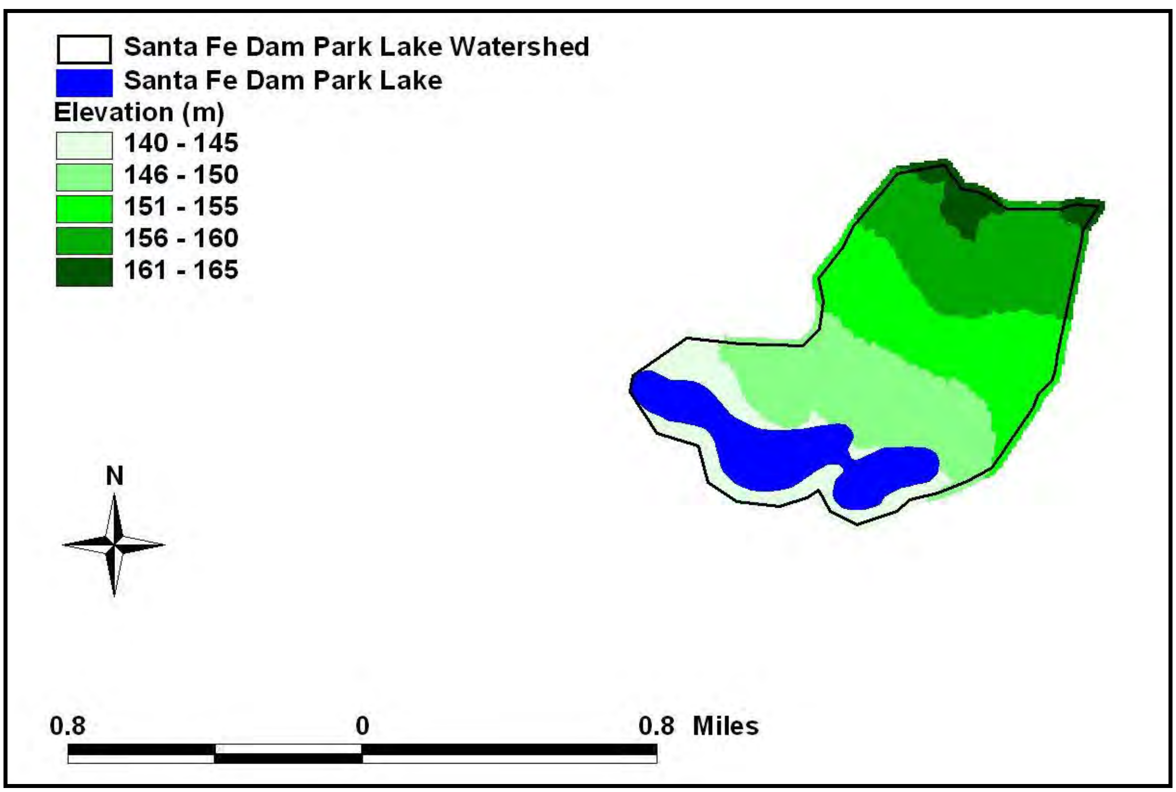

Figure 11-3. **Elevation Data and TMDL Subwatershed Boundaries for Santa Fe Dam Park Lake**

11.1.2 MS4 Permittees

Figure 11-4 shows the MS4 stormwater permittees in the Santa Fe Dam Park Lake subwatershed. The majority of the area is in Irwindale; a small portion is in Azusa. The storm drain coverage used to evaluate whether storm drains are located in the watershed was provided by the county of Los Angeles.

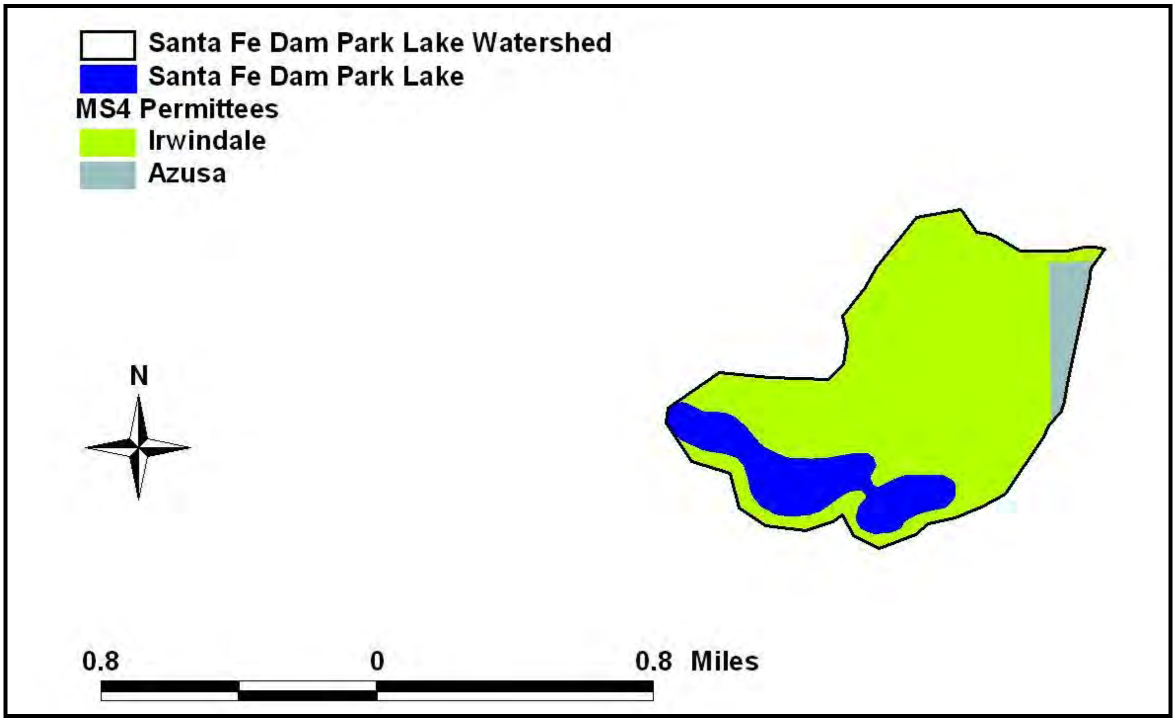

Figure 11-4. **MS4 Permittees in the Santa Fe Dam Park Lake Subwatershed**

11.1.3 Non-MS4 NPDES Dischargers

As of the writing of these TMDLs, there are no non-MS4 NPDES permitted discharges in the Santa Fe Dam Park Lake watershed. This includes non-stormwater discharges (individual and general permits) as well as general stormwater permits associated with construction and industrial activities.

11.1.4 Land Uses and Soil Types

The analyses for the Santa Fe Dam Park Lake watershed include source loading estimates obtained from the San Gabriel River Basin LSPC Model, discussed in Appendix D (Wet Weather Loading) of this TMDL report. Land uses identified in the San Gabriel River Basin LSPC model for this subwatershed are shown in Figure 11-5.

Upon review of the SCAG 2005 database as well as current satellite imagery, it was evident that the portion of area classified by the LSPC model as strip mines had not been mined for some time. The SCAG 2005 database classified this area as vacant; the current satellite imagery shows this area to be re-established shrub/brush rangeland. The 6.25 acres classified by the LSPC model as strip mines were therefore converted to shrub and brush rangeland for this loading analysis. Table 11-1 summarizes the land use areas by jurisdiction.

