U.S. Environmental Protection Agency

Los Angeles Area Lakes TMDLs
March 2012

Section 12 Lake Sherwood TMDL

12 Lake Sherwood TMDL

Lake Sherwood (#CAL4042600019990201154540) is listed as impaired by mercury in fish tissue (note: algae, ammonia, eutrophication, and low dissolved oxygen impairments have been addressed by a previous TMDL). Other impairments, for which TMDLs have already been developed, include algae, ammonia, eutrophication, and organic enrichment/low dissolved oxygen (SWRCB, 2010). This section of the TMDL report describes the mercury impairment and the TMDL developed to address it.

12.1 ENVIRONMENTAL SETTING

Lake Sherwood is located in the Santa Monica Bay Basin (HUC 18070104) between Hidden Valley Wash and Potrero Canyon Creek in Ventura County (Figure 12-1). The lake was created in 1904 from the construction of a dam on the east side of the lake (Figure 12-2). In total, the private lake contains three islands, covers approximately 213 acres and reaches a maximum depth of 30 feet (USEPA, 2003). The lake is primarily fed by watershed runoff but also contains natural springs. Water loss occurs predominantly through evaporation; however, the lake does fill to capacity and discharge to Potrero Canyon Creek during most winters.

The lake was drained for two years during the early 1980s and refilled during 1986 and 1987. The homes surrounding the lake were historically served by individual septic tanks. While the lake was drained they were connected to the Triunfo Sanitation District sewer system. Recreation includes catch and release fishing, boating, and swimming. In addition, a golf course is located on the west end of the lake (Figure 12-3). Bird feeding may be another recreational use at the lake; however, it has not been observed during recent fieldwork. Additional characteristics of the watersheds are summarized below.
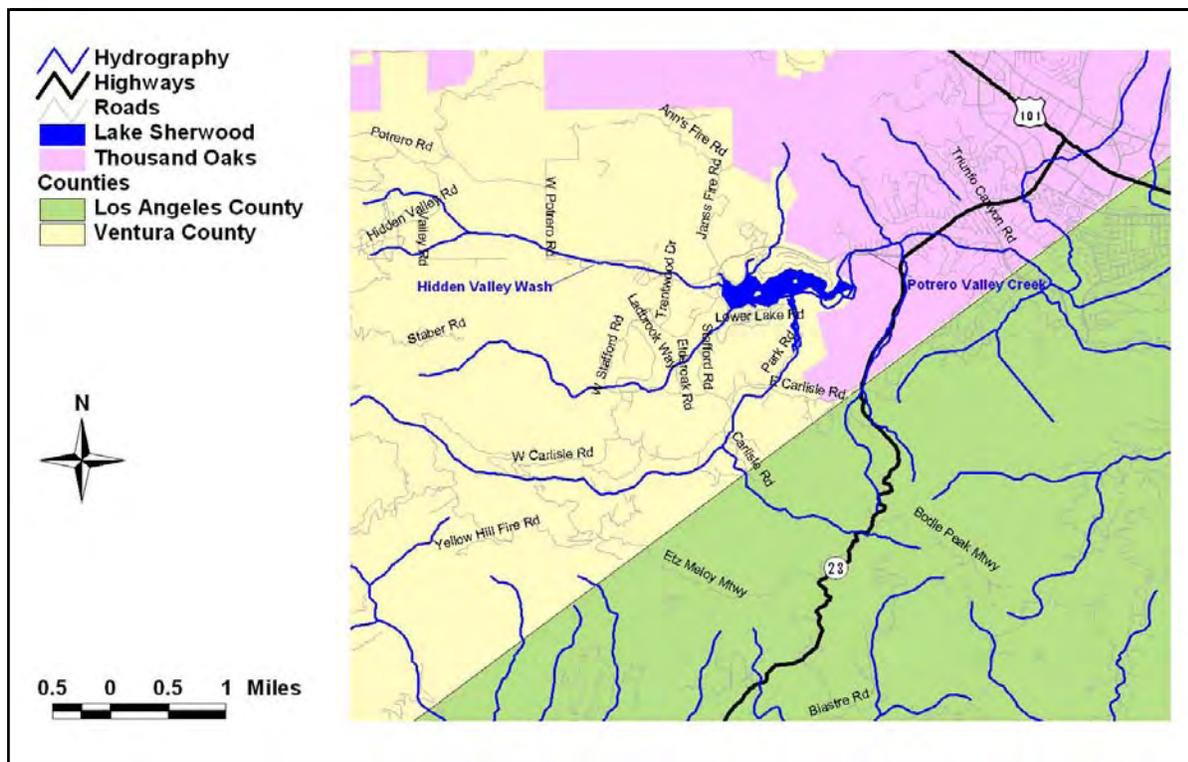

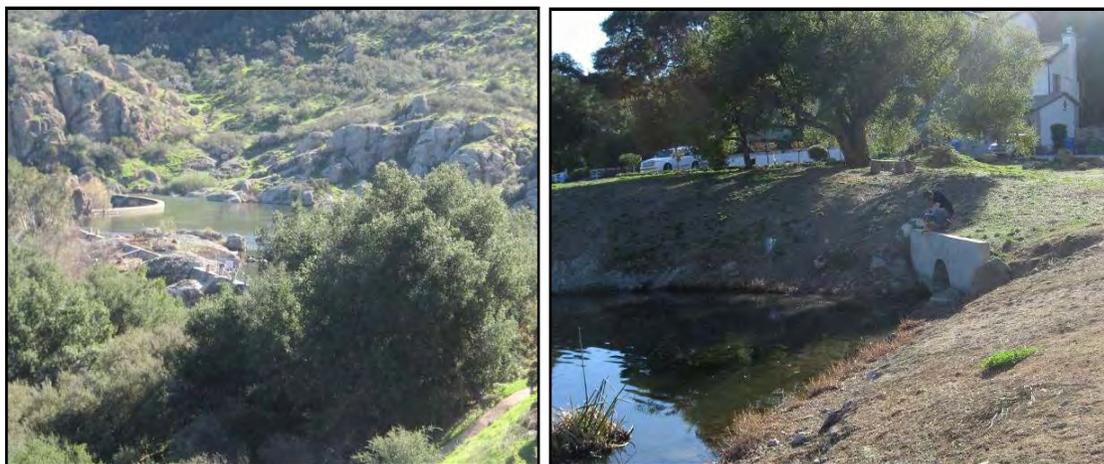Figure 12-1.   **Location of Lake Sherwood**

Figure 12-2.   **Lake Sherwood Dam and One of Several Storm Drains**

Figure 12-3.   **Creek Winding Through Golf Course and Discharging to Lake through Culverts**

12.1.1   Elevation, Storm Drain Networks, and TMDL Subwatershed Boundaries

Six subwatersheds comprise the drainage area (10,656 acres) to Lake Sherwood, which ranges in elevation from 282 meters to 948 meters (Figure 12-4). TMDL subwatershed boundaries for Lake Sherwood were primarily based on a subwatershed boundary dataset maintained by the county of Los Angeles, which includes the portions of the subwatersheds that intersect with Ventura County. Slight modifications were made to some of the boundaries near the lake, based on aerial photography, to exclude the lake arms from the tributary subwatersheds and to separate the undeveloped and developed areas.

