U.S. Environmental Protection Agency

Los Angeles Area Lakes TMDLs
March 2012

Section 10 Puddingstone Reservoir TMDLs

10 Puddingstone Reservoir TMDLs

Puddingstone Reservoir (#CAL4055200019980918113803) is impaired by organic enrichment/low dissolved oxygen, chlordane, DDT, mercury, and PCBs (SWRCB, 2010). In addition a dieldrin impairment has been identified by new data analyses since the 2008-2010 303(d) list data cut off. This section of the TMDL report describes the impairments and the TMDLs developed to address them: nutrients (see Section 10.2), mercury (Section 10.3) and organochlorine (OC) pesticides and PCBs (Section 10.4 through Section 10.7). Nutrient load reductions are required to achieve the chlorophyll *a* target; these reductions are also expected to alleviate DO problems.

10.1 Environmental Setting

Puddingstone Reservoir is located in the San Gabriel River Basin (HUC 18070106) in Bonelli Regional Park (Figure 10-1 and Figure 10-2). The park is located in the county of Los Angeles, immediately surrounded by the cities of San Dimas and Pomona. Located in a flood control basin, the dam was built in 1929 and the area surrounding the reservoir was converted to a park in 1972. Live Oak Wash (Figure 10-3) is the major inflow to the reservoir, which discharges to Walnut Creek. The reservoir has a surface area of 252 acres (based on Southern California Association of Governments [SCAG] 2005 land use), a total volume of 6,200 acre-feet (based on Los Angeles County Department of Public Works volume estimates from 2000 and 2001), and an average depth of 24.6 feet (volume divided by surface area). Recreational uses include swimming, jet skiing, boating, and fishing. According to the California Department of Fish and Game (2009), the reservoir is periodically stocked with trout. Bird feeding may be another recreational activity at Puddingstone Reservoir; however, it has not been observed during recent fieldwork. The areas immediately surrounding the lake receive many visitors as they include a water theme park, equestrian facilities, golf course, and a lakeside RV park. Restrooms on the park grounds are connected to the city sewer system. There is no known use of algaecide in this lake. Additional characteristics of the watershed are summarized below.

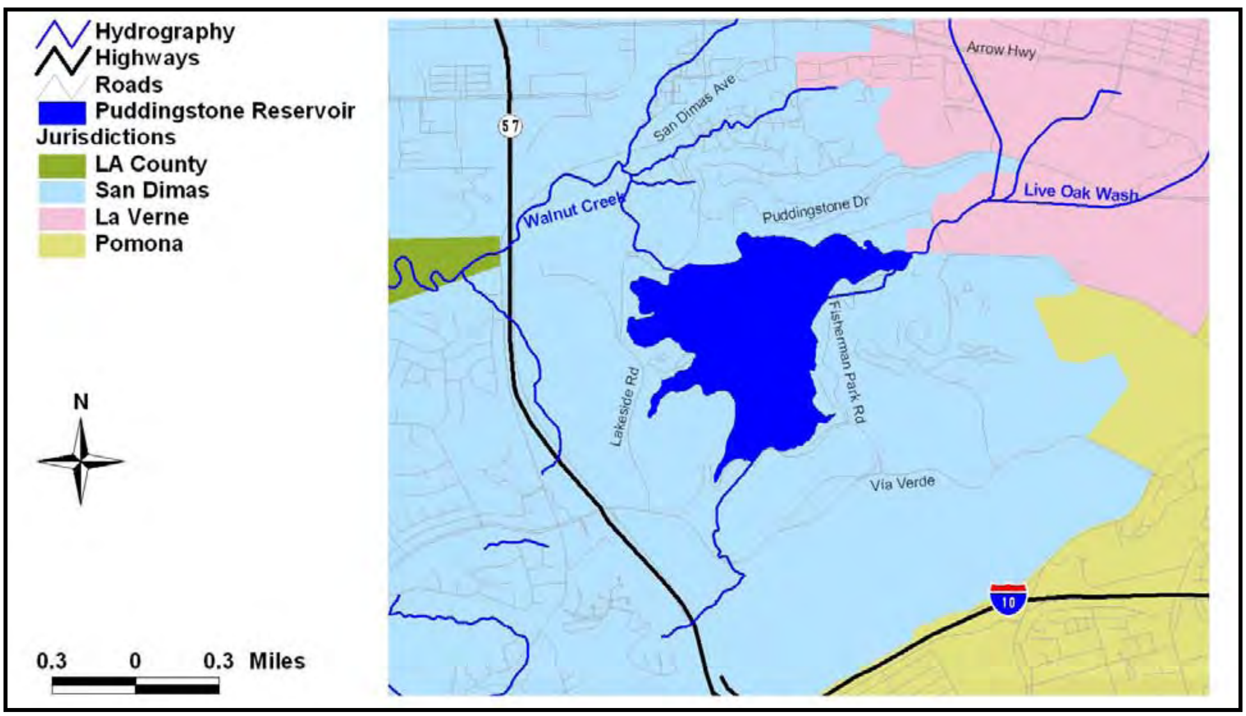

Figure 10-1. **Location of Puddingstone Reservoir**

Figure 10-2. **View of Puddingstone Reservoir**

Figure 10-3. **Live Oak Wash with Puddingstone Channel Joining on the Left**

10.1.1 Elevation, Storm Drain Networks, and TMDL Subwatershed Boundaries

Puddingstone Reservoir drains an area of 8,128 acres that ranges in elevation from 267 meters to 1,125 meters (Figure 10-4). The TMDL subwatershed boundaries selected for Puddingstone Reservoir were based on boundaries obtained from the county of Los Angeles. The county of Los Angeles subwatersheds were aggregated to two larger subwatersheds with an internal boundary chosen to separate those areas that drain to a storm drain (the northern subwatershed) and those that enter the reservoir via natural tributaries or overland flow (the southern subwatershed). Loads generated from the northern subwatershed will be assigned wasteload allocations because they drain to the storm drain network, while loads from the southern subwatershed will be assigned load allocations because they do not drain to pipes or culverts prior to discharge to the reservoir (atmospheric deposition throughout the watershed will also receive load allocations). The subwatershed draining the northern part of the watershed is 6,959 acres, and the southern subwatershed is 1,169 acres.

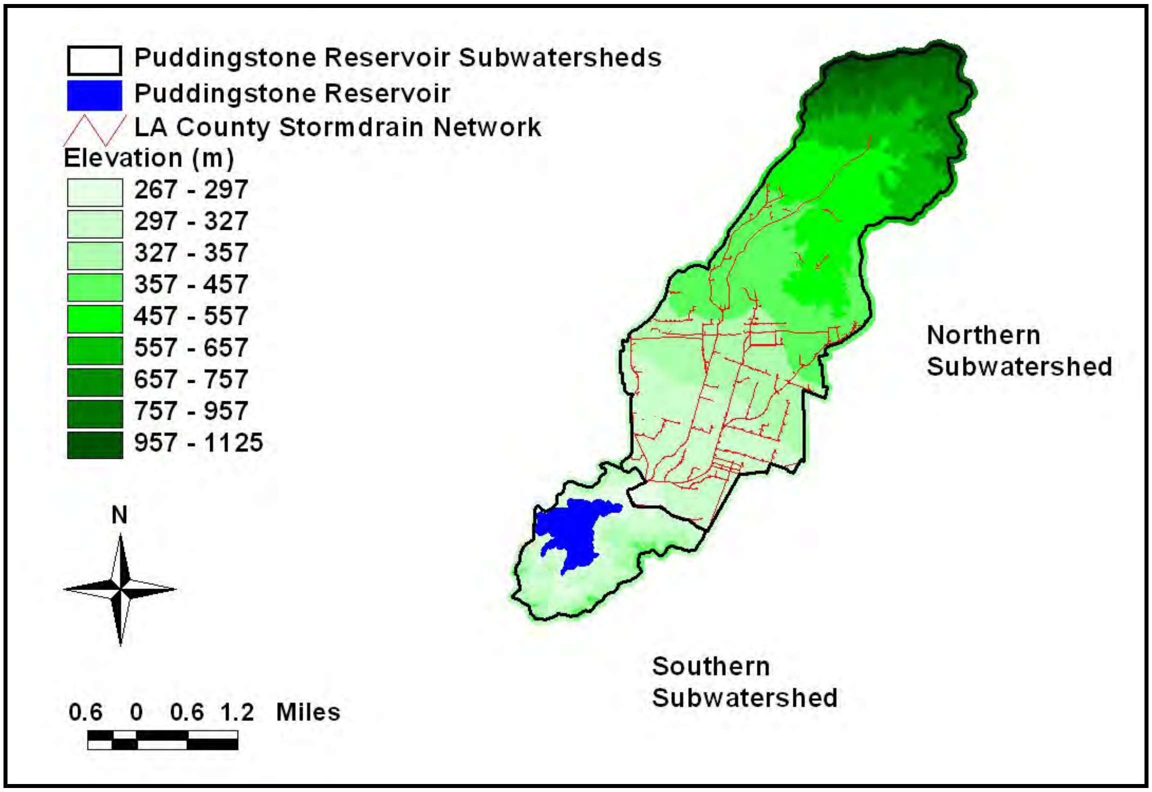

Figure 10-4. **Elevation, Storm Drain Networks, and TMDL Subwatershed Boundaries for Puddingstone Reservoir**

10.1.2 MS4 Permittees

Figure 10-5 shows the MS4 stormwater permittees in the Puddingstone Reservoir watershed. The storm drain coverage was provided by the county of Los Angeles. The northern subwatershed is primarily comprised of the county of Los Angeles, Claremont, and La Verne areas, with a small amount of San Dimas, Caltrans, and Angeles National Forest areas. Loads generated from those jurisdictions in the northern subwatershed will be assigned wasteload allocations because they drain to the storm drain network. The southern subwatershed is comprised of San Dimas, La Verne, and Pomona areas. Loads from those jurisdictions originating in the southern subwatershed will be assigned load allocations because they do not drain to pipes or culverts prior to discharge to the reservoir. Figure 10-6 through Figure 10-8 show some of the storm drain and natural drainages to Puddingstone Reservoir. The small amount of Caltrans area in the southern subwatershed will be assigned a wasteload allocation.

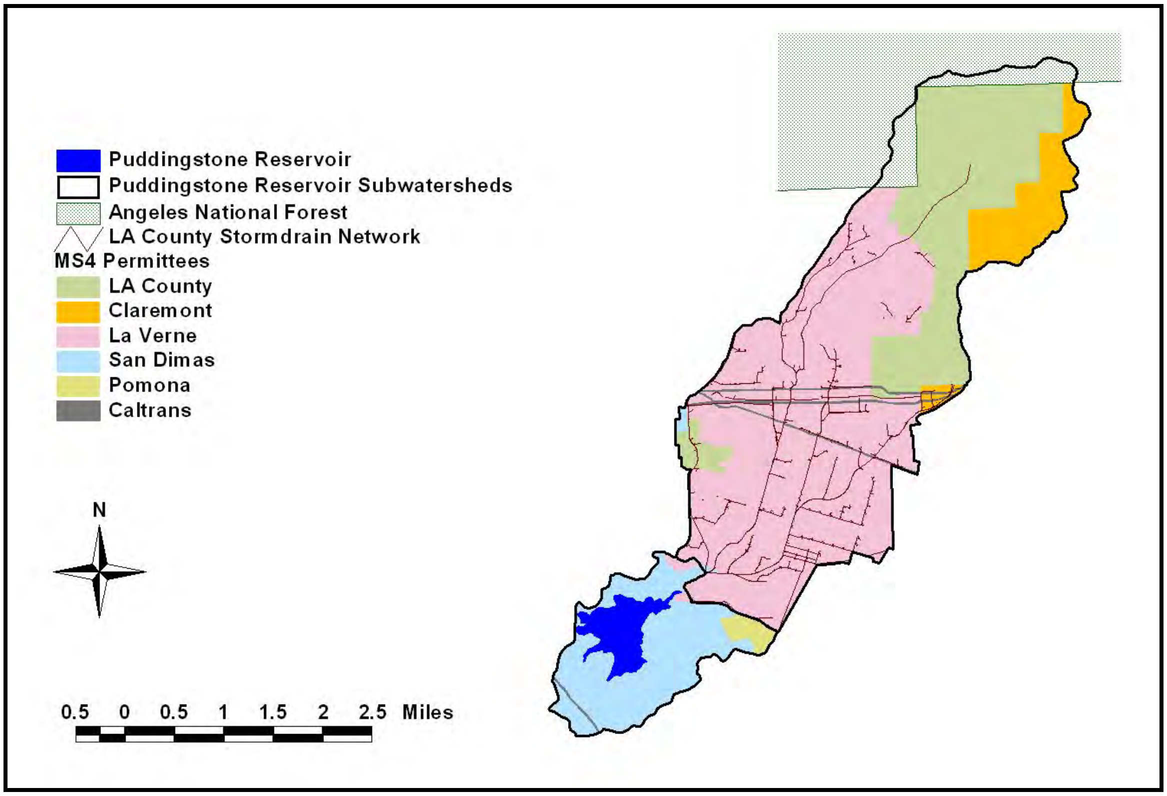

Figure 10-5. **MS4 Permittees and the Storm Drain Network in the Puddingstone Reservoir Subwatersheds**

Figure 10-6. **Storm Drain Discharges to Puddingstone Reservoir**

Figure 10-7. **Natural Drainage Discharge to Puddingstone Reservoir**

Figure 10-8. **Storm Drain Discharge to a Small Depression (that Subsequently Flows to Puddingstone Reservoir)**

10.1.3 Non-MS4 NPDES Dischargers

There are several additional NPDES permits (non-MS4) in the Puddingstone Reservoir watershed (Table 10-1). These include one active discharger covered under a general construction stormwater permit and seven dischargers covered under a general industrial stormwater permit (see Section 3.1 for a detailed discussion of these permit types). These permits were identified by querying excel files of permits from the Regional Board website (Excel files for each watershed are available from this link, www.waterboards.ca.gov/losangeles/water_issues/programs/regional_program/index.shtml#watershed, accessed on October 5, 2009). They are all in the city of La Verne in the northern subwatershed (Figure 10-9) and result in 233 disturbed acres. Specific information is not available regarding these dischargers; however, they are assigned existing loads and wasteload allocations based on their area (industrial stormwater) and disturbed area (construction stormwater).

Table 10-1. Non-MS4 Permits in the Puddingstone Reservoir Watershed

Type of NPDES Permit	Number of Permits	Subwatershed	Jurisdiction	Disturbed Area
General Construction Stormwater (Order No. 99-08-DWQ, CAS000002)	1	Northern	La Verne	36.0 acres
General Industrial Stormwater (Order No. 97-03-DWQ, CAS000001)	7	Northern	La Verne	197 acres

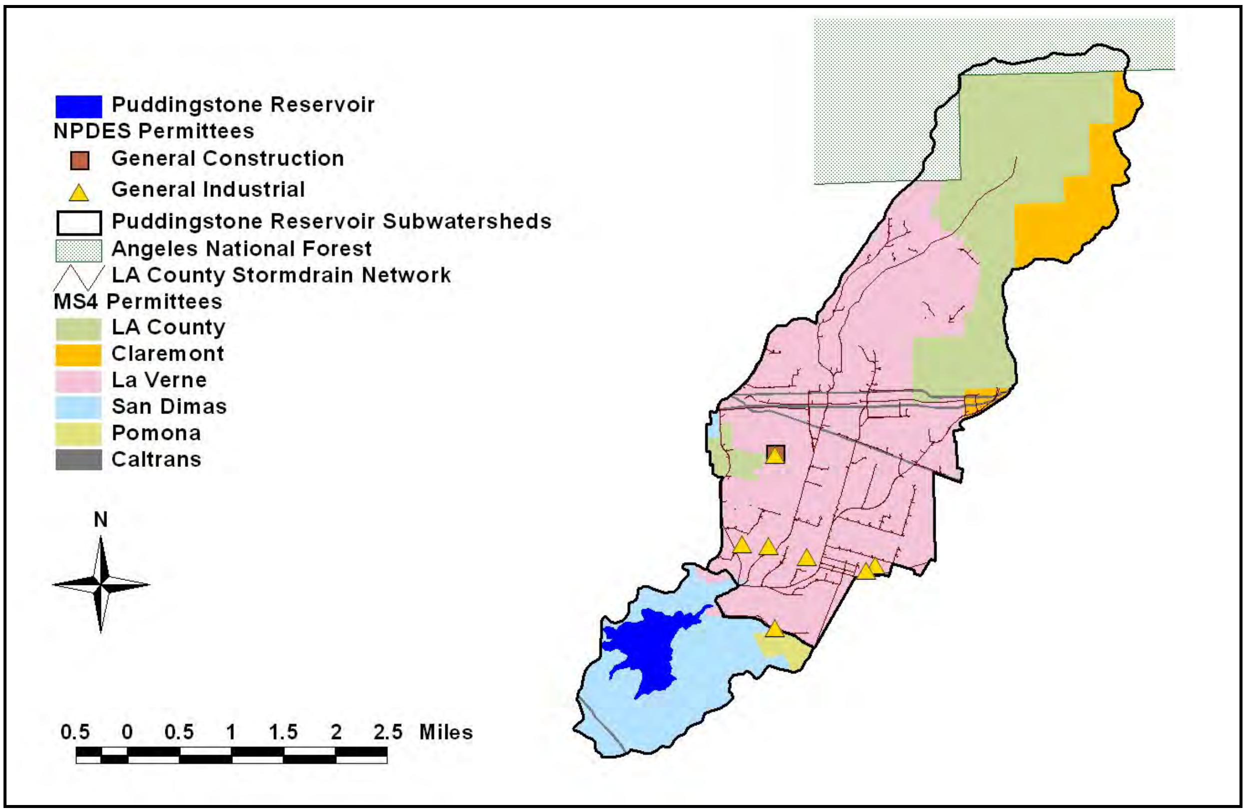

Figure 10-9. **Non-MS4 Permits in the Puddingstone Reservoir Subwatersheds**

10.1.4 Land Uses and Soil Types

Several of the analyses for the Puddingstone Reservoir 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 are largely residential and shrub and brush rangeland and are shown in Figure 10-10 (based on SCAG 2000 land use data). Upon review of the SCAG 2005 database as well as current satellite imagery, it was evident that some of the areas classified by the LSPC model as agriculture or strip mines were inaccurate. Inaccuracies in land use assignment were corrected for each subwatershed and jurisdiction to reflect the more recent SCAG 2005 dataset and current satellite imagery. All areas within the Caltrans jurisdiction were simulated as transportation. Table 10-2 and Table 10-3 summarize the land use areas for each TMDL subwatershed and jurisdiction.

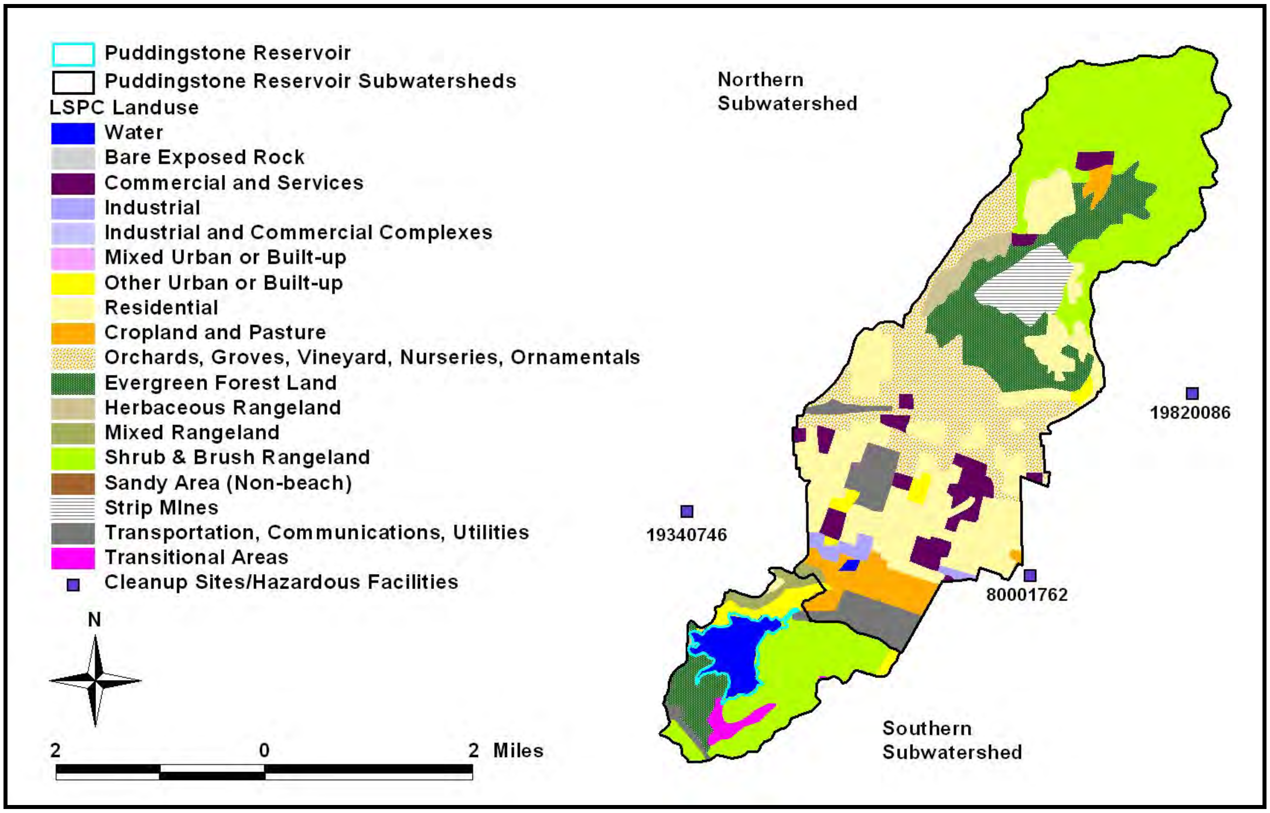

Figure 10-10. **LSPC Land Use Classes for the Puddingstone Reservoir Subwatersheds**

Table 10-2. Land Use Areas (ac) Draining the Northern Subwatershed of Puddingstone Reservoir

Land Use	Claremont	County of Los Angeles	La Verne	Pomona	San Dimas	Caltrans	Angeles National Forest	Total
Commercial and services	0	38.8	295	0.291	11.0	0	0	**345**
Cropland and pasture	2.91	22.5	199	0	0	0	0	**225**
Evergreen forest land	42.9	378	376	0	0	0	0	**797**
Herbaceous rangeland	0	0	123	0	0	0	0	**123**
Industrial	0	0	82.3	0	0	0	0	**82.3**
Mixed rangeland	0	21.5	111	1.08	1.95	0	0	**135**
Other urban or built-up	8.07	9.24	58.2	0.005	2.90	0	0	**78.4**
Residential	28.4	467	2,469	0.260	10.0	0	0	**2,975**

Land Use	Claremont	County of Los Angeles	La Verne	Pomona	San Dimas	Caltrans	Angeles National Forest	Total
Shrub & brush rangeland	496	926	19.7	0.097	0.53	0	293	**1,736**
Transportation, communications, utilities	0	0.97	346	3.55	2.12	110	0	**463**
Transitional areas	0	0	0	0	0	0	0	**0**
Total	**578**	**1,865**	**4,079**	**5.28**	**28.5**	**110**	**293**	**6,959**

Table 10-3. Land Use Areas (ac) Draining the Southern Subwatershed of Puddingstone Reservoir

Land Use	La Verne	Pomona	San Dimas	Caltrans	Total
Commercial and services	0	0	0	0	**0**
Cropland and pasture	0	0	0	0	**0**
Evergreen forest land	0	0	184	0	**184**
Herbaceous rangeland	0	0	4.33	0	**4.33**
Industrial	0	0	0	0	**0**
Mixed rangeland	23.7	0	48.5	0	**72.2**
Other urban or built-up	1.35	19.1	101	0	**122**
Residential	0	0	10.7	0	**10.7**
Shrub & brush rangeland	0.006	62.1	602	0	**664**
Transportation, communications, utilities	8.44	0.616	23.0	11.6	**43.6**
Transitional areas	0	0	68.2	0	**68.2**
Total	**33.5**	**81.8**	**1,042**	**11.6**	**1,169**

Three Resource Conservation and Recovery Act (RCRA) cleanup sites are located near the Puddingstone Reservoir watershed (these are within one mile of the watershed, as illustrated in Figure 10-10). Information regarding these facilities is summarized in Table 10-4. No additional information regarding potential contaminants of concern is available for one site. The potential contaminants of concern identified at these three sites are not relevant to the nutrients, mercury, chlordane, dieldrin, PCBs or DDT impairments. It is not known whether or not these facilities contributed mercury, chlordane, dieldrin, PCBs, or DDT to Puddingstone Reservoir in the past. None of these sites should be contributing loading under existing conditions.

Table 10-4. RCRA Cleanup Sites near the Puddingstone Reservoir Watershed

Envirostor #	Facility Name	Cleanup Status	Potential Contaminants of Concern
19340746	Cropper's Plating Site	Certified	Chromium III, copper and compounds, organic lead (tetra ethyl lead)
19820086	La Puerta Elementary School	Certified	No data in site summary database for this facility
80001762 (CAD980894562)	Safety-Kleen Corp.	Inactive	Cadmium, chromium, lead, benzenes, TCE, PCE and non-halogenated solvents

Figure 10-11 shows the predominant soils identified by STATSGO (Appendix D, Wet Weather Loading) in the Puddingstone Reservoir subwatersheds. The soil type identified as Zamora-Urban land-Ramona (MUKEY 660480) comprises the largest area. The soil hydrologic group for this soil is not identified in the data set, which typically indicates either water, bedrock, or urban impervious surfaces. There are two hydrologic group C soils in the watershed (Soper-Fontana-Calleguas-Balcom-Anaheim, MUKEY 660477 and Sobrante-Exchequer-Cieneba, MUKEY 660501). These soils are characterized as moderately-fine to fine-textured and have low infiltration rates when wet; they consist chiefly of soils having a layer that impedes downward movement of water. A small part of the watershed contains a hydrologic group A soil (Urban land-Tujunga-Soboba-Hanford, MUKEY 660474), which has low runoff potential and high infiltration rates even when wet. This soil consists chiefly of sand and gravel and is well-drained to excessively-drained. The San Gabriel River Basin LSPC model does not explicitly use hydrologic soil group as a modeling parameter, though the characteristics of the hydrologic soil group influence parameters such as infiltration rate.

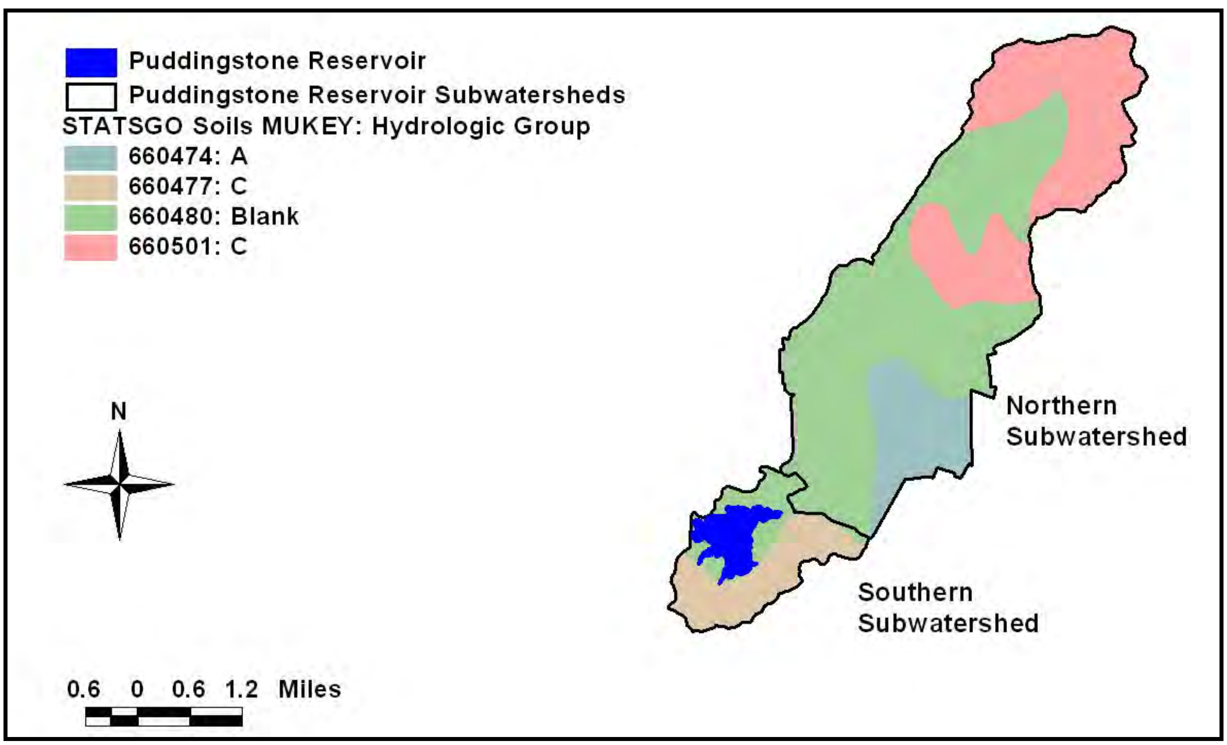

Figure 10-11. **STATSGO Soil Types Present in the Puddingstone Reservoir Subwatersheds**

10.1.5 Additional Inputs

Puddingstone Reservoir does not receive direct inputs from groundwater or potable water sources. Areas around the lake are irrigated with reclaimed water, some of which may reach the reservoir (10.1 percent of the total irrigation volume is assumed to reach the lake). Application of chlorine in the swim beach area may impact pH levels in the lake. The impacts of irrigation and chlorination are discussed in Appendix F (Dry Weather Loading).

