Total Maximum Daily Loads for Nutrients
Malibu Creek Watershed

US Environmental Protection Agency
Region 9

Established by:

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1. Introduction

This document describes the Total Maximum Daily Loads (TMDLs) for nutrient compounds for the Malibu Creek watershed, which includes Malibu Lagoon, Malibu Creek and its tributaries, and four urban lakes. The nutrient compounds addressed in these TMDLs are nitrogen and phosphorus. Malibu Creek and three of its tributaries (Las Virgenes Creek, Medea Creek, and Lindero Creek) exceed the water quality objectives (WQOs) for nuisance effects such as algae, odors, and scum (RWQCB, 1996). Additionally, Malibu Lagoon and four urban lakes (Lindero, Westlake, Sherwood, and Malibou) within the watershed exceed the WQOs for nutrient related effects (i.e., ammonia, dissolved oxygen, or eutrophication). The TMDLs identify the amounts of nitrogen and phosphorous that can be discharged to the water bodies in the Malibu Creek watershed without causing violations of applicable water quality standards, and allocate allowable nutrient loads among different discharge sources.

These TMDLs comply with 40 CFR 130.2 and 130.7, Section 303(d) of the Clean Water Act and U.S. Environmental Protection Agency (EPA) guidance for developing TMDLs in California (U.S. EPA, 2000). This document summarizes the information used by the EPA and the California Regional Water Quality Control Board, Los Angeles Region (Regional Board) to develop TMDLs for nitrogen and phosphorus compounds. The TMDLs are expressed differently for summer and winter conditions because flows, nutrient loads, and nutrient effects vary substantially in different seasons. In this document, the term “summer” is defined as the period between April 15-November 15 and “winter” is defined as the period between November 16-April 14. These two seasonal periods are distinguished in order to account for:

- the winter period in which the Tapia Water Reclamation Facility (WRF) is authorized to discharge most of its treated effluent, which results in substantial differences in flows and nutrient loads between summer and winter, and
- rainfall and runoff patterns (most rainfall and precipitation-related nutrient loading occurs during the winter period).

TMDLs are being established for the following segments within the Malibu Creek Watershed which have been included on the Section 303(d) list as impaired due to effects of nutrients: Lake Sherwood, Westlake Lake, Lake Lindero, Las Virgenes Creek, Lindero Creek, Medea Creek, Malibou Lake, Malibu Creek, Malibu Lagoon. In addition, we have determined that it is necessary to set load allocations and wasteload allocations to limit nutrient discharges to upstream, hydrologically-connected segments within the watershed in order to achieve compliance with water quality standards in the downstream impaired segments for which TMDLs are being established. Allocations are being established for sources that discharge to all of the waters that are tributary to Malibu Creek and Lagoon, including the following upstream water bodies: Hidden Valley Creek, Triunfo Creek, Potrero Canyon Creek, Palo Comado Creek, Cheesebro Creek, Stokes Creek, and Cold Creek. There is some evidence that water quality is impaired due to nutrient effects in some of these upstream tributaries and we believe the loading reductions that will occur pursuant to the load and wasteload allocations established in these TMDLs should be sufficient to address potential nutrient-related impairment in these tributaries. Figure A-1 shows all waterbodies in the Malibu watershed and impaired waters addressed in these TMDLs. Figure A-2 shows the subwatersheds within Malibu Creek watershed as several impaired waters have been grouped together in these TMDLs. (see Appendix for figures)

a. Regulatory Background

Section 303(d) of the Clean Water Act (CWA) requires that each State "shall identify those waters within its boundaries for which the effluent limitations are not stringent enough to implement any water quality standard applicable to such waters." The CWA also requires states to establish a priority ranking for waters on the 303(d) list of impaired waters and establish TMDLs for such waters.

The elements of a TMDL are described in 40 CFR 130.2 and 130.7 and Section 303(d) of the CWA, as well as in U.S. Environmental Protection Agency guidance (U.S. EPA, 1991 and 2000a). A TMDL is defined as the "sum of the individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background" (40 CFR 130.2) such that the capacity of the waterbody to assimilate pollutant loading (the Loading Capacity) is not exceeded. A TMDL is also required to account for seasonal variations and include a margin of safety to address uncertainty in the analysis (USEPA, 2000a).

The Environmental Protection Agency has oversight authority for the 303(d) program and is required to review and either approve or disapprove the TMDLs submitted by states. In California, the State Water Resources Control Board (State Board) and the nine Regional Boards are responsible for preparing lists of impaired waterbodies under the 303(d) program and for preparing TMDLs, both subject to EPA approval. If EPA does not approve a TMDL submitted by a state, EPA is required to establish a TMDL for that waterbody. The Regional Boards also hold regulatory authority for many of the instruments used to implement the TMDLs, such as the National Pollutant Discharge Elimination System (NPDES) and state-specified Waste Discharge Requirements (WDRs).

The State of California identified over 700 waterbody-pollutant combinations in the Los Angeles Region where TMDLs would be required (SWRCB, 1998; RWCQB 1996, 1998). These are referred to as "listed" or "303(d) listed" waterbodies. A schedule for development of TMDLs in the Los Angeles Region was established in a consent decree (Heal the Bay Inc., et al. v. Browner C 98-4825 SBA) approved on March 22, 1999. For the purpose of scheduling TMDL development, the decree combined the more than 700 waterbody-pollutant combinations into 92 TMDL analytical units.

These TMDLs address Analytical Unit 50 specified in the Consent Decree, which consists of Malibu Lagoon, segments of the Malibu Creek and tributaries, and urban lakes impaired by nutrient compounds and effects that appear to be caused by those compounds. The nutrient impairments include ammonia and nutrients (nitrogen and phosphorus) and nuisance effects (dissolved oxygen, algae, scum, and odor). Table 1 identifies the listed waterbodies, the nutrient-related impairments for which each is listed, and the number of linear miles of waterbody in Analytical Unit 50 impaired by each. The consent decree schedule requires that these TMDLs be approved or established by EPA by March 22, 2003. EPA is establishing these

TMDLs at the request of the Regional Board and in order to meet its obligations under the consent decree, because the State was unable to establish these TMDLs in time to meet the consent decree deadlines.

This report presents the nutrient TMDLs and summarizes the analyses performed by EPA and the Regional Board to develop these TMDLs.

Table 1. Malibu Creek Watershed 303(d) listed Waterbodies for Nutrients
(streams = linear miles listed; lakes = acres listed)

Waterbody	Algae	Eutrophy	Scum/ Odors	Ammonia	Organic enrichment	Dissolved Oxygen
Lake Sherwood	213	213		213	213	213
Westlake Lake	186	186		186	186	186
Lake Lindero	14	14	14		14	
Las Virgenes Creek	11.25		11.25			11.25
Lindero Creek	6.56		6.56			
Medea Creek	7.56					
Malibou Lake	69	69			69	69
Malibu Creek	8.43		8.43			
Malibu Lagoon		33				

b. Environmental Setting: The Malibu Creek Watershed

These TMDLs addresses nutrient-related impairments for waterbodies within the Malibu Creek watershed (Table 1). There are a number of waterbodies which were not listed or were not assessed during the 303(d) listing process but were included in the modeling effort since they are hydrologically connected to the impaired waterbodies. These include Hidden Valley Creek, Triunfo Creek, Potrero Canyon Creek, Palo Comado Creek, Cheesebro Creek, Stokes Creek, and Cold Creek. Three of the seven lakes in the Malibu Creek watershed (Lake Eleanor, Las Virgenes Reservoir, and Century Lake) were not addressed in this analysis because they were not listed as impaired and they were not crucial to understanding the hydrology of the watershed.

The Malibu Creek watershed, located about 35 miles west of Los Angeles, California, includes several streams, lakes, and a lagoon that are on the 303(d) list for algae/nutrient impairments. The watershed is 109 square miles and extends from the Santa Monica Mountains and adjacent Simi Hills to the Pacific coast at Santa Monica Bay. Several creeks and lakes are located in the upper portions of the watershed, and these ultimately drain into Malibu Creek at the downstream end of the watershed. Historically, there is little flow in the summer months; much of the natural flow that does occur in the summer in the upper tributaries comes from springs and seepage areas. Malibu Creek drains into Malibu Lagoon, a 13-acre tidal lagoon, which in turn drains into Santa Monica Bay when the entrance to the lagoon is open.

Lake Sherwood is a 213-acre private lake located in the 10,864-acre Hidden Valley subwatershed. Although the lake itself is surrounded by a residential community, it receives the drainage from mostly agricultural and undeveloped lands in its drainage area. The lake is hydraulically connected to a bowl-shaped groundwater aquifer, which is an additional source of summer flows. Fishing, boating and swimming are allowed at the lake and there is a golf course at the west end of the lake. Lake Sherwood was listed as impaired due to problems associated with high algal abundances, organic enrichment, eutrophic conditions and low dissolved oxygen in the lake. Lake water quality was also listed for ammonia toxicity suggesting that excess nitrogen may be the cause of the eutrophication. The lake has a maximum depth of 30 feet. The average lake inflow rate is 2.66 cfs and the residence time is 493 days (Lund *et al.*, 1994). The lake discharges to Potrero Creek.

Westlake Lake is a 186-acre man-made lake, which was constructed in 1976 to provide a private setting for homes and to provide opportunities for boating and fishing to the residents of Westlake Lake. Like Lake Sherwood, Westlake Lake is listed for algae, eutrophic conditions and ammonia toxicity. The primary source of water to Westlake Lake is Potrero Creek that contains flow from Lake Sherwood as well as drainage from Potrero Creek watershed (NRCS, 1995). The lake also receives drainage from the surrounding mountains in the Westlake subwatershed as well as six storm drains (Lund et al., 1994). The lake has a maximum depth of 18 feet. The average lake inflow rate is 9.97 cfs. A minimum flow of 1 cfs is required to be discharged in the summer months for fish. The lake residence time is 40 days (Lund *et al.*, 1994). Flows from Westlake Lake are discharged into Triunfo Creek.

Both Lindero Creek and Lake Lindero are listed for algae and eutrophic conditions. In addition Lake Lindero is listed for organic enrichment and scum/odors. Lake Lindero is a small urban lake that was constructed in 1964. Because flows in the upper reaches of Lindero Creek are relatively small, the main sources of water are runoff from the adjacent lots, a golf course and the streets. Residential areas make up about 37% of the land use pattern in the 5,460-acre Lindero Creek subwatershed. Another 6% is commercial and industrial. The rest is undeveloped or vacant land. The 13.6 acre lake has a maximum depth of 20 feet. The average lake inflow rate is 1.51 cfs with a residence time of 30 days (Lund *et al.*, 1994). Water exits the lake spillway to the lower Lindero Creek and eventually flows to Medea Creek.

Medea Creek has a total length of 7.56 miles. Land use in the Medea Creek subwatershed contains a mix of open space area (61%), residential use (31%) and commercial use (3%). Medea Creek also receives drainage from the subwatersheds associated with Palo Comado Creek and Cheeseboro Creek.

Malibou Lake is listed for both algae and eutrophic conditions. Malibou Lake receives the drainage from most of the subwatersheds in the upper portion of the watershed. The lake has a drainage area of 64 square miles which represents almost 60% of the entire watershed. Water flows from Triunfo and Medea Creek into the lake. The lake was constructed in 1922 for swimming, boating and fishing by members and guests of the Malibou Lake Mountain Club, Ltd. The maximum depth of this 69-acre lake is about 20 feet (Lund *et al.*, 1994). Malibou Lake has mud bottom that is dredged on a continual basis because of sediment loadings from upstream sources. The outflow from the lake discharges into Malibu Creek.

Malibu Creek is listed for algae and scum/foam. The 10-mile creek runs from Malibu Lake to Malibu Lagoon and has an estimated winter mean flow of about 15 cfs and a dry weather average base flow of 2.5 cubic feet per second (cfs). The predominant land use in the Malibu Creek subwatershed is open space (94%). Residential uses make up 1% percent of the subwatershed acreage and commercial/industrial uses make up 3% of the total land use. The

Tapia Water Reclamation Facility (Tapia WRF) is located in this subwatershed and contributes significant flow in the winter months. Malibu Creek also receives flow from Las Virgenes Creek, Cold Creek and Stokes Creek.

Las Virgenes Creek is listed for algae, eutrophic conditions, and low dissolved oxygen. Eleven miles in length, the creek receives drainage from a 12,456-acre area. The land use in the Las Virgenes Creek subwatershed is predominantly open space (83%). Residential land use accounts for 6% of the land use area. Commercial/industrial land use accounts for another 3%. The proposed Ahmanson Ranch development is located in the upper watershed. This proposed project would add 1,097 acres of residential land use and 390 acres of golf course to the land use mix in the watershed. Neither Stokes Creek nor Cold Creek are listed for nutrient related impairments. Both creeks flow through relatively undeveloped areas and water quality in these creeks is presumed to be high.