Figure 12-4. **Elevation Data and TMDL Subwatershed Boundaries for Lake Sherwood**

12.1.2   MS4 Permittees

Figure 12-5shows the responsible jurisdictions and entities located in each subwatershed draining to Lake Sherwood. Sherwood Valley Homeowners Association (SVHOA) owns stormdrains in some of the subwatersheds so the area that falls within the Lake Sherwood Overall Plan jurisdiction that is in subwatersheds in which they own stormdrains is also included in Figure 12-5 and further described in Section 12.1.3. The SVHOA is not an MS4 and the stormdrains they own are excluded from the Ventura County MS4 jurisdiction. Ventura County is the only MS4 permittee in the Western subwatershed. The Hidden Valley Wash subwatershed is mostly unincorporated Ventura County with a small portion in Thousand Oaks. The Northern, Near Lake Undeveloped, and Near Lake Developed subwatersheds are comprised of both Ventura County and Thousand Oak areas. The Carlisle Canyon subwatershed contains Ventura and Los Angeles County areas as well as Thousand Oaks, California Department of Transportation (Caltrans), and California State Park areas. Ventura and Los Angeles Counties as well as the City of Thousand Oaks do not maintain a storm drain system in the Lake Sherwood watershed and these areas do not appear to be currently regulated under the existing Ventura County and Los Angeles County MS4 permits. However, there are residential developments in the vicinity of the lake which drain to culverts and storm drains that ultimately discharge to the lake through stormdrains owned by the SVHOA (these areas are further discussed in the next section). Figure 12-6 shows a major storm drain entering Lake Sherwood located at the base of the Northern subwatershed.

All subwatersheds will receive wasteload allocations except for the Carlisle Canyon and Near Lake Undeveloped subwatersheds because these two subwatersheds do not drain to pipes or culverts prior to discharge to the lake. The small Caltrans area in the Carlisle Canyon subwatershed will also receive a wasteload allocation. The new MS4 permit for Ventura County (Order R4 2010-0108, NPDES Permit No. CAS004002, July 8, 2010) unifies MS4 coverage for that county with the Ventura County Watershed Protection District (VCWPD) as Principal Permittee.
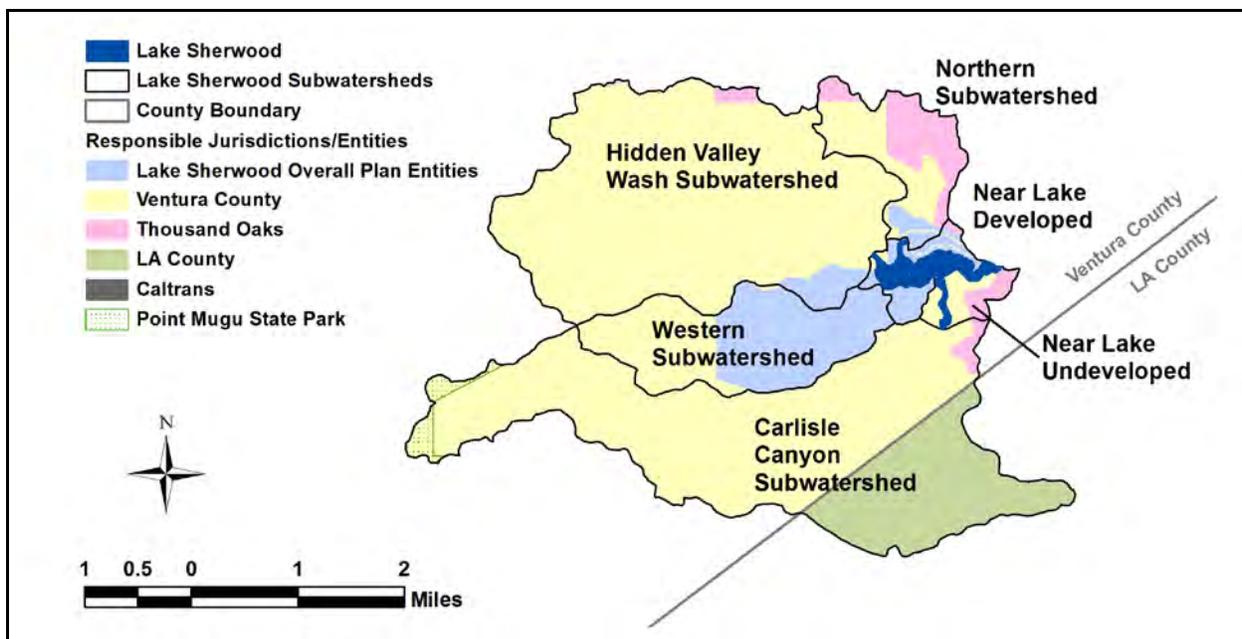
Figure 12-5.   **Responsible Jurisdictions / Entities in the Lake Sherwood Subwatersheds**