10.2 NUTRIENT-RELATED IMPAIRMENTS

A number of the assessed impairments for Puddingstone Reservoir may be associated with nutrients and eutrophication. Nutrient-related impairments for Puddingstone Reservoir include organic enrichment/low dissolved oxygen (DO) (SWRCB, 2010). The loading of excess nutrients enhances algal growth (eutrophication). Algae produce oxygen during photosynthesis but remove oxygen through respiration or decay, resulting in a net depression of DO in the absence of sunlight. Algal photosynthesis can also affect the pH balance of the lake through the removal of carbon dioxide.

10.2.1 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 Puddingstone Reservoir include REC1, REC2, WARM, WILD, MUN, GWR, COLD, RARE, and AGR. Descriptions of these uses are listed in Section 2 of this TMDL report. Elevated nutrient levels are impairing the REC1/REC2, WARM, and COLD, uses and can potentially impair WILD, MUN, GWR and RARE uses by stimulating algal growth that may form mats that impede recreational and drinking water use, alter pH and dissolved oxygen (DO) levels, alter biology that impair aquatic life, and cause odor and aesthetic problems.

10.2.2 Numeric Targets

The Basin Plan for the Los Angeles Region (LARWQCB, 1994) outlines the numeric targets and narrative criteria that apply to Puddingstone Reservoir. The following targets apply to the organic enrichment/low DO impairment (see Section 2 for additional details and Table 10-5 for a summary):

- The Basin Plan addresses excess aquatic growth in the form of a narrative objective for nutrients. Excessive nutrient concentrations (e.g., nitrogen and phosphorous) in a waterbody can lead to nuisance effects such as algae, odors, and scum. The objective specifies, "waters shall not contain biostimulatory substances in concentrations that promote aquatic growth to the extent that such growth causes nuisance or adversely affects beneficial uses." The Regional Board has not adopted numeric targets for biostimulatory nutrients or chlorophyll *a* in Puddingstone Reservoir; however, as described in Tetra Tech (2006), summer (May to September) mean and annual mean chlorophyll *a* concentrations of 20 µg/L are selected as the maximum allowable level consistent with full support of contact recreational use and are also consistent with supporting warm water aquatic life. The mean chlorophyll *a* target must be met at half of the Secchi depth during the summer (May – September) and annual averaging periods.

- The Basin Plan states "at a minimum the mean annual dissolved oxygen concentrations of all waters shall be greater than 7 mg/L, and no single determinations shall be less than 5.0 mg/L, except when natural conditions cause lesser concentrations." In addition, the Basin Plan states, "the dissolved oxygen content of all surface waters designated as WARM shall not be depressed below 5 mg/L as a result of waste discharges" and "the dissolved oxygen content of all surface waters designated as COLD shall not be depressed below 6 mg/L as a result of waste discharges." Deep lakes that thermally stratify during the summer months, such as Puddingstone Reservoir, must meet the DO target in the epilimnion of the water column.

The epilimnion is the upper stratum of more or less uniformly warm, circulating, and fairly turbulent water during summer stratification. The epilimnion floats above a cold relatively undisturbed region called the hypolimnion. The stratum between the two is the metalimnion and is characterized by a thermocline, which refers to the plane of maximum rate of decrease of temperature with respect to depth. For the purposes of these TMDLs the presence of stratification will be defined by whether there is a change in lake temperature greater than 1 degree Celsius per meter. Deep lakes, such as Puddingstone Reservoir, must meet the DO and pH targets in the water column from the surface to 0.3 m above the bottom of the lake when the lake is not stratified. However, when stratification occurs (i.e., a thermocline is present) then the DO and pH targets must be met in the epilimnion, the portion of the water column above the thermocline.

- 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." Deep lakes that thermally stratify during the summer months, such as Puddingstone Reservoir, must meet the pH target in the epilimnion of the water column.

Nitrogen and phosphorus target concentrations are based on simulation of allowable loads with the NNE BATHTUB model (Section 10.2.6). Based on the calibrated model for Puddingstone Reservoir, the target nutrient concentrations within the lake are

- 0.71 mg-N/L summer average (May – September) and annual average
- 0.071 mg-P/L summer average (May – September) and annual average

Table 10-5. Nutrient-Related Numeric Targets for Puddingstone Reservoir

Parameter	Numeric Target	Notes
Chlorophyll *a*	20 µg/L summer average (May – September) and annual average	
Dissolved Oxygen	7 mg/L minimum mean annual concentrations and 6 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	0.71 mg-N/L summer average (May – September) and annual average	Based on simulation of allowable loads from the NNE BATHTUB model
Total Phosphorous	0.071 mg-P/L summer average (May – September) and annual average	Based on simulation of allowable loads from the NNE BATHTUB model

10.2.3 Summary of Monitoring Data

This section briefly summarizes the nutrient-related monitoring data for Puddingstone Reservoir. Appendix G (Monitoring Data) contains more detailed information regarding water quality sampling in the lake.

Puddingstone Reservoir was monitored for water quality in 1992 and 1993 in support of the Urban Lakes Study near the center of the northern half of the lake. TKN ranged from 0.3 mg-N/L to 6.9 mg-N/L, although concentrations greater than 1.2 mg-N/L only occurred at depths greater than or equal to 8 meters. Ammonium ranged from 0.1 mg-N/L to 5.3 mg-N/L with 39 measurements less than the detection limit (0.01 mg-N/L); concentrations did not exceed 0.2 mg-N/L except at depths greater than or equal to 8 meters. Each of the 75 measurements of nitrite was less than the detection limit (0.01 mg-N/L), and 23 nitrate samples were less than the detection limit (0.01 mg-N/L). The maximum concentration of nitrate observed was 2 mg-N/L. Forty-nine of 75 samples of orthophosphate were less than the detection limit (0.01 mg-P/L), and the maximum concentration observed was 1.7 mg-P/L. Total phosphorus was similar with 45 measurements less than the detection limit (0.01 mg-P/L) and a maximum observed concentration of 1.3 mg-P/L. Concentrations of orthophosphate and total phosphorus did not exceed 0.2 mg-P/L except at depths greater than or equal to 14 meters. pH ranged from 7.4 to 9.0, and TOC ranged from 2.8 mg/L to 8.2 mg/L. The summary table from the 1994 Lakes Study Report (UC Riverside, 1994) lists chlorophyll *a* concentrations ranging from 4 μg/L to 22 μg/L with an average of 13 μg/L.

The 1996 Water Quality Assessment Report contains summary information regarding the DO impairment which was listed as not supporting the aquatic life use. DO was measured 187 times with concentrations ranging from 0.1 mg/L to 14.9 mg/L. However, the accompanying database does not contain these measurements so no information regarding location, time, depth, or temperature can be compared. There are some temperature and pH measurements in the database that were collected from December 1977 through March 1978. Temperature ranged from 11.1 ºC to 11.7 ºC, and pH ranged from 6.6 to 7.6.

More recent monitoring of nutrients in Puddingstone Reservoir occurred on November 18, 2008 at four locations in the lake. All samples of ammonia, TKN, nitrate, nitrite, orthophosphate, and total phosphate collected at the four lake stations were below the detection limits of 0.1 mg-N/L, 1 mg-N/L, 0.1 mg-N/L, 0.1 mg-N/L, 0.4 mg-P/L, and 0.5-P mg/L, respectively. Chlorophyll *a* ranged from 11.3 μg/L to 21.4 μg/L.

Puddingstone Reservoir was sampled in February 2009 by USEPA and the Regional Board. The field notes report that approximately 300 gallons of chlorine are pumped into the swim beach area each week during the summer. The edges of the lake are sometimes treated for weeds. Samples were collected from a depth of 1.5 meters at two locations. Secchi depths were 0.76 meters at all locations. Ammonia samples ranged from 0.03 mg-N/L to 0.04 mg-N/L. TKN ranged from 1.3 mg-N/L to 1.7 mg-N/L. Nitrite ranged from 0.02 mg-N/L to 0.05 mg-N/L, and nitrate ranged from 0.02 mg-N/L to 0.26 mg-N/L. Orthophosphate ranged from 0.016 mg-P/L to 0.062 mg-P/L; total phosphorus ranged from 0.098 mg-P/L to 0.121 mg-P/L. Chlorophyll *a* measurements were high during this event and ranged from 66.1 μg/L to 113.5 μg/L. These chlorophyll *a* results are anomalously high compared to later measurements taken during the summer, however, these levels were measured one week after a major rain events that likely delivered high nutrient loads to the lake. Reported concentrations of DO decreased from over 6 mg/L at the surface to 0 mg/L at 3 meters to 4 meters. pH ranged from 7.6 to 9.4 at each station. Temperature at these two stations ranged from 11.3 ºC to 14.6 ºC. Field operators found DO readings suspicious and sent the meter off for repair (Greg Nagle, USEPA Region IX, personal communication, 5/22/09). These DO results were excluded from the relevant data set based on poor quality assurance.

In July 2009, Puddingstone Reservoir was sampled at two locations. Ammonia, nitrite, nitrate, and orthophosphate concentrations were less than the detection limits of 0.03 mg-N/L, 0.01 mg-N/L, 0.01 mg-N/L, and 0.0075 mg-P/L, respectively. Total phosphorus were 0.041 mg-P/L and 0.164 mg-P/L, though the field duplicate for the higher sample was 0.048 mg-P/L. Chlorophyll *a* concentrations were 25.1 µg/L and 27.3 µg/L. DO concentrations were above 8 mg/L throughout the epilimnion. pH ranged from 8.52 to 8.92.

In summary, chlorophyll *a* concentrations are typically above the summer average target concentration of 20 µg/L. Although conditions in February 2009 may have been anomalous (i.e., winter concentrations were significantly higher than all other chlorophyll *a* concentrations), the concentrations measured during the July 2009 event averaged 26 µg/L. Based on the July 2009 profile measurements, DO is meeting the target COLD concentration of 6 mg/L throughout the epilimnion. Readings collected in February may have been collected with a malfunctioning meter. Exceedances of the allowable range for pH (6.5 to 8.5) have been observed as well. The nutrient TMDLs for Puddingstone Reservoir presented in Section 10.2.6 account for summer season critical conditions by assessing loading rates consistent with meeting the summer chlorophyll *a* target concentration of 20 µg/L. These reductions in nutrient loading are expected to alleviate pH, odor, DO, and ammonia problems associated with excessive nutrient loading and eutrophication.

10.2.4 Source Assessment

The majority of nutrient loading to Puddingstone Reservoir originates from the surrounding watershed (Appendix D, Wet Weather Loading; Appendix F, Dry Weather Loading) including irrigation (10.1 percent of the total irrigation volume is assumed to reach the lake). Loading due to direct deposition from the atmosphere is discussed in Appendix E (Atmospheric Deposition). The northern subwatershed comprises 85.6 percent of the drainage area and contributes 86 percent and 90 percent of the total phosphorus and total nitrogen loads, respectively, to Puddingstone Reservoir. The majority of the remaining load originates from the southern subwatershed. All existing loads to Puddingstone Reservoir are summarized in Table 10-6.

Table 10-6. Summary of Average Annual Flows and Nutrient Loading to Puddingstone Reservoir

Subwatershed	Responsible Jurisdiction	Input	Flow (ac-ft)	Total Phosphorus (lb-P/yr) (percent of total load)	Total Nitrogen (lb-N/yr) (percent of total load)
Northern	Caltrans	State Highway Stormwater[1]	141	253 (3.6)	1,603 (3.4)
Northern	Claremont	MS4 Stormwater[1]	206	256 (3.6)	1,786 (3.8)
Northern	County of Los Angeles	MS4 Stormwater[1]	773	1,124 (15.9)	7,299 (15.6)
Northern	La Verne[2]	MS4 Stormwater[1]	2,361	4,209 (59.5)	25,332 (54.0)
Northern	General Industrial Stormwater Permittees (in the city of La Verne)	General Industrial Stormwater [1]	258	409 (5.8)	3,008 (6.4)
Northern	General Construction Stormwater Permittees (in the city of La Verne)	General Construction Stormwater [1]	47.1	74.7 (1.1)	550 (1.2)
Northern	Pomona	MS4 Stormwater[1]	5.48	9.6 (0.1)	60.9 (0.1)
Northern	San Dimas	MS4 Stormwater[1]	26.5	47.2 (0.7)	294 (0.6)
Northern	Angeles National Forest	Stormwater[1]	34.6	10.3 (0.1)	301 (0.6)

Subwatershed	Responsible Jurisdiction	Input	Flow (ac-ft)	Total Phosphorus (lb-P/yr) (percent of total load)	Total Nitrogen (lb-N/yr) (percent of total load)
Southern	Caltrans	State Highway Stormwater[1]	12.4	22.5 (0.3)	148 (0.3)
Southern	La Verne	Runoff	13.0	19.4 (0.3)	147 (0.3)
Southern	Pomona	Runoff	25.1	34.5 (0.5)	276 (0.6)
Southern	San Dimas	Runoff	229	272 (3.8)	2,433 (5.2)
Southern	County of Los Angeles	Parkland Irrigation	163	337 (4.8)	3,425 (7.3)
Lake Surface		Atmospheric Deposition[3]	366	NA	209 (0.4)
Total			**4,661**	**7,078**	**46,872**

[1]This input includes effluent from storm drain systems during both wet and dry weather.

[2] The total area for the City of La Verne in the northern subwatershed is 4,079 acres. Discharges governed by the general construction and general industrial stormwater permits are located in the City of La Verne. The disturbed area associated with general construction and general industrial stormwater permittees (233 acres) was subtracted out of the appropriate city area and allocated to these permits.

[3] 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).

10.2.5 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. To simulate the impacts of nutrient loading on Puddingstone Reservoir, the 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 Puddingstone Reservoir, the following inputs apply: surface area of 252 acres, average depth of 24.6 ft, and volume of 6,200 ac-ft. Based on the phosphorus turnover ratio for this lake (Walker, 1987), the annual averaging period is appropriate (i.e., annual loads are input to the model rather than summer season loads).

The NNE BATHTUB Tool was calibrated to average summer season water quality data observed over twice the typical Secchi depth (2*1.15 m = 2.3 m). To predict the average observed total nitrogen concentration over this depth (1.06 mg-N/L), the calibration factor on the net nitrogen sedimentation rate was set to 1.7. The calibration factor on the net phosphorus sedimentation rate was set to the maximum suggested (2) (Walker, 1987), and the resulting concentration is 0.08 mg-P/L. Although this calibrated sedimentation rate reflects the net effects of phosphorus settling and resuspension, the high calibration factor indicates that settling is the more dominant mechanism in this system, and internal phosphorus loading is likely insignificant relative to the other sources of loading. The reductions in external phosphorus loading in the lake required by this TMDL should lead to further suppression of internal loading. To simulate the average observed chlorophyll *a* concentration, the calibration factor on concentration was set to 1.5 for a predicted concentration of 26 µg/L.

10.2.6 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).

Following calibration of the NNE BATHTUB Tool (Section 10.2.5), the allowable loading combinations of nitrogen and phosphorus were calculated using Visual Basic's GoalSeek function (Appendix A, Nutrient TMDL Development). The loading combination that is predicted to result in an in-lake ratio of total nitrogen concentration to total phosphorus concentration close to 10 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

- 0.71 mg-N/L summer average (May – September) and annual average
- 0.071 mg-P/L summer average (May – September) and annual average

The loading capacities for total nitrogen and total phosphorus are 24,190 lb-N/yr and 5,181 lb-P/yr, respectively. These loading capacities can be further broken down into the wasteload allocations (WLAs), load allocations (LAs), and Margin of Safety (MOS) using the general TMDL equation:

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

For total nitrogen, the allocatable load (divided among WLAs and LAs) is 46.4 percent of the existing load of 46,872 lb-N/yr, or 21,771 lb-N/yr. This value represents 90 percent of the loading capacity, while the MOS is 10 percent of the loading capacity. WLAs and LAs are developed assuming equal percent load reductions in all sources. The resulting TMDL equation for TN is then:

24,190 lb-N/yr = 18,756 lb-N/yr + 3,015 lb-N/yr + 2,419 lb-N/yr

For total phosphorus, the allocatable load (divided among WLAs and LAs) is 65.9 percent of the existing load of 7,078 lb-P/yr, or 4,663 lb-P/yr. This value represents 90 percent of the loading capacity, while the MOS is 10 percent of the loading capacity. The resulting TMDL equation for TP is:

5,181 lb-P/yr = 4,226 lb-P/yr + 437 lb-P/yr + 518 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 simulation of allowable loads with the NNE BATHTUB model (see Section 10.2.5). These in-lake concentrations are calculated from a complex set of equations that consider 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 (and 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.

10.2.6.1 Wasteload Allocations

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. The wasteload allocations for most point sources are mass-based; however, the wasteload allocations for stormwater discharges that are covered under general industrial and construction stormwater permits are concentration-based. In addition, these TMDLs establish alternative wasteload allocations for total phosphorous and alternative wasteload allocations for total nitrogen (collectively, "Approved Lake Management Plan Wasteload Allocations"). The Approved Lake Management Plan Wasteload allocations are concentration-based and are described in Section 10.2.6.1.2. The Approved Lake Management Plan Wasteload allocations will supersede the wasteload allocations in Section 10.2.6.1.1 if the conditions described in Section 10.2.6.1.2 are met.

Under either wasteload allocation scheme responsible jurisdictions are encouraged to consider the construction of wetland systems and bioswales (or other retention or 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 the Proposition O website: http://www.lapropo.org/sitefiles/lariver.htm.

10.2.6.1.1 Wasteload Allocations

The northern subwatershed drains to a series of storm drains prior to discharging to Puddingstone Reservoir. Therefore, all loads associated with this drainage area are assigned WLAs. The loads attributed to the Caltrans areas in the southern subwatershed and the general construction and industrial stormwater permits also receive WLAs. Relevant permit numbers are

- County of Los Angeles (including the cities of Claremont, La Verne, Pomona, and San Dimas): Board Order 01-182 (as amended by Order No. R4-2006-0074 and R4-2007-0042), CAS004001
- Caltrans: Order No 99-06-DWQ, CAS000003
- General Construction Stormwater: Order No. 2009-0009-DWQ, CAS000002
- General Industrial Stormwater: Order No. 97-03-DWQ, CAS000001

Total phosphorus WLAs represent a 34.1 percent reduction in existing loading, and total nitrogen WLAs represent a 53.6 percent reduction in existing loading. These loading values (in pounds per year) represent the TMDLs wasteload allocations (Table 10-7).

Each WLA applies at the point of discharge. As noted in Table 10-7 below, the concentration-based WLAs will be used to evaluate compliance with the allocations for the current discharges authorized by the general industrial stormwater permit and the construction stormwater permit and any future discharges in the watershed authorized by the general industrial and construction stormwater permits. The phosphorous and nitrogen WLA concentrations were calculated by dividing the allowable load (in lb/yr; Table 10-7) by their respective estimated flow rates (258 ac-ft/yr and 47 ac-ft/yr for industrial and construction sites, respectively; Table 10-6) and applying the appropriate conversion factors to yield concentrations in mg/L.

Table 10-7. Wasteload Allocations of Phosphorus and Nitrogen Loading to Puddingstone Reservoir

Subwatershed	Responsible Jurisdiction	Input	Existing Total Phosphorus Load (lb-P/yr)	Wasteload Allocation Total Phosphorus[4] (lb-P/yr)	Existing Total Nitrogen Load (lb-N/yr)	Wasteload Allocation Total Nitrogen[4] (lb/yr)
Northern	Caltrans	State Highway Stormwater[1]	253	167	1,603	745
Northern	Claremont	MS4 Stormwater[1]	256	169	1,786	829
Northern	County of Los Angeles	MS4 Stormwater[1]	1,124	741	7,299	3,390
Northern	La Verne[2]	MS4 Stormwater[1]	4,209	2,772	25,332	11,766
Northern	General Industrial Stormwater Permittees (in the city of La Verne)	General Industrial Stormwater[1]	409	269 (0.4 mg/L P)[3]	3,008	1,397 (2.0 mg/L N)[3]
Northern	General Construction Stormwater Permittees (in the city of La Verne)	General Construction Stormwater[1]	74.7	49 (0.4 mg/L P)[3]	550	255 (2.0 mg/L N)[3]
Northern	Pomona	MS4 Stormwater[1]	9.57	6.30	60.9	28.3

Subwatershed	Responsible Jurisdiction	Input	Existing Total Phosphorus Load (lb-P/yr)	Wasteload Allocation Total Phosphorus[4] (lb-P/yr)	Existing Total Nitrogen Load (lb-N/yr)	Wasteload Allocation Total Nitrogen[4] (lb/yr)
Northern	San Dimas	MS4 Stormwater[1]	47.2	31.1	294	137
Northern	Angeles National Forest	Stormwater[1]	10.3	6.8	301	140
Southern	Caltrans	State Highway Stormwater[1]	22.5	14.8	148	68.2
Total			**6,415**	**4,226**	**40,382**	**18,756**

[1] This input includes effluent from storm drain systems during both wet and dry weather.

[2] The total area for the City of La Verne in the northern subwatershed is 4,079 acres. Discharges governed by the general construction and general industrial stormwater permits are currently located in the City of La Verne. The disturbed area associated with general construction and general industrial stormwater permittees (233 acres) was subtracted out of the appropriate city area and allocated to these permits. Any future discharges governed by the general construction and general industrial stormwater permits will receive the same concentration-based wasteload allocations (see footnote #3).

[3] For these responsible jurisdictions, the concentration-based WLA will be use to evaluate compliance.

[4] Each wasteload allocation must be met at the point of discharge.

10.2.6.1.2 Alternative "Approved Lake Management Plan Wasteload Allocations"

Concentration-based WLAs not exceeding the concentration listed in Table 10-8 are effective and supersede corresponding WLAs for a responsible jurisdiction in Table 10-7 if:

1. The responsible jurisdiction requests that concentration-based wasteload allocations not to exceed the concentrations established in Table 10-8 apply to it;
2. The responsible jurisdiction provides to USEPA and the Regional Board a Lake Management Plan describing actions that will be implemented and cause each of the following to be met: the applicable water quality criteria for ammonia, dissolved oxygen and pH; the chlorophyll *a* targets listed in Table 10-5; and the requested concentration-based WLAs. Responsible jurisdictions may work together to develop, submit and implement the Lake Management Plan. A Lake Management Plan may include the following types of actions: 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; and/or fisheries management actions to reduce nutrient availability from sediments. The responsible jurisdiction may use monitoring data and modeling to show that the water quality criteria, targets and requested WLAs will be met;
3. The Regional Board Executive Officer approves the request and applies concentration-based wasteload allocations for total nitrogen and total phosphorus. These wasteload allocations are not to exceed the concentrations in Table 10-8 as a summer average (May-September) and annual average, and
4. USEPA does not object to the Regional Board's determination within 60 days of receiving notice of it.

Each concentration-based WLA must be met in the lake.

Table 10-8. Alternative Wasteload Allocations of Phosphorus and Nitrogen in Puddingstone Reservoir if an Approved Lake Management Plan Exists

Subwatershed	Responsible Jurisdiction	Input	Maximum Allowable Wasteload Allocation Total Phosphorus[3] (mg-P/L)	Maximum Allowable Wasteload Allocation Total Nitrogen[3] (mg-N/L)
Northern	Caltrans	State Highway Stormwater[1]	0.1	1.0
Northern	Claremont	MS4 Stormwater[1]	0.1	1.0
Northern	County of Los Angeles	MS4 Stormwater[1]	0.1	1.0
Northern	La Verne[2]	MS4 Stormwater[1]	0.1	1.0
Northern	General Industrial Stormwater Permittees (in the city of La Verne)	General Industrial Stormwater[1]	0.1	1.0
Northern	General Construction Stormwater Permittees (in the city of La Verne)	General Construction Stormwater[1]	0.1	1.0
Northern	Pomona	MS4 Stormwater[1]	0.1	1.0
Northern	San Dimas	MS4 Stormwater[1]	0.1	1.0
Northern	Angeles National Forest	Stormwater[1]	0.1	1.0
Southern	Caltrans	State Highway Stormwater[1]	0.1	1.0

[1] This input includes effluent from storm drain systems during both wet and dry weather.

[2] Discharges governed by the general construction and general industrial stormwater permits are currently located in the City of La Verne. Any future discharges governed by the general construction and general industrial stormwater permits will receive the same concentration-based wasteload allocations.

[3] Each concentration-based wasteload allocation must be met in the lake.

10.2.6.2 Load Allocations

These TMDLs establish load allocations (LAs) and alternative LAs for total phosphorous and total nitrogen. The alternative LAs will be effective and supersede the LAs listed in Table 10-9 if the conditions described in Section 10.2.6.2.2 are met.

10.2.6.2.1 Load Allocations

Loads associated with the southern subwatershed are assigned LAs. Total phosphorus LAs represent a 34.1 percent reduction in existing loading, and total nitrogen LAs represent a 53.6 percent reduction in existing loading. LAs are provided for each responsible jurisdiction and input and must be met at the point of discharge. These loading values (in pounds per year) represent the TMDLs load allocations (Table 10-9).

Table 10-9. Load Allocations of Phosphorus and Nitrogen Loading to Puddingstone Reservoir

Subwatershed	Responsible Jurisdiction	Input	Existing Total Phosphorus Load (lb-P/yr)	Load Allocation Total Phosphorus[1] (lb-P/yr)	Existing Total Nitrogen Load (lb-N/yr)	Load Allocation Total Nitrogen[1] (lb/yr)
Southern	La Verne	Runoff	19.4	12.8	147	68.2
Southern	Pomona	Runoff	34.5	22.7	276	128
Southern	San Dimas	Runoff	272	179	2,433	1,130
Southern	County of Los Angeles	Parkland Irrigation	337	222	3,425	1,591
Lake Surface		Atmospheric Deposition[2]	NA	NA	209	97.3
Total			**663**	**437**	**6,490**	**3,015**

[1] Each load allocation must be met at the point of discharge.

[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).

10.2.6.2.2 Alternative "Approved Lake Management Plan Load Allocations"

The load allocation for any responsible jurisdiction listed in Table 10-9 will be superseded, and the load allocation for that responsible jurisdiction in Table 10-10 will apply, if:

1. The responsible jurisdiction requests that concentration-based load allocations not to exceed the concentrations established in Table 10-10 apply to it.
2. The responsible jurisdiction provides to USEPA and the Regional Board a Lake Management Plan describing actions that will be implemented and cause the applicable water quality criteria for ammonia, dissolved oxygen and pH to be met. The plan must also show that the chlorophyll *a* targets listed in Table 10-5 and the alternative total nitrogen and phosphorus targets will be met. Responsible jurisdictions may work together to develop, submit and implement the Lake Management Plan. A Lake Management Plan may include the following types of actions: 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; and/or fisheries management actions to reduce nutrient availability from sediments. The responsible jurisdiction may use monitoring data and modeling to show that the water quality criteria and targets will be met.
3. The Regional Board Executive Officer approves the request and applies concentration-based load allocations for total nitrogen and total phosphorus. These load allocations are not to exceed the concentrations in Table 10-10 as a summer average (May-September) and annual average, and
4. USEPA does not object to the Regional Board's determination within 60 days of receiving notice of it.

Each concentration-based load allocations must be met in the lake.

Table 10-10. Alternative Load Allocations of Phosphorus and Nitrogen Loading to Puddingstone Reservoir if an Approved Lake Management Plan Exists

Subwatershed	Responsible Jurisdiction	Input	Maximum Allowable Load Allocation Total Phosphorus[1] (mg-P/L)	Maximum Allowable Load Allocation Total Nitrogen[1] (mg-N/L)
Southern	La Verne	Runoff	0.1	1.0
Southern	Pomona	Runoff	0.1	1.0
Southern	San Dimas	Runoff	0.1	1,0
Southern	County of Los Angeles	Parkland Irrigation	0.1	1.0

[1] Each concentration-based load allocations must be met in the lake.

10.2.6.3 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. To account for the uncertainties concerning the relationship between nutrient loading and the resultant in-lake chlorophyll *a* an explicit MOS is included in these TMDLs. This explicit MOS is set at 10 percent of the loading capacity for total phosphorus and total nitrogen.

10.2.6.4 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 expected to alleviate any DO problems associated with excessive nutrient loading and eutrophication. These TMDLs therefore protect for critical conditions.

10.2.6.5 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 (2007). Because the majority of nutrient loading to Puddingstone Reservoir occurs during wet weather events that deliver pollutant loads from the surrounding watershed, the daily maximum allowable loads of nitrogen and phosphorus are calculated from the maximum daily storm flow rate (estimated from the 99th percentile flow) to the Reservoir multiplied by the allowable concentrations consistent with achieving the long-term loading targets. 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.

No USGS gage currently exists in the Puddingstone Reservoir watershed. USGS Station 11086400, San Dimas Creek near San Dimas, CA, was selected as a surrogate for flow determination. The 99th percentile flow was chosen to represent the peak flow for this drainage. Choosing the 99th percentile flow eliminates errors due to outliers and is reasonable for development of a daily load expression.

The USGS StreamStats program was used to determine the 99th percentile flow for this San Dimas Creek gage (55 cfs) (Wolock, 2003). To estimate the peak flow to Puddingstone Reservoir, the 99th percentile flow for San Dimas Creek was scaled down by the ratio of drainage areas (8,128 acres/11,712 acres; Puddingstone Reservoir watershed area/San Dimas Creek watershed area at the gage). The resulting peak flow estimate for Puddingstone Reservoir is 38.2 cfs.