Malibu Lagoon, located at the bottom of the watershed, is listed for eutrophic conditions. The lagoon is at the receiving end of the drainage from all upstream subwatersheds. Water quality problems occur especially in the summer months when the lagoon is closed. During the winter months higher flows can cause the lagoon to breach, flushing out much of the water and sediments. Land use in the 681-acre Malibu Lagoon subwatershed consists of a mix of open space (34%), residential areas (36%), and commercial uses (15%).

c. TMDL ELEMENTS

Guidance from USEPA (2000a) identifies seven elements of a TMDL. Sections 2 through 8 of this document are organized such that each section describes one of the elements, with the analysis and findings of these TMDLs for that element. The seven elements are:

1. Problem Statement. This section reviews the evidence used to include the water body on the 303(d) list, and summarizes existing conditions using that evidence along with any new information acquired since the listing. For these TMDLs, the problem encompasses nutrients, which result in excessive algae proliferation and related effects. The problem identification reviews: those reaches that fail to support all designated beneficial uses, the beneficial uses that are not supported for each reach, the water quality objectives (WQOs) designed to protect those beneficial uses and, in summary, the data and information regarding the decision to list each reach, such as the number and severity of exceedances observed.

2. Numeric Targets. For these TMDLs, the numeric targets are based on the numeric and narrative water quality objectives in the Basin Plan. Load reductions and pollutant allocations in the TMDL are developed to ensure that these numeric targets for the impaired waterbodies are met.

3. Source Assessment. This step is a quantitative estimate of point sources and non-point sources of nutrient compounds into the Malibu Creek watershed. The source assessment considers seasonality and flow.

4. Linkage Analysis. This analysis demonstrates how the sources of nutrient compounds (nitrogen and phosphorus) in the waterbody are linked to the observed conditions in the impaired waterbody. The linkage analysis includes an assessment of critical conditions, which are periods when the changing pollutant sources and changing assimilative capacity of the waterbody combine to produce either extreme impairment conditions or conditions especially resistant to improvement. Separate TMDLs may be defined for each critical condition/season.

5. TMDLs and Pollutant Allocations. The total loading capacity for each waterbody is determined. The TMDL is set at the loading capacity. Each pollutant source is allocated an allowed quantity of nitrogen and phosphorus compounds that it may discharge. Allocations are designed such that the waterbody will not exceed numeric targets for any of the compounds or effects in any of its reaches. Point sources are given waste load allocations, and non-point sources are given load allocations. Allocations need to consider worst-case conditions, so that the pollutant loads may be expected to remove the impairment under critical conditions.

6. Implementation Recommendations. This section describes the plans, regulatory tools, or other mechanisms by which the waste load allocations and load allocations may be achieved.

7. Monitoring Recommendations. These TMDLs recommend monitoring the waterbody to ensure that the Waste Load Allocations and Load Allocations are achieved and remove the impairment so that numeric targets are no longer exceeded and that the nutrient-related effects intended to be addressed by these TMDLs also are removed.

2. Problem Statement

Excessive algae in the Malibu Creek watershed has resulted in several waterbodies not supporting their designated beneficial uses associated with aquatic life and recreation (RWQCB, 1996). Algal biomass can lead to impairment of swimming and wading activities. In addition, the proliferation of algae can result in loss of invertebrate taxa through habitat alteration (Biggs, 2000). Algal growth in some instances has produced algal mats in the lakes (Lund et al., 1994), creeks (Ambrose et al., 1995, Kamer et al., 2002, CH2MHill, 2000, Heal the Bay, 2002), and lagoon (Ambrose et al., 2000); these mats may result in eutrophic conditions where dissolved oxygen concentration is low (Briscoe, et al., 2002), and negatively affect aquatic life in the waterbody (Ambrose et al., 2000). The decay of these mats may also cause problems with scum and odors that affect recreational uses of the affected waterbody. In addition, the concentration of ammonia, a nitrogen compound, has been present in concentrations exceeding objectives designed to protect aquatic life (RWQCB, 1996).

This section provides a review of the data used by the Regional Board to list the waterbodies within the Malibu Creek watershed for nutrient-related impacts. Where appropriate the data has been updated with more recent information. As the Regional Board's listing decisions are based on impairments to water quality, and TMDLs are designed to attain water quality standards, it is appropriate to begin this section with a discussion of the applicable water quality standards.

a. Applicable Water Quality Standards

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 in each waterbody in the region. The Water Quality Control Plan for the Los Angeles Region (Basin Plan, 1994) defines 14 beneficial uses for the Malibu Creek watershed. These uses are identified as existing (E), potential (P), or intermittent (I) uses. We have identified ten of the beneficial uses that are sensitive to nutrient compounds and related effects, such that protecting these uses will serve to protect all others too. Therefore this document focuses discussion on these ten use designations: REC1, REC2, WARM, COLD, EST, MAR, WILD, RARE, MIGR, and SPWN. Table 2 contains the beneficial use designations relevant to this TMDL.

Table 2. Malibu Creek Watershed Beneficial Uses

	RECREATION		AQUATIC LIFE USE SUPPORT							
	REC1	REC2	WILD	WARM	RARE	COLD	MIGR	SPWN	EST	MAR
Malibu Lagoon	E	E		E	E		E	E	E	E
Malibu Creek	E	E	E	E	E	E	E	E		
Las Virgenes Creek	E	E	E	E	E	P	P	P		
Malibou Lake	E	E	E	E	E					
Lower Medea Creek	I	I	E	I	E	P				
Upper Medea Creek	E	E	E	E						
Lindero Creek	I	I	E	I						
Lake Lindero	I	I	E	I						
Westlake Lake	E	E	E	E						
Lake Sherwood	E	E	E	E						

Recreational uses for body contact (REC1) and secondary contact (REC2) apply to all the listed waterbodies as existing, potential or intermittent. These uses apply even if access is prohibited to portions of the waterbody. Objectives designed to protect human health (e.g., bacterial objectives) and the aesthetic qualities of the resource (e.g., visual, taste and odors) are appropriate to protect recreational uses of the river.

The use designation for warm water fish (WARM) exists in most of the impaired creeks, with the exception of Medea Creek (Reach 1), and Lindero Creek. This use designation does not apply to the lakes, or the lagoon. The cold-water fisheries designated use (COLD) applies to Malibu Creek, Cold Creek, and Las Virgenes Creek. The Wildlife use designation (WILD) is for the protection of fish and wildlife. This use applies to all impaired waterbodies within the Malibu Creek watershed.

<u>Ammonia</u>. The Basin Plan establishes numeric objectives for ammonia which are protective of fish (COLD), (WARM) and wildlife (WILD) (see Plan Tables 3-1 through 3-4). The numeric objectives for ammonia in the Basin Plan were updated by the Regional Board in April 2002. The objective for chronic exposure is based on a four-day average concentration. The objective for acute toxicity is based on a one-hour average concentration. These objectives are expressed as a function of pH and temperature because un-ionized ammonia (NH_3) is toxic to fish and other aquatic life.

<u>Dissolved Oxygen</u>. Adequate dissolved oxygen levels are required to support aquatic life. Dissolved oxygen requirements are dependent on the beneficial uses of the waterbody for the Malibu Creek watershed. The Basin Plan states *"At a minimum (see specifics below) 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."* The WARM designation applies to all listed waters except Lake Lindero.

The Basin Plan also states, *"the dissolved oxygen content of all surface waters designated as both COLD and SPAWN shall not be depressed below 7 mg/l as a result of waste discharges."* The COLD and SPAWN designation applies to Malibu Lagoon, Malibu Creek, and Lake Lindero. COLD and SPAWN also apply as a potential use for Las Virgenes Creek.

<u>Nitrogen (Nitrate, Nitrite)</u>. Nitrogen requirements are dependent on the beneficial uses of the waterbody for the Malibu Creek watershed. Excess nitrogen in surface waters also leads to excessive aquatic growth and can contribute to elevated levels of nitrate in groundwater as well. The Basin Plan states, *"Waters shall not exceed 10 mg/L nitrogen as sum of nitrate-nitrogen and nitrite-nitrogen, 10 mg/L nitrate-nitrogen (NO_3-N), 45 mg/L nitrate or 1 mg/L as nitrite-nitrogen (NO_2-N)."* The Basin Plan also states *10 mg/L nitrogen [sum of nitrate-nitrogen and nitrite-nitrogen] is the water quality objective for Malibu Creek watershed* (see Plan Table 3-8)*."*

Biostimulatory Substances: Nutrients. The Basin Plan addresses excess aquatic growth in the form of a narrative objective for nutrients. Excessive nutrient (e.g. nitrogen and phosphorous) concentrations 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."* To implement this narrative objective, we have evaluated available data, studies, and other information to estimate the levels of nitrogen and phosphorus that can be present without causing violations of this objective.

Floating Materials: Scum/Foam. The Basin Plan expresses a narrative objective for floating material requiring that the waters should be free of floating material, including foams and scum *"in concentrations that cause nuisance or adversely affect beneficial uses."*

b. Assessment of existing conditions relative to numeric and narrative standards

This section describes conditions in the Malibu Creek watershed, which resulted in the inclusion of waterbodies as impaired on the 1996 Water Quality Assessment (WQA) which formed the basis for the 1996 and 1998 303(d) listings. We also have incorporated new information that was gathered as part of the submittal process for the 2002 303(d) listing process.

Ammonia as Nitrogen. Lake Sherwood and Westlake Lake are the only two waterbodies within the Malibu Creek watershed identified on the 1996 303(d) list as impaired due to ammonia concentrations. The data reviewed for the assessment were collected as part of a Regional Board study entitled, "Evaluation of Water Quality for Selected Lakes in the Los Angeles Hydrological Basin." (Lund et al., 1994). The data were collected between July 1992 and March 1993.

Table 3. Ammonia Concentrations (mg/l) for Lake Sherwood and Westlake Lake

Waterbody Name	Number of samples	Mean (Std Dev)	Range
Lake Sherwood	59	0.99 (1.28)	0.10 – 6.00
Westlake Lake	52	0.35 (0.35)	0.10 – 1.34

These data were evaluated against the updated ammonia criteria in the Basin Plan. Relative to the acute criteria, two of the Lake Sherwood samples exceeded the criteria (3%), and none (0%) of the Westlake Lake samples exceeded the criteria. Relative to the chronic criteria, seven of the Lake Sherwood samples (12%) exceeded the criteria and one of the Westlake Lake samples (2%) exceeded the criteria. There is no more recent data to assess the lakes for ammonia.

We also evaluated the available ammonia data for streams in the Malibu Creek watershed collected by Tapia as part of their NPDES monitoring program from 1991 to 1999. These data represent close to 800 samples. As can be seen in Table 4 below, the ammonia concentrations in the river were generally low. The median concentrations were typically below 0.1 mg/l. Ninety percent of the samples had concentrations below 0.2 mg/l.

Table 4. Summary of ammonia data from Tapia (1991 to 1999)

	Lower Las Virgenes Creek	Upper Malibu Creek	Middle Malibu Creek	Middle Malibu Creek	Lower Malibu Creek	Lower Malibu Creek	Malibu Lagoon	Malibu Lagoon
Station	R6	R9	R1	R2	R13	R3	R4	R11
Count	84	98	96	100	108	108	100	102
Average	0.07	0.03	0.15	0.21	0.05	0.05	0.07	0.06
Median	0.04	0.03	0.06	0.13	0.04	0.04	0.04	0.04
90^{th} percentile	0.09	0.06	0.20	0.21	0.10	0.08	0.12	0.12
Max	1.20	0.18	1.00	4.00	0.23	0.90	1.00	0.53

In the 2002 303(d) listing process, the Regional Board staff re-evaluated the monthly ammonia data collected between November 1988 to December 2000 from Malibu Creek, Cold Creek, Cheeseboro Creek, Medea Creek and Malibu Lagoon relative to the toxicity standard corrected for temperature and pH. When adjusted for pH there were no exceedances of the acute criteria in any of these reaches. There were also no exceedances of the chronic criteria adjusted for temperature and pH in any of the rivers. In summary there is some limited evidence of ammonia toxicity in the lakes and no data to suggest that the streams or lagoons are experiencing ammonia toxicity.

<u>*Dissolved Oxygen*</u>. Las Virgenes Creek was listed in the 1996 WQA as impaired due to depressed dissolved oxygen concentrations that do not meet the recommended water criteria for protection of fresh water aquatic life. This assessment was based on a total of eleven data points sampled over a two-week period in the fall of 1995. Six of the eleven data points were below 7 mg/l. To supplement this assessment, we reviewed data collected by Tapia WRF as part of their NPDES monitoring program of the data from January 1994 to June 1999. These data represent close to 2000 samples.