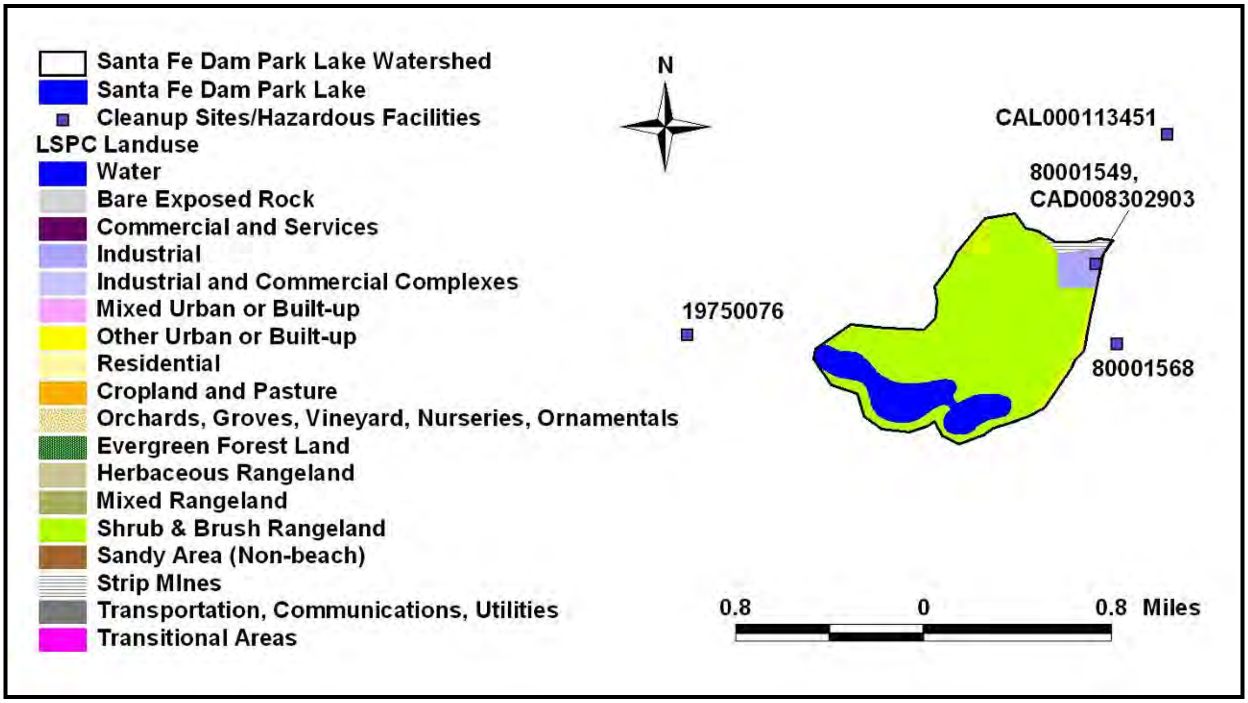

Figure 11-5. **LSPC Land Use Classes for the Santa Fe Dam Park Lake Subwatershed**

Table 11-1. **Land Use Areas (ac) Draining to Santa Fe Dam Park Lake**

Land Use	Azusa	Irwindale	Total
Industrial	11.5	7.16	**18.7**
Other Urban or Built-up	3.94	4.54	**8.48**
Shrub & Brush Rangeland	6.94	328	**335**
Total	**22.4**	**340**	**362**

There is one RCRA cleanup site in the watershed (800001549) and three sites close to the watershed boundary (located within approximately 0.5 miles of the boundary). These are the RCRA cleanup sites in closest proximity to the drainage area and are illustrated in Figure 11-5. Table 11-2 summarizes the information available for these facilities. It is unlikely that these facilities contribute to the pH impairment. Lead is listed as a potential contaminant of concern at three sites below; however, as described below, recent lead samples collected from Santa Fe Dam Park Lake are below the CTR criteria. USEPA recommends the removal of this impairment from this waterbody during the next 303(d) listing cycle.

Table 11-2. **RCRA Cleanup Sites Near the Santa Fe Dam Park Lake Watershed**

Envirostor #	Facility Name	Cleanup Status	Potential Contaminants of Concern
80001549, (CAD008302903)	Veolia ES Technical Solutions	Active, Hazardous Waste Operating Permit	This facility receives a comprehensive suite of hazardous waste including benzenes, dioxins, heavy metals and other toxic organics and inorganics.
80001568	Norac Inc.	Active	Benzoic acid, lead, semi-volatile organics, volatile organics
CAL000113451	Clean Harbors Environmental Services	Evaluation Needed	No data in site summary database for this facility
19750076	Alpha II/Irwindale	No Further Action	Lead, PCBs, Cadmium

The STATSGO soils database shows only one soil type in the watershed, identified as Zamora-Urban land-Ramona (MUKEY 660480). The hydrologic soil group for this soil is not listed in the database.

11.1.5 Additional Inputs

Santa Fe Dam Park Lake receives supplemental flows from groundwater and potable water sources to maintain lake levels. The groundwater is pumped into an artificial stream that then flows into the lake (Figure 11-6). Ten years of monthly usage data were used to estimate the average annual volume pumped from each source. Groundwater and potable water are pumped at average rates of 1,319 ac-ft/yr and 544 ac-ft/yr, respectively. The groundwater source at Santa Fe Dam Park Lake is also used to irrigate 175 acres of parkland and some of this water may reach the lake (9.6 percent of the total irrigation volume is assumed to reach the lake).

In addition to inputs of potable water and groundwater, the swim beach area of Santa Fe Dam Park Lake is disinfected with a 12.5 percent sodium hypochlorite solution (NaOCl) during the summer months. This solution is mixed with lake water in a pump house and then discharged to the lake in the swim area. During the summer, chlorination typically occurs 7 days per week via five pumps. However, due to reduced funding available in 2009, the swim beach was closed Monday through Wednesday and only one chlorine pump was being utilized. The volumes of sodium hypochlorite solution pumped during the summers of 2008 and 2009 were approximately 11,900 gallons each (personal communication, Chris Graham, Los Angeles County Department of Parks and Recreation).

Figure 11-6. **Pumped Groundwater Entering Lake via Artificial Stream**

11.2 pH IMPAIRMENT

Santa Fe Dam Park Lake is listed as impaired by pH. Altered pH chemistry is often a result of elevated nutrient levels that cause excessive growth of algal and plant material. Algal photosynthesis depletes carbon dioxide in the water column, leading to elevated pH during daylight hours, while nighttime respiration releases carbon dioxide, leading to increased concentrations of carbonic acid and depression of pH. However, other circumstances, either natural or anthropogenic, may also lead to impairments in pH. As described below, the pH impairment in Santa Fe Dam Park Lake does not appear to be primarily caused by elevated nutrient levels or chlorination.

11.2.1 Beneficial Uses

California state water quality standards consist of the following elements: 1) beneficial uses, 2) narrative and/or numeric water quality objectives, and 3) an antidegradation policy. In California, beneficial uses are defined by the Regional Water Quality Control Boards (Regional Boards) in the Water Quality Control Plans (Basin Plans). Numeric and narrative objectives are specified in each region's Basin Plan, designed to be protective of the beneficial uses of each waterbody in the region. The existing beneficial uses assigned to Santa Fe Dam Park Lake include REC1, REC2, WARM, WILD, WET, and GWR. A potential beneficial use for this lake is MUN. Descriptions of these uses are listed in Section 2 of this TMDL report. Elevated pH levels can impair the REC1, REC2, WARM, WILD, and WET uses by causing eye irritation for swimmers and altering the habitat and biota in the lake.

11.2.2 Numeric Targets

The Basin Plan for the Los Angeles Region (LARWQCB, 1994) outlines the numeric targets and narrative criteria that apply to Santa Fe Dam Park Lake. The Basin Plan states that "the pH of inland surface waters shall not be depressed below 6.5 or raised above 8.5 as a result of waste discharges. Ambient pH levels shall not be changed more than 0.5 units from natural conditions as a result of waste discharge." The pH target depths for Santa Fe Dam Park Lake are from the surface to 0.3 meters above the lake bottom.