The allowable concentrations for phosphorus and nitrogen were calculated from the annual allowable loads (4,663 lb-P/yr and 21,771 lb-N/yr) divided by the total annual volume delivered to the lake (2,692 ac-ft/yr) (sum of the runoff-associated WLAs and LAs presented in Table 10-7 and Table 10-9, respectively). Multiplying the allowable concentrations (0.637 mg-P/L and 2.97 mg-N/L) by the peak daily flow yields the daily maximum allowable loads which are 131 lb-P/d and 612 lb-N/d. These loads are associated with the MS4 stormwater permittees. For comparison, the existing phosphorus load (7,078 lb-P/yr) would yield an average concentration of 0.967 mg-P/L and a daily load of 199 lb-P/d. The existing nitrogen load (46,872 lb-N/yr) would yield an average concentration of 6.4 mg-N/L and a daily load of 1,318 lb-N/d. 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 every day. The WLA and LA loads presented above are annual loading caps that cannot be exceeded.

10.2.6.6 Future Growth

Much of the Puddingstone Reservoir watershed remains in shrub and brush rangeland. As development occurs in this watershed, best management practices (BMPs) will be required such that loading rates are consistent with the allocations established by these TMDLs. Therefore, no load allocation has been set aside for future growth.

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).

10.3 Mercury Impairment

The listing information for Puddingstone Reservoir (LARWCB, 1996) indicates that fish tissue data collected by the Toxic Substances Monitoring Program (TSMP) exceeded the fish tissue guideline and forms the basis for this listing. Recent data collected by the Surface Water Ambient Monitoring Program (SWAMP) and the San Gabriel Watershed Council (SGWC) indicate that fish tissue levels of mercury remain elevated.

In 2008, the Southern California Coastal Water Research Project (SCCWRP) published a report titled "Extent of Fishing and Fish Consumption by Fishers in Ventura and Los Angeles County Watersheds." The purpose of the study was to document the fishing habits and consumption rates of fishers in these counties (SCCWRP, 2008). Puddingstone Reservoir was visited five times, during which 95 fishers were observed. Forty fishers were interviewed, and 55 percent of those consume fish caught from this waterbody. Of the 19 sampling sites located in the San Gabriel River Basin, Puddingstone Reservoir had the second highest number of observed fishers, and the highest number of people interviewed who consume fish caught from the survey location. As previously noted, according to the California Fish and Game, the reservoir is periodically stocked with trout (California Department of Fish and Game, 2009).

10.3.1 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. Applicable water quality criteria are also specified in the California Toxics Rule (USEPA, 2000a). The existing beneficial uses assigned to Puddingstone Reservoir include REC1, REC2, WARM, WILD, MUN, GWR, COLD, RARE, and AGR. Descriptions of these uses are listed in Section 2 of this TMDL report. Concentrations of mercury measured in fish tissue collected from Puddingstone Reservoir indicate that the REC1, REC2, WARM, and COLD, are currently impaired and at high enough concentrations WILD, MUN, GWR, and RARE uses could be impaired.

10.3.2 Numeric Targets

Numeric targets for mercury in Puddingstone Reservoir apply to both the water column and fish tissue. Water column targets are based on beneficial use. For waters designated MUN (existing, potential, or intermittent), the Basin Plan lists a total mercury maximum contaminant level of 0.002 mg/L, or 2 µg/L. The California Toxics Rule includes total mercury human health criteria for the consumption of "water and organisms" or "organisms only" as 0.050 µg/L and 0.051 µg/L, respectively (USEPA, 2000a). California often implements these values on a 30 day average. The "water and organisms" target applies to Puddingstone because it is designated as an asterisked existing use in the Basin Plan. Because the human health criterion for the consumption of "water and organisms" is the most restrictive criterion, a total mercury water column target of 0.050 µg/L (50 ng/L) is the appropriate target.

In addition, a water column target for dissolved methylmercury of 0.081 ng/L is applicable for Puddingstone Reservoir. This value was calculated by dividing the fish tissue guideline (0.22 ppm) with a national bioaccumulation factor (for dissolved methylmercury) of 2,700,000 applicable for trophic level 4 fish (and multiplying by a factor of 10^6 to convert from milligrams to nanograms).

The fish contaminant goal (FCG) for methylmercury defined by the California Office of Environmental Health Hazard Assessment (OEHHA, 2008) is 220 ppb or 0.22 ppm (wet weight). This concentration is protective of human and wildlife consumers of trophic level four fish. The target length for comparison to this target is 350 mm (13.8 inches) in largemouth bass. Refer to Section 2 of this report for more information regarding these targets.

10.3.3 Summary of Monitoring Data

Total mercury concentrations in the water column of Puddingstone Reservoir have been measured since 1992. In-lake water column mercury concentrations were measured in July and September 1992 as part of the Urban Lakes Study. All 21 measurements were less than the detection limit of 0.5 µg/L (500 ng/L). As the detection limit of this dataset is 10 times higher than the water quality criterion for mercury (50 ng/L), it is difficult to assess compliance in terms of a water column concentration.

More recent samples from November 2008, February 2009, and July 2009 were collected and analyzed with ultra-clean methods and detection limits no greater than 0.5 ng/L. All total mercury samples collected during these events ranged from 0.26 ng/L to 2.52 ng/L and were more than one order of magnitude less than the water column target. Total methylmercury concentrations ranged from 0.025 ng/L to 0.127 ng/L, and one of four samples exceeded the dissolved target concentration of 0.081 ng/L. The average observed methyl mercury concentration (0.065 ng/L) is less than the dissolved target concentration (0.081 ng/L).

Mercury concentrations in the fish tissue of largemouth bass have been measured in Puddingstone Reservoir since 1986 by the TSMP, SGWC, and SWAMP. Figure 10-12 shows the total mercury concentrations in largemouth bass plotted against length, which is an approximate surrogate for age. For composite fish samples, concentration is plotted against mean length. As expected, fish tissue mercury concentrations increase with length. Concentrations exceed 0.22 ppm in all individual or composite samples greater than 345 mm. Twenty-three individual and five composite samples exceed the fish tissue target; five individual samples and one composite had concentrations less than the target. All of the fish tissue data were reported as total mercury concentrations, of which over 90 percent are expected to be in the methyl form (USEPA, 2001a). These total mercury data were compared to the methylmercury fish contaminant guidelines, resulting in conservative assessments.

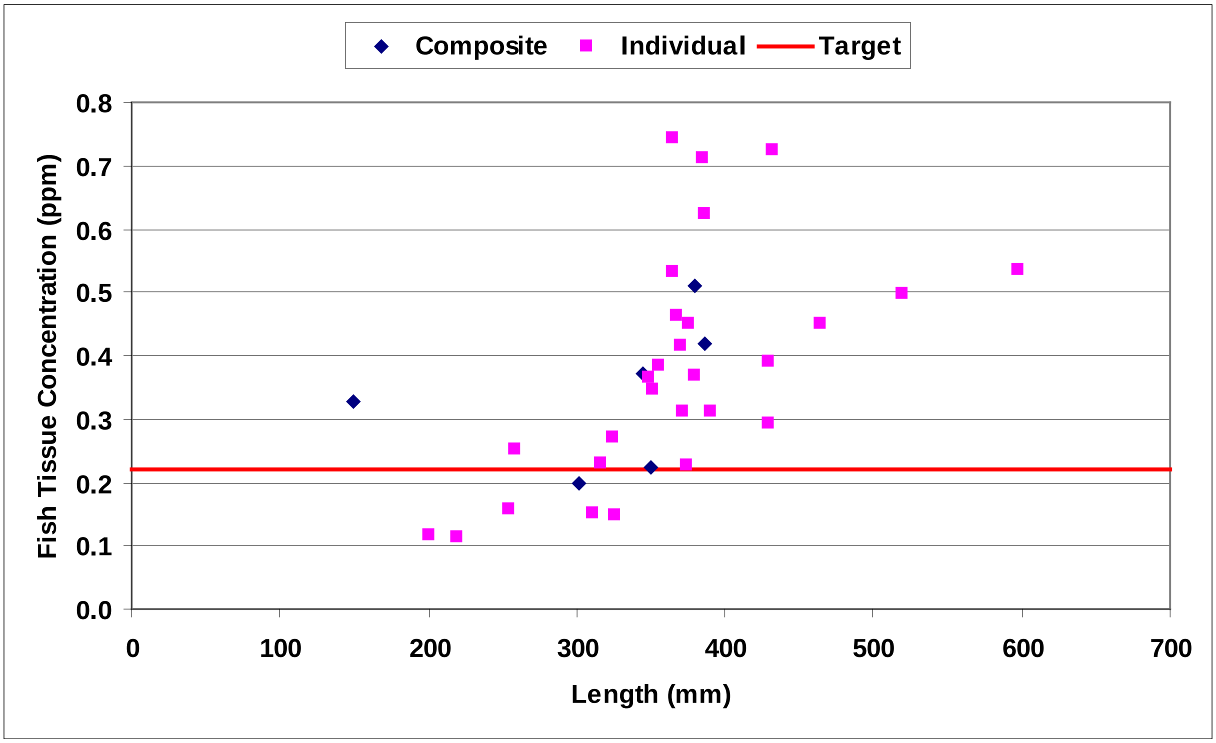

Figure 10-12. **Mercury Concentrations in Largemouth Bass Collected from Puddingstone Reservoir (1986-2007)**

10.3.4 Source Assessment

There are several potential sources of mercury loading in the Puddingstone Reservoir watershed. The majority of loading results from atmospheric deposition to the lake surface. Upland areas are the second largest source; these loads are delivered from tributaries and storm drains in either the water column or sediments. Irrigation of surrounding parklands may contribute loading as well.

Table 10-11 summarizes total mercury loading from the major sources in the watershed. Estimation of watershed loading from MS4 permittees and irrigation of parkland (10.1 percent of the total irrigation volume is assumed to reach the lake) are discussed in more detail in Appendices D and F (Wet and Dry Weather Loading, respectively), Section 10 of both appendices). The atmospheric deposition component of the mercury load is discussed in Appendix E (Atmospheric Deposition). Atmospheric deposition is the largest contributor (47.3 percent) of mercury to Puddingstone Reservoir. The second largest contributor is the MS4 loading from the northern subwatershed (43.6 percent), which contributes loading during wet and dry periods.

Table 10-11. Summary of Existing Total Mercury Loading to Puddingstone Reservoir

Subwatershed	Responsible Jurisdiction	Input	Total Annual Hg Load (g/yr)	Percent of Load
Northern	Caltrans	State Highway Stormwater[1]	1.32	1.85
Northern	Claremont	MS4 Stormwater[1]	1.26	1.78
Northern	County of Los Angeles	MS4 Stormwater[1]	5.24	7.36
Northern	La Verne[2]	MS4 Stormwater[1]	19.9	27.9
Northern	General Industrial Stormwater Permittees (in the city of La Verne)	General Industrial Stormwater[1]	2.41	3.38
Northern	General Construction Stormwater Permittees (in the city of La Verne)	General Construction Stormwater[1]	0.44	0.62
Northern	Pomona	MS4 Stormwater[1]	0.049	0.07
Northern	San Dimas	MS4 Stormwater[1]	0.204	0.29
Northern	Angeles National Forest	Stormwater[1]	0.234	0.33
Southern	Caltrans	MS4 Stormwater[1]	0.096	0.13
Southern	La Verne	MS4 Stormwater[1]	0.097	0.14
Southern	Pomona	MS4 Stormwater[1]	0.166	0.23
Southern	San Dimas	MS4 Stormwater[1]	1.57	2.20
Southern	County of Los Angeles	Parkland Irrigation	4.55	6.39
Lake Surface		Atmospheric Deposition[3]	33.7	47.3
Total			**71.2**	**100**

[1] This input includes effluent from storm drain systems during both wet and dry weather.

[2] The total area for the City of La Verne in the northern subwatershed is 4,079 acres. Discharges governed by the general construction and general industrial stormwater permits are located in the City of La Verne. The disturbed area associated with general construction and general industrial stormwater permittees (233 acres) was subtracted out of the appropriate city area and allocated to these permits.

[3] 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).

10.3.5 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. Specifically, models of watershed loading of mercury are combined with an estimated rate of bioaccumulation in the lake. This enables a translation between the numeric target (expressed as a fish tissue concentration of mercury) and mercury loading rates. The loading capacity is then determined via the linkage analysis as the mercury loading rate that is consistent with meeting the target fish tissue concentration.

Neither data nor resources are available to create and calibrate detailed lake response models for mercury cycling in Puddingstone Reservoir. The TMDL target is based on achieving acceptable concentrations in fish. In midwestern and eastern lakes, methylation in lake sediments is often the predominant source of methylmercury in the water column. However, in western lakes with high sedimentation rates, rapid burial tends to depress the relative importance of regeneration of methylmercury from lake sediments. In lakes with high sedimentation rates, fish tissue concentrations are therefore likely to respond approximately linearly to reductions in the watershed methylmercury and total mercury load. Two studies have summarized sedimentation rates for Puddingstone Reservoir. According to the Reservoir Sedimentation Database (accessed 6/5/2009), the average annual historical sedimentation rate measured from 1915 to 1941 for Puddingstone Reservoir was 16 ac-ft per year (approximately 0.76 inches per year). The Department of Boating and Waterways and State Coastal Conservancy (2002) reports that the average annual sedimentation rate measured in Puddingstone Reservoir from 1925 to 1980 was 31 ac-ft per year (approximately 1.5 inches per year).

Nationally, authors such as Brumbaugh et al. (2001) have shown a log-log linear relationship between methylmercury in water and methylmercury in fish tissue normalized to length. However, this relationship is well-approximated by a linear relationship for the ranges of fish tissue concentration of concern for these impaired lakes. Until such time as a lake response model for mercury is constructed, and sufficient calibration data are collected, an assumption of an approximately linear response of fish tissue concentrations to changes in external loads is sufficient for the development of a TMDL. For a more detailed discussion of the linkage analysis between mercury loading and fish body burden, see Section 3.2.3 of this TMDL report.

10.3.6 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 load consistent with meeting the numeric target of 0.22 ppm for mercury in largemouth bass. The methodology for determining the loading capacity is described briefly in this section. For more detail, refer to Appendix C (Mercury TMDL Development).

Calculating the loading capacity first requires an estimate of the existing mercury concentration in largemouth bass. To do this, a linear regression analysis was performed on tissue concentrations versus length for Puddingstone Reservoir. The resulting regression equation is

$$Hg(fish) = -0.04001 + 0.001149 \cdot Len, \quad R^2 = 0.32$$

where *Hg(fish)* is the total mercury concentration in largemouth bass (ppm) and *Len* is length in mm. The regression analysis is shown in Figure 10-13, along with the one-sided 95 percent upper confidence limits on mean predictions about the regression line (95 percent UCL) and the 95 percent upper prediction intervals on individual predicted concentrations (95 percent UPI). The UPI gives the confidence limit on the individual predictions for a given length while the UCL gives the confidence limit on the average of the predictions for a given length. This regression has a non-zero intercept and should not be considered valid for lengths less than 150 mm.

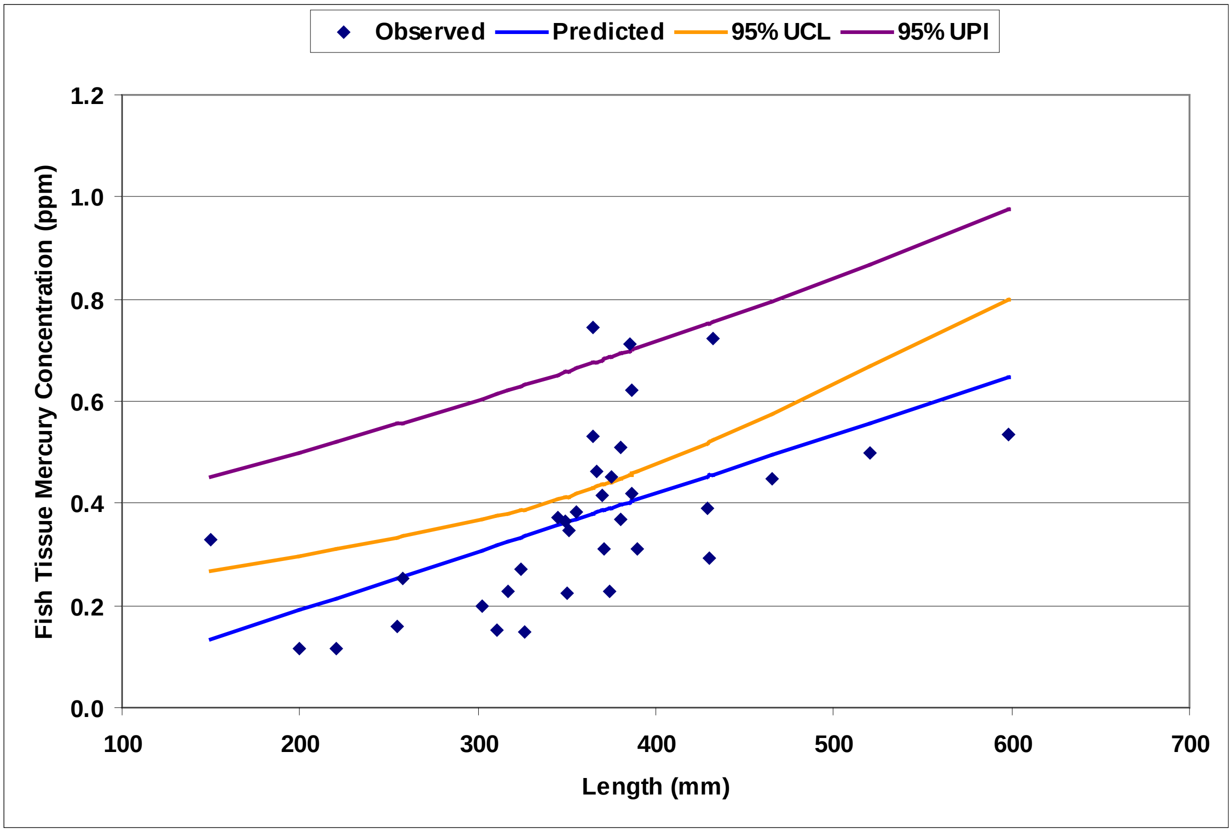

Figure 10-13. **Regression Analysis of Mercury in Puddingstone Reservoir Largemouth Bass**

For mercury, long-term cumulative exposure is the primary concern. Therefore, it is appropriate to use the 95 percent UCL rather than the UPI to provide a Margin of Safety on the appropriate age class. Use of the UCL provides an explicit Margin of Safety because it represents an upper confidence bound on the long-term exposure concentration.

Both the observed data and the predicted concentrations show that mercury concentrations in largemouth bass typically exceed the target of 0.22 ppm in Puddingstone Reservoir. The TMDL target is established for a 350 mm largemouth bass (see Section 2.2.8). The predicted mercury concentration based on the UCL equation for this length is compared to the target concentration to determine the required reduction in mercury loading, which includes an explicit Margin of Safety as described above.

For Puddingstone Reservoir, the fraction of the existing load consistent with attaining the target (the loading capacity) is the ratio of the target (0.22 ppm) to the best estimate of current average concentrations in the target fish population. The difference between the direct regression estimate and the 95 percent UCL provides the Margin of Safety. Therefore, the allocatable fraction of the existing load (the loading capacity less the Margin of Safety) is the ratio of the target to the 95 percent UCL. The resulting loading capacities and allocatable loads are expressed as fractions of the existing load as summarized in Table 10-12. This analysis indicates that a 46.6 percent reduction in mercury loading will be required to bring fish tissue concentrations in 350 mm largemouth bass (see Section 2.2.8) down to 0.22 ppm.

Table 10-12. Estimated Total Mercury Loading Capacity and Allocatable Load (as Fractions of the Existing Load)

Parameter	Value
Target Concentration (ppm)	0.22
Target Length (mm)	350
Predicted Mercury Concentration at Target Length (ppm)	0.362
95^{th} Percent UCL (ppm)	0.412
Loading Capacity (ratio of target to predicted value)	0.608
Allocatable Load (ratio of target to 95^{th} Percent UCL)	0.534
Required Reduction in Existing Load (1 minus allocatable fraction)	0.466
Margin of Safety Fraction (loading capacity fraction minus allocatable fraction)	0.074

The loading capacity can also be expressed as grams per year (g/yr) using the existing load presented in Table 10-11 and the calculated fractions of the existing load (Table 10-12). Specifically, the loading capacity is 60.8 percent of the existing load of 71.2 g/yr, or 43.3 g/yr. This value can be further broken down into the wasteload allocations (WLAs), load allocations (LAs), and margin of safety (MOS) using the equation below.

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

$$43.3g / yr = \sum 16.6g / yr + 21.4g / yr + 5.3g / yr$$

The allocatable load (divided among WLAs and LAs) is 53.4 percent of the existing load of 71.2 g/yr, or 38.0 g/yr. This value represents 88 percent of the loading capacity, while the MOS is 12 percent of the loading capacity. 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.

10.3.6.1 Wasteload Allocations

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). In the Puddingstone Reservoir watershed, WLAs are required for all permittees in the northern subwatershed and Caltrans areas in the southern subwatershed. This TMDL establishes wasteload allocations (WLAs) at their point of discharge. Relevant permit numbers are

- County of Los Angeles (including the cities of Claremont, La Verne, Pomona, and San Dimas): Board Order 01-182 (as amended by Order No. R4-2006-0074 and R4-2007-0042), CAS004001
- Caltrans: Order No 99-06-DWQ, CAS000003
- General Construction Stormwater: Order No. 2009-0009-DWQ, CAS000002
- General Industrial Stormwater: Order No. 97-03-DWQ, CAS000001

Table 10-13 summarizes the existing total mercury loads and WLAs for these sources. The WLAs are a 46.6 percent reduction from the existing loads. These loading values (in grams per year) represent the

TMDL wasteload allocations (Table 10-13). In addition to the WLAs presented below for total mercury, an in-lake water column dissolved methylmercury target of 0.081 ng/L applies.

All responsible jurisdictions must meet the WLAs as a mass load except for storm water permittees under general industrial and construction stormwater permits that are receiving concentration-based WLAs. Each mass based or concentration based wasteload allocation must be met at the point of discharge. In Table 10-13 below, stormwater permittees under general industrial and construction stormwater permits must meet the concentration values to achieve compliance with the WLAs. The WLA concentrations are a 46.6 percent reduction of the existing concentrations associated with these sources, which are calculated by dividing the existing load (in g/yr; see Table 10-13) by the estimated flow rates (258 ac-ft/yr and 47 ac-ft/yr for industrial and construction sites, respectively) and applying the appropriate conversion factors to yield concentrations in ng/L.

Table 10-13. Wasteload Allocations of Total Mercury to the Puddingstone Reservoir

Subwatershed	Responsible Jurisdiction	Input	Area (ac)	Existing Annual Hg Load (g/yr)	Wasteload Allocation[4] (g/yr)
Northern	Caltrans	State Highway Stormwater[1]	110	1.32	0.702
Northern	Claremont	MS4 Stormwater[1]	578	1.26	0.674
Northern	Count of Los Angeles	MS4 Stormwater[1]	1,865	5.24	2.79
Northern	La Verne[2]	MS4 Stormwater[1]	3,846	19.9	10.6
Northern	General Industrial Stormwater Permittees (in the city of La Verne)	General Industrial Stormwater[1]	197	2.41	1.29 (4.0 ng/L Hg)[3]
Northern	General Construction Stormwater Permittees (in the city of La Verne)	General Construction Stormwater[1]	36.0	0.44	0.235 (4.0 ng/L Hg)[3]
Northern	Pomona	MS4 Stormwater[1]	5.28	0.0488	0.026
Northern	San Dimas	MS4 Stormwater[1]	28.5	0.204	0.109
Northern	Angeles National Forest	Stormwater[1]	293	0.234	0.125
Southern	Caltrans	State Highway Stormwater[1]	11.6	0.0960	0.051
Total				**31.1**	**16.6**

[1] This input includes effluent from storm drain systems during both wet and dry weather.

[2] The total area for the City of La Verne in the northern subwatershed is 4,079 acres. Discharges governed by the general construction and general industrial stormwater permits are currently located in the City of La Verne. The disturbed area associated with general construction and general industrial stormwater permittees (233 acres) was subtracted out of the appropriate city area and allocated to these permits. Any future discharges governed by the general construction and general industrial stormwater permits will receive the same concentration-based wasteload allocations (see footnote #3).

[3] For these responsible jurisdictions, the concentration-based WLA will be used to evaluate compliance.

[4] Each mass-based and concentration-based wasteload allocations must be met at the point of discharge.

10.3.6.2 Load Allocations

Load allocations (LAs) are assigned to the non-Caltrans permittees in the southern subwatershed as well as park irrigation and atmospheric deposition. Table 10-14 summarizes the existing total mercury loads and LAs for these sources. The LAs are a 46.6 percent reduction from the existing loads. These loading values (in grams per year) represent the TMDL load allocations (Table 10-14) and each load allocation must be met at the point of discharge. In addition to the LAs presented below for total mercury, an in-lake water column dissolved methylmercury target of 0.081 ng/L applies.

Table 10-14. Load Allocations of Total Mercury to the Puddingstone Reservoir

Subwatershed	Responsible Jurisdiction	Input	Existing Annual Hg Load (g/yr)	Load Allocation[1] (g/yr)
Southern	La Verne	Runoff	0.097	0.0517
Southern	Pomona	Runoff	0.166	0.0887
Southern	San Dimas	Runoff	1.57	0.836
Southern	County of Los Angeles	Parkland Irrigation	4.55	2.43
Lake Surface		Atmospheric Deposition[2]	33.7	18.0
Total			**40.1**	**21.4**

[1] Each mass-based load allocations must be met at the point of discharge.
[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).

10.3.6.3 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 TMDL includes both an implicit and explicit MOS for Puddingstone Reservoir. The implicit MOS includes comparing the total mercury concentration reported for fish tissue samples to the methylmercury fish tissue target. Most mercury in fish tissue is in the methyl form, but not all, so this is a conservative assumption.

In this TMDL, an explicit MOS is also included by selecting the 95 percent UCL to represent the existing mean fish tissue concentration rather than the regression predicted mean (Figure 10-13). Use of the UCL provides a margin of safety because it represents an upper confidence bound on the long-term exposure concentration. For Puddingstone Reservoir, the fraction of the existing load set aside for the explicit MOS is 0.074, or 5.3 g/yr, which represents 12 percent of the loading capacity.

10.3.6.4 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. This TMDL protects beneficial uses by reducing fish tissue concentrations to the FCG target in the northern lake system and maintaining existing water quality in the southern lake system. Because fish bioaccumulate mercury, concentrations in tissues of edible sized game fish integrate exposure over a number of years. As a result, annual mercury loading is more important for the attainment of standards than instantaneous or daily concentrations, and the TMDL is proposed in terms of annual loads. Mercury load is primarily delivered to the reservoir during storm runoff events, so high flows do represent a critical in terms of peak loading rates.

However, the greatest impact to fish occurs when methylmercury, a more biologically available form of mercury, is at its greatest concentration. Bacterially mediated methylation of mercury varies seasonally and typically results in the greatest methylmercury concentrations in the water column in the late summer. However, the impact of seasonal and other short-term variability in loading is damped out by the biotic response since the target concentrations in tissues of edible sized game fish integrate exposure over a number of years. Additionally, this TMDL includes a methylmercury water column target applicable year round. This TMDL therefore protects for critical conditions.

10.3.6.5 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. Although it is long-term cumulative load rather than daily loads of mercury that are driving the bioaccumulation of mercury in fish in Puddingstone Reservoir, this TMDL does present a maximum daily load according to the guidelines provided by USEPA (2007). The daily maximum allowable load of mercury to Puddingstone Reservoir is calculated from the maximum daily storm flow rate (estimated from the 99^{th} percentile flow) to the reservoir multiplied by the allowable concentration for mercury consistent with achieving the long-term loading target. These maximum loads are not allowed each day of the year because the annual loads specified by the TMDL must also be achieved. The WLA and LA loads presented above are annual loading caps that cannot be exceeded.

No USGS gage currently exists in the Puddingstone Reservoir watershed. USGS Station 11086400, San Dimas Creek near San Dimas, CA, was selected as a surrogate for flow determination. The 99^{th} percentile flow was chosen to represent the peak flow for this drainage. Choosing the 99^{th} percentile flow eliminates errors due to outliers and is reasonable for development of a daily load expression.

The USGS StreamStats program was used to determine the 99^{th} percentile flow for this San Dimas Creek gage (55 cfs) (Wolock, 2003). To estimate the peak flow to Puddingstone Reservoir, the 99^{th} percentile flow for San Dimas Creek was scaled down by the ratio of drainage areas (8,128 acres/11,712 acres; Puddingstone Reservoir watershed area/San Dimas Creek watershed area at the gage). The resulting peak flow estimate for Puddingstone Reservoir is 38.2 cfs.

The event mean concentration for mercury was calculated from the allowable load (38.0 g-Hg/yr; sum of the WLAs and LAs presented in Table 10-13 and Table 10-14, respectively) and the average annual simulated stream flow generated by the LSPC model (2,692 ac-ft). The resulting concentration (11.4 ng/L) times the peak flow to Puddingstone Reservoir (38.2 cfs) yields a total maximum daily load of 1.06 g-Hg/d. For comparison, the existing load (71.2 g-Hg/yr) would yield an event mean concentration of 21.4 ng/L and a total maximum daily load of 2.0 g-Hg/d. As described above, in order to achieve fish tissue targets as well as annual load-based allocations, the maximum allowable daily loads cannot be discharged to the lake every day. The WLA and LA loads presented above are annual loading caps that cannot be exceeded.