Table 5. Summary of dissolved oxygen concentrations (mg/l) from Tapia stations (1994-1999)

	Lower Las Virgenes Creek	Upper Malibu Creek	Middle Malibu Creek	Middle Malibu Creek	Lower Malibu Creek	Lower Malibu Creek	Malibu Lagoon	Malibu Lagoon
Station	R6	R9	R1	R2	R13	R3	R4	R11
Count	210	200	248	248	247	242	227	247
Average	7.12	7.64	9.57	8.79	9.27	11.66	12.38	10.87
Median	6.95	7.85	9.70	8.75	9.20	11.50	11.60	10.70
Minimum	4.3	3	5	5.9	6.8	5.3	7.1	0
# <5 mg/l	1	4	0	0	0	0	0	1

Based on these data there does not appear to be a problem with dissolved oxygen concentrations in the Las Virgenes Creek, Malibu Creek or the Lagoon. One criticism of the monitoring effort is that the sampling begins in the upper watershed and ends later in the day at the lagoon. Since DO concentrations are typically higher in the afternoon, this time differential might bias the results. To assess the potential for this bias the Regional Board contracted with SCCWRP to perform a pre-dawn survey at 17 sites in the watershed on September 22-23, 2001 (Briscoe et al, 2002). DO concentrations were less than 7.0 mg/l at 6 of 17 sites. These were generally sites with more developed land use. The average DO was greater than 5.0 mg/l at all sites except Malibu Lagoon where DO concentrations were very low (1.2 mg/l). The diel pattern for in-stream DO concentrations is a natural occurrence and there is insufficient evidence to suggest the DO concentrations in these streams are depressed as a result of waste discharges. On the other hand there is ample evidence that eutrophic conditions in the lagoon can lead to low DO values (Ambrose et al., 1995, Briscoe et al., 2002). Therefore we conclude that the data indicate that Malibu Lagoon does not meet applicable DO objectives. Available data for streams within the watershed are inconclusive as to whether DO objectives are attained in these streams.

The lakes study (Lund et al., 1994) suggested that there might be impairments in three lakes due to low DO. The waters of Sherwood Lake were generally anoxic below the hypolimnion (3 meters) from April to October. Westlake Lake was weakly stratified, but had low DO at depths below 4 meters in the summer. Malibu Lake was generally anoxic below 2.5 meters (April through October). No DO problems were observed in the relatively shallow Lake Lindero.

Biostimulatory Substances: Algae. For the 1996 WQA, impairment decisions were based on observations for the presence of these nuisance effects (also known as aesthetic stressors). Algae observed in "high" amounts were considered to be an exceedance of the narrative standard for floating material and biostimulatory substance. The results of observations made between 1991 and 1995 are summarized below (Table 6). Malibu Creek and three of its tributaries (Las Virgenes Creek, Lindero Creek, and Medea Creek) were listed as impaired due to observations of excessive algal growth.

Table 6. Summary of algae data in 1996 WQA listing.

Stream Reach	# of Observations	High amounts of algae
Malibu Creek	28	4
Las Virgenes Creek	15	5
Lindero Creek R1	2	2
Lindero Creek R2	7	4
Medea Creek R2	8	3

To supplement this data we analyzed the long-term data set from Tapia on percent algal cover in various reaches of Malibu Creek and Las Virgenes Creek (summarized in Table 7). We also reviewed data that was submitted from Heal the Bay (discussed below).

Table 7. Summary of Percent algal coverage for Tapia Data set (1983 to 1999)

All Seasons	Number of samples	Median	#>30%	%>30%
Las Virgenes	426	12.5	77	18%
Upstream of Tapia (R9)	393	12.5	140	36%
Immediately above Tapia discharge (R1)	442	12.5	118	27%
Immediately below Tapia (R2)	439	12.5	26	6%
County Gaging Station (R13)	444	12.5	57	13%
Malibu Canyon area (R3)	422	12.5	124	29%
Cross Creek Road (R4)	407	12.5	80	20%
Lagoon (R11)	434	12.5	39	9%
Summer Months (May - Oct)	**Number of samples**	**Median**	**# >30%**	**%>30%**
Las Virgenes	240	12.5	65	27%
Upstream of Tapia (R9)	210	31.25	105	50%
Immediately above Tapia discharge (R1)	251	12.5	95	38%
Immediately below Tapia (R2)	247	12.5	24	10%
County Gaging Station (R13)	252	12.5	37	15%
Malibu Canyon area (R3)	241	12.5	95	39%
Cross Creek Road (R4)	220	12.5	74	34%
Lagoon (R11)	248	12.5	32	13%
Winter Months (Nov - Apr)	**Number of samples**	**Median**	**#>30%**	**%>30%**
Las Virgenes	186	12.5	12	6%
Upstream of Tapia (R9)	183	12.5	35	19%
Immediately above Tapia discharge (R1)	191	12.5	23	12%
Immediately below Tapia (R2)	192	0	2	1%
County Gaging Station (R13)	192	12.5	20	10%
Malibu Canyon area (R3)	181	12.5	29	16%
Cross Creek Road (R4)	187	12.5	6	3%
Lagoon (R11)	186	0	7	4%

To assist in determining where and when algae were present at levels that cause violations of applicable water quality standards, the Regional Board applied algae assessment guidelines based on a New Zealand Study in the 2002 Section 303(d) listing process (Biggs, 2000). Based on its interpretation of the Biggs report, the Regional Board recommended that waters be considered impaired by algae if algae cover exceeded 30% in more than 10% of available samples. In its comments on EPA's draft TMDLs, the Regional Board also recommended application of this assessment criterion in considering seasonal variations in algae problems as part of TMDL development.

As indicated in Table 7, high algal abundances (i.e., greater than 30% cover) can be observed at many sites on a relatively frequent basis. These data also suggest that high algal abundances are most predominant in the summer months as all eight sites had coverages greater than 30% in 10% of the samples. During the winter months four of the sites had exceedance frequencies at or greater than 10%. The percentage of observations exceeding the 30% target was substantially lower in winter than summer at all eight sites.

As part of the 2002 303 (d) assessment, Regional Board staff analyzed data from 1997 to 1999, a subset of the data summarized above. These data reflect more accurately the recent condition. The patterns are basically similar with the exception that the percent coverage values have increased over this three year time period (CH2MHill, 2000). Although there are some instances in which the % algal cover exceeded 30% in the winter months, the problem is predominantly a dry-weather phenomenon.

We believe it was appropriate to apply the Biggs guidelines in the screening-level exercise entailed by the Section 303(d) listing process; however, it is unclear whether it is appropriate to apply Biggs' recommended guidelines in the manner suggested by the Regional Board to develop the Malibu Creek TMDLs for nutrients to address algal impacts. Based on our review of the Biggs report cited by the State, we believe it is appropriate to consider the Biggs guidelines in the TMDLs but to apply them in a manner somewhat different than applied by the State in the listing process.

We note that Biggs recommended a threshold of 30% cover for filamentous (floating) algae greater than 2 cm in length and a threshold of 60% cover for bottom algae greater than 0.3 cm thick. Biggs did not recommend application of a 10% frequency of exceedance for these cover algae guidelines as suggested by the State. Biggs recommended application of the algae cover guidelines "during summer low flows" and noted that the aesthetics/recreation guidelines are "only expected to be applied over the summer months". Biggs generally recommended evaluation of mean nutrient and biomass levels over relatively long averaging periods (monthly, seasonally, or annually).

Based on these considerations, EPA re-evaluated the Tapia algae data on a seasonal basis and evaluated both the mean values and the range of values at each sampling locations. We compared the seasonal mean values to the guidelines recommended by Biggs for filamentous algae (30%). The Tapia data set is based primarily on floating algae and indicates that mean algal cover at most stations is closer to 30% in the summer than in the winter months.

We also analyzed the data submittal from Heal the Bay that provided data from seven creek stations in the watershed (Cheeseboro Creek, 2 in Cold Creek, 2 in Malibu Creek, Las Virgenes Creek and Medea Creek) (See Appendix Figure A-3 which indicates the seasonal averages and range of values for each station). The data for floating algae was compared to the 30% threshold. The data for mat algae was compared to the 60% threshold. Based on Heal the Bay's floating algae data, average cover is generally less than 30% in both summer and winter. Assessment of the mat algae data indicates average cover near 60% at most sites in the summer. The winter values for mat algae are somewhat less than in the summer.

Our review of available, taken together, indicates that there is evidence of algal impairment in Malibu Creek throughout the year. Our review of the algae data available for Malibu Creek and Lagoon indicates algae are clearly present at levels of concern during the summer season (as defined in the TMDL) throughout the Malibu Creek watershed, and present at levels of potential concern during the winter months at several watershed locations. EPA believes these data support the decision to focus this TMDL primarily on algae impairment in the summer season and secondarily on algae problems in the winter season.

To better quantify the extent of algae coverage and the associated impact on the beneficial uses within the watershed, studies were conducted by SCCWRP and the University of California at

Santa Barbara to address existing data gaps in the knowledge of the spatial extent of algal coverage, and chlorophyll-a data, as well as, the species of algae present and which conditions limit the growth of algae in the streams.

The Chlorophyll-*a* (Chl-*a*) concentrations were generally below 50 mg/l at sites in Cold Creek, Palo Comado Creek and Triunfo. The Chl-*a* concentrations were higher (greater than 100 mg/l) at more developed sites such as Lindero Creek, Medea Creek and Malibu Creek. These sites also had higher percent cover of macroalgae and diatom films. In general the concentrations were higher in October than in August 2001. (see Appendix, Figures A-4, A-5)

The information used to list the lakes as impaired comes from observations by Lund et al. (1994) that suggested that there were problems with algae in all four lakes and macrophytes in Malibu, Sherwood and Lindero. There is no more recent data to evaluate the listing.

In conclusion, there is evidence of algal impairment in Malibu Creek throughout the year. Our review of the algae data available for Malibu Creek, Malibu Lagoon, and the tributaries indicates algae are clearly present at levels of concern during the summer at many locations in the Malibu Creek watershed, and present at levels of potential concern during the winter months at several watershed locations.

Floating Materials: Scum. As indicated in Table 4, Malibu Creek, Las Virgenes Creek, and Lindero Creek R2 are listed on the 1996 305(b) water quality assessment as impaired due to observations of scum and foam. These waterbodies are "Not Supporting" the Basin Plan narrative standard for floating materials. The beneficial uses that are affected by this impairment relate to recreation. The data for the observations were collected between 1991 and 1995. For the most part the observations of scum and odors correspond to areas of high algal abundance.

Table 9. Scum/Odor Observations

River Reach	# of Observations	High
Malibu Creek	23	3
Las Virgenes Creek	15	5
Lindero Creek R2	7	2

Summary of assessment. High levels of algae in the lagoon and streams have the potential to cause problems with DO, aquatic life and aesthetics. The percent algal cover is often greater than 30% in Malibu Creek, Las Virgenes Creek and Medea Creek. Total chlorophyll concentrations can be greater than 100 mg/l in the reaches of the more developed watersheds (Malibu Creek, Medea Creek and Lindero Creek). There is no demonstration that algae in these reaches is affecting dissolved oxygen concentration. However, taken together, the data on the types of algae in the watershed, the coverage of the mats, and total chlorophyll a concentrations observed indicate that streams are near conditions where one would expect eutrophy. These conditions appear to be more predominant in the summer months. This is consistent with the lakes study (Lund et al., 1994) that suggested that nutrients from runoff contribute to algae and macrophytes result in anoxic conditions concentrations in the summer season.

3. Numeric Targets

The streams, lakes and lagoon in the Malibu Creek watershed are 303(d) listed for exceedance of narrative criteria associated with excessive algal and periphyton growth, and associated water quality problems. The pollutants responsible for these conditions are nitrogen and phosphorus, thus the numeric targets for nitrogen and phosphorus are defined and used to calculate the TMDL, as discussed below. Other numeric targets are also developed for in-stream parameters such as dissolved oxygen, ammonia, algal cover and biomass. These other targets serve as indicators of the desired condition for the waterbody. EPA expects these indicators will provide a useful reference in determining the effectiveness of the TMDL in attaining water quality standards, although they are not directly enforceable by EPA.

a. Dissolved oxygen (DO)

The target for the mean annual dissolved oxygen concentration is 7 mg/l for all waters in the Malibu watershed (Table 10). A more restrictive target is required for Lake Lindero, Las Virgenes Creek and Malibu Lagoon to protect existing and potential uses associated with cold-water fisheries and spawning. The Basin Plan standard for waters designated as WARM is that no single determination be below 5.0 mg/l as a result of waste discharges. Recognizing that diel fluctuations in DO are a natural occurrence, we propose that 7.0 mg/l minimum for waters with uses associated with cold water fisheries and spawning be interpreted as an average daily value.