Santa Fe Dam Park Lake is not listed as impaired by algae or eutrophication. However, to determine if elevated nutrient levels, and therefore excessive algal growth, are the cause of the pH impairment in this waterbody, it is useful to compare observed chlorophyll *a* concentrations to target levels. The Regional Board has not adopted numeric targets for chlorophyll *a* in the Santa Fe Dam Park Lake; however, there are applicable narrative criteria that state "Waters shall not contain biostimulatory substances in concentrations that promote aquatic growth to the extent that such growths cause nuisance or adversely affect beneficial uses." As described in Tetra Tech (2006), summer (May – September) mean and annual mean chlorophyll *a* concentrations of 20 µg/L provide a useful cutoff, representing the maximum allowable level consistent with full support of contact recreational use and are also consistent with supporting warm water aquatic life.

Comparison of dissolved oxygen (DO) and ammonia concentrations to their respective targets is also helpful to determine if algal growth is causing the pH impairment. The instantaneous minimum DO target for Santa Fe Dam Park Lake is 5 mg/L based on the beneficial use designation WARM and must be met from the surface to 0.3 meters above the lake bottom. The Basin Plan expresses ammonia targets as a function of pH and temperature because un-ionized ammonia (NH_3) is toxic to fish and other aquatic life. In order to assess compliance with the standard, the pH, temperature and ammonia must be determined at the same time. For the purposes of setting a target for Santa Fe Dam Park Lake in these TMDLs, a median temperature of 22.3 ºC and a 95th percentile pH of 9.5 were used, as explained in Section 2. The resultant acute (one-hour) ammonia target is 0.70 mg-N/L, the four-day average is 0.41 mg-N/L, and the 30-day average (chronic) target is 0.16 mg-N/L (Note: the median temperature and 95th percentile pH values were calculated from the observed data and used in the calculation of the acute and chronic targets. These are presented as example calculations since the actual target varies with the values determined during sample collection.).

Nitrogen and phosphorus target concentrations within the lake are based on existing conditions as explained in Sections 11.2.5 and 11.2.6:

- 0.63 mg-N/L summer season average (May – September) and annual average
- 0.063 mg-P/L summer season average (May – September) and annual average

Table 11-3 presents a summary of the numeric targets for nutrient-related parameters in Santa Fe Dam Park Lake.

Table 11-3. **Nutrient-Related Numeric Targets for Santa Fe Dam Park Lake**

Parameter	Numeric Target	Notes
Ammonia[1]	0.70 mg-N/L acute (one-hour) 0.41 mg-N/L four-day average 0.16 mg-N/L chronic (30-day average)	Based on median temperature and 95th percentile pH
Chlorophyll *a*	20 µg/L summer average (May – September) and annual average	
Dissolved Oxygen	7 mg/L minimum mean annual concentrations and 5 mg/L single sample minimum except when natural conditions cause lesser concentrations	
pH	The pH of inland surface waters shall not be depressed below 6.5 or raised above 8.5 as a result of waste discharges. Ambient pH levels shall not be changed more than 0.5 units from natural conditions as a result of waste discharge. (Basin Plan) 6.5 – 9.0 (EPA's 1986 Recommended Criteria)	The existing water quality criteria for pH is very broad and in cases where waste discharges are not causing the alteration of pH it allows for a wider range of pH than EPA's recommended criteria. For this reason, EPA's recommended criteria is included as a secondary target for pH.
Total Nitrogen	0.63 mg-N/L summer average (May – September)	Conservatively based on existing

Parameter	Numeric Target	Notes
	and annual average	conditions, which are maintaining chlorophyll *a* levels below the target of 20 µg/L
Total Phosphorous	0.063 mg-P/L summer average (May – September) and annual average	Based on an in-lake TN to TP ratio of 10, typical of natural systems

[1] The median temperature and 95th percentile pH values were calculated from the observed data and used in the calculation of the acute and chronic targets. These are presented as example calculations since the actual target is the water quality objective which is dependent on pH and temperature. When assessing compliance refer to the water quality objective as expressed in the Basin Plan.

11.2.3 Summary of Monitoring Data

To assess whether or not the pH impairment is due to elevated nutrient levels, analysis of pH, nutrient concentrations, algal densities (chlorophyll *a*), and dissolved oxygen is required. This section briefly summarizes the relevant monitoring data. Appendix G (Monitoring Data) contains more detailed information regarding water quality sampling at Santa Fe Dam Park Lake.

During the summers of 1992 and 1993, the University of Riverside collected water quality data to assess the health of urban lakes in the Los Angeles area. Santa Fe Dam Park Lake was sampled at one station in the southeast section of the lake on 11 days. Total Kjeldahl nitrogen (ammonia plus organic nitrogen; TKN) ranged from 0.3 mg-N/L to 1.1 mg-N/L. Ammonium generally ranged from 0.1 mg-N/L to 0.2 mg-N/L with 21 measurements less than the detection limit (0.01 mg-N/L) and one measurement of 0.4 mg-N/L collected at a depth of 2 meters. All 37 samples of nitrite were less than the detection limit (0.01 mg-N/L), and the majority of nitrate samples (32) were less than the detection limit (0.01 mg-N/L); the maximum observed nitrate concentration was 0.2 mg-N/L. All orthophosphate and total phosphorus concentrations were less than the detection limits (0.01 mg-P/L for both) except one total phosphorus observation which measured 0.1 mg-P/L. pH ranged from 8.0 to 9.6, and TOC ranged from 2.3 mg/L to 3.4 mg/L. The summary table from the 1994 Lakes Study Report (UC Riverside, 1994) lists chlorophyll *a* concentrations ranging from 1 µg/L to 29 µg/L with an average of 13 µg/L; however, the raw data for chlorophyll *a* were not available.

The 1996 Water Quality Assessment Report (LARWQCB, 1996) states that pH was partially supporting the aquatic life use and not supporting the contact recreation and secondary drinking water uses. Ninety-five measurements of pH were taken, ranging from 7.5 to 9.6 with an average value of 8.7. The associated database did not contain the raw data for these samples.

On March 3rd and August 3rd, 2009, the Regional Board sampled water quality in Santa Fe Dam Park Lake. Overall, both nitrogen and phosphorus levels were very low at the three in-lake stations during both events. TKN ranged from less than the detection limit (0.456 mg-N/L) to 1.1 mg-N/L. Only one sample of ammonia was greater than the detection limit of 0.03 mg-N/L, with a concentration of 0.05 mg-N/L. Nitrite ranged from less than the detection limit (0.01 mg-N/L) to 0.04 mg-N/L; nitrate ranged from less than the detection limit (0.01 mg-N/L) to 0.1 mg-N/L. Phosphate was consistently less than the detection limit of 0.0075 mg-P/L, and total phosphorus ranged from 0.021 mg-P/L to 0.050 mg-P/L. During the winter sampling event, chlorophyll *a* concentrations along the center line of the lake did not exceed 20.5 µg/L, and the average concentration was 17.2 µg/L. In August, chlorophyll *a* was below the detection level of 1 µg/L. pH ranged from 8.6 to 8.8 during both events, with all measurements exceeding the criterion range.

Profile data were collected during the summer monitoring event in the morning and afternoon at two locations in the lake. Over the first 2 meters of depth, DO concentrations were approximately 9.7 mg/L in the morning (~ 9:00 a.m.) and increased to approximately 11.8 mg/L in the afternoon (~4:00 p.m.). pH levels in the morning were approximately 8.5; in the afternoon levels were approximately 8.9. Given that DO concentrations are well above the target of 5 mg/L during the morning hours and pH fluctuations were approximately 0.4 units, algal growth did not appear to be directly causing exceedances of the DO or pH standards during this sampling event. The diurnal change in pH of 0.4 units was less than the allowed change relative to natural conditions of 0.5 units (Section 11.2.2). Additionally, the main discharges to the lake are groundwater and potable water. The pH of the groundwater measured on August 4, 2009 averaged 7.69. Potable water was not measured during a sampling event; however Valley County Water District reported that in 2008 their potable water had an average pH of 7.6 with a range of 7.5-7.7 (Valley County Water District, 2008). The pH standard requires that “the pH of inland surface waters shall not be depressed below 6.5 or raised above 8.5 as a result of waste discharges.” The discharges to the lake do not appear to be causing the elevated pH and therefore the criteria is being met.