10.3.6.6 Future Growth

Much of the Puddingstone Reservoir watershed remains in shrub and brush rangeland. As development occurs in this watershed, best management practices (BMPs) will be required such that loading rates are consistent with the allocations established by this TMDL. Therefore, no load allocation has been set aside for future growth.

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).

10.4 PCBs Impairment

Polychlorinated biphenyls (PCBs) consist of a family of many related congeners. The individual congeners are often referred to by their "BZ" number. Environmental analyses may address individual congeners, homologs (groups of congeners with the same number of chlorine atoms), equivalent concentrations of the commercial mixtures of PCBs known by the trade name Aroclors, or total PCBs. The environmental measurements and targets described in this section are in terms of total PCBs, defined as the "sum of all congener or isomer or homolog or Aroclor analyses" (CTR, 40 CFR 131.38(b)(1) footnote v).

The PCB impairment of Puddingstone Reservoir affects beneficial uses related to recreation, municipal water supply, wildlife health, and fish consumption. PCBs are no longer in production. While some loading of PCBs continues to occur in watershed runoff, the primary source of PCBs in the water column and aquatic life in Puddingstone Reservoir is from historic loads stored in the lake sediments. Like other organochlorine compounds, PCBs accumulate in aquatic organisms and biomagnify in the food chain. As a result, low environmental exposure concentrations can result in unacceptable levels in higher trophic level fish in the lake.

10.4.1 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 Puddingstone Reservoir include REC1, REC2, WARM, WILD, MUN, GWR, COLD, RARE, and AGR. Descriptions of these uses are listed in Section 2 of this TMDL report. Elevated levels of PCBs are currently impairing the REC1, REC2, WARM, and COLD uses by causing toxicity to aquatic organisms and raising fish tissue concentrations to levels that are unsafe for human consumption (which can result in fish consumption advisories) and impair sport fishing recreational uses. At high enough concentrations WILD, MUN, GWR and RARE uses could become impaired.

10.4.2 Numeric Targets

The Basin Plan designates water column concentrations associated with MUN and WARM beneficial uses. There are no numeric criteria specified for sediment or fish tissue concentrations of PCBs listed in the Basin Plan. For the purposes of this TMDL, additional numeric targets for these endpoints are based on the consensus-based sediment quality guidelines defined in MacDonald et al. (2000) and the fish tissue concentration goal, referred to as the fish contaminant goal (FCG), defined by OEHHA (2008) for fish consumption. The numeric targets used for PCBs are listed below. The fish tissue concentration goal was also used to back calculate site-specific targets in sediment, with the most stringent target applying. See Section 2 of this TMDL report for additional details.

The water column criteria for PCBs in the Basin Plan are associated with a specific beneficial use. For waters designated MUN, the Basin Plan lists a maximum contaminant level of 0.0005 mg/L, or 0.5 µg/L, total PCBs in water. The Plan also contains a narrative criterion that toxic chemicals not be present at levels that are toxic or detrimental to aquatic life (LARWQCB, 1994). Each waterbody addressed in this report is designated WARM, at a minimum, and must meet this requirement. A chronic criterion for the sum of PCB compounds in freshwater systems to protect aquatic life is included in the CTR as 0.014 µg/L (USEPA, 2000a). The CTR also provides a human health-based water quality criterion for the consumption of both water and organisms and organisms only of 0.00017 µg/L (0.17 ng/L). The human health criterion of 0.17 ng/L is the most restrictive applicable criteria specified for water column concentrations and is selected as the water column target.

For sediment, the consensus-based sediment quality guidelines provided in MacDonald et al. (2000) for the threshold effects concentration (TEC) for total PCBs in sediment is 59.8 µg/kg dry weight dry weight. The consensus-based guidelines have been incorporated into the most recent set of NOAA Screening Quick Reference Tables (SQuiRT) (Buchman, 2008) and are recommended by the State Water Resources Control Board for interpretation of narrative sediment objectives under the 303(d) listing policy. This target is designed to protect benthic dwelling organisms and explicitly does not consider "the potential for bioaccumulation in aquatic organisms nor the associated hazards to the species that consume aquatic organisms (i.e., wildlife and humans)." The existing sediment PCB concentrations in Puddingstone Reservoir are lower than the consensus-based TEC target, and existing fish tissue concentrations are higher than the fish tissue target. Thus, a separate sediment target calculation based on a biota-sediment accumulation factor (BSAF) is carried out to ensure that fish tissue concentration goals are met.

The fish contaminant goal for PCBs defined by OEHHA (2008) is 3.6 ppb wet weight in muscle tissue (filets). Elevated fish tissue concentrations are largely attributable to foodweb bioaccumulation derived from contaminated sediment. A biota-sediment accumulation factor (BSAF) approach is appropriate to correlate sediment and fish tissue targets. For total PCBs, the corresponding sediment concentration target determined using the BSAF is 0.59 µg/kg dry weight, as described in detail in Section 10.4.5. All applicable targets are shown below in Table 10-15. For sediment, the lower value of the consensus-based TEC target or the BSAF-derived target is selected as the final sediment target.

Table 10-15. PCB Targets Applicable to Puddingstone Reservoir

Medium	Source	Target
Fish (ppb wet weight)	OEHHA FCG	3.6
Sediment (µg/kg dry weight)	Consensus-based TEC	59.8
Sediment (µg/kg dry weight)	BSAF-derived target	0.59
Water (ng/L)	CTR	0.17

Note: Shaded cells represent the selected targets for this TMDL.

10.4.3 Summary of Monitoring Data

This section summarizes the monitoring data for Puddingstone Reservoir related to the PCB impairment. Additional details regarding monitoring data are discussed in Appendix G (Monitoring Data).

For PCBs, as well as other organochlorine compounds, sample analyses include both a detection limit and a reporting limit. For example, a typical detection limit for total PCBs in sediment analyzed by UCLA is 0.5 µg/kg dry weight, while the reporting limit is 5 µg/kg dry weight.

Water column sampling was conducted as part of an organics study performed by UCLA (funded by a grant managed by the Regional Board) in the fall of 2008. Of four samples (two in Live Oak Wash and two in-lake stations), PCBs were below detection limits (1.5 ng/L to 1.52 ng/L) in two samples; in one of the Live Oak Wash samples PCB congeners were detected, but below reporting limits of 15.23 ng/L. One in-lake station had a reportable measurement (17.95 ng/L) of the PCB congener BZ-5.

Water samples from Puddingstone Reservoir were also collected by USEPA and/or the Regional Board on November 18, 2008 at five stations (four in-lake stations and one station in Live Oak Wash), February 24, 2009 at one storm drain station, and July 16, 2009 at four stations (Live Oak Wash, a storm drain, and two in-lake locations). PCBs at all stations were generally below the detection limit of 1 ng/L with three exceptions, including an in-lake concentration of 555 ng/L in November 2008, which is above the CTR water column target of 0.17 ng/L. A summary of the water column data is shown in Table 10-16.

Table 10-16. Summary of Water Column Samples for PCBs in Puddingstone Reservoir

Station	Average Water Concentration (ng/L)	Number of Samples	Number of Samples above Detection Limit	Number of Samples between Detection and Reporting Limits
PR-11 (Live Oak Channel)	[2.78][1]	4	1	1
PR-14 (Northeast Reservoir Side)	(0.63)	2	0	0
PR-15 (Western Reservoir Side)	191	3	2	0
PR-16 (Southern Reservoir Side)	(0.5)[2]	2	0	0
PR-17 (Western Reservoir Side near Shoreline)	(0.5)	1	0	0
PR-SD (Storm drain in northeast reservoir area)	(0.5)	1	0	0
PR-SD2 (Storm drain in northeast reservoir area)	(0.5)	1	0	0
In-Lake Average[2] (PR-14, 15, 16, 17)	48.20			
CTR Water Column Target	0.17			

[1] Total PCBs in a sample represents the sum of all quantified PCB congeners, including results reported below the method reporting limit. If all congeners were non-detect, the total is represented as one-half the detection limit. Results of any laboratory duplicate analyses of the same sample were averaged. Results for each station represent the average of individual samples. Results in parentheses indicate that the sample average is based only on the detection limits of the samples and that no PCBs were quantified in any of the collected samples. Sample averages based only on detected results below the reporting limit plus non-detects are shown in square brackets.

[2] Overall average is the average of individual station averages.

Pollutant concentrations associated with suspended sediments in the lake were analyzed at two in-lake stations as well as Live Oak Wash during the fall of 2008 by UCLA. During the dry weather sampling event, PCBs were detected but below reporting limits (2.11 µg/kg to 36.23 µg/kg dry weight) at each location.

A wet weather composite sample at Live Oak Wash, did not detect any total PCB concentrations (detection limit of 1.57 µg/kg dry weight); an additional grab sample at the outlet of Live Oak Wash was collected 90 minutes into the wet weather and had no detectable concentration of total PCBs (detection limit of 2.70 µg/kg dry weight). Water column samples were also collected during this event (a time series composite and a single time point sample), but not analyzed.

PCBs were analyzed for three porewater samples collected at two in-lake stations. Each sample detected PCB-31; however, concentrations were less than the reporting limit (150 ng/L). Total suspended solids from the porewater samples were also analyzed for PCBs. Two samples were less than the detection limit (0.20 µg/kg to 0.53 µg/kg dry weight) for all PCB congeners. One sample detected PCB-31 at levels less than the reporting limit (3.01 µg/kg dry weight).

UCLA also collected bed sediment samples at two in-lake locations (total of three individual samples) in Puddingstone Reservoir in fall 2008. PCB congeners were detected in one sediment sample (average 10.8 µg/kg dry weight at PR-14), while the other samples were below detection limits (0.39 µg/kg to 1.58 µg/kg dry weight).

Sediment sampling was also conducted by USEPA and the Regional Board at six stations on July 16, 2009 (Live Oak Wash, two in-lake stations, two storm drain stations, and one natural drainage). PCBs were quantified at five of the six stations (one of the stormdrain samples had a concentration of 194.7 µg/kg dry weight and exceeded the sediment consensus-based TEC of 59.8 µg/kg dry weight). A summary of the sediment data is shown in Table 10-17. The lake-wide average of 4.99 µg/kg dry weight is below the concentration associated with inputs (50.3 µg/kg dry weight), and both are less than the consensus-based TEC of 59.8 µg/kg dry weight.

Table 10-17. Summary of Sediment Samples for PCBs in Puddingstone Reservoir

Station	Average Sediment Concentration (µg/kg dry weight)[1]	Number of Samples	Number of Samples above Detection Limit	Number of Samples between Detection and Reporting Limits
PR-11 (Live Oak Channel)	5.1	1	1	0
PR-14 (Northeast Reservoir Side)	5.4	2	1	0
PR-15 (Western Reservoir Side)	[3.67][1]	2	1	1
PR-16 (Southern Reservoir Side)	[5.75]	2	2	2
PR-19 (Natural drainage on South Side)	(0.50)	1	0	0
PR-19SD (Storm drain on South Side)	194.7	1	1	0
PR-SD2 (Storm drain in northeast reservoir area)	[1.00]	1	1	1
In-Lake Average[2] (PR-14, 15, 16)	4.99			
Influent Average	50.3			
Consensus-based TEC	59.8			

[1] Total PCBs in a sample represents the sum of all quantified PCB congeners, including results reported below the method reporting limit. If all congeners were non-detect, the total is represented as one-half the detection limit. Results of any laboratory duplicate analyses of the same sample were averaged. Results for each station represent the average of individual samples. Results in parentheses indicate that the sample average is based only on the detection limits of the samples and that no PCBs were quantified in any of the collected samples. Sample averages based only on detected results below the reporting limit plus non-detects are shown in square brackets.

[2] Overall average is the average of individual station averages.

Eight fish samples (composites of filets from five fish) were collected and analyzed for PCBs as Aroclor equivalents between 1986 and 1999. In 1986, a largemouth bass and common carp sample reported 0 ppb (the detection limits for the historical fish samples are not reported) and 590 ppb wet weight, respectively, while in 1987 another common carp sample had a concentration of 160 ppb wet weight and a bullhead sample reported a zero concentration. In 1988, the reported concentration associated with a brown bullhead sample was 66 ppb wet weight. Three largemouth bass samples had concentrations of 54 ppb, 65 ppb, and 13 ppb wet weight in 1991, 1992, and 1999, respectively. The average reported PCB concentration in all samples from the 1980s and 1990s was 118.5 ppb, including the reported zeros. Results from the individual samples are shown in Appendix G (Monitoring Data).

More recently, SWAMP collected samples in September 2004 and June 2007. Considering only data collected in the past 10 years, the average concentration of total PCBs in largemouth bass was 20.6 ppb wet weight (average lipid fraction of 0.98 percent) and the average concentration of total PCBs in common carp was 30.2 ppb wet weight (average lipid fraction of 3.6 percent). The recent fish-tissue data for Puddingstone Reservoir are summarized in Table 10-18.

Table 10-18. Summary of Recent Fish Tissue Samples for PCBs in Puddingstone Reservoir

Sample Date	Fish Species	Total PCBs (ppb wet weight)[1]
9/22/2004	Largemouth Bass	29.1
9/22/2004	Largemouth Bass	16.0
9/22/2004	Largemouth Bass	35.9
9/22/2004	Largemouth Bass	17.9
9/22/2004	Common Carp	6.5
9/22/2004	Common Carp	49.3
9/22/2004	Common Carp	36.8
9/22/2004	Common Carp	28.3
6/6/2007	Largemouth Bass	18.7
6/6/2007	Largemouth Bass	5.9
2004-2007 Average - Largemouth Bass		20.6
2004 Average - Common Carp		30.2
FCG		3.6

[1] Composite sample of filets from either five (largemouth bass) or three individuals (carp).

In sum, recent fish tissue samples collected from Puddingstone are all elevated above OEHHA fish consumption guidelines for total PCBs. Concentrations in sediment are, on average, below the consensus-based TEC, although an individual sample exceeded this value. Concentrations in water were above detection limits in two samples (out of 14 individual samples); however, all of the detection limits exceeded the CTR criterion.

10.4.4 Source Assessment

PCBs in Puddingstone Reservoir are primarily due to historical loading and storage within the lake sediments, with some ongoing contribution by watershed wet weather loads. Dry weather loading is assumed to be negligible because hydrophobic contaminants primarily move with particulate matter that is mobilized by higher flows. Stormwater loads from the watershed were estimated based on simulated sediment load and observed PCB concentrations on sediment near inflows to the lake.

Watershed loads of PCBs may arise from spills from industrial and commercial uses, improper disposal, and atmospheric deposition. Industrial and commercial spills will tend to be associated with specific land areas, such as older industrial districts, junk yards, and transformer substations. Improper disposal could have occurred at various locations (indeed, waste PCB oils were sometimes used for dust control on dirt roads in the 1950s). Atmospheric deposition occurs across the entire watershed.

There is no definitive information on specific sources of elevated PCB load within the watershed at this time. Therefore, an average concentration on sediment is applied to all contributing areas, while sources of water that do not contribute sediment load, such as irrigation, are considered to provide no significant PCB loading. The average concentration of PCBs on incoming sediment was estimated to be 50.3 µg/kg dry weight (Table 10-17) and the estimated annual sediment load to Puddingstone Reservoir is 265.5 tons/yr (see Appendix D, Wet Weather Loading). The resulting estimated wet weather load is approximately 12.1 g/yr. Table 10-19 shows the annual PCB load estimated from each jurisdiction.

Table 10-19. Total PCB Loads Estimated for Each Jurisdiction and Subwatershed in the Puddingstone Reservoir Watershed (g/yr)

Subwatershed	Responsible Jurisdiction	Input	Sediment Load (tons/yr)	Total PCB Load (g/yr)	Percent of Total Load
Northern	Caltrans	State Highway Stormwater[1]	13.5	0.62	5.10%
Northern	Claremont	MS4 Stormwater[1]	4.5	0.20	1.69%
Northern	County of Los Angeles	MS4 Stormwater[1]	27.7	1.30	10.44%
Northern	La Verne[2]	MS4 Stormwater[1]	168	7.68	63.23%
Northern	General Industrial Stormwater Permittees (in the city of La Verne)	General Industrial Stormwater[1]	24.8	1.13	9.34%
Northern	General Construction Stormwater Permittees (in the city of La Verne)	General Construction Stormwater[1]	4.5	0.21	1.69%
Northern	Pomona	MS4 Stormwater[1]	0.5	0.02	0.18%
Northern	San Dimas	MS4 Stormwater[1]	1.6	0.07	0.62%
Northern	Angeles National Forest	Stormwater[1]	1.4	0.06	0.51%
Southern	Caltrans	State Highway Stormwater[1]	1.4	0.06	0.54%
Southern	La Verne	Runoff	1.2	0.06	0.47%
Southern	Pomona	Runoff	1.7	0.08	0.63%

Subwatershed	Responsible Jurisdiction	Input	Sediment Load (tons/yr)	Total PCB Load (g/yr)	Percent of Total Load
Southern	San Dimas	Runoff	14.8	0.68	5.59%
Southern	County of Los Angeles	Parkland Irrigation	0.0	0.00	0.00%
Total Load from Watershed			**265.5**	**12.12**	**100.00%**

[1]This input includes effluent from storm drain systems during both wet and dry weather.

[2]The total area for the City of La Verne in the northern subwatershed is 4,079 acres. Discharges governed by the general construction and general industrial stormwater permits are currently located in the City of La Verne. The disturbed area associated with general construction and general industrial stormwater permittees (233 acres) was subtracted out of the appropriate city area and allocated to these permits.

As described in Appendix E (Atmospheric Deposition), Section E.5, the net atmospheric deposition of PCBs directly to the lake surface is estimated to be close to zero, with deposited loads balanced by volatilization losses. Atmospheric deposition onto the watershed is implicitly included in the estimates of watershed load.

10.4.5 Linkage Analysis

The linkage analysis provides the quantitative basis for determining the loading capacity of PCBs into Puddingstone Reservoir consistent with achieving water quality standards. The loading capacity is used to calculate the TMDL and corresponding allocations of that load to permitted point sources (wasteload allocations) and nonpoint sources (load allocations).

Lake sediments are often the predominant source of PCBs in biota. The bottom sediment serves as a sink for organochlorine compounds that can be recycled through the aquatic life cycle. PCBs are strongly sorbed to sediments and have long half-lives in sediment and water. Incoming loads of PCBs will mainly be adsorbed to particulates from stormwater runoff (eroded sediments from legacy contamination sites or from atmospheric deposition).

The use of bioaccumulation models and the fish tissue data from Puddingstone Reservoir are discussed in detail in Appendix H (Organochlorine Compounds TMDL Development) and Appendix G (Monitoring Data), respectively. The existing sediment PCB concentrations in Puddingstone Reservoir are lower than the consensus-based TEC target, and existing fish tissue concentrations are higher than the fish tissue target. Therefore, a sediment target based on biota-sediment bioaccumulation (a BSAF approach) is calculated from the smaller of the ratio of the FCG to existing fish tissue concentrations obtained from trophic level 4 fish (TL4; e.g., largemouth bass) and bottom-feeding, trophic level 3 fish (TL3; e.g., common carp). In general, the TL3 number is expected to be more restrictive due to the additional uptake of organochlorine compounds from the sediment by bottom-feeding fish. For PCBs in Puddingstone Reservoir the ratios of the FCG to the existing fish concentrations (Table 10-18) are:

$$TL4: 3.6/20.6 = 0.1750$$

$$TL3: 3.6/30.2 = 0.1191$$

The lower ratio, obtained for the TL3 fish, is applied to the observed in-lake sediment concentration of 4.99 µg/kg dry weight to obtain the site-specific sediment target concentration to achieve fish tissue goals of 0.59 µg/kg dry weight. The fish tissue-based target concentrations were calculated using only recent data (collected in the past 10 years) because the loads and exposure concentrations of PCBs are likely to have declined steadily since the cessation of production and use of the chemical. The resulting fish tissue-based target concentrations of PCBs in the sediment of Puddingstone Reservoir is shown in Table 10-20.

Table 10-20. Fish Tissue-Based PCB Concentration Targets for Sediment in Puddingstone Reservoir

Total PCB Concentration	Sediment (µg/kg dry weight)
Existing	4.99
BSAF-derived Target	0.59
Required Reduction	88.2%

The BSAF-derived sediment target is less than the consensus-based sediment quality guideline TEC of 59.8 µg/kg dry weight. (The consensus-based sediment quality guideline is for the protection of benthic organisms, and explicitly does not address bioaccumulation and human-health risks from the consumption of contaminated fish.) The lower value of the consensus-based TEC target or the BSAF-derived target is selected as the final sediment target. In addition, the CTR criterion for human health (0.17 ng/L) is the selected numeric target for the water column and protects both aquatic life and human health.

The toxicant loading model described in Appendix H (Organochlorine Compounds TMDL Development) can be used to estimate the loading rate that would be required to yield the existing sediment concentration under steady-state conditions. This yields an estimate that a load of 2,245 g/yr would be required to maintain observed sediment concentrations under steady-state conditions. The estimated current watershed loading rate is 12.12 g/yr, or 0.5 percent of this amount. Therefore, impairment due to elevated fish tissue concentrations of PCBs in Puddingstone Reservoir is primarily due to the storage of historic loads of PCBs in the lake sediment.

10.4.6 TMDL Summary

Because PCB impairment in Puddingstone Reservoir is predominantly due to historic loads stored in the lake sediment, this impairment is not amenable to a standard, load-based TMDL analysis. Instead, allocations are first assigned on a concentration basis, with the goal of attaining the concentrations identified above for water and sediment, as well as fish tissue. The concentration targets apply to water and sediment entering the lake and within the lake. The PCB TMDL will be allocated to ensure achievement of the loading capacity. TMDLs are broken down into the wasteload allocations (WLAs), load allocations (LAs), and Margins of Safety (MOS) using the general TMDL equation.

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

Note that since this TMDL is being expressed as a concentration in sediment, in this scenario, the loading capacity is equal to 0.59 µg/kg dry weight total PCBs. The wasteload allocations and load allocations are also equal to 0.59 µg/kg dry weight total PCBs in sediment. There is no explicit MOS. Allocations are assigned for this TMDL by requiring equal concentrations of all sources. Details associated with the WLAs, LAs, and MOS are presented in the following three sections.

10.4.6.1 Wasteload Allocations

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). This TMDL establishes WLAs at their point of discharge. This TMDL also establishes alternative wasteload allocations for total PCBs ("Alternative WLAs if the Fish Tissue Target is Met") described in Section 10.4.6.1.2. The alternative wasteload allocations will supersede the wasteload allocations in Section 10.4.6.1.1 if the conditions described in Section 10.4.6.1.2 are met.

10.4.6.1.1 Wasteload Allocations

In the Puddingstone Reservoir watershed, wasteload allocations (WLAs) are required for all permittees in the northern subwatershed and Caltrans areas in the southern subwatershed. Relevant permit numbers are

- County of Los Angeles (including the cities of Claremont, La Verne, Pomona, and San Dimas): Board Order 01-182 (as amended by Order No. R4-2006-0074 and R4-2007-0042), CAS004001
- Caltrans: Order No 99-06-DWQ, CAS000003
- General Construction Stormwater: Order No. 2009-0009-DWQ, CAS000002
- General Industrial Stormwater: Order No. 97-03-DWQ, CAS000001

PCBs in water flowing into Puddingstone Reservoir are below detection limits, and most PCB load is expected to move in association with sediment. Therefore, suspended sediment in water flowing into the lake is assigned wasteload allocations. Additionally, the TMDL establishes wasteload allocations for PCBs in the water column equal to the CTR based water column target. The CTR based water column target includes both dissolved PCBs and PCBs associated with suspended sediment. The existing concentration on sediment entering the lake is 50.9 µg/kg dry weight. Therefore, a reduction of (50.3 – 0.59)/50.3 = 98.8 percent is required on the sediment-associated load from the watershed.

The wasteload allocations are shown in Table 10-21 and each wasteload allocation must be met at the point of discharge.

Table 10-21. Wasteload Allocations for Total PCBs in Puddingstone Reservoir

Subwatershed	Responsible Jurisdiction	Input	Wasteload Allocation for PCBs Associated with Suspended Sediment[3] (µg/kg dry weight)	Wasteload Allocation for PCBs in the Water Column[3] (ng/L)
Northern	Caltrans	State Highway Stormwater[1]	0.59	0.17
Northern	Claremont	MS4 Stormwater[1]	0.59	0.17
Northern	County of Los Angeles	MS4 Stormwater[1]	0.59	0.17
Northern	La Verne[2]	MS4 Stormwater[1]	0.59	0.17
Northern	General Industrial Stormwater Permittees (in the city of La Verne)	General Industrial Stormwater[1]	0.59	0.17
Northern	General Construction Stormwater Permittees (in the city of La Verne)	General Construction Stormwater[1]	0.59	0.17
Northern	Pomona	MS4 Stormwater[1]	0.59	0.17
Northern	San Dimas	MS4 Stormwater[1]	0.59	0.17
Northern	Angeles National Forest	Stormwater[1]	0.59	0.17

Subwatershed	Responsible Jurisdiction	Input	Wasteload Allocation for PCBs Associated with Suspended Sediment[3] (µg/kg dry weight)	Wasteload Allocation for PCBs in the Water Column[3] (ng/L)
Southern	Caltrans	State Highway Stormwater[1]	0.59	0.17

[1]This input includes effluent from storm drain systems during both wet and dry weather.

[2] Discharges governed by the general construction and general industrial stormwater permits are currently located in the City of La Verne. Any future discharges governed by the general construction and general industrial stormwater permits will receive the same concentration-based wasteload allocations.

[3] Each wasteload allocation must be met at the point of discharge.

10.4.6.1.2 Alternative Wasteload Allocations if the Fish Tissue Target is Met

The wasteload allocations listed in Table 10-21 will be superseded, and the wasteload allocations in Table 10-22 will apply, if:

1. The responsible jurisdictions submit to USEPA and the Regional Board material describing that the fish tissue target of 3.6 ppb wet weight has been met for the preceding three or more years. A demonstration that the fish tissue target has been met in any given year must at minimum include a composite sample of skin off fillets from at least five common carp each measuring at least 350mm in length,
2. The Regional Board Executive Officer approves the request and applies the alternative wasteload allocations in Table 10-22, and
3. USEPA does not object to the Regional Board's determination within 60 days of receiving notice of it.

Each wasteload allocation must be met at the point of discharge.

Table 10-22. Alternative Wasteload Allocations for Total PCBs in Puddingstone Reservoir if the Fish Tissue Target is Met

Subwatershed	Responsible Jurisdiction	Input	Wasteload Allocation for PCBs Associated with Suspended Sediment[3] (µg/kg dry weight)	Wasteload Allocation for PCBs in the Water Column[3] (ng/L)
Northern	Caltrans	State Highway Stormwater[1]	59.8	0.17
Northern	Claremont	MS4 Stormwater[1]	59.8	0.17
Northern	County of Los Angeles	MS4 Stormwater[1]	59.8	0.17
Northern	La Verne[2]	MS4 Stormwater[1]	59.8	0.17
Northern	General Industrial Stormwater Permittees (in the city of La Verne)	General Industrial Stormwater[1]	59.8	0.17
Northern	General Construction Stormwater Permittees (in the city of La Verne)	General Construction Stormwater[1]	59.8	0.17
Northern	Pomona	MS4 Stormwater[1]	59.8	0.17

Subwatershed	Responsible Jurisdiction	Input	Wasteload Allocation for PCBs Associated with Suspended Sediment[3] (µg/kg dry weight)	Wasteload Allocation for PCBs in the Water Column[3] (ng/L)
Northern	San Dimas	MS4 Stormwater[1]	59.8	0.17
Northern	Angeles National Forest	Stormwater[1]	59.8	0.17
Southern	Caltrans	State Highway Stormwater[1]	59.8	0.17

[1]This input includes effluent from storm drain systems during both wet and dry weather.

[2] Discharges governed by the general construction and general industrial stormwater permits are currently located in the City of La Verne. Any future discharges governed by the general construction and general industrial stormwater permits will receive the same concentration-based wasteload allocations.

[3] Each wasteload allocation must be met at the point of discharge.

10.4.6.2 Load Allocations

This TMDL establishes load allocations (LAs) at their point of discharge. This TMDL also establishes alternative load allocations for total PCBs ("Alternative LAs if the Fish Tissue Target is Met") described in Section 10.4.6.2.2. The alternative load allocations will supersede the load allocations in Section 10.4.6.2.1 if the conditions described in Section 10.4.6.2.2 are met.

10.4.6.2.1 Load Allocations

Load allocations (LAs) are assigned to the non-Caltrans permittees in the southern subwatershed, and lake bottom sediments. Additionally, the TMDL establishes load allocations for PCBs in the water column equal to the CTR based water column target. The CTR based water column target includes both dissolved PCBs and PCBs associated with suspended sediment. No load is allocated to atmospheric deposition of PCBs. The legacy PCB stored in lake sediment is the major cause of use impairment associated with elevated fish tissue concentrations, and is assigned a load allocation. The in-lake allocation is in concentration terms: specifically, the responsible jurisdiction (County of Los Angeles) should achieve a PCB concentration of 0.59 µg/kg dry weight in lake bottom sediments (Table 10-23). Each load allocation must be met at the point of discharge, except for the lake bottom sediment load allocation which must be met in the lake.