Figure 12-6.   **Major Storm Drain to Lake Sherwood**

12.1.3   Non-MS4 Stormwater Dischargers

Lake Sherwood is in a 1,900 acre planned community that has been primarily developed by Sherwood Development Company but includes homes existing prior to the 1980's when the lake and the undeveloped lands surrounding the lake were purchased by the Sherwood Development Company. Homes built and sold by the Sherwood Development Company fall under the jurisdiction of the Sherwood Valley Homeowners Association (SVHOA), The Glens HOA, Trentwood HOA, Meadows HOA, and/or Northshore HOA. The community has two golf courses, the Sherwood Country Club which is owned by its members and is in the Western subwatershed and one owned by Sherwood Development Company in the Carlisle Canyon subwatershed. Many undeveloped parcels remain and are owned by Sherwood Development Company. Commonly owned parcels as infrastructure are either owned by the SVHOA or will be passed to the SVHOA by the Sherwood Development Company eventually. The

multitude of parties within the Lake Sherwood Overall Plan, delineated in Figure 12-7, are given a grouped allocation. The stormdrains that discharge to Lake Sherwood within the residential community surrounding Lake Sherwood were initially thought to belong to Ventura County. However, an October 27, 1998 letter from John C. Crowley, Deputy Director of Public Works, Water Resources and Engineering Department, County of Ventura to Board of Directors, Lake Sherwood Community Services District titled "Transfer of Real Property To Sherwood Valley Homeowner Association, Supervisorial District No. 2" and associated Quitclaim Deeds indicate that the stormdrains in the Lake Sherwood Overall Plan area (see Figure 12-7) are owned by SVHOA. Communication with the County indicates that the only exceptions are any storm drainage infrastructure within the 50 foot wide right of way owned by the County of Ventura along Lake Sherwood Drive. This road is the only road within the 1,900 acre planned residential community owned and maintained by the County. Most, but not all, of the community is gated; gates are located on Stafford Road, Trentwood Drive, Pixton Street, Sandcroft Street, Braxfield Court, Ravesnbury Street and Stonecreek Court. Many roads are owned by the SVHOA or Sherwood Development Company and the following roads are private roads owned by the residents of the surrounding houses: Lower Lake Road, Upper Lake Road, Thorsby, Dirt Road, Hereford, and Giles Road on the south side of the Lake; and David Lane and Trentham on the north side of the Lake.

Lake Sherwood Overall Plan area is shown in Figure 12-7. Additionally, site visits to Lake Sherwood identified many stormwater discharges entering the lake from the surrounding land. The observed stormwater outlets owned by SVHOA discharging to the lake are identified on Figure 12-8. Figure 12-5 illustrates this area in relation to the other stormwater dischargers in the watershed. SVHOA and the Sherwood Development Company will receive joint wasteload allocations.
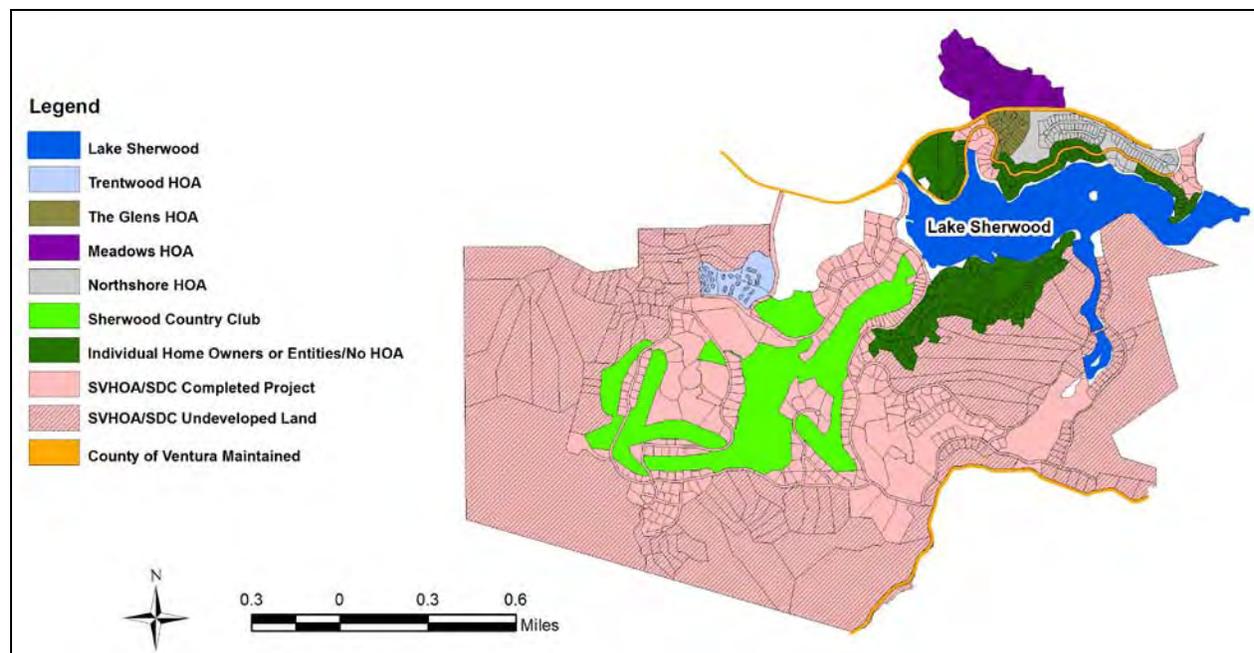

Figure 12-7.   **Parcel Map of the Area Included in the Lake Sherwood Overall Plan**
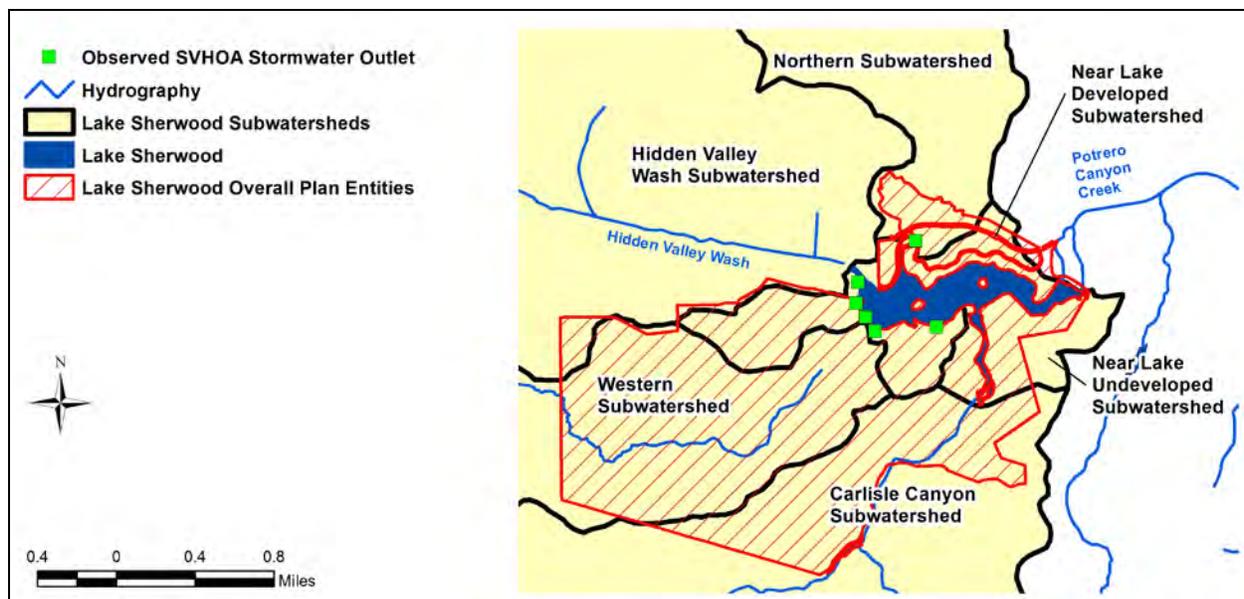
Figure 12-8.   **Lake Sherwood Overall Plan and Observed SVHOA Stormwater Outlets**