On May 4th 2009, Clean Lakes Inc. was contracted by the Los Angeles County Department of Parks and Recreation to conduct baseline water quality monitoring of Santa Fe Dam Park Lake to determine if aquatic weed or algal growth controls were needed. Three locations in the lake were sampled at approximately 10:00 a.m. for water quality at a depth of approximately 1 ft below the water surface. The report stated that the lake did not appear to be impaired with regard to pH, dissolved oxygen, or nutrient levels when compared to the Basin Plan or nutrient TMDLs implemented for other waterbodies in the region. (pH ranged from 7.39 to 7.96 at all locations and depths during this event.) “Light” quantities of pondweed and benthic algae were observed and the lake was noted to have a bluish hue.

On November 17, 2009 the lake was revisited for the collection of metals sampling. pH measurements in the lake ranged from 9.2 to 9.6. pH and DO data were also collected during the December 14, 2009 metals sampling event. At the two midlake stations, pH ranged from 8.63 to 8.90 and DO ranged from 6.1 mg/L to 10.2 mg/L.

On August 12, 2010 the lake was revisited to sample nutrients and metals and to collect diurnal measurements of pH and DO over a 24-hour period. The diurnal sampler placed at SFD-1 measured pH values ranging from 8.75 to 8.97 and DO concentrations ranging from 8.3 mg/L to 9.9 mg/L. At SFD-3, diurnal measurements of pH ranged from 8.82 to 8.97, and DO concentrations ranged from 8.9 mg/L to 11.3 mg/L. TKN ranged from less than the detection limit of 0.5 mg-N/L to 0.594 mg-N/L. Ammonia samples at SFD-1 and SFD-3 were less than the detection limit of 0.03 mg-N/L, and nitrite samples were both detected at 0.035 mg-N/L. Nitrate concentrations were less than the detection limit (0.01 mg-N/L) at SFD-3 and 0.097 mg-N/L at SFD-1. Orthophosphate measurements at both sites were less than the detection limit of 0.0075 mg-P/L; total phosphorus concentrations ranged from 0.023 mg-P/L to 0.129 mg-P/L. Chlorophyll *a* concentrations ranged from 18.4 μg/L to 22.7 μg/L.

In summary, measurements of pH in Santa Fe Dam Park Lake are elevated above the allowable range of 6.5 to 8.5 in both recent and historic datasets. Diurnal sampling shows a variation in pH of less than 0.22 units, indicating that algal and aquatic weed levels are not significantly impacting pH levels. There is no evidence of depressed dissolved oxygen, and limited data on chlorophyll *a* concentrations do not indicate eutrophic conditions (only one measurement exceeded the summer average target of 20 μg/L). There are no dissolved oxygen observations less than the target concentration of 5 mg/L. As explained in greater detail in Section 11.2.5, neither excessive nutrient loading nor chlorination at the lake appear to be causing the elevated pH values that resulted in this listing. Additionally, the main sources of water to these lakes are either groundwater or potable water discharges which account for 97 percent of current flows to the lake. Both of these sources have measured pH values ranging from 7.5 to 7.7 and are not likely to be causing the elevated pH. Based on these multiple lines of evidence, Santa Fe Dam Park Lake is attaining beneficial uses and meets pH water quality standards.

11.2.4 Source Assessment

The elevated pH levels in Santa Fe Dam Park Lake are likely due to natural conditions, as described in Section 11.2.5. Loads of nutrients may also be potentially relevant to the pH impairment, as excess nutrient loads can promote algal growth that depletes CO_2 from the water column and raises pH.

The majority of nutrient loading to Santa Fe Dam Park Lake originates from the groundwater and potable water inputs used to maintain lake levels (Appendix F, Dry Weather Loading). Together these sources account for 82 percent of the total phosphorus load and 95 percent of the total nitrogen load. Other sources include wet weather runoff (Appendix D, Wet Weather Loading), irrigation return flows (9.6 percent of the total irrigation volume is assumed to reach the lake) (Appendix F, Dry Weather Loading) from the surrounding watershed, and atmospheric deposition (Appendix E, Atmospheric Deposition). Table 11-4 summarizes the loadings to the lake.

Table 11-4. **Summary of Average Annual Flows and Nutrient Loading to Santa Fe Dam Park Lake**

Responsible Jurisdiction	Input	Flow (ac-ft)	Total Phosphorus (lb-P/yr) (percent of total load)	Total Nitrogen (lb-N/yr) (percent of total load)
Azusa	Runoff	16.8	27.0 (9.6)	205 (1.6)
Irwindale	Runoff	24.1	23.8 (8.4)	253 (1.9)
County of Los Angeles	Supplemental Water Additions (Groundwater)	1,319	93.3 (33.0)	10,734 (81.5)
County of Los Angeles	Supplemental Water Additions (Potable Water)	544	137 (48.5)	1,789 (13.6)
County of Los Angeles	Parkland Irrigation	16.8	1.2 (0.4)	137 (1.0)
	Atmospheric Deposition (to the lake surface)*	109	NA	51.4 (0.4)
Total		**2,030**	**282**	**13,169**

* Loads for atmospheric deposition are based on direct precipitation to the lake (calculated by the annual average precipitation multiplied by the surface area of the lake).

Loads of anions and cations are also relevant to the pH balance in the lake, as described in the next section.

11.2.5 Linkage Analysis

The linkage analysis defines the connection between numeric targets and identified pollutant sources and may be described as the cause-and-effect relationship between the selected indicators, the associated numeric targets, and the identified sources. This provides the basis for estimating total assimilative capacity and any needed load reductions.

In its reaction with chemical compounds in a waterbody, the water molecule (H_2O) dissociates into hydrogen (H^+) and hydroxyl (OH^-) ions. These ions then react with other compounds present in the waterbody. The pH of water is a measure of the proportion of H^+ ions in the water relative to the amount of OH^- ions in the water. Neutral water ($H^+ = OH^-$) has a pH of 7. When more H+ ions are present, the solution is acidic and the pH is less than 7. When more OH^- ions are present, the solution is basic, and the pH is higher than 7.

In natural waterbodies, the presence of carbon dioxide gas (CO_2) in the water is a key driver of pH along with the proportion of cations (positively charged compounds that react with OH^- ions) and anions (negatively charged compounds that react with H^+ ions). Although carbon dioxide makes up a small percentage of the gases in the earth's atmosphere, it is highly soluble in water and is therefore abundant in surface waters. Both groundwater and rainwater have relatively high concentrations of carbon dioxide and may contribute significantly to the carbon stores of a waterbody. Respiration by plants and animals and the decomposition of organic material further increase carbon dioxide levels in the waterbody. When CO_2 is dissolved in water, the pH is typically lowered as CO_2 combines with H_2O to form carbonic acid (H_2CO_3). This acid may dissociate to bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) and hydrogen ions (H^+), and the pH of the water decreases. Photosynthesis reactions consume CO_2 and typically raise the pH of the waterbody.

To determine if the elevated pH measurements in Santa Fe Dam Park Lake are a result of excessive nutrient loading and eutrophication of the waterbody, the California Nutrient Numeric Endpoints (NNE) BATHTUB Tool was set up and calibrated to lake-specific conditions. The NNE BATHTUB Tool is a version of the US Army Corps of Engineers (USACE) BATHTUB model and was developed to support risk-based nutrient numeric endpoints in California (Tetra Tech, 2006).

BATHTUB is a steady-state model that calculates nutrient concentrations, chlorophyll *a* concentration (or algal density), turbidity, and hypolimnetic oxygen depletion based on nutrient loadings, hydrology, lake morphometry, and internal nutrient cycling processes. BATHTUB uses a typical mass balance modeling approach that tracks the fate of external and internal nutrient loads between the water column, outflows, and sediments. External loads can be specified from various sources including stream inflows, nonpoint source runoff, atmospheric deposition, groundwater inflows, and point sources. Internal nutrient loads from cycling processes may include sediment release and macrophyte decomposition. The net sedimentation rates for nitrogen and phosphorus reflect the balance between settling and resuspension of nitrogen and phosphorus within the waterbody. Thus, internal loading is implicitly accounted for in the model. Since BATHTUB is a steady-state model, it focuses on long-term average conditions rather than day-to-day variations in water quality.