Table 10. Summary of numeric targets for dissolved oxygen

Waterbody	Annual average	Minimum conc. (mg/l)
Malibu Lagoon	7	7
Malibu Creek	7	7
Las Virgenes Creek	7	7
Lindero Creek Reach 1and 2	7	5
Medea Creek Reach 1 and 2	7	5
Malibou Lake	7	5
Lake Lindero	7	7
Westlake Lake	7	5
Lake Sherwood	7	5

b. Ammonia toxicity

Numeric targets for ammonia are based on the water quality standards in the Basin Plan and are set for the two lakes listed on the Section 303(d) list as well as for Malibu Creek itself in order to provide an additional indicator of whether future nutrient reductions result in attainment of ammonia objectives in the Creek. The acute criteria are dependent on pH and the chronic criteria are dependent on pH and temperature. Data on pH and temperature for the creeks and lagoon are based on long-term temperature and pH data collected by Tapia between 1998 and 1995. Targets for lakes are based on data from July 1992 to March 1993 (Lund et al., 1994). The target values for the acute criteria were calculated using the 90th percentile of pH and the 50th percentile of temperature and pH for the chronic criteria.

Table 11. Targets for ammonia toxicity for listed waterbodies

Waterbody	Target NH4 Acute criteria	Target NH4 Chronic criteria
Malibu Creek	2.59 mg/l	1.75 mg/l
Lake Sherwood	6.7 mg/l	2.1 mg/l
Westlake Lake	8.5 mg/l	1.5 mg/l

c. Algae/Chlorophyll *a*

The Regional Board has not established numeric values for nuisance levels of aquatic growth such as algae. These TMDLs establish numeric targets for percent algal cover and algal biomass for the entire Malibu Creek watershed.

Percent cover (Algae). The Regional Board has used 30% cover (with greater than 10 frequency) as an indicator for evaluating excessive nuisance algae for listing purposes based on recommendations from Biggs (2000). We will use 30% algal cover for floating algae (filamentous algae greater than 2 cm in length) and 60% algal cover for bottom algae (diatoms and blue green algae mats greater than 0.3 cm in thickness) expressed seasonal mean as targets in this TMDL for the creeks and lagoon. EPA believes these targets are more consistent with the recommendations found in the Biggs report.

Algal biomass- Chlorophyll a (Chl-a). There is relatively little information on targets for algal biomass in streams or lagoons. Studies by Dodds et al., 1988 suggested that a mean of 70 mg/m^2 Chl-*a* and a maximum of 200 mg/m^2 Chl-*a* might be used as a dividing point between mesotrophic and eutrophic conditions. Others have suggested values between 50 and 100 mg/m^2 Chl-*a* as targets for the mean and values between 100 and 200 mg/m^2 as targets maximum Chl-*a*. In these TMDLs, we use 50 mg/m^2 for the mean and 150 mg/m^2 for the maximum as numeric targets for in-stream chlorophyll-a concentration. This is based on our review of the data for Malibu Creek watershed which indicates that streams in undeveloped areas are generally below 50 mg/m^2 Chl-*a* and that values in developed areas are frequently above 150 mg/m^2 Chl-*a* (Kamer et al., 2002). The value of 150 mg Chl-*a*/m^2 is within biomass range of "critical level[s] for an aesthetic nuisance" as provided by EPA (1999a). The target for lakes of 10 ug/l Chl-*a* is based on EPA guidance (EPA, 1999a).

Table 12. Summary of numeric targets for algae

Waterbody Type	Chlorophyll-*a*	Algae (% coverage)
Lakes	10 ug/l	30
Streams	150 mg/m^2	30 for floating algae, 60 for bottom algae
Lagoon	150 mg/m^2	30 for floating algae, 60 for bottom algae

d. Nitrogen and Phosphorus

EPA is applying numeric targets for nutrients during two seasons. During the summer (April 15-November 15), total N (nitrate-nitrite) and total P targets are 1.0 and 0.1 mg/l respectively for all water bodies.

In the winter months (November 16-April 14), the total N target is 8 mg/l (nitrate-nitrite) for all water bodies. No total P target is applied during the winter months. Table 13 summarizes these targets for each season and each waterbody type. The basis for these targets is discussed below.

EPA stresses that these numeric target values are proposed only for waters in the Malibu Creek watershed. The inclusion of these numeric target values for Malibu watershed is not intended to reflect any judgements about the numeric targets needed for other nutrient TMDLs needed in California.

Table 13. Summary of numeric targets for nitrogen and phosphorus as monthly averages

Waterbody Type	**Summer (April 15 to Nov. 15)**		**Winter (Nov. 16 to April 14)**
	Total Nitrogen (mg/l)	**Total Phosphorous (mg/l)**	**Total Nitrogen (mg/l)**
Lakes	1.0	0.1	8.0
Streams	1.0	0.1	8.0
Lagoon	1.0	0.1	8.0

e. Basis for Summer Nitrogen and Phosphorus Numeric Targets

<u>Streams</u> At the present time there are no numeric nutrient criteria for general waters of California. States are being asked to develop nutrient criteria and Regional Board 4 staff is participating in the EPA and State work groups to development eco-regional specific nutrient criteria. Although studies are underway in a number of watersheds, the deadline for development and implementation of nutrient criteria is several years away.

EPA concluded that it is necessary to set numeric targets more stringent than the existing numeric objectives for total nitrogen in order to ensure attainment of the narrative objective that addresses Biostimulatory Substances. Our review of available data, studies, and information indicate that the numeric objectives are not sufficiently protective during the summer months when algae problems are most pronounced.

In the 1970s there was a recommendation of the use of 0.1 mg/l as a standard for total phosphorous, and many States and some Regional Boards have adopted this as a nutrient standard. Others (including San Diego Regional Board) have also used this number to develop a nitrogen value of 1 mg/l assuming a 10:1 nitrogen to phosphorous (N:P) ratio. EPA and NOAA have recommended values of 0.1 to 1.0 mg/l for nitrogen and 0.01 to 0.1 mg/l for phosphorous as guidelines for evaluating eutrophic conditions in coastal estuaries (NOAA/EPA 1988). Dodds et al. (1998) suggested thresholds of 1.5 mg/l nitrogen and 0.075 mg/l for distinguishing between mesotrophic and eutrophic conditions in streams based on a review of stream data from various locations around the world. However based on the work of Kamer et al. (2002) these values have little predictive power in explaining the patterns in algal abundance or biomass within the Malibu Creek watershed.

There is uncertainty as to what factors control algal abundances in the Malibu Creek watershed (Ambrose et al., 1995, CH2MHill, 2000, Ambrose et al., 2000, Kamer et al., 2002). Working in a number of creeks within the Malibu Creek watershed, Kamer et al. (2002) found that total phosphorus could explain 70% of the variability in benthic Chlorophyll a, and the combination of total phosphorus plus light could explain 68% of the variability in total chlorophyll a concentration. However their data on nitrogen to phosphorus (N:P) ratios were inconclusive suggesting that both N and P may be limiting or alternately that neither N nor P were limiting. Their experiments in the field were also inconclusive, some tests suggesting nitrogen limitation at undeveloped sites and P limitation at the more developed sites. They indicated that there might be other factors such as light and flow that may help to better explain the patterns in algal abundances. The nutrient limitation studies that have been done in the streams are equivocal for setting numeric targets.

Studies were inconclusive in large part due to the destruction of a large number of nutrient diffusers within the field. A follow-up nutrient diffuser study was conducted in the fall of 2002 and the final results are expected to be available by mid-2003. This study is expected to provide more definitive data regarding the relationship between nutrients and algal impairment. The Regional Board should carefully consider the results of this study, which may provide a basis for determining whether the TMDLs need to be revised.

Some efforts have been made to use N:P ratios to identify limiting nutrients in the lagoon. The N:P ratios reported by Ambrose et al. (1995) varied widely with time. The results suggested that averaged over the course of the year the upstream area near the Malibu Creek inlet tended to be more phosphorus limited (general norm for streams) while the central and downstream areas tended to be more nitrogen limited (the general norm of coastal waters). Ambrose et al. (2000) suggested that N was probably more limiting than P based on N:P ratios . However, others (CH2MHill, 2000) have pointed out that although the N:P ratios are suggestive of nitrogen limitation there is very little positive relationship between chemical concentrations and algal abundances in the lagoon. Indeed, in the summer time there is a negative relationship as algae take up nutrients. In addition, a review of the Tapia data indicates that reductions in Tapia loadings in the summer have not had any measurable effect on reducing algal abundances in the Lagoon.

Therefore, when establishing a numeric target to control algal biomass and chlorophyll a concentrations, it is important to consider the factors limiting algal growth. No single study element was identified as the factor most likely limiting algal growth (Ambrose et al., 2000; Kamer et al, 2002). In the absence of conclusive information on limiting factors, the EPA will target both nitrogen and phosphorus for the summer period. The target values (Table 13) and the rationale used to develop these targets are presented below. However, it is anticipated that the limiting condition will be determined prior to full implementation of these TMDLs. Studies are underway to: 1) assess the dissolved oxygen levels within the watershed, 2) assess the level of impairment due to excessive algae, and 3) evaluate the relationship between nutrient water quality and aquatic life impacts. After these determinations, the Regional Board may need to revise these TMDLs.

EPA has utilized the reference waterbody approach to develop numeric targets for impaired streams and lakes within the Malibu watershed. This approach is described in EPA guidance (EPA 2000a, 2000b). For streams, the reference approach involves using relatively undisturbed stream segments to serve as examples of background nutrient concentrations (EPA 2000). Data were reviewed from three locations upstream of the Tapia treatment plant where we have long-term data sets (see Figure A-1 and Table 14). The stations are located in Upper Malibu Creek (R9), Middle Malibu Creek (R1) and Lower Las Virgenes Creek (R6).

Table 14. Median Concentration Values (mg/l) from Tapia Monitoring stations (1991 to 1999)

NUTRIENT COMPOUND	Upper Malibu Creek (R9)	Middle Malibu Creek (R1)	Lower Las Virgenes Creek (R6)	Proposed Target
NO3-N	0.1	0.8	2.61	
TN	0.71	1.51	3.41	1.0
PO4-P	0.08	0.11	0.23	
TP				0.1

The concentrations for both nitrogen and phosphorus at the Upper Malibu Creek and Middle Malibu Creek stations were much lower than at the Las Virgenes Creek station. Data from stations R9 and R1 are believed to be more appropriate for setting target values using the reference approach. Based on data from these stations, the proposed targets are 1.0 mg/l for total nitrogen and 0.1 mg/l as a target for total phosphorus for the summer period. These values are consistent with EPA coastal values (NOAA/EPA 1998) and similar to the values for the eutrophic/mesotrophy proposed by Dodds et al. (2000) (1.5 mg/l TN and 0.075 mg/l TP).

Lakes. Lund et al. (1994) was the primary data source for establishing reference conditions for the lakes. This study evaluated trophic status, including nutrients and effects, for twenty-three lakes within the Los Angeles Region and was the same study used to list the four lakes in the Malibu Creek watershed as impaired. Ideally, reference conditions (nitrogen and phosphorus) are concentrations representative of lake conditions in the absence of anthropogenic pollution sources. However, since most lakes have been impacted by human activity to some measure, reference conditions represent the least impacted or most attainable lake conditions for a specific region (EPA, 2000b). Based on the evaluation, Crystal Lake, an alpine lake in the Los Angeles National Forest, was the least impaired. Nutrient concentrations at Crystal Lake were low, and these concentrations are felt to represent the most attainable nutrient and effects target.

Table 15. Summary of nutrient concentrations (mg/l) for five lakes (adapted from Lund et al., 1994)

Nutrient	Lake Sherwood	Westlake Lake	Malibu Lake	Lake Lindero	Crystal Lake	Proposed Lake Targets
NO3	0.5	0.3	0.5	0.4	<0.1	
NH4	0.8	0.4	0.1	0.1	0.2	
TKN	1.7	1.3	1.2	1.1	0.2	
TN	2.23	1.69	1.78	1.58	<0.3	1.0
TP	0.25	0.16	0.14	0.13	<0.1	0.1
PO4	0.25	0.16	0.13	0.09	<0.1	
Chl-*a*	16	14	44	23	4	

The proposed targets for these TMDLs are 1.0 mg/l for total N and 0.1 mg/l for total P for the summer period. The TP value of 0.1 mg/l is based on concentration at Crystal Lake. The TN value of 1.0 mg/l is derived from the Crystal Lake TP value assuming an N:P ratio of 10 to 1 ratio. The lake report (Lund et al., 1994) indicated that there were excessively high nitrogen values at Lake Sherwood, Westlake, Malibu Lake and Lake Lindero and high phosphorus values at Sherwood Lake and Lake Lindero. They suggested that Lake Sherwood and Westlake Lake were both N and P limited and that Malibou Lake and Lake Lindero might be P limited. Compliance with these targets will result in significant improvements in nitrogen concentrations in all four lakes, significant improvement in phosphorus concentrations in Sherwood Lake and Westlake Lake and minor improvements in phosphorus concentrations in Malibou Lake and Lake Lindero.