12.1.4   Non-MS4 NPDES Dischargers

As of the writing of this TMDL, there are no (non-MS4) NPDES permits in the Lake Sherwood watershed. This includes non-stormwater discharges (individual and general permits) as well as general stormwater permits associated with construction and industrial activities.

12.1.5   Land Uses and Soil Types

Lake Sherwood is located in the Santa Monica Bay Basin and is impaired by mercury. For consistency with the other two mercury impaired lakes addressed by this TMDL (Puddingstone Reservoir and the El Dorado Park lakes), the upland mercury loads will be calculated from tributary monitoring data collected in 2009 and estimates of runoff volumes and sediment loading predicted by an LSPC model (Appendix D, Wet Weather Loading). Though an LSPC model has not been developed for the Santa Monica Bay Basin, the land use coverage for the Los Angeles River Basin LSPC model covers the drainage area to Lake Sherwood and was used to predict runoff volumes and sediment loads by land use to Lake Sherwood.

Land uses identified in the Los Angeles River LSPC model are shown in Figure 12-9. The watershed is comprised of open space, agriculture, residential, and other urban areas. A single parcel of commercial development was identified in the Near Lake Developed subwatershed. Review of SCAG 2005 land use data confirmed that much of the watershed is currently used for agriculture. The area in the Carlisle Canyon subwatershed under the Caltrans jurisdiction was simulated as industrial to estimate sediment loading and runoff volumes from the area associated with this State highway. Table 12-1 through Table 12-6 summarize the land use areas by subwatershed and jurisdiction.

Figure 12-9.   **LSPC Land Use Classes for the Lake Sherwood Subwatersheds**

Table 12-1.   **Land Use Areas (ac) Draining from the Northern Subwatershed**

Land Use	Ventura County	Thousand Oaks	Lake Sherwood Overall Plan	Total
Agriculture	42	0	0	**42**
Commercial	0	0	0	**0**
Industrial	0	0	0	**0**
Open	301	338	29	**669**
Other Urban	7.2	0	34	**41**
Residential	0.20	0	2	**2**
Total	**351**	**338**	**65**	**754**

Table 12-2.   **Land Use Areas (ac) Draining from the Hidden Valley Wash Subwatershed**

Land Use	Ventura County	Thousand Oaks	Total
Agriculture	1,328	0	**1,328**
Commercial	0	0	**0**
Industrial	0	0	**0**
Open	2,441	40.4	**2,482**
Other Urban	19.7	0	**20**
Residential	3.97	0	**4**
Total	**3,793**	**40.4**	**3,833**

Table 12-3.   **Land Use Areas (ac) Draining from the Western Subwatershed**

Land Use	Ventura County	Lake Sherwood Overall Plan	Total
Agriculture	0	0	**0**
Commercial	0	0	**0**
Industrial	0	0	**0**
Open	548	587	**1,136**
Other Urban	0	165	**165**
Residential	0	20	**20**
Total	**548**	**772**	**1,321**

Table 12-4.   **Land Use Areas (ac) Draining from the Carlisle Canyon Subwatershed**

Land Use	Ventura County	Thousand Oaks	LA County	Caltrans	Point Mugu State Park	Total
Agriculture	5.24	0	0.118	0	0	**5.36**
Commercial	0	0	0	0	0	**0**
Industrial	0	0	0	2.75	0	**2.75**
Open	2,866	50.4	1,149	0	101	**4,166**
Other Urban	34.2	0	0.06	0	0	**34**
Residential	0	0	0	0	0	**0**
Total	**2,905**	**50**	**1,149**	**2.75**	**101**	**4,209**

Table 12-5.   **Land Use Areas (ac) Draining from the Near Lake Undeveloped Subwatershed**

Land Use	Ventura County	Thousand Oaks	Total
Agriculture	0	0	**0**
Commercial	0	0	**0**
Industrial	0	0	**0**
Open	126	70.9	**197**
Other Urban	0	0	**0**
Residential	0.004	0	**0.004**
Total	**126**	**70.9**	**197**

Table 12-6. **Land Use Areas (ac) Draining from the Near Lake Developed Subwatershed**

Land Use	Ventura County	Thousand Oaks	Lake Sherwood Overall Plan	Total
Agriculture	0	0	0	**0.0**
Commercial	1.13	0	0	**1.1**
Industrial	0	0	0	**0**
Open	15	8.8	143	**167**
Other Urban	3.3	0	110	**113**
Residential	4.4	0	57	**61**
Total	**24**	**8.8**	**310**	**343**

There are no Resource Conservation and Recovery Act (RCRA) contaminated industrial facilities located near the Lake Sherwood watershed. Figure 12-10 shows the predominant soils identified by STATSGO (Appendix D, Wet Weather Loading) in the Lake Sherwood subwatersheds. The most predominant soil type is MUKEY 661018, which is Rock outcrop-Lithic Xerorthents-Hambright Gilroy, a hydrologic group D soil with high runoff potential, very low infiltration rates, and consists chiefly of clay soils. Areas around the lake as well as a large portion of the Hidden Valley Wash subwatershed are comprised of Xerofluvents-Salinas-Pico-Mocho-Metz-Anacapa (soil MUKEY 661012), which is a hydrologic group B soil. These soils have moderate infiltration rates and moderately coarse textures.

Figure 12-10. **STATSGO Soil Types Present in the Lake Sherwood Subwatersheds**

12.1.6   Additional Inputs

Lake Sherwood was included in the 1994 Urban Lakes Study (UC Riverside, 1994). The primary inflows to the lake were identified as several springs and a large tributary on the west end of the lake (Hidden Valley Wash; Figure 12-11 and Figure 12-12) that drains a portion of the Santa Monica Mountains.