Table 10-23. Load Allocations for Total PCBs in Puddingstone Reservoir

Subwatershed	Responsible Jurisdiction	Input	Load Allocation for PCBs Associated with Suspended Sediment or Lake Bottom Sediments (µg/kg dry weight)
Southern	La Verne	Runoff[1]	0.59
Southern	Pomona	Runoff[1]	0.59
Southern	San Dimas	Runoff[1]	0.59
Southern	County of Los Angeles	Parkland Irrigation[1]	0.59
Lake Surface	County of Los Angeles	Lake bottom sediments[2]	0.59

[1] Each load allocation must be met at the point of discharge.

[2] The load allocation must be met in the lake.

10.4.6.2.2 Alternative Load Allocations if the Fish Tissue Target is Met

The load allocations listed in Table 10-23 will be superseded, and the load allocations in Table 10-24 will apply, if:

1. The responsible jurisdiction submits to USEPA and the Regional Board material describing that the fish tissue target of 3.6 ppb wet weight has been met for the preceding three or more years. A demonstration that the fish tissue target has been met in any given year must at minimum include a composite sample of skin off fillets from at least five largemouth bass each measuring at least 350mm in length,
2. The Regional Board Executive Officer approves the request and applies the alternative load allocations in Table 10-24, and
3. USEPA does not object to the Regional Board's determination within 60 days of receiving notice of it.

Each load allocation must be met at the point of discharge, except for the lake bottom sediment load allocation which must be met in the lake.

Table 10-24. Alternative Load Allocations for Total PCBs in Puddingstone Reservoir if the Fish Tissue Target is Met

Subwatershed	Responsible Jurisdiction	Input	Load Allocation (µg/kg dry weight)
Southern	La Verne	Runoff[1]	59.8
Southern	Pomona	Runoff[1]	59.8
Southern	San Dimas	Runoff[1]	59.8
Southern	County of Los Angeles	Parkland Irrigation[1]	59.8
Lake Surface	County of Los Angeles	Lake bottom sediments[2]	59.8

[1] Each load allocation must be met at the point of discharge.

[2] The load allocation must be met in the lake.

10.4.6.3 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 TMDL contains an implicit MOS based on conservative assumptions. The allocations are set based on the lower of either the BSAF-derived sediment target or the consensus-based TEC sediment target to ensure achievement of the OEHHA FCG target in fish tissue. The selected BSAF-derived target concentration in sediment is considerably lower than the consensus-based TEC target.

10.4.6.4 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. This TMDL protects beneficial uses by reducing fish tissue concentrations to the FCG target and protecting benthic biota in sediment. Because fish bioaccumulate PCBs, concentrations in tissues of edible sized game fish integrate exposure over a number of years. As a result, overall average loading is more important for the attainment of standards than instantaneous or daily concentrations. WLAs and LAs in this TMDL are assigned as concentrations and protect during all seasons and in both high and low flow conditions. This TMDL therefore protects for critical conditions.

10.4.6.5 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. This TMDL includes a maximum daily load estimated according to the guidelines provided by USEPA (2007).

Because the PCB WLAs are expressed as concentrations on sediment, the daily maximum allowable load is calculated from the maximum daily sediment load multiplied by the TMDL WLA concentration. The maximum daily sediment load is estimated from the 99th percentile daily flow and the sediment event mean concentration that yields the estimated annual sediment load.

No USGS gage currently exists in the Puddingstone Reservoir watershed. USGS Station 11086400, San Dimas Creek near San Dimas, CA, was selected as a surrogate for flow determination. The 99th percentile flow was chosen to represent the peak flow for this drainage. Choosing the 99th percentile flow eliminates errors due to outliers and is reasonable for development of a daily load expression.

The USGS StreamStats program was used to determine the 99th percentile flow for San Dimas Creek (55 cfs) (Wolock, 2003). To estimate the peak flow to Puddingstone Reservoir, the 99th percentile flow for San Dimas Creek was scaled down by the ratio of drainage areas (8,128 acres/11,712 acres; Puddingstone Reservoir watershed area/San Dimas Creek watershed area at the gage). The resulting peak flow estimate for Puddingstone Reservoir is 38.2 cfs.

The event mean concentration of sediment in stormwater (45.5 mg/L) was calculated from the estimated existing watershed sediment load of 265.5 tons/yr (Table 10-19) divided by the total annual wet weather flow volume delivered to the lake (4,295 ac-ft/yr). Multiplying the sediment event mean concentration by the 99th percentile peak daily flow (38.2 cfs) yields a daily maximum sediment load from stormwater of 4,249 kg/d (4.7 tons/d). Applying the wasteload allocation concentration of 0.59 µg total PCBs per dry kg of sediment yields the stormwater daily maximum allowable load of 0.0025 g/d of total PCBs. This load is associated with the MS4 stormwater permittees. The maximum allowable daily load must be met on all days, and the concentration-based WLAs must be met to ensure compliance with the TMDL.

10.4.6.6 Future Growth

USEPA regulates PCBs under the Toxic Substances Control Act (TSCA), which generally bans the manufacture, use, and distribution in commerce of the chemicals in products at concentrations of 50 parts per million or more, although TSCA allows USEPA to authorize certain uses, such as to rebuild existing electrical transformers during the transformers' useful life. Therefore, no additional allowance is made for future growth in the PCB TMDL.

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).

10.5 Chlordane Impairment

Total chlordane consists of a family of related chemicals, including cis- and trans-chlordane, oxychlordane, trans-nonachlor, and cis-nonachlor. Observations and targets discussed in this section all refer to total chlordane. Chlordane was used as a pesticide in field, commercial, and residential uses. Chlordane is no longer in production, but persists in the environment from legacy loads.

The chlordane impairment of Puddingstone Reservoir affects the beneficial uses related to recreation, municipal water supplies, wildlife health, and fish consumption. While some loading of chlordane continues to occur in watershed runoff, the primary source of chlordane in the water column and aquatic life in Puddingstone Reservoir is from historic loads stored in the lake sediments. Chlordane, like other organochlorine compounds, accumulates in aquatic organisms and biomagnifies in the food chain. As a result, low environmental concentrations can result in unacceptable levels in higher trophic level fish in the lake. The approach for chlordane is similar to that for PCBs.

10.5.1 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 Puddingstone Reservoir include REC1, REC2, WARM, WILD, MUN, GWR, COLD, RARE, and AGR. Descriptions of these uses are listed in Section 2 of this TMDL report. Elevated levels of chlordane are currently impairing the REC1, REC2, WARM, and COLD uses by causing toxicity to aquatic organisms and raising fish tissue concentrations to levels that are unsafe for human consumption (which can result in fish consumption advisories) and impairing sport fishing recreational uses. At high enough concentrations WILD, MUN, GWR and RARE uses could become impaired.

10.5.2 Numeric Targets

The Basin Plan designates water column concentrations associated with MUN and WARM beneficial uses. There are no numeric criteria specified for sediment or fish tissue concentrations of chlordane in the Basin Plan. For the purposes of this TMDL, additional numeric targets for these endpoints are based on the consensus-based sediment quality guidelines defined in MacDonald et al. (2000) and the fish tissue concentration goal, referred to as the fish contaminant goal (FCG), for chlordane defined by the Office of Environmental Health Hazard Assessment (OEHHA) for fish consumption. The numeric targets used for chlordane are listed below. The fish tissue concentration goal was also used to back calculate site-specific targets in sediment, with the most stringent target applying. See Section 2 of this TMDL report for additional details.

The water column criteria for chlordane in the Basin Plan are associated with a specific beneficial use. For waters designated MUN, the Basin Plan lists a maximum contaminant level of 0.0001 mg/L, or 0.1 µg/L. The Basin Plan also contains a narrative criterion that toxic chemicals not be present at levels that are toxic or detrimental to aquatic life (LARWQCB, 1994). Puddingstone Reservoir is also designated WARM, COLD, and RARE, and must at least meet this requirement. Acute and chronic criteria for chlordane in freshwater systems are defined by the California Toxics Rule as 2.4 µg/L and 0.0043 µg/L, respectively (USEPA, 2000a). The CTR also includes human health criteria for the consumption of water and organisms and for the consumption of organisms only as 0.00057 µg/L and 0.00059 µg/L, respectively (USEPA, 2000a). Because the human health criterion for the consumption of water and organisms is the most restrictive criterion applicable to Puddingstone Reservoir, a water column target of 0.00057 µg/L (0.57 ng/L) is the appropriate target.

For sediment, the consensus-based sediment quality guidelines provided in MacDonald et al. (2000) for the threshold effects concentration (TEC) for chlordane is 3.24 µg/kg dry weight. The consensus-based guidelines have been incorporated into the most recent set of NOAA Screening Quick Reference Tables (SQuiRT) (Buchman, 2008) and are recommended by the State Water Resources Control Board for interpretation of narrative sediment objectives under the 303(d) listing policy. This target is designed to protect benthic dwelling organisms and explicitly does not consider "the potential for bioaccumulation in aquatic organisms nor the associated hazards to the species that consume aquatic organisms (i.e., wildlife and humans)." The existing sediment chlordane concentrations in Puddingstone Reservoir are lower than the consensus-based TEC target, and existing fish tissue concentrations are higher than the fish tissue target. Thus, a separate sediment target calculation based on a biota-sediment accumulation factor (BSAF) is carried out to ensure that fish tissue concentration goals are met.

The fish contaminant goal for chlordane defined by OEHHA (2008) is 5.6 ppb wet weight in muscle tissue (filets). Elevated fish tissue concentrations are largely attributable to foodweb bioaccumulation derived from contaminated sediment. A biota-sediment accumulation factor (BSAF) approach is appropriate to correlate sediment and fish tissue targets. For chlordane, the corresponding sediment concentration target determined using the BSAF is 0.75 µg/kg dry weight, as described in Section 10.5.5. All applicable targets are shown below in Table 10-25. For sediment, the lower value of the consensus-based TEC target or the BSAF-derived target is selected as the final sediment target.

Table 10-25. Total Chlordane Targets for Puddingstone Reservoir

Media	Source	Target
Fish (ppb wet weight)	OEHHA FCG	5.6
Sediment (ng /dry g)	Consensus-based TEC	3.24
Sediment (µg/kg dry weight)	BSAF-derived target	0.75
Water (ng/L)	CTR	0.57

Note: Shaded cells represent the selected targets for this TMDL.

10.5.3 Summary of Monitoring Data

This section summarizes the monitoring data related to the chlordane impairment in Puddingstone Reservoir. Additional details regarding monitoring data are discussed in Appendix G (Monitoring Data).

Water column sampling was conducted as part of an organics study performed by UCLA (funded by a grant managed by the Regional Board) in the fall of 2008. These analyses measured cis- and trans-chlordane, but not oxychlordane or nonachlor. Of four samples (two in Live Oak Wash and two in-lake stations), chlordane was consistently below the detection limits (1.5 ng/L to 1.57 ng/L; the detection limit for chlordane is higher than the water column criterion of 0.57 ng/L).

Water samples from Puddingstone Reservoir were also collected by USEPA and/or the Regional Board on November 18, 2008 at five stations (four in-lake stations and one station in Live Oak Wash) and July 16, 2009 at four stations (Live Oak Wash, a storm drain, and two in-lake locations). These analysis did include oxychlordane and nonachlor. Chlordane concentrations at all stations were below the detection limit of 1 ng/L, which is above the CTR water column target of 0.57 ng/L. A summary of the water column data is shown in Table 10-26.

Table 10-26. Summary of Water Column Samples for Total Chlordane in Puddingstone Reservoir

Station	Average Water Concentration (ng/L)	Number of Samples	Number of Samples Above Detection Limits[1]
PR-11 (Live Oak Channel)	(0.63)[2]	4	0
PR-14 (Northeast Reservoir Side)	(0.63)	2	0

Station	Average Water Concentration (ng/L)	Number of Samples	Number of Samples Above Detection Limits[1]
PR-15 (Western Reservoir Side)	(0.60)	3	0
PR-16 (Southern Reservoir Side)	(0.50)	2	0
PR-17 (Western Reservoir Side near Shoreline)	(0.50)	1	0
PR-SD2 (Storm drain in northeast reservoir area)	(0.50)	1	0
In-Lake Average (PR-14, 15, 16, 17)[3]	(0.56)		
CTR Water Column Target	0.57		

[1] Non-detect samples were included in reported averages at one-half of the sample detection limit.

[2] Numbers in parentheses indicate that the sample is based only on the detection limits of the samples, and that no chlordanes were quantified in any of the collected samples.

[3] Overall average is the average of individual station averages.

Pollutant concentrations associated with suspended sediments in the lake were analyzed at two in-lake stations as well as Live Oak Wash during the fall of 2008 by UCLA. Concentrations of chlordane in the suspended sediment samples were less than the detection limits (2 µg/kg to 36 µg/kg dry weight) at the two in-lake stations; chlordane was detected but not at reportable amounts in the Live Oak Wash suspended sediment sample. A grab sample at the outlet of Live Oak Wash that was collected 90 minutes into a wet weather event had no detectable results (detection limit of 2.70 µg/kg dry weight); the composite sample for this event was also less than the detection limit (1.57 µg/kg dry weight). Water column samples were collected during this event (a time series composite and a single time point sample) as well, but not analyzed. Chlordane concentrations were also analyzed in porewater; all samples were less than the detection limit of 15 ng/L. The suspended sediments associated with the porewater had concentrations less than detection limits (0.2 µg/kg to 0.53 µg/kg dry weight).

UCLA collected bed sediment samples at two in-lake locations (total of three individual samples) in Puddingstone Reservoir in fall 2008. As with the water column analyses by UCLA, these report cis- and trans-chlordane, but not oxychlordane or nonachlor. Total chlordane was consistently below detection limits (0.39 µg/kg to 1.58 µg/kg dry weight). Sediment sampling was conducted by USEPA and the Regional Board at six stations on July 16, 2009 (Live Oak Wash, two in-lake stations, two storm drain stations, and one natural drainage). Total chlordane (including oxychlordane and nonachlor) was quantified at each of the six stations with values ranging from 1.1 µg/kg to 6.5 µg/kg dry weight (two of the six samples had a concentration exceeding the sediment consensus-based TEC of 3.24 µg/kg dry weight). A summary of the sediment data is shown in Table 10-27. The lake-wide average of 2.15 µg/kg dry weight is less than the concentration associated with inputs (5.11 µg/kg dry weight), and the lake-wide average is less than the consensus-based TEC of 3.24 µg/kg dry weight.

Table 10-27. Summary of Sediment Samples for Total Chlordane in Puddingstone Reservoir

Station	Average Sediment Concentration (µg/kg dry weight)[1]	Number of Samples	Number of Samples above Detection Limits	Number of Samples between Detection and Reporting Limits
PR-11 (Live Oak Channel)	10.15	1	1	0
PR-14 (Northeast Reservoir Side)	(0.22)	2	0	0

Station	Average Sediment Concentration (µg/kg dry weight)[1]	Number of Samples	Number of Samples above Detection Limits	Number of Samples between Detection and Reporting Limits
PR-15 (Western Reservoir Side)	3.77	2	1	0
PR-16 (Southern Reservoir Side)	[2.45]	2	1	1
PR-19 (Natural Drainage on South Side)	[2.20]	1	1	1
PR-19SD (Storm Drain on South Side)	[4.50]	1	1	1
PR-SD2 (Storm drain in northeast reservoir area)	[3.60]	1	1	1
In-Lake Average[2] (PR-14, 15, 16)	2.15			
Influent Average	5.11			
Consensus-based TEC	3.24			

[1] Total chlordane in a sample represents the sum of all reported measurements for alpha and gamma chlordane, oxychlordane, and cis- and trans-nonachlor, including results reported below the method reporting limit. If all components were non-detect, the total is represented as one-half the detection limit. Results of any laboratory duplicate analyses of the same sample were averaged. Results for each station represent the average of individual samples. Results in parentheses indicate that the sample average is based only on the detection limits of the samples and that no chlordane quantified in any of the collected samples. Sample averages based only on detected results below the reporting limit plus non-detects are shown in square brackets.

[2] Overall average is the average of individual station averages.

Fish tissue concentrations of total chlordane from Puddingstone Reservoir have been analyzed in largemouth bass, common carp, bullhead, and brown bullhead (SWAMP and TSMP). Eight fish samples (composites of filets from five fish) were collected and analyzed for total chlordane between 1986 and 1999. In 1986, a largemouth bass and common carp sample reported 10.4 ppb and 460 ppb wet weight, respectively, while in 1987 another common carp sample had a concentration of 193.5 ppb wet weight and a bullhead sample reported a concentration of 44.4 ppb wet weight. In 1988, the reported concentration associated with a brown bullhead sample was 48.5 ppb wet weight. Three largemouth bass samples had concentrations of 16.1 ppb, 31.7 ppb, and 2.8 ppb wet weight in 1991, 1992, and 1999, respectively. The average reported chlordane concentration in all samples from the 1980s and 1990s was 100.9 ppb wet weight. Results from the individual samples are shown in Appendix G (Monitoring Data).

More recently, SWAMP collected samples in September 2004 and June 2007. Considering only data collected in the past 10 years, the average concentration of total chlordane in largemouth bass was 8.7 ppb wet weight (average lipid fraction of 0.98 percent), and the average concentration of total chlordane in common carp was 30.2 ppb wet weight (average lipid fraction of 3.6 percent). The recent fish-tissue data for Puddingstone Reservoir are summarized in Table 10-28.

Table 10-28. Summary of Recent Fish Tissue Samples for Total Chlordane in Puddingstone Reservoir

Sample Date	Fish Species	Total Chlordane (ppb wet weight)[1]
9/22/2004	Largemouth Bass	12.4
9/22/2004	Largemouth Bass	5.9

Sample Date	Fish Species	Total Chlordane (ppb wet weight)[1]
9/22/2004	Largemouth Bass	13.6
9/22/2004	Largemouth Bass	7.3
9/22/2004	Common Carp	1.2
9/22/2004	Common Carp	27.3
9/22/2004	Common Carp	20.0
9/22/2004	Common Carp	15.6
6/6/2007	Largemouth Bass	9.3
6/6/2007	Largemouth Bass	3.8
2004-2007 Average - Largemouth Bass		8.7
2004 Average - Common Carp		16.0
FCG		5.6

[1] Composite sample of filets from five (largemouth bass) or three individuals (common carp).

In sum, a majority (80 percent) of recent fish tissue samples collected from Puddingstone are elevated above OEHHA fish consumption guidelines for total chlordane (5.6 ppb; the average concentration is also above the FCG). Concentrations in sediment are, on average, below the consensus-based TEC, although individual samples exceeded this value. Water column samples have all been below detection limits; however, all of the detection limits exceeded the CTR criterion.

10.5.4 Source Assessment

Chlordane in Puddingstone Reservoir is primarily due to historical loading and storing within the lake sediments, with some ongoing contribution by watershed wet weather loads. Dry weather loading is assumed to be negligible because hydrophobic contaminants primarily move with particulate matter that is mobilized by higher flows. Stormwater loads from the watershed were estimated based on simulated sediment load and observed chlordane concentrations on sediment near inflows to the lake. Watershed loads of chlordane may arise from past pesticide applications, improper disposal, and atmospheric deposition. Pesticide applications were most likely associated with agricultural, commercial, and residential areas. Improper disposal could have occurred at various locations, while atmospheric deposition occurs across the entire watershed.

There is no definitive information on specific sources within the watershed at this time. Therefore, an average concentration on sediment is applied to all contributing areas, while sources of water that do not contribute sediment load, such as irrigation, are considered to provide no significant chlordane loading. The average concentration of total chlordane on incoming sediment is estimated to be 5.11 µg/kg dry weight (Table 10-27) and the annual sediment load to Puddingstone Reservoir is 265.5 tons/yr (see Appendix D, Wet Weather Loading). The resulting estimated wet weather load of chlordane is approximately 1.23 g/yr (Table 10-29).

Table 10-29. Total Chlordane Loads Estimated for Each Jurisdiction and Subwatershed in the Puddingstone Reservoir Watershed (g/yr)

Subwatershed	Responsible Jurisdiction	Input	Sediment Load (tons/yr)	Total Chlordane Load (g/yr)	Percent of Total Load
Northern	Caltrans	State Highway Stormwater[1]	13.5	0.063	5.10%
Northern	Claremont	MS4 Stormwater[1]	4.5	0.021	1.69%
Northern	County of Los Angeles	MS4 Stormwater[1]	27.7	0.128	10.43%
Northern	La Verne[2]	MS4 Stormwater[1]	168	0.778	63.22%
Northern	General Industrial Stormwater Permittees (in the city of La Verne)	General Industrial Stormwater[1]	24.8	0.115	9.34%
Northern	General Construction Stormwater Permittees (in the city of La Verne)	General Construction Stormwater[1]	4.5	0.021	1.69%
Northern	Pomona	MS4 Stormwater[1]	0.5	0.002	0.18%
Northern	San Dimas	MS4 Stormw[1]ater	1.6	0.008	0.62%
Northern	Angeles National Forest	Stormwater[1]	1.4	0.006	0.51%
Southern	Caltrans	State Highway Stormwater[1]	1.4	0.007	0.54%
Southern	La Verne	Runoff	1.2	0.006	0.47%
Southern	Pomona	Runoff	1.7	0.008	0.63%
Southern	San Dimas	Runoff	14.8	0.069	5.59%
Southern	County of Los Angeles	Parkland Irrigation	0.0	0.000	0.00%
Total Load from Watershed			**265.5**	**1.23**	**100.00%**

[1]This input includes effluent from storm drain systems during both wet and dry weather.

[2]The total area for the City of La Verne in the northern subwatershed is 4,079 acres. Discharges governed by the general construction and general industrial stormwater permits are currently located in the City of La Verne. The disturbed area associated with general construction and general industrial stormwater permittees (233 acres) was subtracted out of the appropriate city area and allocated to these permits.

As described in Appendix E (Atmospheric Deposition), Section E.5, the net atmospheric deposition of total chlordane directly to the lake surface is estimated to be close to zero, with deposited loads balanced by volatilization losses. Atmospheric deposition onto the watershed is implicitly included in the estimates of watershed load.

10.5.5 Linkage Analysis

The linkage analysis provides the quantitative basis for determining the loading capacity of total chlordane into Puddingstone Reservoir. The loading capacity is used to estimate the TMDL and corresponding allocations of that load to permitted point sources (wasteload allocations) and nonpoint sources (load allocations).

Lake sediments are often the predominant source of total chlordane in biota. The bottom sediment serves as a sink for organochlorine compounds that can be recycled through the aquatic life cycle. Chlordanes are strongly sorbed to sediments and have long half-lives in sediment and water. Incoming loads of total chlordane will mainly be adsorbed to particulates from stormwater runoff (eroded sediments from legacy contamination sites or from atmospheric deposition).

The use of bioaccumulation models and the fish tissue data from Puddingstone Reservoir are discussed in detail in Appendix H (Organochlorine Compounds TMDL Development) and Appendix G (Monitoring Data), respectively. The existing sediment chlordane concentrations in Puddingstone Reservoir are lower than the consensus-based TEC target, and existing fish tissue concentrations are higher than the fish tissue target. Therefore, a sediment target based on biota-sediment bioaccumulation (a BSAF approach) is calculated from the smaller of the ratio of the FCG to existing fish tissue concentrations obtained from trophic level 4 fish (TL4; e.g., largemouth bass) and bottom-feeding, trophic level 3 fish (TL3; e.g., common carp). In general, the TL3 number is expected to be more restrictive due to the additional uptake of organochlorine compounds from the sediment by bottom-feeding fish. For chlordane in Puddingstone Reservoir, the ratios of the FCG to the existing fish concentrations (Table 10-27) are:

$$\text{TL4: } 5.6/8.7 = 0.6424$$

$$\text{TL3: } 5.6/16.0 = 0.3500$$

The lower ratio, obtained for the TL3 fish, is applied to the observed sediment concentration of 2.15 µg/kg dry weight to obtain the site-specific sediment target concentration to achieve fish tissue goals of 0.75 µg/kg dry weight.

The fish tissue-based target concentrations were calculated using only recent data (collected in the past 10 years) because the loads and exposure concentrations of total chlordane are likely to have declined steadily since the cessation of production and use of the chemicals. The resulting fish tissue-based target concentration of total chlordane in the sediment of Puddingstone Reservoir is shown in Table 10-30.

Table 10-30. Fish Tissue-Based Chlordane Concentration Targets for Sediment in Puddingstone Reservoir

Total Chlordane Concentration	Sediment (µg/kg dry weight)
Existing	2.15
BSAF-derived Target	0.75
Required Reduction	65.1%

The BSAF-derived sediment target is less than the consensus-based TEC of 3.24 µg/kg dry weight. (The consensus-based sediment quality guideline is for the protection of benthic organisms, and explicitly does not address bioaccumulation and human-health risks from the consumption of contaminated fish.) The lower value of the consensus-based TEC target or the BSAF-derived target is selected as the final sediment target. In addition, the CTR criterion for human health (0.57 ng/L) is the selected numeric target for the water column and protects both aquatic life and human health.

The toxicant loading model described in Appendix H (Organochlorine Compounds TMDL Development) can be used to estimate the loading rate required to yield the existing sediment concentration under steady-state conditions. This yields an estimate that a load of 1,379 g/yr would be required to maintain observed sediment concentrations under steady-state conditions. The estimated current watershed loading rate is 1.23 g/yr, or 0.09 percent of this amount. Therefore, impairment due to elevated fish tissue concentrations of chlordane in Puddingstone Reservoir is primarily due to the storage of historic loads of chlordane in the lake sediment.

10.5.6 TMDL Summary

Because chlordane impairment in Puddingstone Reservoir is predominantly due to historic loads stored in the lake sediment, this impairment is not amenable to a standard, load-based TMDL analysis. Instead, allocations are first assigned on a concentration basis, with the goal of attaining the concentrations identified above for water and sediment, as well as fish tissue. The concentration targets apply to water and sediment entering the lake and within the lake.

The chlordane TMDL will be allocated to ensure achievement of the loading capacity. TMDLs are broken down into the wasteload allocations (WLAs), load allocations (LAs), and Margins of Safety (MOS) using the general TMDL equation.

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

Note that since this TMDL is being expressed as a concentration in sediment, in this scenario, the loading capacity is equal to 0.75 µg/kg dry weight chlordane. The wasteload allocations and load allocations are also equal to 0.75 µg/kg dry weight chlordane in sediment. There is no explicit MOS. Allocations are assigned for this TMDL by requiring equal concentrations of all sources. Details associated with the WLAs, LAs, and MOS are presented in the following three sections.

10.5.6.1 Wasteload Allocations

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). This TMDL establishes WLAs at their point of discharge. This TMDL also establishes alternative wasteload allocations for chlordane (“Alternative WLAs if the Fish Tissue Target is Met”) described in Section 10.5.6.1.2. The alternative wasteload allocations will supersede the wasteload allocations in Section 10.5.6.1.1 if the conditions described in Section 10.5.6.1.2 are met.

10.5.6.1.1 Wasteload Allocations

In the Puddingstone Reservoir watershed, wasteload allocations (WLAs) are required for all permittees in the northern subwatershed and Caltrans areas in the southern subwatershed. Relevant permit numbers are

- County of Los Angeles (including the cities of Claremont, La Verne, Pomona, and San Dimas): Board Order 01-182 (as amended by Order No. R4-2006-0074 and R4-2007-0042), CAS004001
- Caltrans: Order No 99-06-DWQ, CAS000003
- General Construction Stormwater: Order No. 2009-0009-DWQ, CAS000002
- General Industrial Stormwater: Order No. 97-03-DWQ, CAS000001

Total chlordane concentrations in water flowing into Puddingstone Reservoir are below detection limits, and most chlordane load is expected to move in association with sediment. Therefore, suspended sediment in the water flowing into the lake is assigned wasteload allocations. Additionally, the TMDL establishes wasteload allocations for chlordane in the water column equal to the CTR based water column target. The CTR based water column target includes both dissolved chlordane and chlordane associated with suspended sediment. The existing concentration of sediment entering the lake is 5.11 µg/kg dry weight. Therefore, a reduction of (5.11 – 0.75)/5.11 = 85.3 percent is required on the sediment-associated load from the watershed. The reduction in watershed load is greater than the reduction needed for in-lake sediments because the estimated concentration on influent sediment is greater than the lake-wide average.

The wasteload allocations are shown in Table 10-31 and each wasteload allocation must be met at the point of discharge.

Table 10-31. Wasteload Allocations for Total Chlordane in Puddingstone Reservoir

Subwatershed	Responsible Jurisdiction	Input	Wasteload Allocation for Total Chlordane Associated with Suspended Sediment[3] (µg/kg dry weight)	Wasteload Allocation for Chlordane in the Water Column[3] (ng/L)
Northern	Caltrans	State Highway Stormwater[1]	0.75	0.57
Northern	Claremont	MS4 Stormwater[1]	0.75	0.57
Northern	County of Los Angeles	MS4 Stormwater[1]	0.75	0.57
Northern	La Verne[2]	MS4 Stormwater[1]	0.75	0.57
Northern	General Industrial Stormwater Permittees (in the city of La Verne)	General Industrial Stormwater[1]	0.75	0.57
Northern	General Construction Stormwater Permittees (in the city of La Verne)	General Construction Stormwater[1]	0.75	0.57
Northern	Pomona	MS4 Stormwater[1]	0.75	0.57
Northern	San Dimas	MS4 Stormwater[1]	0.75	0.57
Northern	Angeles National Forest	Stormwater[1]	0.75	0.57
Southern	Caltrans	State Highway Stormwater[1]	0.75	0.57

[1]This input includes effluent from storm drain systems during both wet and dry weather.

[2]Discharges governed by the general construction and general industrial stormwater permits are currently located in the City of La Verne. Any future discharges governed by the general construction and general industrial stormwater permits will receive the same concentration-based wasteload allocations.