Lagoon. Targets for the Lagoon were derived from the EPA/NOAA guidance for estuaries (NOAA/EPA 1988). The targets are 1.0 mg/l for nitrogen and 0.1 mg/l phosphorus for the summer period. We used the high-end range for these values because of the uncertainty regarding which factors are limiting algal abundances. For comparison, average lagoon values during the summer were 1.39 mg/l for nitrogen and 0.49 mg/l (Ambrose et al., 2000). The average winter concentrations measured by Ambrose et al were 4.0 mg/l for nitrogen and 0.63 mg/l for phosphorus.

f. Basis for Winter Season Nitrogen Numeric Targets

The Regional Board's Basin Plan includes a numeric objective for Malibu Creek of 10 mg/l of nitrogen (sum of nitrate-nitrogen and nitrite-nitrogen). As discussed in the problem statement, Section 2, there is clear evidence of algae problems in the summer months and some evidence of algae problems in the winter months. In EPA's judgment, it would be unwarranted to apply the summer season numeric target values for nitrogen and phosphorus at this time given the significant uncertainty concerning the existence and degree of algae problems as well as the uncertainty concerning the relationship between algae growth and nutrient levels in the winter months. However, EPA has concluded that it is necessary and appropriate to set numeric targets for total nitrogen because the Basin Plan specifies numeric objectives for total nitrogen that apply throughout the year and because there is some evidence of algae problems in the winter. To account for these uncertainties, EPA is setting numeric targets for the winter months that are less stringent than the nitrogen targets selected for the summer season but more stringent than the Basin Plan numeric objective for total nitrogen. EPA is incorporating a 20% explicit margin of safety in the winter season numeric targets for total nitrogen in order to help address uncertainty concerning algal growth problems in winter and to ensure that the 10 mg/l numeric objective is met in all waterbodies during the winter months. Therefore, the numeric targets for the winter season are 8 mg/l for the streams, lakes, and lagoon.

4. Source Assessment

An inventory of possible sources of nutrients to the waterbody was compiled, and both simple methods and computer modeling were used to estimate nutrient loads for those sources. Provided below is a description of the sources and a summary of the load estimates. For more detailed information on the source assessment, please refer to the modeling report (Tetra Tech, 2002). The Tetra Tech analysis provided both annual and summer loading estimates for nitrogen and phosphorus. The summer analysis covered May 1 to October 31 and included storm events during that period.

For purposes of allocations among nutrient sources, federal regulations distinguish between allocations for point sources regulated under NPDES permits (for which wasteload allocations are established) and nonpoint sources not regulated through NPDES permits (for which load allocations are established) (see 40 CFR 130.2).

Sources of nutrient discharges to waters in the Malibu Creek watershed that are regulated in whole or in part through NPDES permits include direct discharges from the Tapia WRF and urban stormwater discharges regulated under municipal stormwater permits. As discussed further in the allocation section below, for some source categories, it is difficult to distinguish between discharges regulated under stormwater permits and discharges that are not subject to permit requirements. In the source assessment section, source categories are discussed based on the physical characteristics of the discharge rather than their regulatory status.

Nutrient loads for storm water runoff were estimated by using the Hydrodynamic Simulation Program Fortran, a computer model (Tetra Tech, 2002). Loads from nonpoint sources discussed in this section were estimated using simple mass balance calculations.

The major categories of nutrient sources in the Malibu Creek watershed are:

- direct and indirect discharges from Tapia WRF
- septic systems
- runoff from residential and commercial areas
- runoff and erosion from undeveloped areas
- runoff associated with agricultural/livestock
- golf course irrigation and fertilization
- groundwater
- atmospheric deposition

a. Tapia Water Reclamation Facility (WRF)

There are two types of discharges from the Tapia WRF operated by the Las Virgenes Municipal Water District (LVMWD). Direct discharges include discharges of treated effluent directly to Malibu Creek and effluent discharges to percolation beds and then to Malibu Creek. Indirect discharges include loads associated with effluent irrigation and sludge disposal, which may reach water bodies through surface runoff or subsurface flows.

Direct discharges. The discharges from Tapia WRF and the percolation beds were calculated from TWRF monitoring data and represented in the linkage analysis as a direct discharge into middle Malibu Creek.

The Tapia WRF was built in 1965 (RWQCB, 1997). The facility has been expanded several times over the years as increasing urbanization and population growth in the watershed has increased wastewater flows. The plant capacity was expanded from 10 mgd to 16.1 mgd in 1994 (RWQCB, 1997). In 1984, the plant was converted from secondary to tertiary treatment. Currently, discharge to Malibu Creek is not allowed during the summer season when the sand berm forms and closes off the entrance to Malibu Lagoon from the ocean. Regional Board Order No. 97-135 was adopted on November 3, 1997, and requires a discharge prohibition to the creek from April 15 through November 15 (RWQCB, 2000). Previously, discharges to Malibu Creek were fairly low during the season, when there is demand for the reclaimed wastewater. The mean summer effluent discharge rates during April to September ranged from <0.1 to 0.6 mgd. In comparison, the mean discharge rates during the winter months (October to February) were approximately 8 to 10 mgd (LVMWD, 1996-2000).

The treated effluent from Tapia has one of two end destinations. The effluent is either reclaimed for irrigation and industrial uses, or is discharged to streams. Effluent is discharged to Malibu Creek or Las Virgenes Creek through discharge points 001 and 002 (Table 16). No discharge is currently routed to the percolation ponds. The 004 discharge point was eliminated in 1999.

Table 16. Tapia Effluent Discharge Points

Discharge No.	Description	Subwatershed	Receiving Water
1	Primary outfall pipe	Middle Malibu Creek	Malibu Creek
2	Reservoir No. 2 outfall	Lower Las Virgenes Creek	Las Virgenes Creek

The primary discharge outfall into Malibu Creek is Discharge No. 001, which is located about 0.3 mile upstream of the confluence with Cold Creek (about 5 miles upstream of the lagoon). Discharge No. 002 flows into lower Las Virgenes Creek, and is used to release surplus effluent from Las Virgenes Reservoir No. 2, which is used for distribution of the reclaimed water system.

The effluent concentrations of nutrients discharged to Malibu Creek from 1992 to 2000 for phosphate-P concentrations ranged from 1.9 to 2.9 mg/l, and averaged 2.6 mg/l. Nitrate-N was the dominant nitrogen species, with concentrations ranging from 8 mg/l to 19 mg/l, and averaging 14 mg/l. Nitrite-N was negligible and was generally below the detection limit of 0.01 mg/l. Ammonia-N was generally below the detection limit of 0.2 mg/l. Organic-N concentrations ranged from 0.4 mg/l to 0.8 mg/l, and averaged 0.6 mg/l. The total nitrogen concentration averaged 14.6 mg/l, and the N/P ratio of the effluent was 5.6. (LVMWD, 1993-2000).

The nutrient loads discharged to Malibu Creek from Tapia were estimated from the monthly flow and concentration measurements collected by the Las Virgenes Municipal Water District for their NPDES monitoring reports (LVMWD, 1993-2000). The discharge prohibition was initiated in water year 1998.

Table 17. Annual nitrogen and phosphorus loadings from Tapia (1992-1999)

Year	1992	1993	1994	1995	1996	1997	1998	1999
Total Nitrogen	155,058	128,284	114,527	137,788	92,365	79,208	185,407	95,788
Total Phosphorus (PO_4)	46,728	39,032	18,295	19,623	15,833	9,092	29,620	16,104

The facility represents 30% of the nitrogen and 48% of the phosphorus loadings to the Malibu Creek watershed on an annual basis. Prior to the discharge prohibition, Tapia loadings represented 4.6% of the summer season loadings for nitrogen and 8% of the summer season loadings for phosphorus.

Indirect Discharges of Reclaimed Wastewater and Sludge Disposal. The Las Virgenes Municipal Water District (LVMWD) sells approximately 4,000 acre-feet per year of reclaimed wastewater from its Tapia WRF that is used for irrigating open space and landscaping (Abramson et al., 1998). In addition, Tapia composts the solid wastes from its treatment facility into fertilizer at their Rancho Las Virgenes Compost Facility (LVMWD, 1994; RWQCB, 1997; Abramson et al., 1998). Another portion of the sludge from Tapia is digested and pumped to their Rancho Las Virgenes Farm for subsurface injection. The sludge is used to fertilize the oat, barley, Sudan grass, silage corn, and Sudan hybrid crops that are grown during the various seasons at the 91-acre site (RWQCB, 1997). While these practices make good use of the reclaimed wastewater, they are essentially the same as fertilization and will add nonpoint sources of nutrients if the nutrient application rates are higher than the plant uptake rates. The excess nutrients will migrate to waterways through shallow groundwater flows, or increase the nutrient loads in surface runoff during storms (Tetra Tech, 2002).

Tables 18 and 19 present total loads of nitrogen and phosphorus, respectively, produced by effluent irrigation in the Malibu Creek Watershed. During model calibration, net loading of nitrogen was reduced to 25% of total produced loads due to plant uptake and soil retention, except for Tapia percolation beds that have no adjustments since they flow into Malibu Creek. During calibration, net phosphorus loads were reduced to 10% of total produced loads due to plant uptake and soil retention, except for the Tapia percolation beds that have no adjustments since they flow into Malibu Creek. In contrast to the common assumption that phosphorus is relatively immobile in soils, phosphorus loads from effluent irrigation were necessary to explain the observed concentrations in the waterways.

Table 18. Annual Nitrogen Loads associated with effluent irrigation in the Malibu Creek Watershed

Source	1992	1993	1994	1995	1996	1997	1998	1999
Triunfo Sanitation District	21,109	9,120	17,762	21,588	50,743	53,342	38,652	63,649
Western Las Virgenes Municipal Water District	117,522	75,110	80,883	98,653	80,737	94,253	81,021	100,741
Calabasas	46,673	38,975	56,946	60,743	60,080	50,754	46,498	60,749
Las Virgenes Valley	4,865	8,294	11,854	10,947	10,988	6,534	5,613	9,795
Rancho Las Virgenes	4,018	2,632	2,324	925	2,591	2,375	1,820	3,487
Rancho Las Virgenes Composting	0	0	0	0	0	0	148	150
Tapia Percolation Beds	46,585	20,185	69,882	91,645	69,745	72,300	0	0
Malibu Creek Park	0	0	0	0	0	0	0	40
Tapia Spray Fields and Wastewater Reclamation Facility	2,320	825	2,742	1,165	719	27,796	148	150
Tapia Yard	27,576	19,854	21,177	21,113	24,131	0	0	0
TOTAL	272,660	176,988	265,564	308,774	301,730	309,351	175,898	240,760

Table 19. Annual Phosphorus Loads associated with effluent irrigation in the Malibu Creek Watershed

Source	1992	1993	1994	1995	1996	1997	1998	1999
Triunfo Sanitation District	6,568	2,504	2,768	2,456	8,569	10,137	5,987	10,667
Western Las Virgenes Municipal Water District	36,704	21,302	12,374	11,721	13,637	14,793	14,563	17,221
Calabasas	14,554	10,981	8,978	7,204	10,241	8,063	8,395	10,747

Las Virgenes Valley	1,535	2,688	2,003	1,023	1,880	868	1,028	1,703
Rancho Las Virgenes	1,218	1,248	338	52	439	390	351	580
Rancho Las Virgenes Composting	0	0	0	0	0	0	25	25
Tapia Percolation Beds	14,348	5,902	10,741	12,372	11,972	8,741	0	0
Malibu Creek Park	0	0	0	0	0	0	0	10
Tapia Spray Fields and Wastewater Reclamation Facility	722	293	511	106	145	4,086	25	25
Tapia Yard	8,356	6,115	3,898	2,774	3,678	0	0	0
TOTAL	85,997	53,026	43,605	39,703	52,557	49,075	32,372	42,977

Table 20. Sludge injection loads at Rancho Las Virgenes Farm

Year	Sludge biosolids loading (ton/yr)	Total Nitrogen load (lb/yr)	Total Phosphorus Load (lb/yr)	Net Nitrogen Load to waters (lb/yr)
1997	307	49,120	6,140	24,560
1998	90	14,400	1,800	7,200
1999	1	160	20	80

Effluent irrigation and sludge injection are estimated to contribute 9% of the annual nitrogen load and 6% of the annual phosphorus load (Tetra Tech, 2002). These sources are estimated to contribute 15% of the nitrogen and 13% of the phosphorus loadings (Tetra Tech, 2002) during the summer season.

b. Septic Systems

Septic systems can be significant sources of nutrients, even when they are well sited and functioning properly, since they introduce nutrients to shallow groundwater that may eventually enter surface waters. Nitrogen is particularly mobile in groundwater, while phosphorus has a tendency to be adsorbed by the soils.