Runoff from the surrounding areas also enters the lake. This TMDL accounts for loads delivered from the watershed, but USEPA and the Los Angeles Regional Board were not able to locate or sample the referenced springs during any field reconnaissance or sampling visits. These additional inputs are therefore not considered in the TMDL.

Note: Bridge shown connects to the lake.

Figure 12-11. **Input from Hidden Valley Wash Subwatershed on Northwest Side of Lake Sherwood**

Note: Picture was taken where the wash enters a culvert heading towards the sediment retention basin.

Figure 12-12. **Hidden Valley Wash as it Enters Culvert on Northwest Side of Lake Sherwood**

12.2 MERCURY IMPAIRMENT

The listing information for Lake Sherwood (LARWCB, 1996) indicates that fish tissue data collected by the Toxic Substances Monitoring Program (TSMP) exceeded the fish tissue guideline for mercury and forms the basis for this listing. Continued sampling of largemouth bass from this lake confirms that Lake Sherwood is impaired by mercury.

Lake Sherwood was visited three times in support of the report "Extent of Fishing and Fish Consumption by Fishers in Ventura and Los Angeles County Watersheds" (SCCWRP, 2008). On average, two fishers were observed during each of the three visits. Because Lake Sherwood is a private lake, these fishers were not interviewed, so no direct information is available to determine fishing habits and consumption

information for Lake Sherwood. Though no direct information is available regarding consumption of fish caught from Lake Sherwood, a TMDL is required to address the fish tissue impairment because there is the potential to catch and consume fish from this lake.

12.2.1   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. Applicable water quality criteria are also specified in the California Toxics Rule (USEPA, 2000a). The existing beneficial uses assigned to Lake Sherwood include REC1, REC2, WARM, WILD, WET, GWR, and NAV. A potential beneficial use for Lake Sherwood is MUN. Descriptions of these uses are listed in Section 2 of this TMDL report. Concentrations of mercury measured in fish tissue collected from Lake Sherwood indicate that the REC1, REC2, WARM, and COLD uses are currently impaired. At high enough concentrations WILD, WET, and GWR uses could become impaired.

12.2.2   Numeric Targets

Numeric targets for mercury in Lake Sherwood 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. 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 Lake Sherwood. 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.

12.2.3   Summary of Monitoring Data

Total mercury concentrations in the water column of Lake Sherwood have been measured twice to assess compliance with the water quality target. On February 25, 2009, the observed concentration was 3.32 ng/L; on July 15, 2009, the observed concentration was 0.75 ng/L. Both measurements were more than an order of magnitude less than the target (50 ng/L). Total methylmercury concentrations observed during these events were 0.189 ng/L and 0.329 ng/L, and likely exceeded the water column target for dissolved methylmercury (0.081 ng/L). Based on the average observed total methylmercury concentrations, reductions in methylmercury loading of 68.7 percent are needed (Note: the observed data were based on the total fraction, while the water column target is for the dissolved fraction, resulting in more conservative assessments). [Mercury reductions required by the fish tissue data (Section 12.2.5) are

higher than 68.7 percent so meeting the reductions for fish tissue should also result in attainment of the water column target for methylmercury.]

The concentrations of mercury observed in largemouth bass have consistently exceeded the fish tissue target since monitoring began in 1991. The TSMP collected three individual specimens in the 1990s with total mercury concentrations ranging from 0.214 ppm to 1.60 ppm. In the summer of 2007, the Surface Water Ambient Monitoring Program (SWAMP) collected 16 individual specimens with total mercury concentrations ranging from 0.219 ppm to 0.802 ppm. The Sherwood Valley HOA sampled five individual fish in 2007; tissue concentrations of total mercury ranged from 0.284 ppm to 0.670 ppm. SWAMP resampled the lake in 2010: five individual samples had concentrations ranging from 0.664 ppm to 1.09 ppm. Figure 12-13 shows the concentration data plotted against fish length; length data for the Sherwood Valley HOA samples were not retained so this data set cannot be plotted. The majority of fish sampled exceed the target concentration of 0.22 ppm. All of the fish tissue data were reported as total mercury concentrations, of which most is expected to be in the methyl form (USEPA, 2001a). These total mercury data were compared to the methylmercury fish tissue guideline, resulting in conservative assessments.

SWAMP also collects total mercury fish tissue concentrations from redear sunfish in Lake Sherwood. These data were not considered in the linkage analysis because redear sunfish are not consumed by humans and, therefore, not relevant for the protection of human health. The composite concentrations (based on five fish per composite) collected on April 19, 2010 range from 0.140 to 0.185 ppm of total mercury.
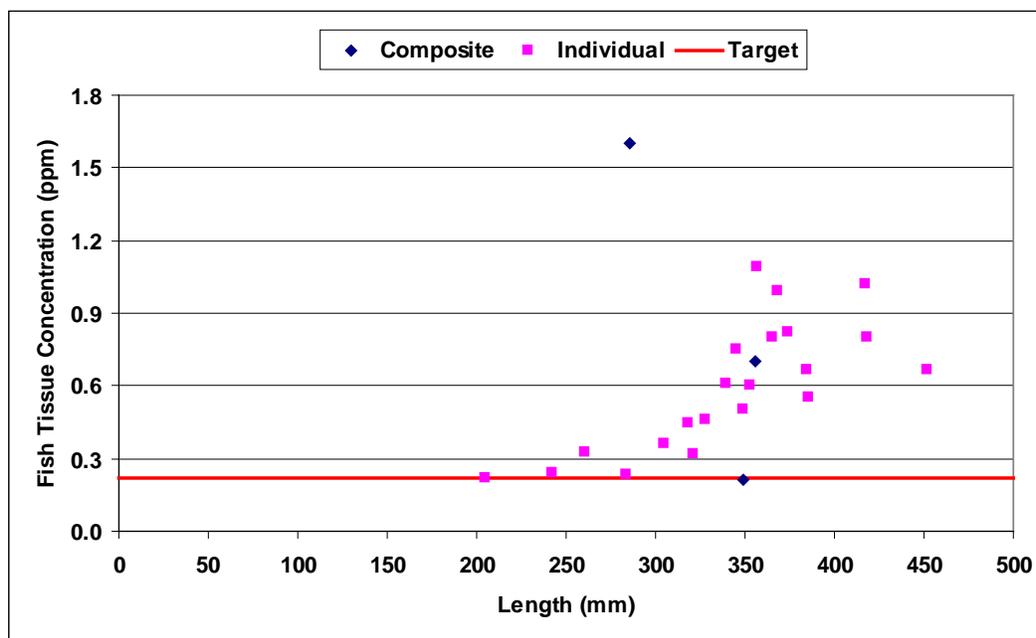

Figure 12-13. **Mercury Concentrations in Largemouth Bass Collected from Lake Sherwood (1991-2010)**

12.2.4   Source Assessment

There are two main components of mercury loading identified in the Lake Sherwood watershed. The majority of loading originates from upland areas and is delivered from tributaries and storm drains in either the water column or sediments. In addition, mercury is deposited from the atmosphere directly to the lake surface.