Target nutrient loads and resulting allocations are determined based on the secondary target – summer mean chlorophyll *a* concentration. The NNE spreadsheet tool allows the user to specify a chlorophyll *a* target and predicts the probability that current conditions will exceed the target, as well as showing a matrix of allowable nitrogen and phosphorus loading combinations to meet the target. The user-defined chlorophyll *a* target can be input directly by the user, or can be calculated based on an allowable change in water transparency measured as Secchi depth. Appendix A (Nutrient TMDL Development) describes additional details on the NNE BATHTUB Tool and its use in determining allowable loads of nitrogen and phosphorus.

In addition to loading rates of nitrogen and phosphorus, the NNE BATHTUB Tool requires basic bathymetry data for the simulation of chlorophyll *a* during the summer. For Santa Fe Dam Park Lake the following inputs apply: surface area of 70.6 acres, average depth of 6 ft, and volume of 423.6 ac-ft. Without adjusting calibration factors in the model, the average annual loads presented in Section 11.2.4 yield total nitrogen, total phosphorus, and chlorophyll *a* concentrations of 1.64 mg-N/L, 0.04 mg-P/L, and 17.8 µg/L, respectively. (Simulated in-lake total nitrogen concentrations are relatively high due to the groundwater input which makes up the majority of the loading and has a concentration of approximately 3 mg-N/L.)

Average conditions for Santa Fe Dam Park Lake with regard to algal stimulation are assessed based on measurements collected between the surface and twice the observed Secchi depth. Average summer observed total nitrogen, total phosphorus, and chlorophyll *a* concentrations over the assessment depth (2 meters) are 0.63 mg-N/L, 0.024 mg-P/L, and 8.5 µg/L, respectively, assuming measurements less than detection are equal to half the detection limit. Even with simulated nitrogen and phosphorus concentrations 1.7 to 2.6 times higher than those observed in the lake (i.e., calibration factors left at 1), simulated chlorophyll *a* (17.8 µg/L) remains below the target concentration of 20 µg/L. Calibrating the NNE BATHTUB Tool would result in lower simulated concentrations of nitrogen, phosphorus, and chlorophyll *a*. Thus, the NNE BATHTUB Tool indicates that Santa Fe Dam Park Lake is not directly impaired by elevated nutrient loads or excessive algal growth. (Since the calibration factor on the net phosphorus sedimentation rate would have been adjusted even lower during calibration, the method described in Appendix A (Nutrient TMDL Development) was used to estimate internal loading. Based on the inflow concentrations, in-lake concentrations, and residence time of this system, the internal loading calculation resulted in a negative number which indicates that settling is more dominant than resuspension, and internal loading of phosphorus is insignificant relative to other sources.) However, the observed algal densities may contribute to depression of CO_2 and weaken the buffering system.

A steady-state, chemical equilibrium model was also set up for Santa Fe Dam Park Lake to determine if elevated pH is due to natural conditions, algal impacts, or the addition of chlorine in the form of sodium hypochlorite, NaOCl, for disinfection of the swim beach area (Section 11.1.5). When NaOCl is added to water, it dissociates into sodium ions (Na^+) and hypochlorite ions (OCl^-). The sodium ion is quickly surrounded by water molecules and is not likely to react further. However, the hypochlorite ion will combine with hydrogen (H^+) that results from the hydrolysis of water ($H_2O = H^+ + OH^-$). The reaction of H^+ with OCl^- results in more hydroxyl ions (OH^-) relative to hydrogen ions (H^+) in the water, and the pH of the solution increases. These acid/base reactions are very rapid and achieve equilibrium within seconds to minutes:

$$NaOCl + H_2O \leftrightarrow HOCl + Na^+ + OH^-$$

The geochemical speciation model, Visual MINTEQ V2.61 (Gustafsson, 2009), was used to investigate the pH conditions in the lake. The model was selected to perform pH simulation based on the available data for Santa Fe Dam Park Lake. The model requires total analytical concentrations and physical inputs to evaluate various geochemical reactions. Visual MINTEQ uses the equilibrium-constant approach to solve chemical equilibrium conditions and uses the same numerical solution method as USEPA’s MINTEQA2 (Allison et al., 1991).

The Visual MINTEQ model was used to simulate conditions observed in Santa Fe Dam Park Lake on March 3rd 2009, August 3rd 2009, and August 12th 2010. Average water quality observed on these three days (Table 11-5) was input to the model along with default assumptions regarding the carbon dioxide content of groundwater, atmospheric pressure of carbon dioxide, and concentrations of additional cations and anions based on the available data (calcium, magnesium, and carbonate):

- Because major cation data were not available for the lake, hardness was used to estimate the concentrations of dissolved calcite (Ca) and magnesium (Mg) for each sampling date. The average hardness values ranged from 92.7 mg/L (as $CaCO_3$ mg/L) to 132 mg/L (as $CaCO_3$ mg/L) and were converted to Ca and Mg using the following equation:

  $$\text{Total hardness} = 2.497(Ca^{2+}\text{ mg/L}) + 4.118(Mg^{2+}\text{ mg/L})$$

  Assuming the chemical formula of disordered dolomite ($CaMg(CO_3)_2$), the molecular weight ratio of Mg to Ca of 0.6 was applied to magnesium. The calculation resulted in Ca concentrations ranging from 19 mg/L to 27 mg/L and Mg concentrations ranging from 11 mg/L to 16 mg/L. The anion associated with Ca and Mg was assumed to be carbonate according to the dolomite formula. Additional carbonate value was estimated from the observed alkalinity which was assumed to be dominated by carbonate. In addition to carbonate, phosphorus and ammonia could also contribute to alkalinity; however, the relatively low concentrations of these species indicate that these elements are not a major contributor to alkalinity.

- Total organic carbon (TOC) data were used to estimate the possible amount of carbonic acid generated through microbial activities to estimate biodegradable carbon content. Assuming that TOC has the simple sugar glucose structure ($C_6H_{12}O_6$), all TOC values were converted to carbonic acid by microorganism respiration and included in the model.
- Chemical reactions with metal hydroxides associated with clay minerals were not considered in this analysis because the observed TSS concentrations were relatively low.
- Precipitation of saturated calcite solids was not simulated based on the assumption that observed hardness values used to estimate calcium and magnesium concentrations were in the dissolved form and that any potential solid was already precipitated out under the observed water quality conditions.
- Anaerobic decay of organic matter on the lake bottom was not considered in this analysis. However, the lake sediment and adjacent boundary diffusion layer could result in pH changes due to CO_2 generation by microbial activity in conjunction with reduction reactions consuming some of the CO_2 acidity (Morel and Hering, 1993). The depth profile data conducted on August 3rd 2009 show a minimum pH of 7.45 collected at 3 meters from the lake surface. Though the available data do not allow for a quantitative assessment of the influence of microbial activity on pH in the water column, it does indicate that conditions at the sediment-water interface are not acidic and that microbial activity does not appear to have a significant impact on pH throughout the water column.

To test the impacts of algal photosynthesis and respiration on the pH levels, algal densities were assumed at the maximum average levels observed (17 μg/L for the March 3rd 2009 sampling event and 20.05 μg/L for the August 12th 2010 sampling event), and it was also assumed that nitrogen and phosphorus levels were not limiting the rates of photosynthesis or respiration for these organisms.