Except for the city of Malibu, most of the medium to high-density residential developments in the watershed are on sewer systems. However, septic systems are still used in lower density rural residential areas and in a few communities. The total number of septic systems in the watershed was estimated at 2,300 in the mid-1990s (NRCS, 1995).

The City of Malibu has about 6,000 septic systems, of which about 200 are estimated to be within the watershed boundaries based on information compiled by the Regional Board (RWQCB, 2000a). An estimated 70,000 to 80,000 gallons of septic effluent per day are discharged from about 20 commercial septic systems in shopping centers and commercial areas in the vicinity of Malibu Lagoon. Several hundred thousands of gallons per day are estimated to be discharged from private residences in the Malibu area of the lower watershed. Septic system discharges within the Malibu city limits (including areas outside of the watershed) are estimated to range from 840,000 to 1,200,000 gallons per day.

Although anecdotal reports indicate that illicit "greywater" discharges are a source of nutrient loads in areas where septic systems are utilized (LACDHS, 2001), the extent of the loading could not be quantified from available data.

Table 21 presents the total annual nutrient loads generated from septic systems in the Malibu Creek watershed. It was assumed that normal operating septic systems would remove 50 percent of the nitrogen and 90 percent of the phosphorous, that short-circuited systems would remove none of the nitrogen and 30% of the phosphorous, and that failing systems would not remove any of the nitrogen or phosphorous. The septic system nutrient loads were then adjusted to account for grass uptake, which resulted in about 13 percent removal for both nitrogen and phosphorus.

Table 21. Total Annual Nutrient Loads (lbs/yr) Generated from Septic Systems

Subwatershed	Total number of septics	Normal Septics	Failed Septics	Short-Circuited Septics	Comm-ercial Septics	Total effluent flow (gal/day)	Nitrogen Load (lbs/yr)	Phos-phorus Load (lbs/yr)
Hidden Valley Creek	625	500	125			171,250	30,879	5,147
Potrero Cyn Creek								
Westlake Lake	60	48	12			16,440	2,957	493
Upper Lindero Creek								
Lower Lindero Creek								
Upper Medea Creek								
Palo Comado Creek								
Cheeseboro Creek								
Lower Medea Creek	110	88	22			30,140	5,439	905
Triunfo Creek	820	656	164			224,680	40,515	6,753
Upper Malibu Creek	95	76	19			26,030	4,709	781
Upr L.Virgenes Crk								
Lwr L.Virgenes Crk	50	40	10			13,700	2,482	412
Stokes Creek	85	68	17			23,290	4,198	701
Middle Malibu Creek	50	40	10			13,700	2,482	412
Cold Creek	300	240	60			82,200	14,819	2,471
Lower Malibu Creek	5	4	1			1,370	256	40
Malibu Lagoon								
Above Lagoon	170	136	34			46,580	8,395	1,398
Adjacent to Lagoon	30			30		8,220	1,497	248
Commercial near lagoon	20				20	75,000	13,542	2,256
Total	**2420**	**1896**	**474**	**30**	**20**	**732,600**	**132,094**	**22,017**

Note: The Regional Board report (2000a) provided descriptions of various septic categories. Normal systems represent the majority of the septic systems that are properly sited and are functioning according to normal design standards. Failing systems represent septic systems that are not operating properly due to a variety of reasons. Failing systems include systems that have backed up or that have surfacing effluent, as well as systems that routinely have poorly functioning leach fields. Estimates of septic system failure rates ranged from 20 to 30 percent in the Malibu Creek watershed. A 20 percent maximum failure rate was assumed for the modeling, and was applied to each subwatershed that has septic systems. Short-circuited systems represent septic systems that are sited close to waterways and that have very shallow groundwater tables so that little nutrient or pathogen removal takes place. This category was used for the residential septic systems in Malibu Colony and the commercial septic systems in the Cross Creek shopping center that have been shown to influence Malibu Lagoon.

We estimate that on an annual basis septic systems contribute about 10% of the nitrogen loadings and 10% of the phosphorus loadings. During the summer season septic systems contribute about 22% of the nitrogen and 21% of phosphorus loadings. We understand that the City of Malibu is conducting a risk assessment to accurately characterize the impact of septic systems on groundwater in the Lower Malibu Creek and Malibu Lagoon watershed (City of Malibou, 2001). Data from this study will provide greater certainty on the estimates of actual loadings from septic systems to the creek and lagoon.

c. Runoff from Residential and Commercial Areas

Runoff from residential and commercial areas can be important sources of nutrients and bacteria. Most of the major residential and commercial areas are in the cities of Westlake Village, Thousand Oaks, Agoura Hills, Calabasas, and Malibu. Lower density residential areas are scattered in many areas of the watershed, and include the communities around Lake Sherwood and Malibou Lake, the Hidden Valley area, the Palo Comado Creek area east of Agoura Hills, and the community of Monte Nido. The potential nutrient sources include fertilizer used for lawns and landscaping; organic debris from gardens, landscaping, and parks; phosphorus in detergents used to wash cars or driveways; trash such as food wastes; domestic animal waste; and human waste from areas inhabited by homeless. Human and domestic animal waste are also sources of bacteria. These pollutants build up, particularly on impervious surfaces, and are washed into the waterways through storm drains when it rains. These loads are typically highest during the first major storms after extended dry periods, when the pollutants have accumulated.

Activities such as watering lawns and landscaping, washing cars, and washing parking lots and driveways can contribute pollutants between storms. A portion of the nutrients from all of the above sources will also infiltrate into the soils of pervious areas, and may enter the waterways through shallow groundwater flows (Tetra Tech, 2002).

On an annual basis runoff from developed land areas contributes 13% of the total nitrogen load and 10% of the total phosphorus loads. During the summer season these land uses contribute 19% of the nitrogen loadings and 17% of the phosphorus loadings.

d. Runoff from Undeveloped Areas

More than 75% of the Malibu Creek watershed is undeveloped land (open space) consisting primarily of chaparral, scrub, and woodlands, with smaller areas of grasslands and forests. Runoff from these areas contributes nutrients to the waterways in both particulate and soluble forms. Particulate forms generally predominate and are introduced through the erosion of soils that contain organic litter from the overlying vegetation. Soluble nutrients are released during litter decomposition and may enter the waterways as a component of surface runoff or through shallow groundwater transport.

In addition, wildlife wastes may contribute to the nutrient loads from the large undeveloped portions of the watershed. The abundance of wildlife varies among the different habitat and vegetation types. Approximately 50 species of mammals and 380 species of birds occur in the watershed (NRCS, 1995). The important mammals include mule deer, hares, rabbits, squirrels, foxes, bobcats, badgers, ring-tailed cats, weasels, coyotes, raccoons, skunks, mountain lions, and a variety of small rodents (rats, mice, gophers, voles).

Waterfowl are important components of the Malibu Lagoon ecosystem, and may also contribute nutrients and bacteria to the various lakes in the watershed. Waterfowl were considered as a separate loading source only for Malibu Lagoon, since birds may be an important source of nutrients in the lagoon (Warshall et al., 1992). Waterfowl loads were not evaluated for the lakes since bird counts were not available. Table 22 presents the annual nutrient loads produced by waterfowl near Malibu Lagoon.

Table 22. Nutrient loadings (lbs) produced by waterfowl in Malibu Lagoon (Reference: Topanga-Las Virgenes Resource Conservation District)

Month	Bird Population	Nitrogen (lbs/mo)	Phosphorus (lbs/mo)
January	1000	237	85
February	1500	290	104
March	1630	293	105
April	400	54	19
May	300	42	15
June	320	43	16
July	230	105	38
August	200	42	15
September	400	54	19
October	750	105	38
November	780	297	107
December	1100	209	75
Annual Total (lbs/yr)		**1771**	**637**

Runoff from undeveloped land contributes 20% of the nitrogen and 17% of the phosphorus on an annual basis. The percent contribution during the summer is 9% for nitrogen and 11% for phosphorus. Birds contribute a relatively small fraction of the annual nitrogen load (0.3%) and phosphorus load (0.7%). The summer contribution is also a small percentage (0.5%) about 2% of phosphorus. The effects of birds and may be more significant on a local scale.

e. Agriculture/Livestock

Most of the agricultural activity in the Malibu Creek watershed is concentrated in the Hidden Valley area and consists primarily of pastures and grazing. Smaller agricultural areas are found in parts of the Stokes Creek, Lower Las Virgenes Creek, and Triunfo Creek subwatersheds. Orchards or vineyards occur in a few areas of the Triunfo Creek, Hidden Valley, Lower Malibu Creek, and Malibu Lagoon subwatersheds. Agricultural lands introduce nutrients to waterways through both surface runoff and erosion during storms and through shallow groundwater flows. The nutrient sources include fertilizers applied during cultivation; organic litter from the plants, grasses, or trees; erosion of the surface soils; waste accumulation from grazing animals; and soluble nutrients released during the decomposition and mineralization of plant litter and animal waste.

Manure produced by horses, cattle, sheep, goats, birds, and other wildlife in the Malibu Creek watershed are sources of both nutrients and bacteria. These loads can be introduced directly to the receiving waters in the case of waterfowl or cattle wading in streams, or they may occur as nonpoint sources during storm runoff. Horses are the most prevalent livestock in the watershed. Although horses are scattered throughout much of the watershed, most of the horses are concentrated in a few areas. These are Hidden Valley, the Palo Comado Creek area east of Agoura Hills, the Triunfo Creek and Lower Medea Creek areas in the vicinity and upstream of Malibou Lake, and the Cold Creek area around the community of Monte Nido. Cattle grazing is confined primarily to the Hidden Valley area in the upper western portion of the watershed. Approximately 250 cattle are estimated to reside in this area. Approximately 200 sheep and goats reside in the Ahmanson Ranch and pasture area north and east from the Rancho Las Virgenes. In the past years, cattle grazing also has occurred on the Rancho Las Virgenes property of the upper Las Virgenes Creek subwatershed. The Natural Resources Conservation Service study provided the above estimates (NRCS, 1995).

Tables 23 and 24 present gross nutrient loads from horse and livestock manure, respectively, in the Malibu Creek watershed. The horse loads are reduced by forty percent for input into the model, due to collection of horse manure from stables, except for Hidden Valley subwatershed where there are many open pastures. Additionally, loads were reduced by twenty percent for horses and thirty percent for cows and sheep because these percentages were assumed to occur as urine and instead contribute nutrients to shallow groundwater (ASAE, 1998). Because horse and livestock loads occur as non-point sources in the model, there is a buildup of the nutrients during the dry periods and thus reduced contribution of the nutrients to the stream reaches during these periods.

Table 23- Gross Annual Horse Nutrient Loads

Subwatershed	Number of Horses	Total N (lbs/yr)	Total P (lbs/yr)
Hidden Valley Creek	920	100,740	23,842
Portereo Canyon Creek	40	4,380	1,037
Westlake Lake			
Upper Lindero Creek			
Lower Lindero Creek	5	548	131
Upper Medea Creek	20	2,190	518
Palo Comado Creek	100	10,950	2,592
Cheeseboro Creek			
Lower Medea Creek	140	15,330	3,628
Triunfo Creek	160	17,520	4,146
Upper Malibu Creek			
Upper Las Virgenes Creek	15	1,643	391
Lower Las Virgenes Creek	5	548	131
Stokes Creek	45	4,928	1,168
Middle Malibu Creek	30	3,285	777
Cold Creek	115	12,593	2,982
Lower Malibu Creek			
Malibu Lagoon	100	10,950	2,592
Total	**1695**	**185,603**	**43,928**

Table 24. Gross Annual Other Livestock Nutrient Loads

Subwatershed	Cattle	Sheep/Goats	Total N (lbs/yr)	Total P (lbs/yr)
Hidden Valley Creek	250		24,820	6,716
Upper Las Virgenes Creek	15		1,489	402
Upper Las Virgenes Creek		200	1,840	380
Total	**265**	**200**	**28,149**	**7,501**

On an annual basis, agriculture/livestock contribute about 5% of nitrogen and about 2% of annual phosphorus. During the summer season the percent contribution increases to about 8% for nitrogen and about 4% for phosphorus.

f. Golf Courses

Golf courses can be major sources of nutrients since the typical fertilization and watering rates are generally much greater than the amounts utilized by the golf course grasses. The excess nutrients accumulate in the soils and can be transported to waterways in shallow groundwater flows and stormwater runoff. Most of the golf courses are adjacent to waterways. Both Lake Sherwood and Lake Lindero have golf courses just upstream of the lakes, and Westlake Lake has a golf course about 0.6 miles northeast of the lake. In addition, two golf courses are located in the upper portions of the Westlake and Upper Lindero Creek watersheds near perennial or intermittent streams. There is also a small private golf course on the west side of Malibu Lagoon in the Malibu Colony area.