Watershed loading was determined for six subwatersheds and associated jurisdictions. Estimation of watershed loading during wet weather is discussed in detail in Appendix D (Wet Weather Loading), Section 12; dry weather loading is discussed in Appendix F (Dry Weather Loading), Section 12. Assumptions used to estimate loading from the atmosphere are discussed in Appendix E (Atmospheric Deposition). Table 12-7 summarizes the total mercury loading from each source. On average, 41.7 grams of mercury are delivered to Lake Sherwood each year. The majority of the loading (approximately 45.2 percent) originates from the Hidden Valley Wash subwatershed. Loads from the Near Lake Developed subwatershed are the next largest contributor (17.5 percent).

Table 12-7.   **Summary of Existing Total Mercury Loading to Lake Sherwood**

Subwatershed	Responsible Jurisdiction / Entities	Input	Area (ac)	Total Annual Hg Load (g/yr)	Percent of Load
Western	Ventura County	Runoff	549	0.43	1.04
Western	Lake Sherwood Overall Plan Entities*	Runoff	772	2.62	6.29
Hidden Valley Wash	Thousand Oaks	Runoff	40.4	0.031	0.07
Hidden Valley Wash	Ventura County	Runoff	3,793	18.8	45.12
Near Lake Undeveloped	Thousand Oaks	Runoff	70.9	0.043	0.10
Near Lake Undeveloped	Ventura County	Runoff	126	0.077	0.19
Near Lake Developed	Thousand Oaks	Runoff	8.85	0.021	0.05
Near Lake Developed	Ventura County	Runoff	23.8	0.38	0.91
Near Lake Developed	Lake Sherwood Overall Plan Entities*	Runoff	310	6.90	16.55
Northern	Thousand Oaks	Runoff	338	0.786	1.89
Northern	Ventura County	Runoff	351	1.70	4.09
Northern	Lake Sherwood Overall Plan Entities*	Runoff	65.1	1.45	3.47
Carlisle Canyon	Caltrans	State Highway Stormwater[1]	2.75	0.049	0.12
Carlisle Canyon	County of Los Angeles	Runoff	1,149	0.708	1.70
Carlisle Canyon	Thousand Oaks	Runoff	50.4	0.031	0.07
Carlisle Canyon	Ventura County	Runoff	2,905	2.32	5.56
Carlisle Canyon	Point Mugu State Park	Runoff	101	0.06	0.15
Lake Surface		Atmospheric Deposition[2]	137	5.27	12.64
Total				**41.7**	**100**

[*]Lake Sherwood Overall Plan Entities jointly includes the following: the Glens HOA, Trentwood HOA, Meadows HOA, Northshore HOA, Sherwood Country Club, SVHOA, Sherwood Development Company and individual home owners.

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

[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).

12.2.5 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. 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 Lake Sherwood. 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. For Lake Sherwood, reported average annual sedimentation rates measured from 1905 to 1938 ranged from 2.5 to 10 acre-feet per year (0.22 to 0.88 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.

12.2.6   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 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 Lake Sherwood. The outlier (length = 286 mm, concentration = 1.6 ppm) was removed from the regression to improve fit with the majority of data. The resulting regression equation is

$$Hg(fish) = -0.54236 + 0.003285 \cdot Len, \ \ R^2 = 0.490$$

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 12-14, 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 200 mm.
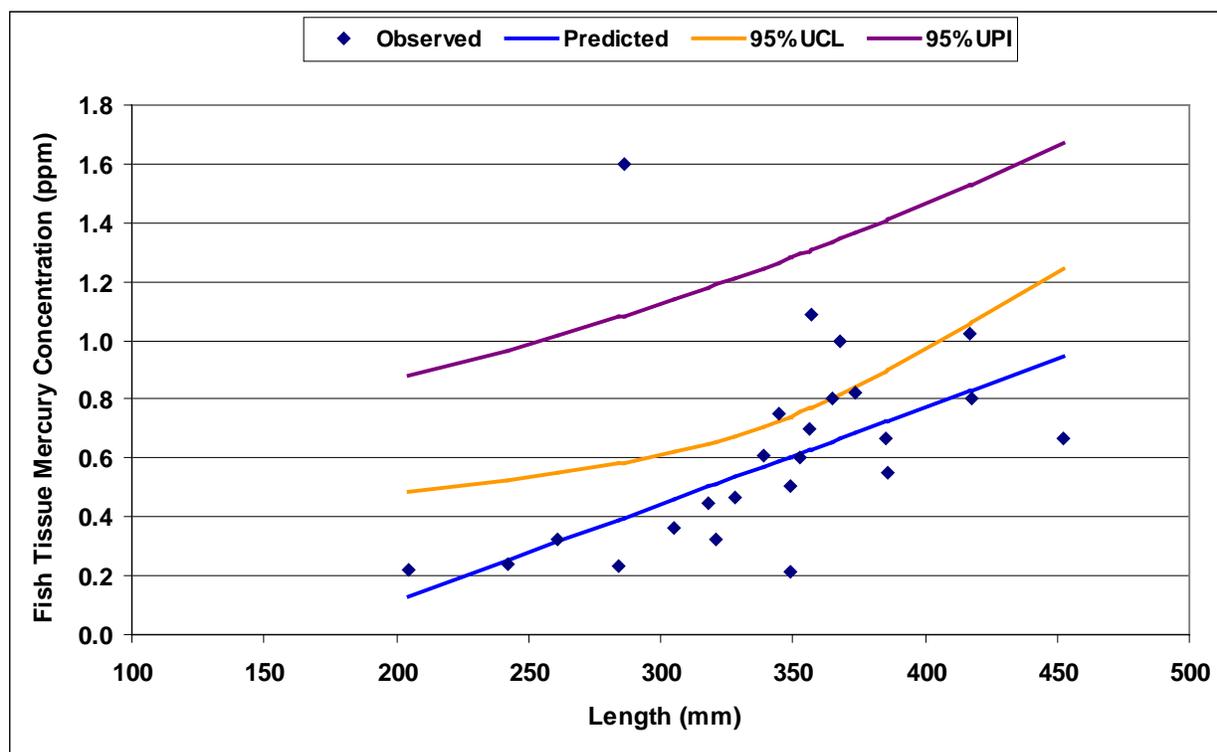
Figure 12-14. **Regression Analysis of Mercury in Lake Sherwood Largemouth Bass (Outlier not included in regression.)**