The average observed pH during the March 3rd event was 8.68. When algal impacts were ignored, the MINTEQ model predicted an average pH of 8.69. When the impacts of algae were simulated, pH was predicted to increase to 8.89 as a result of photosynthesis. During the August 3rd event, chlorophyll *a* levels were less than the detection limit of 1 μg/L. The average observed pH during this event was 8.73 and the average simulated pH was 8.78 (impacts of algae were not included in this scenario since observed algal densities were insignificant). The observed pH during the August 12th 2010 event was 8.8. When algal impacts were ignored, the MINTEQ model predicted an average pH of 8.82. When the impacts of algae were simulated, pH was predicted to increase to 8.94 as a result of photosynthesis.

Table 11-5. **Average Water Quality Conditions in Santa Fe Dam Park Lake on March 3rd and August 3rd 2009 and August 12th 2010**

Date	TKN (mg/L)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	PO_4-P (mg/L)	Total P (mg/L)	Chlorophyll *a* (µg/L)	Secchi Depth (m)	Chloride (mg/L)	Temper-ature (°C)	pH	Total Alkalinity (mg/L)	Total Hardness as $CaCO_3$ (mg/L)	TDS (mg/L)	TSS (mg/L)	TOC (mg/L)
3/3/2009	1.02	0.03	0.04	0.08	0.004	0.03	17.17	0.76	27.97	15.50	8.68	115.33	103.72	296.67	7.67	4.67
8/3/2009	0.43	0.02	0.02	0.01	0.004	0.04	0.5	0.54	35.36	27.73	8.73	124.00	131.90	302.67	11.30	3.57
8/12/2010	0.41	0.02	0.04	0.05	0.004	0.08	20.5	0.68	35.7	25.9	8.8	153.00	92.70	241.00	13.90	4.21

Note: Samples reported as less than the detection limit were assumed equal to one-half the detection limit for the purposes of estimating average water quality conditions.

The sensitivity of pH to the addition of NaOCl was tested to examine the impacts of increased concentrations of NaOCl. The original concentration injected into the lake, following mixing of lake water with 12.5 percent NaOCl in the pump house, was assumed 0.05 mg/L based on literature values (Metcalf and Eddy, 2003). During the sensitivity analysis, the concentration was varied from 0 mg/L to 0.50 mg/L. Results of the MINTEQ modeling indicate that the addition of NaOCl has an insignificant impact on pH: the lake volume appears to overwhelm the base effect of hypochlorite ion (OCl^-).

The results of the MINTEQ modeling indicate that the pH of Santa Fe Dam Park Lake is above the target range of 6.5 to 8.5 due to natural conditions including background water quality and gas exchange of carbon dioxide at the air-water interface. While current levels of nutrient loading and algal densities have a minimal impact on pH (less than 0.22 units based on diurnal measurements) and are not responsible for the exceedance of the pH target range, increases in nutrient loading above existing levels could stimulate algal production and result in a problematic increase in pH for this waterbody. Additionally, the main discharges to the lake are groundwater and potable water. The pH of the groundwater at Santa Fe ranged from 7.69 to 7.81 during two sampling events and Valley County Water District reports their potable water had an average pH of 7.6 with a range of 7.5-7.7 (Valley County Water District, 2008). Since the exceedances outside of the target pH range observed in Santa Fe Dam Park Lake are not due to waste discharges or anthropogenic sources, the lake is meeting the pH standard. While carbon dioxide and cations in the water tend to decrease the pH, the presence of anions such as chlorides, silicates, arsenates, and aluminates (Cole, 1994) increase pH. In Santa Fe Dam Park Lake, the elevated pH is likely due to the presence of naturally occurring anions. USEPA concludes that preparing a TMDL for pH is unwarranted at this time and recommends that Santa Fe Dam Park not be identified as impaired by pH in California's next 303(d) list. The nutrient TMDLs will therefore be allocated based on existing conditions as an antidegredation measure to ensure that future loading does not increase algal densities that may further alter the pH of the system.

11.2.6 TMDL Summary

A waterbody's loading capacity represents the maximum load of a pollutant that can be assimilated without violating water quality standards (40 CFR 130.2(f)). This is the maximum nutrient load consistent with meeting the numeric target of 20 µg/L of chlorophyll *a* as a summer average. The methodology for determining the loading capacity is described briefly in this section. For more detail, refer to Appendix A (Nutrient TMDL Development).

Based on simulated and observed levels of chlorophyll *a* in Santa Fe Dam Park Lake, existing levels of nitrogen and phosphorus loading are resulting in attainment of the chlorophyll *a* target concentration and are not significantly impacting the pH. Monitoring data indicate that the average in-lake total nitrogen concentration is 0.63 mg-N/L (Appendix G, Monitoring Data). Because the majority of in-lake phosphorous samples have been less than the detection limits for the analytical laboratory, the phosphorus target concentration is based on an in-lake ratio of total nitrogen concentration to total phosphorus concentration close to 10. This ratio was selected to match that typically observed in natural systems and to balance biomass growth and prevent limitation by one nutrient (Thomann and Mueller, 1987). The corresponding in-lake concentrations of nitrogen and phosphorus are

- 0.63 mg-N/L summer average (May – September) and annual average
- 0.063 mg-P/L summer average (May – September) and annual average

To prevent degradation of this waterbody, nutrient TMDLs are allocated based on existing loading. These TMDLs are broken down into the wasteload allocations (WLAs), load allocations (LAs), and Margins of Safety (MOS) using the general TMDL equation. Note that the MOS is zero as there is no evidence of excess algal growth or significant pH elevation above background conditions.

$$TMDL = \sum WLA + LA + MOS$$

For total nitrogen, the allocatable load is equal to the existing load and is divided among WLAs and LAs. The resulting TMDL equation for total nitrogen is then:

13,169 lb-N/yr = 12,523 lb-N/yr + 646 lb-N/yr + 0 lb-N/yr

For total phosphorus, the allocatable load is equal to the existing load and allocated to WLAs and LAs. The resulting TMDL equation for total phosphorous is then:

282 lb-P/yr = 230 lb-P/yr + 52 lb-P/yr + 0 lb-P/yr

Allocations are assigned for these TMDLs by requiring equal percentage reductions of all sources. Details associated with the WLAs, LAs, and MOS are presented in the following three sections.

As previously mentioned, in-lake concentrations of nitrogen and phosphorus have been determined based on recent and historical monitoring data (see Section 11.2.5). These in-lake concentrations reflect internal cycling processes (see Appendix A, Nutrient TMDL Development) and, therefore, differ from concentrations associated with various inflows. Nutrient concentrations associated with the WLA and LA inputs are described below. These values are provided as examples as they are calculated based on existing flow volumes (they will need to be recalculated if flow volumes change). Because the input concentrations do not consider internal cycling processes and are based on existing flow volumes, they do not match the allowable in-lake nitrogen and phosphorous concentrations.

11.2.6.1 Wasteload Allocations

Responsible jurisdictions are encouraged to consider the construction of wetland systems and bioswales (or other retention and treatment options) to treat the stormwater and supplemental water flows entering the lake, as well as stormwater diversion and infiltration using methods such as porous pavements and rain gardens. Implementing these options can reduce the lake's nutrient loads and, in the case of recirculation through constructed wetlands, reduce in-lake nutrient concentrations. Additionally, persons that apply algaecides as part of an overall lake management strategy must comply with the Aquatic Pesticide General Permit (General Permit Order No. 2004-0009-DWQ, CAG990005).

Local jurisdictions have performed studies on nearby waterbodies that may be considered when evaluating nutrient-reduction strategies for this lake. For example, the City of Los Angeles has modeled expected nutrient concentration reductions to stormwater flows to Echo Park Lake from constructed wetlands, and construction is currently underway. Information about this and other City of Los Angeles water quality improvement projects are available on Proposition O website: http://www.lapropo.org/sitefiles/lariver.htm.