[3]Each wasteload allocation must be met at the point of discharge.

10.5.6.1.2 Alternative Wasteload Allocations if Fish Tissue Targets Are Met

The wasteload allocations listed in Table 10-31 will be superseded, and the wasteload allocations in Table 10-32 will apply, if:

1. The responsible jurisdictions submit to USEPA and the Regional Board material describing that the fish tissue target of 5.6 ppb wet weight has been met for the preceding three or more years. A demonstration that the fish tissue target has been met in any given year must at minimum include

a composite sample of skin off fillets from at least five common carp each measuring at least 350mm in length,

2. The Regional Board Executive Officer approves the request and applies the alternative wasteload allocations in Table 10-32, and
3. USEPA does not object to the Regional Board's determination within 60 days of receiving notice of it.

Each wasteload allocation must be met at the point of discharge.

Table 10-32. Alternative Wasteload Allocations for Total Chlordane in Puddingstone Reservoir if the Fish Tissue Target is Met

Subwatershed	Responsible Jurisdiction	Input	Wasteload Allocation for Total Chlordane Associated with Suspended Sediment[3] (µg/kg dry weight)	Wasteload Allocation for Chlordane in the Water Column[3] (ng/L)
Northern	Caltrans	State Highway Stormwater[1]	3.24	0.57
Northern	Claremont	MS4 Stormwater[1]	3.24	0.57
Northern	County of Los Angeles	MS4 Stormwater[1]	3.24	0.57
Northern	La Verne[2]	MS4 Stormwater[1]	3.24	0.57
Northern	General Industrial Stormwater Permittees (in the city of La Verne)	General Industrial Stormwater[1]	3.24	0.57
Northern	General Construction Stormwater Permittees (in the city of La Verne)	General Construction Stormwater[1]	3.24	0.57
Northern	Pomona	MS4 Stormwater[1]	3.24	0.57
Northern	San Dimas	MS4 Stormwater[1]	3.24	0.57
Northern	Angeles National Forest	Stormwater[1]	3.24	0.57
Southern	Caltrans	State Highway Stormwater[1]	3.24	0.57

[1]This input includes effluent from storm drain systems during both wet and dry weather.

[2] Discharges governed by the general construction and general industrial stormwater permits are currently located in the City of La Verne. Any future discharges governed by the general construction and general industrial stormwater permits will receive the same concentration-based wasteload allocations.

[3] Each wasteload allocation must be met at the point of discharge.

10.5.6.2 Load Allocations

This TMDL establishes load allocations (LAs) at their point of discharge. This TMDL also establishes alternative load allocations for chlordane ("Alternative LAs if the Fish Tissue Target is Met") described in Section 10.5.6.2.2. The alternative load allocations will supersede the load allocations in Section 10.5.6.2.1 if the conditions described in Section 10.5.6.2.2 are met.

10.5.6.2.1 Load Allocations

Load allocations (LAs) are assigned to the non-Caltrans permittees in the southern subwatershed and lake bottom sediments. Additionally, the TMDL establishes load allocations for chlordane in the water column equal to the CTR based water column target. The CTR based water column target includes both dissolved chlordane and chlordane associated with suspended sediment. No load is allocated to atmospheric deposition of total chlordane. The legacy chlordane stored in lake sediment is the major cause of use impairment associated with elevated fish tissue concentrations, and is assigned a load allocation. The in-lake allocation is in concentration terms: specifically, the responsible jurisdiction (County of Los Angeles) should achieve a total chlordane concentration of 0.75 µg/kg dry weight in lake bottom sediments (Table 10-33). Each load allocation must be met at the point of discharge, except for the lake bottom sediment load allocation which must be met in the lake.

Table 10-33. Load Allocations for Total Chlordane in Puddingstone Reservoir

Subwatershed	Responsible Jurisdiction	Input	Load Allocation for Chlordane Associated with Suspended Sediment or Lake Bottom Sediments (µg/kg dry weight)
Southern	La Verne	Runoff[1]	0.75
Southern	Pomona	Runoff[1]	0.75
Southern	San Dimas	Runoff[1]	0.75
Southern	County of Los Angeles	Parkland Irrigation[1]	0.75
Lake Surface	County of Los Angeles	Lake bottom sediments[2]	0.75

[1] Each load allocation must be met at the point of discharge.

[2] The load allocation must be met in the lake.

10.5.6.2.2 Alternative Load Allocations if the Fish Tissue Target is Met

The load allocations listed in Table 10-33 will be superseded, and the load allocations in Table 10-34 will apply, if:

1. The responsible jurisdiction submits to USEPA and the Regional Board material describing that the fish tissue target of 5.6 ppb wet weight has been met for the preceding three or more years. A demonstration that the fish tissue target has been met in any given year must at minimum include a composite sample of skin off fillets from at least five largemouth bass each measuring at least 350mm in length,
2. The Regional Board Executive Officer approves the request and applies the alternative load allocations in Table 10-34, and
3. USEPA does not object to the Regional Board's determination within 60 days of receiving notice of it.

Each load allocation must be met at the point of discharge, except for the lake bottom sediment load allocation which must be met in the lake.

Table 10-34. Alternative Load Allocations for Total Chlordane in Puddingstone Reservoir if the Fish Tissue Target is Met

Subwatershed	Responsible Jurisdiction	Input	Load Allocation (µg/kg dry weight)
Southern	La Verne	Runoff[1]	3.24
Southern	Pomona	Runoff[1]	3.24
Southern	San Dimas	Runoff[1]	3.24
Southern	County of Los Angeles	Parkland Irrigation[1]	3.24
Lake Surface	County of Los Angeles	Lake bottom sediments[2]	3.24

[1] Each load allocation must be met at the point of discharge.

[2] The load allocation must be met in the lake.

10.5.6.3 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 TMDL contains an implicit MOS based on conservative assumptions. The allocations are set based on the lower of either the BSAF-derived sediment target or the consensus-based TEC sediment target to ensure achievement of the OEHHA FCG target in fish tissue. The selected BSAF-derived target concentration in sediment is considerably lower than the consensus-based TEC target.

10.5.6.4 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. This TMDL protects beneficial uses by reducing fish tissue concentrations to the FCG target and protecting benthic biota in sediment. Because fish bioaccumulate chlordane, concentrations in tissues of edible sized game fish integrate exposure over a number of years. As a result, overall average loading is more important for the attainment of standards than instantaneous or daily concentrations. WLAs and LAs in this TMDL are assigned as concentrations and protect during all seasons and in both high and low flow conditions. This TMDL therefore protects for critical conditions.

10.5.6.5 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. This TMDL includes a maximum daily load estimated according to the guidelines provided by USEPA (2007).

Because the total chlordane WLAs are expressed as concentrations on sediment, the daily maximum allowable load is calculated from the maximum daily sediment load multiplied by the TMDL WLA concentration. The maximum daily sediment load is estimated from the 99th percentile daily flow and the sediment event mean concentration that yields the estimated annual sediment load.

No USGS gage currently exists in the Puddingstone Reservoir watershed. USGS Station 11086400, San Dimas Creek near San Dimas, CA, was selected as a surrogate for flow determination. The 99th percentile flow was chosen to represent the peak flow for this drainage. Choosing the 99th percentile flow eliminates errors due to outliers and is reasonable for development of a daily load expression.

The USGS StreamStats program was used to determine the 99th percentile flow for San Dimas Creek (55 cfs) (Wolock, 2003). To estimate the peak flow to Puddingstone Reservoir, the 99th percentile flow for San Dimas Creek was scaled down by the ratio of drainage areas (8,128 acres/11,712 acres; Puddingstone Reservoir watershed area/San Dimas Creek watershed area at the gage). The resulting peak flow estimate for Puddingstone Reservoir is 38.2 cfs.

The event mean concentration of sediment in stormwater (45.5 mg/L) was calculated from the estimated existing watershed sediment load of 265.5 tons/yr (Table 10-29) divided by the total annual wet weather flow volume delivered to the lake (4,295 ac-ft/yr). Multiplying the sediment event mean concentration by the 99th percentile peak daily flow (38.2 cfs) yields a daily maximum sediment load from stormwater of 4,249 kg/d (4.7 tons/d). Applying the wasteload allocation concentration of 0.75 µg total chlordane per dry kg of sediment yields the stormwater daily maximum allowable load of 0.0032 g/d of total chlordane. This load is associated with the MS4 stormwater permittees. The maximum allowable daily load must be met on all days, and the concentration-based WLAs must be met to ensure compliance with the TMDL.

10.5.6.6 Future Growth

The manufacture and use of chlordane is currently banned. Therefore, no additional allowance is made for future growth in the chlordane TMDL.

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).

10.6 Dieldrin Impairment

Dieldrin is a chlorinated insecticide originally developed as an alternative to DDT and was in wide use from the 1950s to the 1970s. Dieldrin in the environment also arises from use of the insecticide aldrin. Aldrin is not itself toxic to insects, but is metabolized to dieldrin in the insect body. The use of both dieldrin and aldrin was discontinued in the 1970s.

The dieldrin impairment of Puddingstone Reservoir affects beneficial uses related to recreation, municipal water supply, wildlife health, and fish consumption. Dieldrin, like PCBs, chlordane and DDT, is an organochlorine compound that is strongly sorbed to sediment and lipids and is no longer in production. As such, the approach for dieldrin impairment is similar to that for PCBs, chlordane, and DDT.

10.6.1 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 Puddingstone Reservoir include REC1, REC2, WARM, WILD, MUN, GWR, COLD, RARE, and AGR. Descriptions of these uses are listed in Section 2 of this TMDL report. Elevated levels of dieldrin are impairing the REC1, REC2, WARM, and COLD uses by causing toxicity to aquatic organisms and raising fish tissue concentrations to levels that are unsafe for human consumption (which can result in fish consumption advisories), and impair sport fishing recreational uses. At high enough concentrations WILD, MUN, GWR and RARE uses could become impaired.

10.6.2 Numeric Targets

The Basin Plan designates water column concentrations associated with MUN and WARM beneficial uses. There are no numeric criteria specified for sediment or fish tissue concentrations of dieldrin in the Basin Plan. For the purposes of this TMDL, additional numeric targets for these endpoints are based on the consensus-based sediment quality guidelines defined in MacDonald et al. (2000) and the fish tissue concentration goal, referred to as the fish contaminant goal (FCG), defined by OEHHA (2008) for fish consumption. The numeric targets for dieldrin are listed below. The fish tissue concentration goal was also used to back calculate site-specific targets in sediment, with the most stringent target applying. See Section 2 of this TMDL report for additional details.

The water column criteria for dieldrin in the Basin Plan are associated with a specific beneficial use. The Basin Plan also contains a narrative criterion that toxic chemicals not be present at levels that are toxic or detrimental to aquatic life (LARWQCB, 1994). Acute and chronic criterion for the protection of aquatic life in freshwater systems are included in the CTR for dieldrin as 0.24 µg/L and 0.056 µg/L, respectively (USEPA, 2000a). CTR criteria are considered protective of aquatic life. The CTR also provides a human health-based water quality criterion for the consumption of organisms only and the consumption of water and organisms as 0.00014 µg/L (0.14 ng/L). The human health criterion of 0.00014 µg/L (0.14 ng/L) is the most restrictive of the applicable criteria specified for water column concentrations and is selected as the water column target.

For sediment, the consensus-based sediment quality guidelines provided in MacDonald et al. (2000) for the threshold effects concentration (TEC) of dieldrin in sediment is 0.46 µg/kg dry weight. The consensus-based guidelines have been incorporated into the most recent set of NOAA Screening Quick Reference Tables (SQuiRT) (Buchman, 2008) and are recommended by the State Water Resources Control Board for interpretation of narrative sediment objectives under the 303(d) listing policy. This target is designed to protect benthic dwelling organisms and explicitly does not consider "the potential for bioaccumulation in aquatic organisms nor the associated hazards to the species that consume aquatic organisms (i.e., wildlife and humans)." The estimated existing sediment dieldrin concentrations in Puddingstone Reservoir are lower than the consensus-based TEC target, and existing fish tissue concentrations are higher than the fish tissue target. Thus, a separate sediment target calculation based on a biota-sediment accumulation factor (BSAF) is carried out to ensure that fish tissue concentration goals are met.

The fish contaminant goal for dieldrin defined by the OEHHA (2008) is 0.46 ppb wet weight in muscle tissue (filets). Elevated fish tissue concentrations are largely attributable to foodweb bioaccumulation derived from contaminated sediment. A biota-sediment accumulation factor (BSAF) approach is appropriate to correlate sediment and fish tissue targets. For dieldrin, the corresponding sediment concentration target estimated using the BSAF approach is 0.22 µg/kg dry weight, as described in detail in Section 10.6.5. All applicable targets are shown below in Table 10-35. For sediment, the lower value of the consensus-based TEC target or the BSAF-derived target is selected as the final sediment target.

Table 10-35. Dieldrin Targets Applicable to Puddingstone Reservoir

Medium	Source	Target
Fish (ppb wet weight)	OEHHA FCG	0.46
Sediment (µg/kg dry weight)	Consensus-based TEC	1.9
Sediment (µg/kg dry weight)	BSAF-derived target	0.22
Water (ng/L)	CTR	0.14

Note: Shaded cells represent the selected targets for this TMDL.

10.6.3 Summary of Monitoring Data

This section summarizes the monitoring data for Puddingstone Reservoir related to the dieldrin impairment. Additional details regarding monitoring data are discussed in Appendix G (Monitoring Data).

Water column sampling was conducted as part of an organics study performed by UCLA (funded by a grant managed by the Regional Board) in the fall of 2008. All four samples (two in Live Oak Wash and two in-lake stations) were below detection limits for dieldrin (3.05 ng/L to 3.14 ng/L).

Water samples from Puddingstone Reservoir were also collected by USEPA and/or the Regional Board on November 18, 2008 at five stations (four in-lake stations and one station in Live Oak Wash), February 24, 2009 at one storm drain station, and July 16, 2009 at four stations (Live Oak Wash, one storm drain, and two in-lake locations). Dieldrin concentrations at all stations were below the detection limit of 1 ng/L. Although no water column samples have had detectable quantities of dieldrin, the detection limits for these samples (1 ng/L or greater) are higher than the CTR water column target of 0.14 ng/L. A summary of the water column data is shown in Table 10-36.

Table 10-36. Summary of Water Column Samples for Dieldrin in Puddingstone Reservoir

Station	Average Water Concentration (ng/L)	Number of Samples	Number of Samples above Detection Limit[1]	Number of Samples between Detection and Reporting Limits
PR-11 (Live Oak Channel)	(1.01) [2]	4	0	0
PR-14 (Northeast Reservoir Side)	(1.01) [2]	2	0	0
PR-15 (Western Reservoir Side)	(0.86) [2]	3	0	0
PR-16 (Southern Reservoir Side)	(0.50) [2]	2	0	0
PR-17 (Western Reservoir Side near Shoreline)	(0.50) [2]	1	0	0
PR-SD (Storm drain in northeast reservoir area)	(0.50) [2]	1	0	0
PR-SD2 (Storm drain in northeast reservoir area)	(0.50) [2]	1	0	0
In-Lake Average[3] (PR-14, 15, 16, 17)	(0.72) [2]			
CTR Water Column Target	0.17			

[1] Non-detect samples were included in reported averages at one-half of the sample detection limi.

[2] Numbers in parentheses indicate that the sample is based only on the detection limits of the samples, and that no dieldrin was quantified in any of the collected samples.

[3] Overall average is the average of individual station averages.

Pollutant concentrations associated with suspended sediments in the lake were analyzed at two in-lake stations as well as Live Oak Wash during the fall of 2008 by UCLA, but did not quantify dieldrin at detectable limits (4 µg/kg to 72 µg/kg dry weight). A composite sample during a wet weather event did not detect any dieldrin (detection limit of 3.14 µg/kg dry weight). A grab sample at the outlet of Live

Oak Wash was collected 90 minutes into the wet weather event, which had no detectable results (detection limit of 5.39 µg/kg dry weight).

A wet weather composite sample at Live Oak Wash, did not detect any dieldrin (detection limit of 1.57 µg/kg dry weight); an additional grab sample at the outlet of Live Oak Wash was collected 90 minutes into the wet weather and had no detectable concentration of dieldrin (detection limit of 2.70 µg/kg dry weight). Water column samples were also collected during this event (a time series composite and a single time point sample), but not analyzed.

Dieldrin was analyzed for three porewater samples collected at two in-lake stations. Both samples were less than the detection limit of 30 ng/L. Total suspended solids from the porewater samples were also analyzed for dieldrin, but were less than detection limits of 0.4 – 1.06 µg/kg dry weight.

UCLA also collected bed sediment samples at two in-lake locations (total of three individual samples) in Puddingstone Reservoir in fall 2008. For dieldrin, all the samples were below detection limits (0.77 µg/kg to 3.17 µg/kg dry weight).

Sediment sampling was also conducted by USEPA and the Regional Board at six stations on July 16, 2009 (Live Oak Wash, two in-lake stations, two storm drain stations, and one natural drainage). All samples were less than a detection limit of 1 µg/kg dry weight for dieldrin. Because dieldrin does appear in fish at levels greater than the FCG, and because these body burdens of dieldrin are believed to arise from the sediment, EPA decided to represent statistical estimates for the sediment concentrations of dieldrin by setting the concentration of non-detected samples to the detection limit. A summary of the sediment data is shown in Table 10-37. The lake-wide average of <1.32 µg/kg dry weight for dieldrin is less than the consensus-based TEC of 5.28 µg/kg dry weight.

Table 10-37. Summary of Sediment Samples for Dieldrin in Puddingstone Reservoir

Station	Average Sediment Concentration (µg/kg dry weight)[1]	Number of Samples	Number of Samples above Detection Limits[1]	Number of Samples between Detection and Reporting Limits
PR-11 (Live Oak Channel)	(1.0) [1]	1	0	0
PR-14 (Northeast Reservoir Side)	(0.89)	2	0	0
PR-15 (Western Reservoir Side)	(2.08)	2	0	0
PR-16 (Southern Reservoir Side)	(1.0)	1	0	0
PR-19 (Natural drainage on South Side)	(1.0)	1	0	0
PR-19SD (Storm drain on South Side)	(1.0)	1	0	0
PR-SD2 (Storm drain in northeast reservoir area)	(1.0)	1	0	0
In-Lake Average (PR-14,15, 16)[2]	(1.32) [1]			
Influent Average	(1.00)			
Consensus-based TEC	5.28			

[1] All sample results were below detection limits. An upper-bound analysis was performed using the reported sample detection limits for dieldrin. Numbers in parentheses indicate that sample is based only on the detection limits of the samples, and that no dieldrin was quantified in any of the collected samples.

[2] Overall average is the average of individual station averages.

Eight fish samples (composites of filets from five fish) were collected and analyzed for dieldrin between 1986 and 1999. All four largemouth bass and both bullhead samples were below detection limits (the detection limits for the historical fish samples are not reported). However, common carp samples collected in 1986 and 1988 had concentrations of 12 and 5 ppb wet weight, respectively. Results from the individual samples are shown in Appendix G (Monitoring Data).

More recently, SWAMP collected samples in September 2004 and June 2007. Considering only data collected in the past 10 years, the average concentration of dieldrin in largemouth bass was 1.2 ppb wet weight (average lipid fraction of 0.98 percent) and the average concentration of dieldrin in common carp was 2.7 ppb wet weight (average lipid fraction of 3.6 percent). The recent fish-tissue data for Puddingstone Reservoir are summarized in Table 10-38.

Table 10-38. Summary of Recent Fish Tissue Samples for Dieldrin in Puddingstone Reservoir

Sample Date	Fish Species	Dieldrin (ppb wet weight)[1]
9/22/2004	Largemouth Bass	1.7
9/22/2004	Largemouth Bass	0.9
9/22/2004	Largemouth Bass	1.6
9/22/2004	Largemouth Bass	1.2
9/22/2004	Common Carp	0.7
9/22/2004	Common Carp	4.3
9/22/2004	Common Carp	3.4
9/22/2004	Common Carp	2.5
6/6/2007	Largemouth Bass	0.7
6/6/2007	Largemouth Bass	(0.2) [2]
2004-2007 Average - Largemouth Bass		1.2
2004 Average - Common Carp		2.7
FCG		0.46

1 Composite sample of filets from either five (largemouth bass) or three individuals (carp).

2 Non-detect samples were included in reported averages at one-half of the sample detection limit (shown in parentheses).

In sum, all but one of the recent fish tissue samples collected from Puddingstone are elevated above OEHHA fish consumption guidelines for dieldrin. Concentrations in sediment are, on average, below the consensus-based TEC, although an individual sample exceeded this value. Concentrations in water were below detection limits; however, all of the detection limits exceeded the CTR criterion.

10.6.4 Source Assessment

Dieldrin present in Puddingstone Reservoir is primarily due to historical loading and storage within the lake sediments, with some ongoing contribution by watershed wet weather loads. Dry weather loading and direct atmospheric deposition to the lake are considered negligible sources of dieldrin. Stormwater loads from the watershed could not be directly estimated because all sediment and water samples were below detection limits. Watershed loads of dieldrin may arise from past pesticide applications, improper disposal, and atmospheric deposition. Pesticide applications were most likely associated with agricultural, commercial, and residential areas. Improper disposal could have occurred at various locations, while atmospheric deposition occurs across the entire watershed.

There is no definitive information on specific sources of elevated dieldrin load within the watershed at this time. Therefore, an average concentration on sediment is applied to all contributing areas, while sources of water that do not contribute sediment load, such as irrigation, are considered to provide no significant dieldrin loading. The average concentration of total dieldrin on incoming sediment was estimated to be < 1.0 µg/kg dry weight Table 10-39 – based on the average detection limit of samples), and the annual sediment load to Puddingstone Reservoir is 265.5 tons/yr (see Appendix D, Wet Weather Loading). The resulting estimated wet-weather load of dieldrin is approximately 0.24 g/yr (Table 10-39).

Table 10-39. Dieldrin Loads Estimated for Each Jurisdiction and Subwatershed in the Puddingstone Reservoir Watershed (g/yr)

Subwatershed	Responsible Jurisdiction	Input	Sediment Load (tons/yr)	Dieldrin Load (g/yr)	Percent of Total Load
Northern	Caltrans	State Highway Stormwater[1]	13.5	0.012	5.10%
Northern	Claremont	MS4 Stormwater[1]	4.5	0.004	1.69%
Northern	County of Los Angeles	MS4 Stormwater[1]	27.7	0.025	10.43%
Northern	La Verne[2]	MS4 Stormwater[1]	168	0.152	63.22%
Northern	General Industrial Stormwater Permittees (in the city of La Verne)	General Industrial Stormwater[1]	24.8	0.022	9.34%
Northern	General Construction Stormwater Permittees (in the city of La Verne)	General Construction Stormwater[1]	4.5	0.004	1.69%
Northern	Pomona	MS4 Stormwater[1]	0.5	0.000	0.18%
Northern	San Dimas	MS4 Stormwater[1]	1.6	0.001	0.62%
Northern	Angeles National Forest	Stormwater[1]	1.4	0.001	0.51%
Southern	Caltrans	State Highway Stormwater[1]	1.4	0.001	0.54%
Southern	La Verne	Runoff	1.2	0.001	0.47%
Southern	Pomona	Runoff	1.7	0.002	0.63%
Southern	San Dimas	Runoff	14.8	0.013	5.59%
Southern	County of Los Angeles	Parkland Irrigation	0.0	0.000	0.00%
Total Load from Watershed			**265.5**	**0.24**	**100.00%**

[1]This input includes effluent from storm drain systems during both wet and dry weather.

[2]The total area for the City of La Verne in the northern subwatershed is 4,079 acres. Discharges governed by the general construction and general industrial stormwater permits are located in the City of La Verne. The disturbed area associated with general construction and general industrial stormwater permittees (233 acres) was subtracted out of the appropriate city area and allocated to these permits.

As described in Appendix E (Atmospheric Deposition), Section E.5, the net atmospheric deposition of dieldrin directly to the lake surface is estimated to be close to zero, with deposited loads balanced by volatilization losses. Atmospheric deposition onto the watershed is implicitly included in the estimates of watershed load. Direct atmospheric deposition of dieldrin to the lake is accordingly assigned a load allocation of zero.

10.6.5 Linkage Analysis

The linkage analysis provides the quantitative basis for determining the loading capacity of dieldrin into Puddingstone Reservoir consistent with achieving water quality standards. The loading capacity is used to calculate the TMDL and corresponding allocations of that load to permitted point sources (wasteload allocations) and nonpoint sources (load allocations).

Lake sediments are often the predominant source of dieldrin in biota. The bottom sediment serves as a sink for organochlorine compounds that can be recycled through the aquatic life cycle. Dieldrin is strongly sorbed to sediments and has long half-lives in sediment and water. Incoming loads of dieldrin will mainly be adsorbed to particulates from stormwater runoff (eroded sediments from legacy contamination sites or from atmospheric deposition).

The use of bioaccumulation models and the fish tissue data from Puddingstone Reservoir are discussed in detail in Appendix H (Organochlorine Compounds TMDL Development) and Appendix G (Monitoring Data), respectively. The existing sediment dieldrin concentrations in Puddingstone Reservoir are lower than the consensus-based TEC target, and existing fish tissue concentrations are higher than the fish tissue target. Therefore, a sediment target based on biota-sediment bioaccumulation (a BSAF approach) is calculated from the smaller of the ratio of the FCG to existing fish tissue concentrations obtained from trophic level 4 fish (TL4; e.g., largemouth bass) and bottom-feeding, trophic level 3 fish (TL3; e.g., common carp). In general, the TL3 number is expected to be more restrictive due to the additional uptake of organochlorine compounds from the sediment by bottom-feeding fish. For dieldrin in Puddingstone Reservoir the ratios of the FCG to the existing fish concentrations (Table 10-38) are:

$$\text{TL4: } 0.46/1.2 = 0.3831$$

$$\text{TL3: } 0.46/2.7 = 0.1692$$

The lower ratio, obtained for the TL3 fish, is applied to the observed in-lake sediment concentration of 1.32 µg/kg dry weight to obtain the site-specific sediment target concentration to achieve fish tissue goals of 0.22 µg/kg dry weight. The fish tissue-based target concentrations were calculated using only recent data (collected in the past 10 years) because the loads and exposure concentrations for dieldrin are likely to have declined steadily since the cessation of production and use of the chemical. The resulting fish tissue-based target concentrations of dieldrin in the sediment of Puddingstone Reservoir is shown in Table 10-40.

Table 10-40. Fish Tissue-Based Dieldrin Concentration Targets for Sediment in Puddingstone Reservoir

Total Dieldrin Concentration	Sediment (µg/kg dry weight)
Existing	1.32
BSAF-derived Target	0.22
Required Reduction	83.3%

The BSAF-derived sediment target is less than the consensus-based sediment quality guideline TEC of 1.9 µg/kg dry weight. (The consensus-based sediment quality guideline is for the protection of benthic organisms, and explicitly does not address bioaccumulation and human-health risks from the consumption of contaminated fish.) The lower value of the consensus-based TEC target or the BSAF-derived target is selected as the final sediment target. In addition, the CTR criterion for human health (0.14 ng/L) is the selected numeric target for the water column and protects both aquatic life and human health.

The toxicant loading model described in Appendix H (Organochlorine Compounds TMDL Development) can be used to estimate the loading rate that would be required to yield the existing sediment concentration under steady-state conditions. This yields an estimate that a load of 1,500 g/yr would be required to maintain observed sediment concentrations under steady-state conditions. The estimated current watershed loading rate is 0.24 g/yr, or 0.02 percent of this amount. Therefore, impairment due to elevated fish tissue concentrations of dieldrin in Puddingstone Reservoir is primarily due to the storage of historic loads of dieldrin in the lake sediment.

10.6.6 TMDL Summary

Because dieldrin impairment in Puddingstone Reservoir is predominantly due to historic loads stored in the lake sediment, this impairment is not amenable to a standard, load-based TMDL analysis. Instead, allocations are first assigned on a concentration basis, with the goal of attaining the concentrations identified above for water and sediment, as well as fish tissue. The concentration targets apply to water and sediment entering the lake and within the lake. The dieldrin TMDL will be allocated to ensure achievement of the loading capacity. TMDLs are broken down into the wasteload allocations (WLAs), load allocations (LAs), and Margins of Safety (MOS) using the general TMDL equation.

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

Note that since this TMDL is being expressed as a concentration in sediment, in this scenario, the loading capacity is equal to 0.22 µg/kg dry weight dieldrin. The wasteload allocations and load allocations are also equal to 0.22 µg/kg dry weight dieldrin in sediment. There is no explicit MOS. Allocations are assigned for this TMDL by requiring equal concentrations of all sources. Details associated with the WLAs, LAs, and MOS are presented in the following three sections.

10.6.6.1 Wasteload Allocations

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). This TMDL establishes WLAs at their point of discharge. This TMDL also establishes alternative wasteload allocations for dieldrin ("Alternative WLAs if the Fish Tissue Target is Met") described in Section 10.6.6.1.2. The alternative wasteload allocations will supersede the wasteload allocations in Section 10.6.6.1.1 if the conditions described in Section 10.6.6.1.2 are met.