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 Lake Sherwood. 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 Lake Sherwood, 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 12-8. This analysis indicates that a 70.4 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 12-8.   **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)	**0.607**
95th Percent UCL (ppm)	**0.744**
Loading Capacity (ratio of target to predicted value)	**0.362**
Allocatable Load (ratio of target to 95th Percent UCL)	**0.296**
Required Reduction in Existing Load (1 minus allocatable fraction)	**0.704**
Margin of Safety Fraction (loading capacity fraction minus allocatable fraction)	**0.067**

The loading capacity can also be expressed as grams per year (g/yr) of total mercury using the existing load presented in Table 12-7 and the calculated fractions of the existing load. Specifically, the loading capacity is 36.2 percent of the existing load of 41.7 g/yr, or 15.1 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.

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

$$15.1\,g/yr = \sum 9.79\,g/yr + 2.5\,g/yr + 2.8\,g/yr$$

The allocatable load (divided among WLAs and LAs) is 29.6 percent of the existing load of 41.7 g/yr, or 12.3 g/yr. This value represents 81.5 percent of the loading capacity, while the MOS is 18.5 percent of the loading capacity. Allocations are assigned for this TMDL by requiring equal percentage reductions of all sources. Details associated with the WLAs, LAs, and MOS are presented in the following three sections.

12.2.6.1 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). Wasteload allocations are required for all waters that discharge to the lake through stormdrains or culverts. Responsible entities located in the Northern, Western, Hidden Valley Wash, and Near Lake Developed subwatersheds discharge to the lake through stormdrains or culverts that are not currently part of the Ventura or Los Angeles County MS4s. The stormdrains in the Northern, Western and Near Lake Developed subwatersheds are owned and operated by the SVHOA. In those subwatersheds any land in the Sherwood Lake Overall Plan area is allocated jointly to the following entities: the Glens HOA, Trentwood HOA, Meadows HOA, Northshore HOA, Sherwood Country Club, SVHOA, Sherwood Development Company and individual home owners. This TMDL establishes WLAs at their point of discharge. A WLA is also required for the Caltrans area in the Carlisle Canyon subwatershed. The relevant permit number is

- Caltrans: Order No 99-06-DWQ, CAS000003.

Table 12-9 summarizes the existing loads and WLAs of total mercury for these sources. The WLAs are a 70.4 percent reduction from the existing loads. These loading values (in grams per year) represent the TMDL wasteload allocations (Table 12-9). In addition to the WLAs presented below for total mercury, an in-lake water column dissolved methylmercury target of 0.081 ng/L also applies.

Table 12-9. **Wasteload Allocations of Mercury in the Lake Sherwood Watershed**

Subwatershed	Responsible Jurisdiction / Entities	Input	Area (ac)	Existing Annual Hg Load (g/yr)	Wasteload Allocation[2] (g/yr)
Western	Ventura County	Runoff[3]	548	0.43	0.128
Western	Lake Sherwood Overall Plan Entities*	Runoff[3]	772	2.62	0.774
Hidden Valley Wash	Thousand Oaks	Runoff[3]	40	0.03	0.009
Hidden Valley Wash	Ventura County	Runoff[3]	3,793	18.8	5.559
Near Lake Developed	Thousand Oaks	Runoff[3]	9	0.021	0.006
Near Lake Developed	Ventura County	Runoff[3]	24	0.38	0.112
Near Lake Developed	Lake Sherwood Overall Plan Entities*	Runoff[3]	310	6.90	2.039
Northern	Thousand Oaks	Runoff[3]	338	0.786	0.232
Northern	Ventura County	Runoff[3]	351	1.70	0.504
Northern	Lake Sherwood Overall Plan Entities*	Runoff[3]	65	1.45	0.427
Carlisle Canyon	Caltrans	State Highway Stormwater[1]	2.75	0.049	0.014
Total				**33.1**	**9.79**

[*]Lake Sherwood Overall Plan Entities jointly includes the following: the Glens HOA, Trentwood HOA, Meadows HOA, Northshore HOA, Sherwood Country Club, SVHOA, Sherwood Development Company and individual home owners.

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

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

[3]This input includes effluent carried through the stormdrain system owned by SVHOA that is not currently included in either the Los Angeles or Ventura County MS4 permits.

12.2.6.2 Load Allocations

Load allocations (LAs) of total mercury are assigned to all sources not subject to permits in the Near Lake Undeveloped subwatershed, non-Caltrans sources in the Carlisle Canyon subwatershed, and atmospheric deposition. Table 12-10 summarizes the existing loads and LAs for these sources. The LAs are a 70.4 percent reduction from the existing loads. LAs are provided for each responsible jurisdiction and input. These loading values (in grams per year) represent the TMDL load allocations (Table 12-10) 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 also applies.

Table 12-10. **Load Allocations of Mercury in the Lake Sherwood Watershed**

Subwatershed	Responsible Jurisdiction	Input	Area (ac)	Existing Annual Hg Load (g/yr)	Load Allocation[1] (g/yr)
Near Lake Undeveloped	Thousand Oaks	Runoff	70.9	0.043	0.013
Near Lake Undeveloped	Ventura County	Runoff	126	0.077	0.023
Carlisle Canyon	County of Los Angeles	Runoff	1,149	0.708	0.209
Carlisle Canyon	Thousand Oaks	Runoff	50.4	0.031	0.009
Carlisle Canyon	Ventura County	Runoff	2,905	2.32	0.685
Carlisle Canyon	Point Mugu State Park	Runoff	101	0.062	0.018
Lake Surface		Atmospheric Deposition[2]	137	5.27	1.56
Total				**8.51**	**2.51**

[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).

12.2.6.3 Margin of Safety

TMDLs must include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality. The MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. This TMDL includes both an implicit and explicit MOS for Lake Sherwood. 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 12-14). Use of the UCL provides a margin of safety because it represents an upper confidence bound on the long-term exposure concentration. For Lake Sherwood, the fraction of the existing load set aside for the explicit MOS is 0.067, or 2.8 g/yr, which represents 18.5 percent of the loading capacity.