Federal regulations require that NPDES permits incorporate water quality based effluent limitations (WQBELs) consistent with the requirements and assumptions of any available wasteload allocations (WLAs). These TMDLs establish WLAs at their point of discharge. There are no MS4 discharges to Santa Fe Dam Park Lake and no other (non-MS4) permitted dischargers in the watershed. The supplemental water addition (groundwater and potable water) inputs are the only sources of nutrient loading to Santa Fe Dam Park Lake that are assigned wasteload allocations (WLAs) (Table 11-6). Note that WLAs are equal to existing loading rates because no reductions in loading are required. These loading values (in pounds per year) represent the TMDLs wasteload allocations (Table 11-6). Each wasteload allocation must be met at the point of discharge. A three-year average will be used to evaluate compliance. However, if applicable water quality criteria for ammonia, dissolved oxygen and pH, and the chlorophyll *a* target are met in the lake, then the total phosphorous and total nitrogen allocations are considered attained.

Table 11-6. **Wasteload Allocations of Phosphorus and Nitrogen Loading to Santa Fe Dam Park Lake**

Responsible Jurisdiction	Input	Total Phosphorus (lb-P/yr)[1]	Total Nitrogen (lb-N/yr)[1]
County of Los Angeles	Supplemental Water Additions (Groundwater)	93.3	10,734
County of Los Angeles	Supplemental Water Additions (Potable Water)	137	1,789
Total		**230**	**12,523**

[1] Each wasteload allocation must be met at the point of discharge. A three year average will be used to evaluate compliance. However, if applicable water quality criteria for ammonia, dissolved oxygen and pH, and the chlorophyll *a* target are met in the lake, then the total phosphorous and total nitrogen allocations are considered attained.

11.2.6.2 Load Allocations

There are no storm drains that discharge runoff flows into Santa Fe Dam Park Lake. Therefore, all loads associated with the surrounding drainage area are assigned load allocations (LAs) (Table 11-7). Atmospheric deposition is also assigned an LA. These loading values (in pounds per year) represent the TMDLs load allocations (Table 11-7). Each load allocation must be met at the point of discharge. A three-year average will be used to evaluate compliance. However, if applicable water quality criteria for ammonia, dissolved oxygen and pH, and the chlorophyll *a* target are met in the lake, then the total phosphorous and total nitrogen allocations are considered attained.

Table 11-7. **Load Allocations of Phosphorus and Nitrogen Loading to Santa Fe Dam Park Lake**

Responsible Jurisdiction	Input	Total Phosphorus (lb-P/yr)[1]	Total Nitrogen (lb-N/yr)[1]
Azusa	Runoff	27.0	205
Irwindale	Runoff	23.8	253
County of Los Angeles	Parkland Irrigation	1.2	137
	Atmospheric Deposition (to the lake surface)[2]	NA	51.4
Total		**52**	**646**

[1] Each load allocation must be met at the point of discharge. A three year average will be used to evaluate compliance. However, if applicable water quality criteria for ammonia, dissolved oxygen and pH, and the chlorophyll *a* target are met in the lake, then the total phosphorous and total nitrogen allocations are considered attained.

[2] Loads for atmospheric deposition are based on direct precipitation to the lake (calculated by the annual average precipitation multiplied by the surface area of the lake).

11.2.6.3 Margin of Safety

TMDLs must include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality. The MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. This lake is currently achieving the in-lake chlorophyll a target and TMDLs are being established at the existing loads. This conservative anti-degradation measure is the implicit margin of safety for these TMDLs.

11.2.6.4 Critical Conditions/Seasonality

TMDLs must include consideration of critical conditions and seasonal variation to ensure protection of the designated uses of the waterbody at all times. Critical conditions for nutrient impaired lakes typically occur during the warm summer months when water temperatures are elevated and algal growth rates are high. Elevated temperatures not only reduce the saturation levels of DO, but also increase the toxicity of ammonia and other chemicals in the water column. Excessive rates of algal growth may cause large swings in DO, elevated pH, odor, and aesthetic problems. Loading of nutrients to lakes during winter months are often biologically available to fuel algal growth in summer months. These nutrient TMDLs account for summer season critical conditions by using the NNE Bathtub model to calculate possible annual loading rates consistent with meeting the summer chlorophyll *a* target concentration of 20 µg/L. These TMDLs are based on existing conditions as an anti-degradation measure since nitrogen and phosphorus levels are currently achieving the chlorophyll *a* target level. These TMDLs therefore protect for critical conditions.

11.2.6.5 Daily Load Expression

USEPA recommends inclusion of a daily load expression for all TMDLs to comply with the 2006 D.C. Circuit Court of Appeals decision for the Anacostia River. These TMDLs present a maximum daily load according to the guidelines provided by USEPA (2007b). The majority of nutrient loading to Santa Fe Dam Park Lake comes from the supplemental water additions used to maintain lake levels. These maximum loads are not allowed each day of the year because the annual loads specified by the TMDLs must also be achieved. The WLA and LA loads presented above are annual loading caps that cannot be exceeded.

The maximum daily loads from the combined supplemental water inputs were calculated by multiplying the highest metered monthly flowrates with the long-term average concentrations consistent with meeting the TMDLs. Allowable concentrations of phosphorus and nitrogen are 0.045 mg-P/L and 2.47 mg-N/L for the combined supplemental water additions (Section 11.2.6.1). The maximum combined metered monthly flow rate is 4,497 ac-ft/mo or 145.1 ac-ft/d (4,497 ac-ft/mo divided by 31 d/mo). Multiplying this maximum daily flowrate by the allowable concentrations yields maximum daily nutrient loads of 17.7 lb-P/d and 975 lb-N/d associated with the combined supplemental water additions. As described above, in order to achieve in-lake nutrient targets as well as annual load-based allocations, the maximum allowable daily loads cannot be discharged to the lake systems every day. The WLA and LA loads presented above are annual loading caps that cannot be exceeded.

11.2.6.6 Future Growth

The Santa Fe Dam Park Lake watershed is comprised entirely of parkland/rangeland with a small section of adjacent industrial area. It is not likely that the watershed will be developed and it is expected to remain primarily as open space. No load allocation has been set aside for future growth, and it is unlikely that any dischargers will be permitted in the watershed.

If any sources currently assigned load allocations are later determined to be point sources requiring NPDES permits, those load allocations are to be treated as wasteload allocations for purposes of determining appropriate water quality-based effluent limitations pursuant to 40 CFR 122.44(d)(1).

11.3 LEAD IMPAIRMENT

Santa Fe Dam Park Lake was listed as impaired for lead in 1996 based on an assessment in the Regional Board's Water Quality Assessment and Documentation Report (LARWQCB, 1996). Consistent with project plan recommendations provided in California's Impaired Waters Guidance (SWRCB, 2005), EPA and local agencies collected 32 additional samples (12 wet weather) between March 2009 and August 2010 to evaluate current water quality conditions. There were zero dissolved lead exceedances in 32 samples (Appendix G, Monitoring Data). USEPA also collected two sediment samples during the month of August 2010 to further evaluate lake conditions. There were zero sediment lead exceedances of the 128 ppm freshwater (Probable Effect Concentrations) sediment target (Appendix G, Monitoring Data). Therefore, Santa Fe Dam Park Lake meets lead water quality standards, and USEPA concludes that preparing a TMDL for lead is unwarranted at this time. USEPA recommends that Santa Fe Dam Park Lake not be identified as impaired by lead in California's next 303(d) list.

11.4 COPPER IMPAIRMENT

Santa Fe Dam Park Lake was listed as impaired for copper in 1996 based on an assessment in the Regional Board's Water Quality Assessment and Documentation Report (LARWQCB, 1996). Consistent with project plan recommendations provided in California's Impaired Waters Guidance (SWRCB, 2005), EPA and local agencies collected 32 additional samples (12 wet weather) between March 2009 and August 2010 to evaluate current water quality conditions. There were zero dissolved copper exceedances in 32 samples (Appendix G, Monitoring Data). USEPA also collected two sediment samples during the month of August 2010 to further evaluate lake conditions. There were zero sediment copper exceedances of the 149 ppm freshwater (Probable Effect Concentrations) sediment target (Appendix G, Monitoring Data). Therefore, Santa Fe Dam Park Lake meets copper water quality standards, and USEPA concludes that preparing a TMDL for copper is unwarranted at this time. USEPA recommends that Santa Fe Dam Park Lake not be identified as impaired by copper in California's next 303(d) list.