Table 25 presents golf course total nutrient loads and those remaining after grass uptake. During model calibration, it was assumed that fifty percent of the net nitrogen loads and ten percent of the net phosphorus loads reached the waterways because of reductions from processes such as plant uptake and soil retention (Reed et al., 1988). For the Hidden Valley golf course, it was assumed that 100% of the net nitrogen load and twenty percent of the net phosphorus load reached Lake Sherwood because the golf course is adjacent to the lake. In contrast to the common assumption that phosphorus is relatively immobile in soils, phosphorus loads from golf courses were necessary to explain the observed concentrations in the waterways.

Table 25. Golf Course Total and Net Nutrient Loads (lbs/yr) after Grass Uptake

Subwatershed	**Adjacent Tributary**	**Total acres**	**Gross N Loading (lbs/yr)**	**Gross P Loading (lbs/yr)**	*Net N Loading* (lbs/yr)	*Net P Loading* (lbs/yr)
Hidden Valley Creek	Lake Sherwood	150.6	47,172	20,604	15,552	14,568
Westlake (2 courses)	Westlake Tributary Triunfo Creek Trib	199.2	66,708	27,996	24,876	20,016
Upper Lindero Creek (2 courses)	Lake Lindero Upper Lindero Creek	103.6	32,556	14,196	10,800	10,044
Malibu Lagoon	Malibu Lagoon	10.5	3,288	1,440	1,080	1,020
Total			149,724	64,236	52,308	45,648

On an annual basis, golf course contributes 5% of the total nitrogen and 7% of the total phosphorus loadings. During the summer the percentages increase to 9% for nitrogen and 16% for phosphorus.

g. Groundwater

Shallow groundwater provides the base flows to the streams and is a major source of water during the summer season. Therefore, dissolved nutrients in groundwater can be important sources during dry periods. The nutrient concentrations in groundwater depend on the nature of the soils, geology, vegetation type and coverage, and nutrient sources such as septic systems and fertilization (Flowers, 1972).

Information on nitrate concentrations in groundwater is available from detection monitoring programs at the Rancho Las Virgenes Farm and the Calabasas Landfill. Background nitrate concentrations can be estimated from the monitoring locations that are either upgradient of the sites, or that have been determined to be unimpacted by the site operations. The average nitrate nitrogen concentration at the upgradient wells was 1.58 mg/l during 1997 to 2000 (CSDLC, 2000). The range at these wells was 0.05 to 12.3 mg/l. In the impacted area downgradient of Rancho Las Virgenes Farm, the average nitrate nitrogen concentration in monitoring wells was 153 mg/l, and the range was 0.3 to 370 mg/l (Tetra Tech, 2002). See Table 26 for groundwater summary data.

Table 26. Nitrate Concentrations in Groundwater

Well location - Watershed	Sample Period	No. of wells with data	No. of analyses	Average NO_3-N (mg/l)
Malibu Creek	Pre-1973	40	46	1.9
Malibu Creek	Pre-1973	20	53	1.6
Las Virgenes	Pre-1973	6	7	1.6
Lindero Canyon	Pre-1973	14	17	3.4
Triunfo Canyon	Pre-1973	6	7	0.9
Russell Valley	Pre-1973	4	16	3.25
Sherwood	Pre-1973	21	40	1.3
Up gradient RLV Farm	1997-2000	3	58	1.58
Down gradient RLV Farm	1997-2000	5	49	153.4

Background nutrient loads from the shallow groundwater were estimated using flow rates simulated by HSPF and the average nitrate concentration (1.0 mg/l) from the upgradient well datasets from Rancho Las Virgenes Farm and the Calabasas landfill. The concentration of phosphorus was estimated at 0.13 mg/l. The concentration was based on the measurements in some upstream tributaries during base flow periods (Tetra Tech, 2002). It is not known whether these “background” groundwater nutrient levels are naturally occurring or are also influenced by anthropogenic inputs. We estimate that on an annual basis, groundwater loadings represent about 6% of the nitrogen and phosphorus to the watershed. During the summer season groundwater loadings represent about 9% of the nitrogen and about 12% of the phosphorus.

g. Atmospheric Deposition

Atmospheric deposition rates for nitrogen in the Malibu Creek watershed were estimated from recent measurements and modeling conducted by Ambrose et al., 2000 and the Southern California Coastal Water Research Project (SCCWRP).

The total nutrient loads from atmospheric deposition can be substantial since they are applied to the whole watershed. However, much of these nutrients are taken up and cycled by plants in the large vegetated areas of the watershed, so only a small portion of the deposited nutrients actually enters the waterways. In urbanized or agricultural areas, other activities such as fertilization or detergent use provide larger loads on a per unit area basis. Therefore, atmospheric deposition of nutrients was considered as a separate nonpoint source loading category only to the surfaces of receiving waters. Atmospheric deposition to land was included in the total nutrient build-up and washoff parameters that were defined for each land use and vegetation type that was modeled with HSPF (Tetra Tech, 2002). Table 27 summarizes the atmospheric deposition loads to Malibu Lagoon and the four study lakes.

Table 27. Nutrient loads from atmospheric deposition

Waterbody	Surface area (acres)	Nitrogen Load (lb/yr)	Phosphorus Load (lb/yr)
Lake Sherwood	163	3602	43.7
Westlake Lake	95	2100	25.5
Lake Lindero	12	265	3.2
Malibou Lake	55	1216	14.7
Malibu Lagoon	13	287	3.5

In summary, direct atmospheric deposition accounts for about 1% of the total nitrogen and a much smaller fraction (0.1%) of the total phosphorus on an annual basis. Atmospheric deposition contributes a larger percentage of the summer period loadings representing about 5% of the nitrogen and 0.5% of the phosphorus.

h. Sediments

Nutrient loads from sediment release and aquatic plant decomposition were considered for the four lakes and Malibu lagoon. Nitrogen and phosphorus loadings from Malibu Lagoon sediments were based on measurements and estimates performed by UCLA (Ambrose et al., 1995 and 2000). Nitrogen and phosphorus release rates from the sediments of the four lakes were estimated using typical release rates measured in other lakes (Tetra Tech, 2002 and references therein).

Estimates of nutrient loads associated with sediments are relatively minor on a watershed basis (about 3% of the annual nitrogen and about 4% of the total phosphorus). In places like Malibu Lagoon and perhaps Malibou Lake, the release from the sediments may have a major effect on nitrogen and phosphorus concentrations. We estimate that in the summer, when the algae problem is the worst, sediments account for about 16% of the nitrogen and phosphorus loaded to the lagoon. Although there is ample evidence that sediments are scoured out of the lagoon during heavy winter storms (Ambrose et al., 2000), little is known about how much of the annual nitrogen and phosphorus loads to Malibu Lagoon are deposited and retained in the sediments.

i. Tidal Inflow

Tidal inflow loads of nutrients were calculated from estimated tidal inflow rates from the UCLA study (Ambrose et al., 2000) and nutrient concentrations in coastal waters measured during the Malibu Technical investigation (RWQCB, 2000). The concentrations were averaged from measurements at all beach surf zone stations. The average concentration for phosphorus was 0.03 mg/l. and 0.47 mg/l for nitrogen.

Tidal inflow accounts for 4% of the annual nitrogen and 2% of the annual phosphorus loadings for the entire watershed. During the summer season, tidal inflow accounts for 5% of the nitrogen loads and about 3% of the phosphorus loads. These loadings affect the lagoon only.

j. Dry Weather Storm Drain Loads to Malibu Lagoon

Three major storm drains discharge to Malibu Lagoon. The Civic Center drain collects runoff from much of the floodplain, nearby hillsides, and the Civic Center area northwest of the lagoon

(Warshall et al., 1992; Ambrose et al., 2000) and discharges to Malibu Creek near the entrance to Malibu Lagoon. The Cross Creek Road drains the Cross Creek Plaza shopping center and surrounding commercial areas, and discharges to Malibu Lagoon next to the highway. The Malibu Colony drain collects runoff from the areas around Malibu Colony Plaza and Malibu Road and discharges into the western edge of the lagoon.

Dry weather nutrient loads from the two drains were calculated in the UCLA study using measured nutrient concentrations in washwater from the commercial parking lots (16 mg/l N and 0.36 mg/l P), estimates of the amount of wash water used, and the acreages of the washed commercial areas determined from field observations (Ambrose et al., 2000). From a watershed basis, the loadings from these sources were almost negligible. They represent less than 0.1% of the total annual nitrogen and 0.01% of the total annual phosphorus. Even on a local scale the contribution is small representing less than half a percent of the summer nitrogen load and 0.1% of the summer phosphorus load from the Malibu Lagoon subwatershed.

k. Summary of source assessment

Based on watershed modeling study (Tetra Tech, 2002) the following conclusions are provided. On an annual basis, Tapia WRF contributes a large percentage of the nitrogen and phosphorus loadings. High nitrogen and phosphorus loadings are also associated with wet-weather runoff associated with commercial and residential land uses and also with wet-weather runoff from undeveloped areas (see Appendix, Figure A-6). The loadings during the summer (defined by Tetra Tech as May to October) are at least an order of magnitude lower, partly due to the Tapia discharge prohibition, but primarily due to the decrease in runoff associated with large storms. During the summer, sources like septic systems, golf course irrigation and fertilization, and urban runoff provide a greater percentage of the load (see Appendix, Figure A-7). Sources and associated loadings are not distributed evenly throughout the watershed, so that reductions made at local scales (subwatersheds) are likely to have immediate effects on water quality even though they may represent a small fraction of the overall loadings to the watershed. Distribution of estimated loads for each nutrient by watershed are shown in Tables A-1 through A-4 (see Appendix).

5. Linkage Analysis: Linking Sources with Water Quality Targets

Information on sources of pollutants provides one part of the TMDL analysis. To determine whether those pollutants impair a waterbody, it is also necessary to determine the assimilative capacity of the receiving water under critical conditions. This section describes the methods used to determine the nutrient loadings that can be assimilated by the receiving waters and ensure attainment of the numeric targets (described in Section 2). In this section, we also describe the approaches for defining the critical conditions and developing an appropriate Margin of Safety (MOS) to ensure that water quality standards will be met. (Reminder these nutrient TMDLs define summer as April 15 to November 15 and winter as November 16 to April 14.)

To assist in analyzing these TMDLs, EPA and its contractors used receiving water quality models to estimate pollutant loads and predict the nutrient concentrations in the various streams, lakes, and lagoon in the watershed. The models assisted in the analysis of linkages between sources of pollutants to in-stream water quality concentrations and impacts in receiving waters (rivers, lakes and lagoon). The models also assisted in evaluating the relationship between pollutant loads and the in-stream water quality targets for the listed reaches (Tetra Tech, 2002).

The Hydrodynamic Simulation Program FORTRAN (HSPF) model selected for the watershed loading analyses includes a receiving water model applicable to both streams and well-mixed lakes. The HSPF model includes different forms of the limiting nutrients for algal growth (phosphorus and nitrogen), nutrient cycles, phytoplankton, and other water quality variables such as dissolved oxygen and biochemical oxygen demand (BOD). HSPF was selected since it could be linked directly with the watershed and stream-modeling framework and would apply to both rivers and the lagoon system.

The BATHTUB model was used to develop the linkage between loadings to the lakes, nutrient concentrations and algal biomass. BATHTUB also uses mass balance models to predict phosphorus and nitrogen concentrations in the water column as functions of loading rates, outflow (flushing) loss rates, and internal loss rates. Phytoplankton concentrations were estimated based on steady-state relationships that include processes such as photosynthesis, settling, respiration, grazing mortality, and flushing (Tetra Tech, 2002).

a. Critical conditions and seasonality

EPA has reviewed available monitoring data and has concluded the most critical time period for impairment is during the summer months when the potential for eutrophication and hypoxia are the greatest. Based on comparison of impairments in surface waters and local rainfall data, the "summer" time period corresponds to April 15 to November 15. For the lakes, this is the period when the percent algal coverage and biomass appear to be the greatest (see Problem Statement section). The summer also reflects the critical period for exceedance of the ammonia toxicity standard because of higher lake temperatures. For Malibu Lagoon, the algae problem appears greatest during the summer months since the lagoon is impounded and the streams have areas of little flow which allows algal growth to proliferate due to minimal flushing combined with longer daylight levels and warmer waters. Therefore, TMDLs are being established for both nutrients—total Nitrogen and total Phosphorus during the summer in all water bodies.

Some evidence of excessive algae also exists in streams and lakes during the winter months (November 16 to April 14). However the percent algae coverage is much less in the winter than during the summer months and given the fairly high degree of subjectivity for making these algae assessments, there is uncertainty regarding the degree of impairment. As previously discussed several studies within the watershed have not clarified the issue of nutrient limitation nor direct effect of nutrients on algae growth. EPA is establishing only nitrogen TMDLs for the winter months because the Basin Plan contains a numeric objective for total nitrogen which the TMDLs must meet, and because the need for phosphorus TMDLs during the winter has not been firmly established.