12.2.6.4 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. This TMDL protects beneficial uses by reducing fish tissue concentrations to the FCG target in Lake Sherwood. 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 Lake Sherwood during storm runoff events, so high flows do represent a critical period 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.

12.2.6.5   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. Although it is long-term cumulative load rather than daily loads of mercury that are driving the bioaccumulation of mercury in fish in Lake Sherwood, this TMDL does present a maximum daily load according to the guidelines provided by USEPA (2007). The daily maximum allowable load to Lake Sherwood is calculated from the maximum daily storm volume (estimated from the 99th 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 Lake Sherwood watershed. USGS Station 11105500, Malibu Creek at Crater Camp near Calabasas, CA, was selected as a surrogate for flow determination. This gage is located downstream of Lake Sherwood on Malibu Creek. 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 Malibu Creek (355 cfs) (Wolock, 2003). To estimate the peak flow to Lake Sherwood, the 99th percentile flow for Malibu Creek was scaled down by the ratio of drainage areas (10,656 acres/67,200 acres; Lake Sherwood watershed area/Malibu Creek watershed area at the gage). The resulting peak flow estimate for Lake Sherwood is 56.3 cfs.

The event mean concentration for mercury was calculated from the allowable load (12.3 g-Hg/yr; sum of the WLAs and LAs) and the average annual total flow (wet weather plus dry weather 1,492 ac-ft). The resulting concentration (6.70 ng/L) times the peak flow to Lake Sherwood (56.3 cfs) yields a total maximum daily load of 0.922 g-Hg/d associated with the MS4 permittees. For comparison, the existing load (41.7 g-Hg/yr) would yield an event mean concentration of 22.7 ng/L and a daily load of 3.12 g-Hg/d.

12.2.6.6   Future Growth

The majority of land in the Lake Sherwood Watershed is either in agricultural or undeveloped uses. As more development occurs in the watershed, best management practices will need to be employed to maintain the wasteload and load allocations defined in this TMDL. No allocation has been set aside for expansion of permitted discharges in the watershed, such as wastewater treatment facilities, as no facilities currently exist or are planned in the watershed.

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

12.3 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; and reducing stormwater discharges by improved infiltration. 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 include bacteria, nutrients, trash, metals and sediment. Reducing sediment loads would reduce 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 12.4 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.

12.3.1   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, and the Conditional Waiver for Discharges from Irrigated Lands, adopted by the Los Angeles Regional Water Quality Control Board on November 3, 2005. 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 12-10.

12.3.2   Point Sources and the Implementation of Wasteload Allocations

Wasteload allocations apply to Ventura County, Thousand Oaks, Caltrans as well as the Lake Sherwood Overall Plan Entities (Table 12-9). The mass-based waste load allocations for Caltrans will be incorporated into the Caltrans permit; the Regional or State Board may develop a new permit to cover the previously unpermitted stormwater discharges to the lake from Ventura County, Thousand Oaks and Lake Sherwood Overall Plan Entities.

12.3.3   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, as well as stormwater diversion and infiltration using methods such as porous pavements and rain gardens. Source reduction and pollutant removal BMPs designed to reduce sediment loading are management practices that 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. This is likely occurring at the mouth of Hidden Valley Wash, where concentrations of methylmercury in the water column and sediments have been observed at levels one order of magnitude

greater than other locations in the watershed (see Appendix D, Wet Weather Loading; Appendix G, Monitoring Data).

Dissolved loading associated with stormwater contributes the largest amount of mercury loading to Lake Sherwood. 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. BMPs that provide filtration or infiltration processes may retain dissolved mercury in the upland areas.

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 Lake Sherwood. Maintaining shallow water levels that do not fluctuate will allow penetration of sunlight, which degrades methylmercury, and reduce the wetting and drying conditions that favor methylation. Existing and ongoing efforts by the Sherwood Valley Homeowner's Association to improve lake water quality by reducing nutrient loading to the lake and improving aeration have likely reduced methylation rates within the lake overall. Further reductions of nutrient levels and improvements to aeration would have the combined benefit of reducing methylation of mercury and implementing load allocations called for in the nutrient TMDL established in 2003.

Unfortunately, sediment reduction BMPs will not mitigate mercury loading from the second 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 US, mercury emissions from most facilities have been reduced over the past few decades as the best available technology has improved over the years.

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 reductions in mercury air loading and deposition in the Los Angeles area.

12.4 MONITORING RECOMMENDATIONS

Although estimates of the loading capacity and allocations are based on best available data and incorporate an 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 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 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 mercury loading.

To assess compliance with the mercury TMDL, 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 in each lake. At a minimum, compliance monitoring should measure the following in-lake water quality parameters: total mercury, dissolved 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, 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. At Lake Sherwood wasteload allocations are assigned to stormwater inputs from various subwatersheds. These sources should be measured near the point where they enter the lake twice a year for at minimum: total mercury, methyl mercury, chloride, sulfate, total organic carbon, alkalinity, total suspended solids, and total dissolved solids.

It may also be helpful to investigate potential sources of methylmercury loading in the watershed, such as wetlands, sedimentation basins, and any areas impacted by forest fires. Specifically, there are several springs that have been documented to feed the lake, however, sampling of these sources was not possible during USEPA site visits. Springs sometimes have elevated mercury so finding these springs and measuring their mercury loading is a high priority activity to fully characterize all sources to Lake Sherwood. Additionally, sampling conducted for the development of this TMDL found that one of the tributaries to the lake (Hidden Valley Wash) discharged to the lake through a sedimentation basin with high methylation. Further sampling of tributaries to determine other likely methylation sources may be appropriate in order to target BMPs.

The mercury TMDL for Lake Sherwood concludes that a reduction in total mercury loading to the lake of 70.4 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 (Appendix D, Wet Weather Loading; Appendix F, Dry Weather Loading), targeted concentrations of total mercury in stormwater from the Northern, Western, Hidden Valley Wash, and Near Lake Developed subwatersheds may be 9.94 ng/L, 2.92 ng/L, 10.38 ng/L, and 9.94 ng/L. The targeted concentration in the stormwater from the Caltrans area in the Carlisle Canyon subwatershed may be 4.37 ng/L. Similarly, the targeted concentration of total mercury in runoff from the Near Lake Undeveloped subwatershed may be 2.06 ng/L. The targeted concentration in the runoff from the non-Caltrans areas in the Carlisle Canyon subwatershed may be 2.32 ng/L. 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.