11.5 IMPLEMENTATION RECOMMENDATIONS

Implementation measures may be developed in the future by the Regional Board through an implementation plan, NPDES permits, or non-point source enforcement. This section describes USEPA's recommendations to the Regional Board as to the implementation procedures and regulatory mechanisms that could be used to provide reasonable assurances that water quality standards will be met. General information about various lake management strategies can be found in a USEPA document titled *Managing Lakes and Reservoirs (EPA 841-B-01-006)*. Lake management options that would reduce pollutant loading to this lake include but are not limited to: increasing the volume of the lake that is aerated; installing hydroponic islands to remove nutrients; increasing flow volume or circulation in the lake; reducing stormwater discharges by improved infiltration; treating stormwater or supplemental water inputs with a wetland system; alum treatment to immobilize nutrients in sediments; dredging in lake sediments; and/or fisheries management actions to reduce nutrient availability from sediments.

If necessary, these TMDLs may be revised as the result of new information (See Section 11.6 Monitoring Recommendations).

11.5.1 Nonpoint Sources and the Implementation of Load Allocations

Regional Board may regulate nonpoint pollutant sources through the authority contained in sections 13263 and 13269 of the California Water Code, in conformance with the State Water Resources Control Board's Nonpoint Source Implementation and Enforcement Policy. Additionally, South Coast Air

Quality Management District has authority to regulate air emissions throughout the basin that affect air deposition. Load allocations are expressed in Table 11-7.

11.5.2 Point Sources and the Implementation of Wasteload Allocations

Wasteload allocations apply to supplemental water additions (Table 11-6). These mass-based waste load allocations will be implemented by the Regional Board.

11.5.3 Source Control Alternatives

The nutrient-response analysis for Santa Fe Dam Park Lake indicates that existing levels of nitrogen and phosphorus loading are resulting in attainment of the summer average chlorophyll *a* target concentration of 20 µg/L and are not significantly impacting pH levels in the waterbody. As an antidegradation measure, nitrogen and phosphorus TMDLs are allocated based on existing loading. Future land use changes are not expected in this watershed. In the event that development does occur, source reduction and pollutant removal BMPs, designed to reduce sediment loading, could be implemented as these management practices will also reduce the nutrient loading associated with sediments. Dissolved loading associated with dry and wet weather runoff also contributes nutrient loading to Santa Fe Dam Park Lake. Some of the sediment reduction BMPs may also result in decreased concentrations of nitrogen and phosphorus in the runoff water. Storage of storm flows in wet or dry ponds may allow for adsorption and settling of nutrients from the water column. BMPs that provide filtration, infiltration, and vegetative uptake and removal processes may retain nutrient loads in the upland areas.

Responsible jurisdictions are encouraged to consider the construction of wetland systems and bioswales (or other biofiltration options) to treat the stormwater and supplemental water flows entering the lake, as well as stormwater diversion and infiltration using methods such as porous pavements and rain gardens. Implementing these options can reduce the lake's nutrient loads and, in the case of recirculation through constructed wetlands, reduce in-lake nutrient concentrations. The City of Los Angeles has modeled expected nutrient concentration reductions to stormwater flows to Echo Park Lake from constructed wetlands, and plans to finalize the design and begin construction in the near future. Information about this and other City of Los Angeles water quality improvement projects are available on Proposition O website: http://www.lapropo.org/sitefiles/lariver.htm.

Education of park maintenance staff regarding the proper placement, timing, and rates of fertilizer application will also result in reduced nutrient loading to the lake. Park staff should be advised to follow product guidelines regarding fertilizer amounts and to spread fertilizer when the chance of heavy precipitation in the following days is low. Encouraging pet owners who visit the park to properly dispose of pet wastes will also reduce nutrient loading associated with fecal material that may wash directly into the lake. Discouraging feeding of birds at the lake will reduce nutrient loading associated with excessive bird populations.

In order to meet the fine particulate ($PM_{2.5}$) and ozone (O_3) national ambient air quality standards by their respective attainment dates of 2015 and 2024, the South Coast Air Quality Management District and the California Air Resources Board have prepared an air quality management plan that commits to reducing nitrogen oxides (NOx, a precursor to both $PM_{2.5}$ and ozone) by over 85 percent by 2024. These reductions will come largely from the control of mobile sources of air pollution such as trucks, buses, passenger vehicles, construction equipment, locomotives, and marine engines. These reductions in NOx emissions will result in reductions of ambient NOx levels and atmospheric deposition of nitrogen to the lake surface.

11.6 MONITORING RECOMMENDATIONS

Although estimates of the loading capacity and allocations are based on best available data and incorporate a MOS, these estimates may potentially need to be revised as additional data are obtained. The mass-based loading capacity will be affected by changes in flow volumes; therefore, loading capacities may be reconsidered if significant volume reductions or additions occur.

To provide reasonable assurances that the assigned allocations result in compliance with the chlorophyll *a* target, a commitment to continued monitoring and assessment is warranted. The purposes of such monitoring will be 1) to determine compliance with wasteload and load allocations, 2) to determine if numeric targets are being attained, 3) to evaluate whether numeric targets and allocations need to be adjusted to attain beneficial uses, 4) to document trends over time in algal densities and bloom frequencies.

To assess compliance with the nutrient TMDLs, monitoring for nutrients and chlorophyll *a* should occur at least twice during the summer months and once in the winter. At a minimum, compliance monitoring should measure the following in-lake water quality parameters: ammonia, TKN or organic nitrogen, nitrate plus nitrite, orthophosphate, total phosphorus, total suspended solids, total dissolved solids and chlorophyll *a*. Measurements of the temperature, dissolved oxygen, pH and electrical conductivity should also be taken throughout the water column with a water quality probe along with Secchi depth measurement. All parameters must meet target levels at half the Secchi depth. DO and pH must meet target levels from the surface of the water to 0.3 meters above the lake bottom. Additionally, in order to accurately calculate compliance with wasteload allocations to the lake expressed in yearly loads, monitoring should include flow estimation or monitoring as well as the water quality concentration measurements. At Santa Fe Dam Park Lake the only wasteload allocation s are for supplemental water additions. These sources should be monitoring once a year during the summer months (the critical condition) for at minimum; ammonia, TKN or organic nitrogen, nitrate plus nitrite, orthophosphate, total phosphorus, total suspended solids and total dissolved solids.

The nutrient-response analysis for Santa Fe Dam Park Lake indicates that existing levels of nitrogen and phosphorus loading are resulting in attainment of the summer average chlorophyll *a* target concentration of 20 µg/L and are not significantly impacting pH levels in the waterbody. As an antidegradation measure, nitrogen and phosphorus TMDLs are allocated based on existing loading. As an example of concentrations that responsible jurisdiction may need to target in order to meet and comply with the mass-based WLAs and LAs, this discussion provides concentrations calculated based on existing conditions (a recalculation is needed if flow volumes change). Assuming flow volumes remain at existing levels (Table 11-4), the target concentrations of phosphorus and nitrogen may be 0.045 mg-P/L and 2.47 mg-N/L for the combined supplemental water additions. The target concentrations of phosphorus and nitrogen in the city of Azusa may be 0.591 mg-P/L and 4.49 mg-N/L. Targeted concentrations may be 0.363 mg-P/L and 3.86 mg-N/L for the city of Irwindale. Targeted concentration in the irrigated parkland return flows to the lake may be 0.026 mg-P/L and 3.0 mg-N/L (9.6 percent of the total irrigation volume is assumed to reach the lake). Assuming an average precipitation depth, the targeted concentration of nitrogen in precipitation may be 0.196 mg-N/L. As stated above, these concentrations are provided as guidelines; however, mass-based WLAs must be achieved.

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