10.6.6.1.1 Wasteload Allocations

In the Puddingstone Reservoir watershed, wasteload allocations (WLAs) are required for all permittees in the northern subwatershed and Caltrans areas in the southern subwatershed. Relevant permit numbers are

- County of Los Angeles (including the cities of Claremont, La Verne, Pomona, and San Dimas): Board Order 01-182 (as amended by Order No. R4-2006-0074 and R4-2007-0042), CAS004001
- Caltrans: Order No 99-06-DWQ, CAS000003
- General Construction Stormwater: Order No. 2009-0009-DWQ, CAS000002

- General Industrial Stormwater: Order No. 97-03-DWQ, CAS000001

Dieldrin in water flowing into Puddingstone Reservoir is below detection limits, and most dieldrin load is expected to move in association with sediment. Therefore, suspended sediment in water flowing into the lake is assigned waste load allocations. Additionally, the TMDL establishes wasteload allocations for dieldrin in the water column equal to the CTR based water column target. The CTR based water column target includes both dissolved dieldrin and dieldrin associated with suspended sediment. The existing concentration on sediment entering the lake is estimated to be 1.0 µg/kg dry weight or less. Therefore, a reduction of up to (1.0 – 0.22)/1.0 = 78 percent is required on the sediment-associated load from the watershed.

The wasteload allocations are shown in Table 10-41 and each wasteload allocation must be met at the point of discharge.

Table 10-41. Wasteload Allocations for Dieldrin in Puddingstone Reservoir

Subwatershed	Responsible Jurisdiction	Input	Wasteload Allocation for Dieldrin Associated with Suspended Sediment[3] (µg/kg dry weight)	Wasteload Allocation for Dieldrin in the Water Column[3] (ng/L)
Northern	Caltrans	State Highway Stormwater[1]	0.22	0.14
Northern	Claremont	MS4 Stormwater[1]	0.22	0.14
Northern	County of Los Angeles	MS4 Stormwater[1]	0.22	0.14
Northern	La Verne[2]	MS4 Stormwater[1]	0.22	0.14
Northern	General Industrial Stormwater Permittees (in the city of La Verne)	General Industrial Stormwater[1]	0.22	0.14
Northern	General Construction Stormwater Permittees (in the city of La Verne)	General Construction Stormwater[1]	0.22	0.14
Northern	Pomona	MS4 Stormwater[1]	0.22	0.14
Northern	San Dimas	MS4 Stormwater[1]	0.22	0.14
Northern	Angeles National Forest	Stormwater[1]	0.22	0.14
Southern	Caltrans	State Highway Stormwater[1]	0.22	0.14

1 This input includes effluent from storm drain systems during both wet and dry weather.

2 Discharges governed by the general construction and general industrial stormwater permits are currently located in the City of La Verne. Any future discharges governed by the general construction and general industrial stormwater permits will receive the same concentration-based wasteload allocations.

3 Each wasteload allocation must be met at the point of discharge.

10.6.6.1.2 Alternative Wasteload Allocations if Fish Tissue Targets Are Met

The wasteload allocations listed in Table 10-41 will be superseded, and the wasteload allocations in Table 10-42 will apply, if:

1. The responsible jurisdictions submit to USEPA and the Regional Board material describing that the fish tissue target of 0.46 ppb wet weight has been met for the preceding three or more years. A demonstration that the fish tissue target has been met in any given year must at minimum include a composite sample of skin off fillets from at least five common carp each measuring at least 350mm in length,

4. The Regional Board Executive Officer approves the request and applies the alternative wasteload allocations in Table 10-42, and

2. USEPA does not object to the Regional Board's determination within 60 days of receiving notice of it.

Each wasteload allocation must be met at the point of discharge.

Table 10-42. Alternative Wasteload Allocations for Dieldrin in Puddingstone Reservoir if the Fish Tissue Target is Met

Subwatershed	Responsible Jurisdiction	Input	Wasteload Allocation for Dieldrin Associated with Suspended Sediment[3] (µg/kg dry weight)	Wasteload Allocation for Dieldrin in the Water Column[3] (ng/L)
Northern	Caltrans	State Highway Stormwater[1]	1.90	0.14
Northern	Claremont	MS4 Stormwater[1]	1.90	0.14
Northern	County of Los Angeles	MS4 Stormwater[1]	1.90	0.14
Northern	La Verne[2]	MS4 Stormwater[1]	1.90	0.14
Northern	General Industrial Stormwater Permittees (in the city of La Verne)	General Industrial Stormwater[1]	1.90	0.14
Northern	General Construction Stormwater Permittees (in the city of La Verne)	General Construction Stormwater[1]	1.90	0.14
Northern	Pomona	MS4 Stormwater[1]	1.90	0.14
Northern	San Dimas	MS4 Stormwater[1]	1.90	0.14
Northern	Angeles National Forest	Stormwater[1]	1.90	0.14
Southern	Caltrans	State Highway Stormwater[1]	1.90	0.14

[1] This input includes effluent from storm drain systems during both wet and dry weather.

[2] Discharges governed by the general construction and general industrial stormwater permits are currently located in the City of La Verne. Any future discharges governed by the general construction and general industrial stormwater permits will receive the same concentration-based wasteload allocations.

[3] Each wasteload allocation must be met at the point of discharge.

10.6.6.2 Load Allocations

This TMDL establishes load allocations (LAs) at their point of discharge. This TMDL also establishes alternative load allocations for dieldrin ("Alternative LAs if the Fish Tissue Target is Met") described in Section 10.6.6.2.2. The alternative load allocations will supersede the load allocations in Section 10.6.6.2.1 if the conditions described in Section 10.6.6.2.2 are met.

10.6.6.2.1 Load Allocations

Load allocations (LAs) are assigned to the non-Caltrans permittees in the southern subwatershed and lake bottom sediments. Additionally, the TMDL establishes load allocations for dieldrin in the water column equal to the CTR based water column target. The CTR based water column target includes both dissolved dieldrin and dieldrin associated with suspended sediment. No load is allocated to atmospheric deposition of dieldrin. The legacy dieldrin stored in lake sediment is the major cause of use impairment associated with elevated fish tissue concentrations, and is assigned a load allocation. The in-lake allocation is in concentration terms: specifically, the responsible jurisdiction (County of Los Angeles) should achieve a dieldrin concentration of 0.22 µg/kg dry weight in lake bottom sediments (Table 10-43). Each load allocation must be met at the point of discharge, except for the lake bottom sediment load allocation which must be met in the lake.

Table 10-43. Load Allocations for Dieldrin in Puddingstone Reservoir

Subwatershed	Responsible Jurisdiction	Input	Load Allocation (µg/kg dry weight)
Southern	La Verne	Runoff[1]	0.22
Southern	Pomona	Runoff[1]	0.22
Southern	San Dimas	Runoff[1]	0.22
Southern	County of Los Angeles	Parkland Irrigation[1]	0.22
Lake Surface	County of Los Angeles	Lake bottom sediments[2]	0.22

[1] Each load allocation must be met at the point of discharge.

[2] The load allocation must be met in the lake.

10.6.6.2.2 Alternative Load Allocations if the Fish Tissue Target is Met

The load allocations listed in Table 10-43 will be superseded, and the load allocations in Table 10-44 will apply, if:

1. The responsible jurisdiction submits to USEPA and the Regional Board material describing that the fish tissue target of 0.46 ppb wet weight has been met for the preceding three or more years. A demonstration that the fish tissue target has been met in any given year must at minimum include a composite sample of skin off fillets from at least five largemouth bass each measuring at least 350mm in length,
2. The Regional Board Executive Officer approves the request and applies the alternative load allocations in Table 10-44, and
3. USEPA does not object to the Regional Board's determination within 60 days of receiving notice of it.

Each load allocation must be met at the point of discharge, except for the lake bottom sediment load allocation which must be met in the lake.

Table 10-44. Alternative Load Allocations for Dieldrin in Puddingstone Reservoir if the Fish Tissue Target is Met

Subwatershed	Responsible Jurisdiction	Input	Load Allocation (µg/kg dry weight)
Southern	La Verne	Runoff[1]	1.90
Southern	Pomona	Runoff[1]	1.90
Southern	San Dimas	Runoff[1]	1.90
Southern	County of Los Angeles	Parkland Irrigation[1]	1.90
Lake Surface	County of Los Angeles	Lake bottom sediments[2]	1.90

[1] Each load allocation must be met at the point of discharge.

[2] The load allocation must be met in the lake.

10.6.6.3 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 TMDL contains an implicit MOS based on conservative assumptions. The allocations are set based on the lower of either the BSAF-derived sediment target or the consensus-based TEC sediment target to ensure achievement of the OEHHA FCG target in fish tissue. The selected BSAF-derived target concentration in sediment is considerably lower than the consensus-based TEC target.

10.6.6.4 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. This TMDL protects beneficial uses by reducing fish tissue concentrations to the FCG target and protecting benthic biota in sediment. Because fish bioaccumulate dieldrin, concentrations in tissues of edible-sized game fish integrate exposure over a number of years. As a result, overall average loading is more important for the attainment of standards than instantaneous or daily concentrations. WLAs and LAs in this TMDL are assigned as concentrations and protect during all seasons and in both high and low flow conditions. This TMDL therefore protects for critical conditions.

10.6.6.5 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. This TMDL includes a maximum daily load estimated according to the guidelines provided by USEPA (2007).

Because the dieldrin WLAs are expressed as concentrations on sediment, the daily maximum allowable load is calculated from the maximum daily sediment load multiplied by the TMDL WLA concentration. The maximum daily sediment load is estimated from the 99th percentile daily flow and the sediment event mean concentration that yields the estimated annual sediment load.

No USGS gage currently exists in the Puddingstone Reservoir watershed. USGS Station 11086400, San Dimas Creek near San Dimas, CA, was selected as a surrogate for flow determination. The 99th percentile flow was chosen to represent the peak flow for this drainage. Choosing the 99th percentile flow eliminates errors due to outliers and is reasonable for development of a daily load expression.

The USGS StreamStats program was used to determine the 99th percentile flow for San Dimas Creek (55 cfs) (Wolock, 2003). To estimate the peak flow to Puddingstone Reservoir, the 99th percentile flow for San Dimas Creek was scaled down by the ratio of drainage areas (8,128 acres/11,712 acres; Puddingstone Reservoir watershed area/San Dimas Creek watershed area at the gage). The resulting peak flow estimate for Puddingstone Reservoir is 38.2 cfs.

The event mean concentration of sediment in stormwater (45.5 mg/L) was calculated from the estimated existing watershed sediment load of 265.5 tons/yr (Table 10-39) divided by the total annual wet weather flow volume delivered to the lake (4,295 ac-ft/yr). Multiplying the sediment event mean concentration by the 99th percentile peak daily flow (38.2 cfs) yields a daily maximum sediment load from stormwater of 4,249 kg/d (4.7 tons/d). Applying the wasteload allocation concentration of 0.22 µg dieldrin per dry kg of sediment yields the stormwater daily maximum allowable load of 0.00086 g/d of dieldrin. This load is associated with the MS4 stormwater permittees. The maximum allowable daily load must be met on all days, and the concentration-based WLAs must be met to ensure compliance with the TMDL.

10.6.6.6 Future Growth

The manufacture and use of dieldrin is currently banned. Therefore, no additional allowance is made for future growth in the dieldrin TMDL.

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).

10.7 DDT Impairment

Dichlorodiphenyltrichloroethane (DDT) is a synthetic organochlorine insecticide once used throughout the world to control insects. Technically DDT consists of two isomers, 4,4’-DDT and 2,4’-DDT, of which the former is the most toxic. In the environment, DDT breaks down to form two related compounds: DDD (tetrachlorodiphenylethane) and DDE (dichlorodiphenyl-dichloroethylene). DDD and DDE often predominate in the environment and USEPA (2000c) recommends that fish consumption guidelines be based on the sum of DDT, DDD, and DDE – collectively referred to as total DDTs.

The DDT impairment of Puddingstone Reservoir affects beneficial uses related to recreation, municipal water supply, wildlife health, and fish consumption. DDT, like PCBs and chlordane, is an organochlorine compound that is strongly sorbed to sediment and lipids, and is no longer in production. As such, the approach for the DDT impairment is similar to that for PCBs and chlordane.

10.7.1 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 Puddingstone Reservoir include REC1, REC2, WARM, WILD, MUN, GWR, COLD, RARE, and AGR. Descriptions of these uses are listed in Section 2 of this TMDL report. Elevated levels of DDT are currently impairing the REC1, REC2, WARM, and COLD uses by causing toxicity to aquatic organisms and raising fish tissue concentrations to levels that are unsafe for human consumption (which can result in fish consumption advisories) and impair sport fishing recreational uses. At high enough concentrations WILD, MUN, GWR and RARE uses could become impaired.

10.7.2 Numeric Targets

Targets for DDT are complex because of the many different ways in which the compound is measured. The Basin Plan designates water column concentrations associated with MUN and WARM beneficial uses for several DDTs. There are no numeric criteria specified for sediment or fish tissue concentrations of DDTs listed in the Basin Plan. For the purposes of this TMDL, additional numeric targets for these endpoints are based on the consensus-based sediment quality guidelines defined in MacDonald et al. (2000) and the fish tissue concentration goal, referred to as the fish contaminant goal (FCG), defined by OEHHA (2008) for fish consumption. The numeric targets used for DDTs are listed below. The fish tissue concentration goal was also used to back calculate site-specific targets in sediment, with the most stringent target applying. See Section 2 of this TMDL report for additional details.

The water column criteria for DDT in the Basin Plan are associated with a specific beneficial use. The Basin Plan also contains a narrative criterion that toxic chemicals not be present at levels that are toxic or detrimental to aquatic life (LARWQCB, 1994). Each waterbody addressed in this report is designated WARM, at a minimum, and must meet this requirement. Acute and chronic criteria for 4,4'-DDT in freshwater systems are included in the CTR as 1.1 µg/L and 0.001 µg/L, respectively (USEPA, 2000a). CTR criteria are considered protective of aquatic life. Acute and chronic values for other DDT compounds were not specified. The CTR also includes human health criteria for 4,4'-DDT for the consumption of water and organisms or organisms only as 0.00059 µg/L for both uses (USEPA, 2000a). Because the human health criterion is the most restrictive applicable criterion, a water column target of 0.00059 µg/L (0.59 ng/L) for 4,4'-DDT is the appropriate target. The CTR also specifies a criterion of 0.59 ng/L for 4,4'-DDE (for both consumption of water and organisms or organisms only), while for 4,4'-DDD the criteria are 0.83 ng/L for consumption of water and organisms and 0.84 ng/L for consumption of organisms only. For Puddingstone Reservoir, there is an existing MUN use, so the water and organisms criteria are the appropriate targets. This TMDL the DDT, DDD, and DDE targets in CTR are selected as water column targets.

For sediment, the consensus-based sediment quality guidelines provided in MacDonald et al. (2000) for the threshold effects concentration (TEC) for 4,4'- plus 2,4'-DDT is 4.16 µg/kg dry weight, and the TEC for total DDTs is 5.28 µg/kg dry weight. The consensus-based guidelines have been incorporated into the most recent set of NOAA Screening Quick Reference Tables (SQuiRT) (Buchman, 2008) and are recommended by the State Water Resources Control Board for interpretation of narrative sediment objectives under the 303(d) listing policy. These targets are designed to protect benthic dwelling organisms and explicitly do not consider "the potential for bioaccumulation in aquatic organisms nor the associated hazards to the species that consume aquatic organisms (i.e., wildlife and humans)." Thus, a separate sediment target calculation based on a biota-sediment accumulation factor (BSAF) is carried out to ensure that fish tissue concentration goals are met.

The fish contaminant goal for total DDTs defined by OEHHA (2008) is 21 ppb wet weight in muscle tissue (filets). Elevated fish tissue concentrations are largely attributable to foodweb bioaccumulation derived from contaminated sediment. A biota-sediment accumulation factor (BSAF) approach is appropriate to correlate sediment and fish tissue targets. For DDTs, the corresponding sediment target concentration determined using the BSAF is 3.94 µg/kg dry weight, as described in further detail in Section 10.7.5. All applicable targets are shown below in Table 10-45. For sediment, the lower value of the consensus-based TEC target or the BSAF-derived target is selected as the final sediment target.

Table 10-45. DDT Targets Applicable to Puddingstone Reservoir

Medium	Source	4,4'-DDT	4,4'-DDT + 2,4'-DDT	DDE[1]	DDD[1]	Total DDTs
Fish (ppb wet weight)	OEHHA FCG					21
Sediment (µg/kg dry weight)	Consensus-based TECs		4.16	3.16[1]	4.88[1]	5.28
Sediment (µg/kg dry weight)	BSAF-derived target					3.94
Water (ng/L)	CTR	0.59		0.59[1]	0.83[1]	

[1] Consensus-based TECs specify sediment targets for total DDE and total DDD. The CTR specifies water column targets specifically for 4,4'-DDE and 4,4'-DDD.

Note: Shaded cells represent the selected targets for this TMDL.

10.7.3 Summary of Monitoring Data

This section summarizes the monitoring data for Puddingstone Reservoir related to the DDT impairment. Additional details regarding monitoring data are discussed in Appendix G (Monitoring Data).

Water column sampling was conducted as part of an organics study performed by UCLA (funded by a grant managed by the Regional Board) in the fall of 2008. These analyses quantified only the 4,4' isomers of DDT, DDD, and DDE. Of four samples (two in Live Oak Wash and two in-lake stations), total DDT was consistently below the detection limits (3.0 ng/L to 3.14 ng/L; the detection limit for total DDT is higher than the water column criterion of 0.59 ng/L).

Water samples from Puddingstone Reservoir were also collected by USEPA and/or the Regional Board on November 18, 2008 at five stations (four in-lake stations and one station in Live Oak Wash) and July 16, 2009 at four stations (Live Oak Wash, storm drain, and two in-lake locations). These analyses included both the 4,4' and 2,4' isomers. Total DDT at all stations was below the detection limit of 1 ng/L, which is above the CTR water column target of 0.59 ng/L. A summary of the water column data is shown in Table 10-46.

Table 10-46. Summary of Water Column Samples for Total DDT in Puddingstone Reservoir

Station	Average Water Concentration (ng/L)	Number of Samples	Number of Samples above Detection Limits[1]
PR-11 (Live Oak Channel)	(1.01)[2]	4	0
PR-14 (Northeast Reservoir Side)	(1.01)	2	0
PR-15 (Western Reservoir Side)	(0.86)	3	0
PR-16 (Southern Reservoir Side)	(0.50)	2	0
PR-17 (Western Reservoir Side near Shoreline)	(0.50)	1	0
PR-SD2 (Storm drain in northeast reservoir area)	(0.50)	1	0
In-Lake Average[3] (PR-14, 15, 16, 17)	(0.72)		
CTR Water Column Target	0.59		

[1] Non-detect samples were included in reported averages at one-half of the sample detection limit.

[2] Numbers in parentheses indicate that the sample is based only on the detection limits of the samples, and that no DDTs were quantified in any of the collected samples.

[3] Overall average is the average of individual station averages.

Pollutant concentrations associated with suspended sediments in the lake were analyzed at two in-lake stations as well as Live Oak Wash during the fall of 2008 by UCLA. Concentrations of total DDT in the suspended sediment samples were less than the detection limits at all three stations (4 µg/kg to 72 µg/kg dry weight). A composite sample during a wet weather event did not detect any DDT (detection limit of 3.14 µg/kg dry weight). A grab sample at the outlet of Live Oak Wash was collected 90 minutes into the wet weather event, which had no detectable results (detection limit of 5.39 µg/kg dry weight). Water column samples were also collected during this event (a time series composite and a single time point sample), but not analyzed. Total DDT concentrations were analyzed in porewater; all samples were less than the detection limit of 30 ng/L. The total suspended sediment associated with the porewater samples also had DDT concentrations less than the detection limits (0.4 µg/kg to 1.06 µg/kg dry weight).

UCLA collected bed sediment samples at two in-lake locations (total of six individual samples) in Puddingstone Reservoir in fall 2008. As with the UCLA water column samples, these included only the 4,4' isomers. Total DDT was consistently below detection limits (0.77 µg/kg to 3.17 µg/kg dry weight). Sediment sampling was also conducted by USEPA and the Regional Board at six stations on July 16, 2009 (Live Oak Wash, two in-lake stations, two storm drain stations, and one natural drainage). Total DDT (including both the 4,4' and 2,4' isomers) was detected at five of the six stations with values ranging from non-detect to 18.6 µg/kg dry weight (four of the six samples had a concentration exceeding the sediment consensus-based TEC of 5.28 µg/kg dry weight). A summary of the sediment data is shown in Table 10-47. The lake-wide average of 7.44 µg/kg is greater than the concentration associated with inputs (5.5 µg/kg), and both are above the consensus-based TEC of 5.28 µg/kg dry weight.

Table 10-47. Summary of Sediment Samples for Total DDT in Puddingstone Reservoir

Station	Average Sediment Concentration (µg/kg dry weight)[1]	Number of Samples	Number of Samples above Detection Limits	Number of Samples between Detection and Reporting Limits
PR-11 (Live Oak Channel)	5.2	1	1	0
PR-14 (Northeast Reservoir Side)	(0.44)	2	0	0
PR-15 (Western Reservoir Side)	10.07	2	1	0
PR-16 (Southern Reservoir Side)	11.8	2	2	0
PR-19 (Natural Drainage on South Side)	7.80	1	1	0
PR-19SD (Storm Drain on South Side)	8.50	1	1	0
PR-SD2 (Storm drain in northeast reservoir area)	(0.50)	1	0	0
In-Lake Average[2] (PR-14, 15, 16)	7.44			
Influent Average	5.50			
Consensus-based TEC[3]	5.28			

[1] Total DDT in a sample represents the sum of all reported measurements for DDT, DDE, and DDD isomers, including results reported below the method reporting limit. If all components were non-detect, the total is represented as one-half the detection limit. Results of any laboratory duplicate analyses of the same sample were averaged. Results for each station represent the average of individual samples. Results in parentheses indicate that the sample average is based only on the detection limits of the samples and that no chlordane quantified in any of the collected samples. Sample averages based only on detected results below the reporting limit plus non-detects are shown in square brackets.

[2] Overall average is the average of individual station averages.

[3] CBSQC TEC is for Total DDTs (DDDs + DDEs + DDTs)

Fish tissue concentrations of total DDT from Puddingstone Reservoir have been analyzed in largemouth bass, common carp, bullhead, and brown bullhead (SWAMP and TSMP). Eight fish samples (composites of filets from five fish) were collected and analyzed for total DDT between 1986 and 1999. In 1986, a largemouth bass and common carp sample reported 16 ppb and 880 ppb wet weight, respectively, while in 1987 another common carp sample had a concentration of 358 ppb wet weight and a bullhead sample reported a concentration of 70 ppb wet weight. In 1988, the reported concentration associated with a brown bullhead sample was 72 ppb wet weight. Three largemouth bass samples had concentrations of 25 ppb, 36 ppb, and 10.7 ppb wet weight in 1991, 1992, and 1999, respectively. The average reported total DDT concentration in all samples from the 1980s and 1990s was 183.5 ppb wet weight. Results from the individual samples are shown in Appendix G (Monitoring Data).

More recently, SWAMP collected samples in September 2004 and June 2007. Considering only data collected in the past 10 years, the average concentration of total DDT in largemouth bass was 24.3 ppb wet weight (average lipid fraction of 0.98 percent), and the average concentration of total DDT in common carp was 39.7 ppb wet weight average lipid fraction of 3.6 percent. The recent fish-tissue data for Puddingstone Reservoir are summarized in Table 10-48.

Table 10-48. Summary of Recent Fish Tissue Samples for Total DDT in Puddingstone Reservoir

Sample Date	Fish Species	Total DDT (ppb wet weight)[1]
9/22/2004	Largemouth Bass	33.7
9/22/2004	Largemouth Bass	15.6
9/22/2004	Largemouth Bass	35.3
9/22/2004	Largemouth Bass	19.4
9/22/2004	Common Carp	2.5
9/22/2004	Common Carp	69.4
9/22/2004	Common Carp	47.7
9/22/2004	Common Carp	39.1
6/6/2007	Largemouth Bass	30.8
6/6/2007	Largemouth Bass	10.8
2004-2007 Average - Largemouth Bass		24.3
2004 Average - Common Carp		39.7
FCG		21

[1] Composite sample of filets from five (largemouth bass) or three individuals (common carp).

In sum, recent fish tissue samples collected from Puddingstone are elevated above OEHHA fish consumption guidelines for total DDT (21 ppb) in three of the six largemouth bass samples and three of the four common carp samples (the average concentrations are also greater than the FCG). Concentrations in sediment are, on average, above the consensus-based TEC, indicating that the lake continues to be impaired by DDT. Water column samples have all been below detection limits; however, all of the detection limits exceeded the CTR criterion.

10.7.4 Source Assessment

Total DDTs present in Puddingstone Reservoir are primarily due to historical loading and storage within the lake sediments, with some ongoing contribution by watershed wet weather loads. Dry weather loading is assumed to be negligible because hydrophobic contaminants primarily move with particulate matter that is mobilized by higher flows. Stormwater loads from the watershed were estimated based on simulated sediment load and observed DDT concentrations on sediment data near inflows to the lake. Watershed loads of DDT may arise from past pesticide applications, improper disposal, and atmospheric deposition. Pesticide applications were most likely associated with agricultural, commercial, and residential areas. Improper disposal could have occurred at various locations, while atmospheric deposition occurs across the entire watershed.

There is no definitive information on specific sources of elevated DDT load within the watershed at this time. Therefore, an average concentration on sediment is applied to all contributing areas, while sources of water that do not contribute sediment load, such as irrigation, are considered to provide no significant DDT loading.

The average concentration of total DDTs on incoming sediment was estimated to be 5.5 µg/kg dry weight (Table 10-47), and the annual sediment load to Puddingstone Reservoir is 265.5 tons/yr (see Appendix D, Wet Weather Loading). The resulting estimated wet-weather load of total DDTs is approximately 1.3 g/yr (Table 10-49).

Table 10-49. Total DDTs Loads Estimated for Each Jurisdiction and Subwatershed in the Puddingstone Reservoir Watershed (g/yr)

Subwatershed	Responsible Jurisdiction	Input	Sediment Load (tons/yr)	Total DDT Load (g/yr)	Percent of Total Load
Northern	Caltrans	State Highway Stormwater[1]	13.5	0.068	5.10%
Northern	Claremont	MS4 Stormwater[1]	4.5	0.022	1.69%
Northern	County of Los Angeles	MS4 Stormwater[1]	27.7	0.138	10.44%
Northern	La Verne[2]	MS4 Stormwater[1]	168	0.838	63.23%
Northern	General Industrial Stormwater Permittees (in the city of La Verne)	General Industrial Stormwater[1]	24.8	0.124	9.34%
Northern	General Construction Stormwater Permittees (in the city of La Verne)	General Construction Stormwater[1]	4.5	0.022	1.69%
Northern	Pomona	MS4 Stormwater[1]	0.5	0.002	0.18%
Northern	San Dimas	MS4 Stormwater[1]	1.6	0.008	0.62%
Northern	Angeles National Forest	Stormwater[1]	1.4	0.007	0.51%
Southern	Caltrans	State Highway Stormwater[1]	1.4	0.007	0.54%
Southern	La Verne	Runoff	1.2	0.006	0.47%
Southern	Pomona	Runoff	1.7	0.008	0.63%

Subwatershed	Responsible Jurisdiction	Input	Sediment Load (tons/yr)	Total DDT Load (g/yr)	Percent of Total Load
Southern	San Dimas	Runoff	14.8	0.074	5.59%
Southern	County of Los Angeles	Parkland Irrigation	0.0	0.00	0.00%
Total Load from Watershed			**265.5**	**1.32**	**100.00%**

[1]This input includes effluent from storm drain systems during both wet and dry weather.

[2]The total area for the City of La Verne in the northern subwatershed is 4,079 acres. Discharges governed by the general construction and general industrial stormwater permits are located in the City of La Verne. The disturbed area associated with general construction and general industrial stormwater permittees (233 acres) was subtracted out of the appropriate city area and allocated to these permits.

As described in Appendix E (Atmospheric Deposition), Section E.5, the net atmospheric deposition of total DDT directly to the lake surface is estimated to be close to zero, with deposited loads balanced by volatilization losses. Atmospheric deposition onto the watershed is implicitly included in the estimates of watershed load. Direct atmospheric deposition of total DDT to the lake is accordingly assigned a load allocation of zero.

10.7.5 Linkage Analysis

The linkage analysis provides the quantitative basis for determining the loading capacity for DDTs in Puddingstone Reservoir consistent with achieving water quality standards. The loading capacity is used to calculate the TMDL and corresponding allocations of that load to permitted, point sources (wasteload allocations) and other nonpoint sources (load allocations). Lake sediments are often the predominant source of DDT in biota. The bottom sediment serves as a sink for organochlorine compounds that can be recycled through the aquatic life cycle. DDT is strongly sorbed to sediment and has a long half-life in sediment and water. Incoming loads of DDT will mainly be adsorbed to particulates from stormwater runoff (eroded sediments from legacy contamination sites or from atmospheric deposition).

The use of bioaccumulation models and the fish tissue data in Puddingstone Reservoir are discussed in detail in Appendix H (Organochlorine Compounds TMDL Development) and Appendix G (Monitoring Data), respectively. A sediment target to achieve FCGs is calculated based on biota-sediment bioaccumulation (a BSAF approach), using the smaller of the ratio of the FCG to existing fish tissue concentrations obtained from trophic level 4 fish (TL4; e.g., largemouth bass) and bottom-feeding, trophic level 3 fish (TL3; e.g., common carp). In general, the TL3 number is expected to be more restrictive due to the additional uptake of organochlorine compounds from the sediment by bottom-feeding fish. For DDT in Puddingstone Reservoir the ratios of the FCG to the existing fish concentrations (Table 10-48) are:

$$\text{TL4: } 21.0/24.3 = 0.8653$$

$$\text{TL3: } 21.0/39.7 = 0.5296$$

The smaller ratio, obtained for the TL3 fish, is applied to the estimated lake sediment concentration of 7.44 µg/kg dry weight to obtain the site-specific sediment target concentration to maintain fish tissue goals of 3.94 µg/kg dry weight. The fish tissue-based target concentrations were calculated using only recent data (collected in the past 10 years) because the loads and exposure concentrations of total DDT are likely to have declined steadily since the cessation of production and use of the chemical. The resulting fish tissue-based target concentrations of DDT in sediment of Puddingstone Reservoir is shown in Table 10-50.

Table 10-50. Fish Tissue-Based Total DDTs Concentrations for Sediment in Puddingstone Reservoir

Total DDTs Concentration	Sediment (µg/kg dry weight)
Existing	7.44
BSAF-derived Target	3.94
Required Reduction	47.0%

The BSAF-derived sediment target is less than the consensus-based TEC for total DDTs of 5.28 µg/kg dry weight. (The consensus-based sediment quality guideline is for the protection of benthic organisms, and explicitly does not address bioaccumulation and human-health risks from the consumption of contaminated fish) The lower value of the consensus-based TEC target or the BSAF-derived target is selected as the final sediment target.

The toxicant loading model described in Appendix H (Organochlorine Compounds TMDL Development) can be used to estimate the loading rate that would be required to yield the existing sediment concentration under steady-state conditions. This yields an estimate that a load of 218 g/yr would be required to maintain observed sediment concentrations under steady-state conditions. The estimated current watershed loading rate is 1.32 g/yr, or 0.6 percent of this amount. Thus, concentrations of total DDTs in fish tissue in Puddingstone Reservoir appear to be primarily due to the storage of historic loads of DDT in the lake sediment.

10.7.6 TMDL Summary

Because DDT impairment in Puddingstone Reservoir is predominantly due to historic loads stored in the lake sediment, this impairment is not amenable to a standard, load-based TMDL analysis. Instead, allocations are first assigned on a concentration basis, with the goal of attaining the concentrations identified above for water and sediment, as well as fish tissue. The concentration targets apply to water and sediment entering the lake and within the lake.

The DDT TMDL will be allocated to ensure achievement of the loading capacity. TMDLs are broken down into the wasteload allocations (WLAs), load allocations (LAs), and Margins of Safety (MOS) using the general TMDL equation.

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

Note that since this TMDL is being expressed as a concentration in sediment, in this scenario, the loading capacity is equal to 3.94 µg/kg dry weight total DDTs. The wasteload allocations and load allocations are also equal to 3.94 µg/kg dry weight total DDTs in sediment. There is no explicit MOS. Allocations are assigned for this TMDL by requiring equal concentrations of all sources. Details associated with the WLAs, LAs, and MOS are presented in the following three sections.

10.7.6.1 Wasteload Allocations

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). This TMDL establishes WLAs at their point of discharge. This TMDL also establishes alternative wasteload allocations for total DDTs (“Alternative WLAs if the Fish Tissue Target is Met”) described in Section 10.7.6.1.2. The alternative wasteload allocations will supersede the wasteload allocations in Section 10.7.6.1.1 if the conditions described in Section 10.7.6.1.2 are met.

10.7.6.1.1 Wasteload Allocations

In the Puddingstone Reservoir watershed, wasteload allocations (WLAs) are required for all permittees in the northern subwatershed and Caltrans areas in the southern subwatershed. Relevant permit numbers are

- County of Los Angeles (including the cities of Claremont, La Verne, Pomona, and San Dimas): Board Order 01-182 (as amended by Order No. R4-2006-0074 and R4-2007-0042), CAS004001
- Caltrans: Order No 99-06-DWQ, CAS000002
- General Construction Stormwater: Order No. 2009-0009-DWQ, CAS000002
- General Industrial Stormwater: Order No. 97-03-DWQ, CAS000001

DDT in water flowing into Puddingstone Reservoir is below detection limits, and most DDT load is expected to move in association with sediment. Therefore, suspended sediment in water flowing into the lake is assigned wasteload allocations. Additionally, the TMDL establishes wasteload allocations for DDT in the water column equal to the CTR based water column target. The CTR based water column target includes both dissolved DDT and DDT associated with suspended sediment. The existing concentration of sediment entering the lake is 5.5 µg/kg dry weight. Therefore, a reduction of 28.4 percent [(5.5 – 3.94)/5.5*100] is required on the sediment-associated load from the watershed. The reduction in watershed load is less than the reduction needed for in-lake sediments because the estimated concentration on influent sediment is below the lake-wide average.

The wasteload allocations are shown in Table 10-51 and each wasteload allocation must be met at the point of discharge.

Table 10-51. Wasteload Allocations for DDT in Puddingstone Reservoir

Subwatershed	Responsible Jurisdiction	Input	Wasteload Allocation for Total DDTs Associated with Suspended Sediment[3] (µg/kg dry weight)	Wasteload Allocation for 4-4' DDT in the Water Column[3,4] (ng/L)
Northern	Caltrans	State Highway Stormwater[1]	3.94	0.59[3]
Northern	Claremont	MS4 Stormwater[1]	3.94	0.59
Northern	County of Los Angeles	MS4 Stormwater[1]	3.94	0.59
Northern	La Verne[2]	MS4 Stormwater[1]	3.94	0.59
Northern	General Industrial Stormwater Permittees (in the city of La Verne)	General Industrial Stormwater[1]	3.94	0.59
Northern	General Construction Stormwater Permittees (in the city of La Verne)	General Construction Stormwater[1]	3.94	0.59
Northern	Pomona	MS4 Stormwater[1]	3.94	0.59
Northern	San Dimas	MS4 Stormwater[1]	3.94	0.59
Northern	Angeles National Forest	Stormwater[1]	3.94	0.59

Subwatershed	Responsible Jurisdiction	Input	Wasteload Allocation for Total DDTs Associated with Suspended Sediment[3] (µg/kg dry weight)	Wasteload Allocation for 4-4' DDT in the Water Column[3,4] (ng/L)
Southern	Caltrans	State Highway Stormwater[1]	3.94	0.59

[1] This input includes effluent from storm drain systems during both wet and dry weather.

[2] Discharges governed by the general construction and general industrial stormwater permits are currently located in the City of La Verne. Any future discharges governed by the general construction and general industrial stormwater permits will receive the same concentration-based wasteload allocations.

[3] Each wasteload allocation must be met at the point of discharge.

[4] The target water column concentration of 0.59 ng/L specified in the CTR is for 4,4'-DDT. The CTR also specifies targets for DDE and DDD, but does not specify a target for total DDTs. The lowest DDT target is selected for the purposes of representing Total DDTs in this table. If analytical results that resolve individual DDT compounds are available, all of the CTR criteria should be applied individually.

10.7.6.1.2 Alternative Wasteload Allocations if the Fish Tissue Target is Met

The wasteload allocations listed in Table 10-51 will be superseded, and the wasteload allocations in Table 10-52 will apply, if:

1. The responsible jurisdictions submit to USEPA and the Regional Board material describing that the fish tissue target of 21 ppb wet weight has been met for the preceding three or more years. A demonstration that the fish tissue target has been met in any given year must at minimum include a composite sample of skin off fillets from at least five common carp each measuring at least 350mm in length,
2. The Regional Board Executive Officer approves the request and applies the alternative wasteload allocations in Table 10-52, and
3. USEPA does not object to the Regional Board's determination within 60 days of receiving notice of it.

Each wasteload allocation must be met at the point of discharge.

Table 10-52. Alternative Wasteload Allocations for DDT in Puddingstone Reservoir if the Fish Tissue Target is Met

Subwatershed	Responsible Jurisdiction	Input	Wasteload Allocation for Total DDTs Associated with Suspended Sediment[3] (µg/kg dry weight)	Wasteload Allocation for 4-4' DDT in the Water Column (ng/L)[3,4]
Northern	Caltrans	State Highway Stormwater[1]	5.28	0.59
Northern	Claremont	MS4 Stormwater[1]	5.28	0.59
Northern	County of Los Angeles	MS4 Stormwater[1]	5.28	0.59
Northern	La Verne[2]	MS4 Stormwater[1]	5.28	0.59
Northern	General Industrial Stormwater Permittees (in the city of La Verne)	General Industrial Stormwater[1]	5.28	0.59

Subwatershed	Responsible Jurisdiction	Input	Wasteload Allocation for Total DDTs Associated with Suspended Sediment[3] (µg/kg dry weight)	Wasteload Allocation for 4-4' DDT in the Water Column (ng/L)[3,4]
Northern	General Construction Stormwater Permittees (in the city of La Verne)	General Construction Stormwater[1]	5.28	0.59
Northern	Pomona	MS4 Stormwater[1]	5.28	0.59
Northern	San Dimas	MS4 Stormwater[1]	5.28	0.59
Northern	Angeles National Forest	Stormwater[1]	5.28	0.59
Southern	Caltrans	State Highway Stormwater[1]	5.28	0.59

[1]This input includes effluent from storm drain systems during both wet and dry weather.

[2]Discharges governed by the general construction and general industrial stormwater permits are currently located in the City of La Verne. Any future discharges governed by the general construction and general industrial stormwater permits will receive the same concentration-based wasteload allocations.

[3]Each wasteload allocation must be met at the point of discharge.

[4]The target water column concentration of 0.59 ng/L specified in the CTR is for 4,4'-DDT. The CTR also specifies targets for DDE and DDD, but does not specify a target for total DDTs. The lowest DDT target is selected for the purposes of representing Total DDTs in this table. If analytical results that resolve individual DDT compounds are available, all of the CTR criteria should be applied individually.

10.7.6.2 Load Allocations

This TMDL establishes load allocations (LAs) at their point of discharge. This TMDL also establishes alternative load allocations for DDTs ("Alternative LAs if the Fish Tissue Target is Met") described in Section 10.7.6.2.2. The alternative load allocations will supersede the load allocations in Section 10.7.6.2.1 if the conditions described in Section 10.7.6.2.2 are met.

10.7.6.2.1 Load Allocations

Load allocations (LAs) are assigned to the non-Caltrans permittees in the southern subwatershed and lake bottom sediments. Additionally, the TMDL establishes load allocations for DDTs in the water column equal to the CTR based water column target. The CTR based water column target includes both dissolved DDTs and total DDTs associated with suspended sediment. No load is allocated to atmospheric deposition of total DDTs. The legacy DDT stored in lake sediment is the major cause of exposure to aquatic organisms and sport fish, and is assigned a load allocation. The in-lake allocation is in concentration terms: specifically, the responsible jurisdiction (County of Los Angeles) should achieve a total DDTs concentration of 3.94 µg/kg dry weight in lake bottom sediments in (Table 10-53). Each load allocation must be met at the point of discharge, except for the lake bottom sediment load allocation which must be met in the lake.

Table 10-53. Load Allocations for Total DDTs in Puddingstone Reservoir

Subwatershed	Responsible Jurisdiction	Input	Load Allocation (µg/kg dry weight)
Southern	La Verne	Runoff[1]	3.94
Southern	Pomona	Runoff[1]	3.94
Southern	San Dimas	Runoff[1]	3.94

Subwatershed	Responsible Jurisdiction	Input	Load Allocation (µg/kg dry weight)
Southern	County of Los Angeles	Parkland Irrigation[1]	3.94
Lake Surface	County of Los Angeles	Lake bottom sediments[2]	3.94

[1] Each load allocation must be met at the point of discharge.

[2] The load allocation must be met in the lake.

10.7.6.2.2 Alternative Load Allocations if the Fish Tissue Target is Met

The load allocations listed in Table 10-53 will be superseded, and the load allocations in Table 10-54 will apply, if:

1. The responsible jurisdiction submits to USEPA and the Regional Board material describing that the fish tissue target of 21 ppb wet weight has been met for the preceding three or more years. A demonstration that the fish tissue target has been met in any given year must at minimum include a composite sample of skin off fillets from at least five largemouth bass each measuring at least 350mm in length,
2. The Regional Board Executive Officer approves the request and applies the alternative load allocations in Table 10-54, and
3. USEPA does not object to the Regional Board's determination within 60 days of receiving notice of it.

Each load allocation must be met at the point of discharge, except for the lake bottom sediment load allocation which must be met in the lake.

Table 10-54. Alternative Load Allocations for Total DDTs in Puddingstone Reservoir if the Fish Tissue Target is Met

Subwatershed	Responsible Jurisdiction	Input	Load Allocation (µg/kg dry weight)
Southern	La Verne	Runoff[1]	5.28
Southern	Pomona	Runoff[1]	5.28
Southern	San Dimas	Runoff[1]	5.28
Southern	County of Los Angeles	Parkland Irrigation[1]	5.28
Lake Surface	County of Los Angeles	Lake bottom sediments[2]	5.28

[1] Each load allocation must be met at the point of discharge.

[2] The load allocation must be met in the lake.

10.7.6.3 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 TMDL contains an implicit MOS based on conservative assumptions. The allocations are set based on the lower of either the BSAF-derived sediment target or the consensus-based TEC sediment target to ensure achievement of the OEHHA FCG target in fish tissue. The selected consensus-based TEC concentration in sediment is considerably lower than the BSAF-derived target.

10.7.6.4 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. This TMDL protects beneficial uses by reducing fish tissue concentrations to the FCG target and protecting benthic biota in sediment. Because fish bioaccumulate DDT, concentrations in tissues of edible sized game fish integrate exposure over a number of years. As a result, overall average loading is more important for the attainment of standards than instantaneous or daily concentrations. WLAs and LAs in this TMDL are assigned as concentrations and protect during all seasons and in both high and low flow conditions. This TMDL therefore protects for critical conditions.

10.7.6.5 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. This TMDL includes a maximum daily load estimated according to the guidelines provided by USEPA (2007).

Because the total DDTs WLAs are expressed as concentrations on sediment, the daily maximum allowable load is calculated from the maximum daily sediment load multiplied by the TMDL WLA concentration. The maximum daily sediment load is estimated from the 99^{th} percentile daily flow and the sediment event mean concentration that yields the estimated annual sediment load.

No USGS gage currently exists in the Puddingstone Reservoir watershed. USGS Station 11086400, San Dimas Creek near San Dimas, CA, was selected as a surrogate for flow determination. The 99^{th} percentile flow was chosen to represent the peak flow for this drainage. Choosing the 99^{th} percentile flow eliminates errors due to outliers and is reasonable for development of a daily load expression.

The USGS StreamStats program was used to determine the 99^{th} percentile flow for San Dimas Creek (55 cfs) (Wolock, 2003). To estimate the peak flow to Puddingstone Reservoir, the 99^{th} percentile flow for San Dimas Creek was scaled down by the ratio of drainage areas (8,128 acres/11,712 acres; Puddingstone Reservoir watershed area/San Dimas Creek watershed area at the gage). The resulting peak flow estimate for Puddingstone Reservoir is 38.2 cfs.

The event mean concentration of sediment in stormwater (45.5 mg/L) was calculated from the estimated existing watershed sediment load of 265.5 tons/yr (Table 10-29) divided by the total annual wet weather flow volume delivered to the lake (4,295 ac-ft/yr). Multiplying the sediment event mean concentration by the 99^{th} percentile peak daily flow (38.2 cfs) yields a daily maximum sediment load from stormwater of 4,249 kg/d (4.7 tons/d). Applying the wasteload allocation concentration of 3.94 µg total DDTs per dry kg of sediment yields the stormwater daily maximum allowable load of 0.0167 g/d of total DDTs. This load is associated with the MS4 stormwater permittees. The maximum allowable daily load must be met on all days, and the concentration-based WLAs must be met to ensure compliance with the TMDL.

10.7.6.6 Future Growth

The manufacture and use of DDT is currently banned. Therefore, no additional allowance is made for future growth in the DDT TMDL.

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).

10.8 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 can reduce pollutant loading to lakes 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.

Additionally, responsible jurisdictions implementing these TMDLs are encouraged to utilize Los Angeles County's Structural Best Management Practice (BMP) Prioritization Methodology which helps identify priority areas for constructing BMP projects. The tool is able to prioritize based on multiple pollutants. The pollutants that it can prioritize includes bacteria, nutrients, trash, metals and sediment. Reducing sediment loads would reduce OC pesticides and PCBs as well as mercury delivery to the lake in many instances. More information about this prioritization tool is available at: labmpmethod.org

If necessary, these TMDLs may be revised as the result of new information (See Section 10.9 Monitoring Recommendations). The State Board is in the early stages of developing a Statewide Mercury Policy and Mercury Control Program for Reservoirs. According to CEQA scoping materials, the Policy would define an overall structure for adopting water quality objectives; general implementation requirements; and control plans for mercury impaired water bodies. The final structure of the control program could include a total maximum daily load (TMDL) for mercury in reservoirs along with an implementation plan to achieve the TMDL; or an implementation plan that does not rely on a TMDL. How this upcoming policy and program will affect implementation of this TMDL is unknown at this time.

10.8.1 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 10-9, Table 10-14, Table 10-23, Table 10-33, and Table 10-53 for nutrients, mercury, PCBs, chlordane, and DDT, respectively.

10.8.2 Point Sources and the Implementation of Wasteload Allocations

Wasteload allocations apply to MS4, Caltrans, and General Industrial and Construction Stormwater permits. Wasteload allocations are expressed in Table 10-7, Table 10-13, Table 10-21, Table 10-31, and Table 10-51 for nutrients, mercury, PCBs, chlordane, and DDT, respectively. The concentration and mass-based wasteload allocations will be incorporated into the Caltrans and Los Angeles County MS4 permits. Concentration-based wasteload allocations will be incorporated into the General Industrial and Construction Stormwater permits.

10.8.3 Source Control Alternatives

Responsible jurisdictions are encouraged to consider the construction of wetland systems and bioswales (or other retention or 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. 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.

Puddingstone Reservoir has nutrient-related, mercury, chlordane, DDT, and PCBs impairments. While there are some management strategies that would address all of these impairments (i.e., sediment BMPs placed in upland areas), their differences warrant separate implementation and monitoring discussions.

10.8.3.1 Nutrient-Related Impairments

To address nutrient-related impairments, source reduction and pollutant removal BMPs, designed to reduce sediment loading, could be implemented throughout the watershed 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 Puddingstone Reservoir. 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.

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. 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 to properly dispose of pet wastes will also reduce nutrient loading associated with fecal material that may wash directly into the lake or into storm drains that eventually discharge to 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.

10.8.3.2 Mercury Impairment

Source reduction and pollutant removal BMPs designed to reduce sediment loading could be implemented throughout the watershed as these management practices will also reduce the mercury loading associated with sediments. However, sedimentation basins or water quality ponds that go anoxic at the sediment-water interface may actually result in increased concentrations of methylmercury. Monitoring of dissolved oxygen levels in these ponds and measurement of total and methylmercury concentrations during warm summer months will assist in the management of these basins to reduce methylmercury loading to Puddingstone Reservoir. Maintaining shallow water levels that do not fluctuate in sedimentation basins will allow penetration of sunlight, which degrades methylmercury, and reduce the wetting and drying conditions that favor methylation.

Dissolved loading associated with storm event runoff also contributes mercury loading to Puddingstone Reservoir. Some of the sediment reduction BMPs may also result in decreased concentrations of mercury in the runoff water. Storage of storm flows in wet or dry ponds may allow for adsorption and settling of mercury from the water column as well as photodegradation. BMPs that provide filtration or infiltration processes may retain dissolved mercury in the upland areas. Additionally, reducing nutrient loading to the lake and improving aeration would likely reduce methylation rates within the lake overall.

Unfortunately, sediment reduction BMPs will not mitigate mercury loading from the largest source in the watershed, atmospheric deposition to the lake surface. Mercury available for deposition in the southwest region typically originates from both local and global sources. In the U.S., mercury emissions from most facilities have been reduced over the past few decades as the best available technology has improved over the years.

To provide reasonable assurances that the assigned allocations will indeed result in compliance with the fish tissue target, a commitment to continued monitoring and assessment is warranted. The purposes of such monitoring will be: 1) to evaluate the efficacy of control measures instituted to achieve the needed load reductions, 2) to document trends over time in mercury loading, and 3) to determine if the load reductions proposed for the TMDL lead to attainment of standards. To assess compliance, it is recommended that a detailed plan be incorporated as part of the implementation plan for this TMDL. This should include annual mercury monitoring of fish tissue as well as quarterly sampling for total and methylmercury in the sediment and water both in-lake and from the tributaries (tributary sampling should also include flow monitoring). It may also be necessary to investigate potential sources of methylmercury loading in the watershed, such as wetlands, sedimentation basins, and areas impacted by forest fires.

In 2008 USEPA modeled mercury air emissions nationally as a tool for tracking airborne mercury to assist in watershed planning. The mercury emission estimates were principally based on 2001 data. The highest modeled impact in California was located in the Long Beach area and the largest single source contributor was the Long Beach South East Resource Recovery facility which combusts municipal waste to produce electricity. Since that time USEPA has promulgated regulations to reduce mercury from solid waste incinerators and the emissions from this facility and another solid waste incinerator in the City of Commerce have been significantly reduced. In addition to these regulations for solid waste combustors, USEPA is in the process of finalizing regulations for Portland Cement plants which also contribute to mercury air loading and deposition in the Los Angeles area.

10.8.3.3 Organochlorine Pesticides and PCBs Impairments

The manufacture and use of chlordane, DDT, dieldrin, and PCBs are currently banned. Therefore, no additional allowances for future growth are needed in the TMDLs. Source control BMPs and pollutant removal are the most suitable courses of action to reduce OC pesticides and PCBs in Puddingstone Reservoir. The TMDL calculations performed for each pollutant (described above in their individual sections) indicated internal lake storage as the greatest contributing source and driving factor affecting fish tissue concentrations. Additionally, the watershed loads for chlordane, dieldrin, and PCBs are less than one percent of the total loading that would be required to maintain the current sediment concentrations in the lake under steady-state conditions. Therefore, the most effective remedial actions and/or implementation efforts will focus on addressing the internal lake storage, such as capping or removal of contaminated lake sediments.

When properly conducted, removal of contaminated lake sediments, or dredging, can be an effective remediation option. The object of sediment dredging is to eliminate the pollutants that have accumulated in sediments at the lake bottom. Dredging is optimal in waterbodies with known spatial distribution of contamination because sediment removal can focus on problem areas. However, no spatial pattern of pollutant contamination was apparent in Puddingstone Reservoir. Removal of the contaminated sediments reduces the pollutants available to the in-lake cycling by discontinuing exposure to benthic organisms, water column loading, and consequential bioaccumulation in higher trophic level fish. Potential negative effects of dredging include increased turbidity and lowered dissolved oxygen concentrations in the short term, and disturbance to the benthic community and reactivation of buried sediment and any associated pollutants.

In some cases, sediment capping may be appropriate to sequester contaminated sediments below an uncontaminated layer of sediment, clay, gravel, or material. Capping is effective in restricting the mobility of OC pesticides and PCBs; however, it is most useful in deep lakes and is likely not a viable solution for some parts of Puddingstone Reservoir. Capping implementation should be restricted to areas with sediments that can support the weight of a capped layer, and to areas where hydrologic conditions of the waterbody will not disturb the cap.

The in-lake options for remediation are costly, but would be the only way to achieve full use support in a short timeframe. It is, however, also true that the OC pesticides and PCBs in question are no longer manufactured and will tend to decline in concentration due to dilution by clean sediment and natural attenuation. Natural attenuation includes the chemical, biological, and physical processes that degrade compounds, or remove them from lake sediments in contact with the food chain, and reduce the concentrations and bioavailability of contaminants. These processes occur naturally within the environment and do not require additional remediation efforts; however, the half-lives of OC pesticides and PCBs in the environment are long, and natural attenuation often requires decades before observing significant improvement.

Loading from the watershed can also be expected to decline over time due to natural attenuation. While reductions are called for in watershed loads, these loads are a small fraction of the historic loads already stored in the lakes. Limited sampling has not identified any hotspots of elevated loading under current conditions. It may, however, be necessary to further investigate potential sources of OC pesticides and PCBs loading in the watershed, such as active and abandoned industrial sites, waste disposal areas, former chemical storage areas, and other potential hotspots.

10.9 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 will result in compliance with the chlorophyll *a* and fish tissue targets 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 evaluate the efficacy of control measures instituted to achieve the needed load reductions, and 5) to document trends over time in algal densities and bloom frequencies and fish tissue mercury and organochlorine compounds concentrations.

10.9.1 Nutrient-Related Impairments

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. Deep lakes, such as Puddingstone Reservoir, must meet the DO and pH targets in the water column from the surface to 0.3 meters above the bottom of the lake when the lake is not stratified. However, when stratification occurs (i.e., a thermocline is present) then the DO and pH targets must be met in the epilimnion, the portion of the water column above the thermocline. 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. Wasteload allocations are assigned to stormwater inputs. These sources should be measured near the point where they enter the lakes twice a year for at minimum: ammonia, TKN or organic nitrogen, nitrate plus nitrite, orthophosphate, total phosphorus, total suspended solids and total dissolved solids.

The nutrient TMDLs for Puddingstone Reservoir conclude that a 34.1 percent reduction in total phosphorus loading and a 53.6 percent reduction in total nitrogen loading are needed to maintain a summer average chlorophyll *a* concentration of 20 µg/L. As an example of concentrations that responsible jurisdictions 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 flow volumes (a recalculation is needed if flow volumes change). Assuming flow volumes remain at existing levels (Table 10-5), the target concentrations of total phosphorus and total nitrogen may be 0.40 mg-P/L and 1.78 mg-N/L at the outlet of the northern subwatershed. Targeted concentrations for the Caltrans areas in the northern subwatershed may be 0.43 mg-P/L and 1.94 mg-N/L. For the Caltrans areas in the southern subwatershed targeted concentrations may be 0.44 mg-P/L and 2.05 mg-N/L. Similarly, the target concentrations of total phosphorus and total nitrogen may be 0.30 mg-P/L and 1.84 mg-N/L for wet weather runoff from the southern subwatershed; target concentrations in the parkland irrigation return flows to the lake may be 0.50 mg-P/L and 3.59 mg-N/L (10.1 percent of the total irrigation volume is assumed to reach the lake). As stated above, these concentrations are provided as guidelines; however, mass-based WLAs must be achieved.

10.9.2 Mercury Impairment

To assess compliance with the mercury TMDLs, monitoring should include monitoring of largemouth bass (325-375mm in length) fish tissue (skin-off fillets) at least every three years as well as twice yearly sediment and water column sampling. At a minimum, compliance monitoring should measure the following in-lake water quality parameters: total mercury, methylmercury, chloride, sulfate, total organic carbon, alkalinity, total suspended solids, and total dissolved solids; as well as the following in-lake sediment parameters: total mercury, dissolved methylmercury, total organic carbon, total solids and sulfate. 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. Additionally, in order to accurately calculate compliance with allocations expressed in yearly loads, monitoring should include flow estimation or monitoring as well as water quality concentration measurements. Wasteload allocations are assigned to stormwater inputs. These sources should be measured near the point where they enter the lakes twice a year for at minimum: total mercury, methyl mercury, chloride, sulfate, total organic carbon, alkalinity, total suspended solids, and total dissolved solids.

The mercury TMDL for Puddingstone Reservoir concludes that a reduction in total mercury loading to the lake of 46.6 percent will result in compliance with the fish tissue target of 0.22 ppm. As an example of concentrations that responsible jurisdictions 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 flow volumes (a recalculation is needed if flow volumes change). Assuming flow volumes remain at existing levels (Table 10-5), the target concentration of total mercury may be 3.48 ng/L at the outlet of the northern subwatershed and 3.36 ng/L in runoff from the Caltrans areas in the southern subwatershed. Similarly, the target mercury concentrations may be 2.96 ng/L for wet weather runoff and 12.1 ng/L for parkland irrigation return flows in the southern subwatershed (10.1 percent of the total irrigation volume is assumed to reach the lake). As stated above, these concentrations are provided as guidelines; however, mass-based WLAs must be achieved. An in-lake water column dissolved methylmercury target of 0.081 ng/L also applies.

10.9.3 Organochlorine Pesticides and PCBs Impairments

To assess compliance with the organochlorine compounds TMDLs, monitoring should include monitoring of fish tissue at least every three years as well as once yearly sediment and water column sampling. For the OC pesticides and PCBs TMDLs a demonstration that fish tissue targets have been met in any given year must at minimum include a composite sample of skin off fillets from at least five common carp each measuring at least 350mm in length. At a minimum, compliance monitoring should measure the following in-lake water quality parameters: total suspended sediments, total PCBs, total chlordane, dieldrin, and total DDTs; as well as the following in-lake sediment parameters: total organic carbon, total PCBs, total chlordane, dieldrin, and total DDTs. Environmentally relevant detection limits should be used (i.e., detection limits lower than applicable target), if available at a commercial laboratory. 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. Wasteload allocations are assigned to stormwater inputs. These sources should be measured near the point where they enter the lakes once a year during a wet weather event. Sampling should be designed to collect sufficient volumes of suspended solids to allow for the analysis of at minimum: total organic carbon, total suspended solids, total PCBs, total chlordane, dieldrin, and total DDTs. Measurements of the temperature, dissolved oxygen, pH and electrical conductivity should also be taken.

WLAs and LAs for each pollutant were assigned to the sediment-associated load from the watershed as well as the lake sediments. The concentration-based WLAs and LAs for chlordane, total DDTs, dieldrin, and total PCBs are 0.75 µg/kg dry weight, 3.94 µg/kg dry weight, 0.22 µg/kg dry weight, and 0.59 µg/kg dry weight, respectively. The associated reductions from the watershed load needed to meet the WLAs are 85.3 percent for total chlordane, 28.4 percent for total DDTs, up to 78 percent for dieldrin, and 98.8 percent for total PCBs.

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