The best information currently available to EPA indicates that exceedances of standards during the summer period are not exacerbated by nutrient discharges during the winter period that might remain in the system during summer (CH2MHill, 2000). Therefore, EPA has concluded that it is not necessary to reduce the loading capacity estimates (particularly during the wetter winter period) to account for potentially delayed effects during summer associated with winter nutrient discharges.

Summer. For the summer season, the loading capacity was calculated by determining the median flow value at the Malibu Creek gaging station (below Cold Creek, LACPWD site #F130-R) during the summer season and multiplying that median flow by the concentration-based numeric targets for total nitrogen and total phosphorous and a units correction factor to yield daily loading capacities. The loading capacity estimate is based on median flow values for the 1998-2001 period, which is the period following the imposition of new permit requirements for the direct Tapia WRF discharge that essentially prohibit discharge from Tapia between April 15-November 15. EPA concluded that it is appropriate to base the loading capacity estimate on median flow because summer season nutrient effects in the Malibu Creek watershed are principally associated with algae growth which occurs over relatively long time periods (more than a week) that are best represented by the median flow values rather than mean flows. EPA also rejected the 90^{th} percentile flow level (2.5 cfs) because that flow level does not account for periodic wet weather-related loads in the summer season which could cause substantial nutrient loads. Applying the 90^{th} percentile flow would result in TMDLs that are more stringent than necessary to implement the applicable water quality standards and that may not be attainable. The selection of summer median flows as the appropriate critical flows is also based on the consideration that the TMDL addresses algae growth in several lakes and the Malibu Lagoon, which are less sensitive to short term variations in flows and nutrient loads than are most streams.

The long-term median summer flow value was approximately 5.2 cfs. This value was multiplied by the numeric target values of 1.0 mg/l total nitrogen and 0.1 mg/l total phosphorus and an appropriate correction factor to yield loading capacity estimates of 77.1 lbs/day of total nitrogen and 7.7 lbs/day of total phosphorus for the summer season. These loading capacities are expressed as average daily values yet can be easily converted to monthly or summer values by multiplying by the appropriate number of days.

Winter. For the winter season, EPA considered applying a similar mass load based approach to calculating loading capacities for nitrogen. However, because flows and loads vary much more in Malibu Creek during the winter season in response to much more frequent wet weather events, EPA concluded that it would be more appropriate to identify concentration-based loading capacities (which are more sensitive to variations in flow levels) than to estimate mass based loading capacities based on simplified critical flow estimates. Based on these considerations, the winter season loading capacity for nitrogen is 8 mg/l of nitrate-N plus nitrite-N for all water bodies in the watershed, which is equivalent to the numeric target for total nitrogen in the winter season.

6. TMDLs and Pollutant Allocations

a. TMDLs

These TMDLs are set equivalent to the loading capacities (i.e., the assimilative capacities) for the water bodies addressed in these TMDLs. The loading capacity calculations were discussed in the preceding section. Table 28 summarizes the TMDLs.

Table 28: TMDLs for Nitrogen and Phosphorus

Season	Total Nitrogen	Total Phosphorus
Summer (April 15- November 15)	27 lbs/day	2.7 lbs/day
Winter (November 16- April 14)	8 mg/l*	n/a

* nitrate-N+nitrite-N

b. Allocations

Consistent with the TMDLs defined above, EPA has defined allocations for each pollutant source for the winter and summer seasons. Each pollutant source is allocated a quantitative load of nitrogen and phosphorus compounds for summer and nitrogen for winter. Allocations are designed such that each waterbody will not exceed the seasonal TMDLs, and not exceed numeric targets for any of the nutrient compounds or effects in any of the listed reaches. Consequently each waterbody will attain water quality standards. As required by EPA regulations, the TMDL is the sum of the wasteload allocations and load allocations, including natural background.

Point sources are given wasteload allocations, and non-point sources are given load allocations. The direct discharges from the Tapia WRF are regulated through an NPDES permit; therefore, this source is assigned wasteload allocations in this TMDL. In addition, EPA recognizes that discharges of stormwater and other runoff from some urbanized areas in the watershed are regulated pursuant to the Los Angeles and Ventura County municipal stormwater permits. Discharges in the following allocation categories likely include some discharges regulated through these stormwater permits:

- Runoff from developed lands,
- Golf courses,
- Dry weather urban runoff, and
- other source categories.

EPA was unable to specifically distinguish the amounts of pollutant loads from each of these allocation categories associated with areas regulated by the stormwater permits. Therefore, allocations for the source categories other than the direct Tapia WRF discharge are termed load allocations in these TMDLs. If it is later determined that nutrient loads associated with any of these load allocation categories are actually subject to regulation through NPDES permits, these allocations are to be considered wasteload allocations for purposes of implementing the permitting provisions of 40 CFR 122.44(d).

Tables 29, 30, 31 identify the specific wasteload and load allocations proposed for total nitrogen and total phosphorus during the summer and winter periods. Details concerning the calculation of these allocations are discussed below.

Table 29. Summer nitrogen allocations by source category

Source Category	Existing Loads (lbs/day)	% of existing load	Target Reduction (%)	Load Allocation (lbs/day, except Tapia)
Wasteload Allocations				
Tapia Direct Discharge	19	5%	100%	0*
Load Allocations				
Septic Systems	91	22%	93	6
Effluent Irrigation/Sludge	61	15%	100	0
Runoff from developed areas	26	6%	90	3
Golf Course Fertilization	37	9%	100	0
Agriculture/Livestock	32	8%	90	3
Dry Weather Urban Runoff	52	13%	90	5
Runoff from undeveloped land	37	9%	90	4
Other	56	14%	85	8
Total	**411**	**100%**	**93%**	**27**

Existing Loads determined from Tetra Tech, 2002
Developed areas = sum of commercial/industrial, high/medium density residential, low density residential, and rural residential.
Undeveloped areas = sum of vacant, chaparral/sage scrub, grasslands, and woodlands.
Other = sum of atmospheric deposition, lagoon drains, birds, tidal inflow, groundwater, and sediment release.
*See text for discussion of Tapia allocation.

Table 30. Summer phosphorus allocations by source category

Source Category	Existing Loads (lbs/day)	% of existing load	Target Reduction (%)	Load Allocation (lbs/day, except Tapia)
Wasteload Allocations				
Tapia Discharge	3.5	8	100	0*
Load Allocations				
Septic Systems	8.9	21	90	0.9
Effluent Irrigation/Sludge	5.3	13	100	0
Runoff from developed lands	2.6	6	90	0.3
Golf Course Fertilization	6.6	16	100	0
Agriculture/Livestock	1.7	4	90	0.2
Dry Weather Urban Runoff	4.6	11	90	0.5
Runoff from undeveloped lands	4.8	11	90	0.5
Other	4.1	10	90	0.6
Total	**42.3**	**100%**	**94%**	**2.7**

Existing Loads determined from Tetra Tech, 2002
Other footnotes see Table 29
*See text for discussion of Tapia allocation

Table 31. Winter concentration-based nitrogen allocations by source category

Source Category	Existing Loads (lbs/6 mo)	% of Existing Load	Daily Load Allocation (mg/l)*
Wasteload Allocations			
Tapia Discharge	187,508	34%	8
Load Allocations			
Septic Systems	47,285	9%	8
Effluent Irrigation/Sludge	44,298	8%	0
Runoff from Developed Areas	59,030	11%	8
Golf Course Fertilization	27,141	5%	8
Agriculture/Livestock	27,343	5%	8
Dry Weather Urban Runoff	8,500	2%	8
Runoff from undeveloped land	123,933	22%	8
Other	27,637	5%	8
Total	**552,675**	**100%**	**8**

*nitrate-N+nitrite-N
Existing Loads determined from Tetra Tech, 2002
Other footnotes see Table 29

Waste Load Allocations

Tapia's Direct Discharge. Seasonal wasteload allocations are proposed for Tapia. Order No. 99-142 prohibits discharge from Tapia to Malibu Creek from April 15 to November 15, with minor exceptions during storm flow events and minimal (<2.5 cfs) stream flow conditions. The summer Tapia WLA is set at zero; however, this WLA is not intended to negate these exceptions. We understand that to date, Tapia has not had to discharge in the summer, and we expect that such discharges would be very sporadic in the future. We believe these discharges will have an insignificant effect on average summer loads and that it is therefore unnecessary to account for them in the cumulative loading allowed under the TMDL. The State should ensure that these discharges do not result in exceedances of any applicable water quality standards.

During the winter period, Tapia's wasteload allocation is 8 mg/l total nitrogen, equal to the numeric target established in the TMDL It will be necessary for Tapia to reduce nitrogen loads from their historical levels of about 14 mg/l by approximately 43% to meet the new winter wasteload allocation.

These wasteload allocations apply during wet and dry weather conditions during the respective summer and winter periods. EPA proposes these allocations be set as average daily values, to be averaged over no more than a one-month period.

Load Allocations

Load allocations (LAs) are set based on source categories evaluated in the source analysis. This approach of setting LAs for different source categories is consistent with the requirements of 40 CFR 130.2(g), which authorizes establishment of LAs as "gross allotments". The LAs apply to all discharges from these source categories to listed segments and to upstream, hydrologically connected segments within the Malibu Creek watershed. This means that LAs apply both to discharges to segments for which TMDLs are being established, as well as to discharges to segments that are tributary to the segments for which TMDLs are established. It is necessary and appropriate to set LAs for discharges to the upstream tributaries in order to meet water quality standards in the downstream-impaired segments in the Malibu Creek watershed. These upstream tributaries flow into and contribute to impairment of Section 303(d)-listed segments. TMDLs and associated LAs and WLAs must be set at levels that will implement applicable water quality standards for the listed water bodies (40 CFR 130.7(c)(1)).

Effluent irrigation and sludge disposal. The waste discharge requirements issued by the Regional Board that regulate effluent irrigation and sludge disposal prohibit application of effluent or sludge at levels that would result in pollutant discharges to receiving waters (RWQCB Order No. 87-86, 94-055). The effluent irrigation waste discharge requirements require application of reclaimed water at agronomic rates that do not result in percolation of nutrients to groundwater. Based on these requirements, the load allocations for discharges to surface waters associated with effluent irrigation and sludge disposal during both the winter and summer periods are zero. We understand that sludge is no longer being applied and the only on-going nutrient applications in this category are associated with effluent irrigation. If reclaimed water is used for irrigation consistent with the requirements of the existing waste discharge requirements, there should be no nutrient loading to surface waters associated with this activity.

Septic Systems. The load allocations for this source category are set at levels that will require large reductions in nutrient loading from septic tanks throughout the watershed. Implementation of the load allocation will probably necessitate aggressive actions to identify and repair all septic systems that do not function properly. The highest priority for implementation is to ensure that discharges from commercial septic systems do not cause nutrient discharges to surface waters, particularly in the Malibu Lagoon area. We expect that actions taken to address septic systems will provide improvements in discharge quality throughout the year; therefore, the winter LAs should be met if the summer LAs are met.

Urban runoff. Although runoff from commercial and residential areas can contribute large loads of nitrogen and phosphorus to the system on an annual basis, the critical time period is the summer period. In addition, work by Kamer et al. (2002) indicates there are higher algal problems in developed urban areas. The summer load allocations would necessitate large reductions in nutrient loads from this source category. We expect that measures implemented to reduce urban runoff will provide improvements in discharge quality during dry periods throughout the year. Because total nitrogen levels in wet weather stormwater runoff are usually below the proposed WLA, we do not expect that extensive work will be needed to address wet weather nutrient loads from this source category.

Golf Course. The load allocation for golf course irrigation in the summer is zero. The goal is to allow effluent irrigation only for fertilization in amounts that plants can utilize. In practice we would assume that once implemented these practices would be applied year round, so that substantial nutrient reductions may also be obtained during the winter period. It is unknown whether additional controls will be needed to implement the winter LA for this source category. Reduction in the excess nutrients from golf course fertilization in the Hidden Valley, Westlake, and Lindero Creek subwatersheds will particularly improve water quality in Lake Sherwood, Westlake Lake and Lake Lindero.

Agriculture/Livestock. Load reductions of approximately 90% of excess nutrients from agriculture and livestock discharges during the summer are established for the Malibu Creek watershed. The goal is to effectively eliminate runoff of manure from stables and to minimize nutrient contaminated runoff both from stables and manure piles. In practice we would assume that once implemented these practices would be applied year round, so that substantial nutrient reductions may also be obtained during the winter period. It is unknown whether additional controls will be needed to implement the winter LA for this source category.

Runoff from undeveloped land. The load allocations provide for reductions of 90% in nutrient loading from undeveloped land areas. These reductions are needed in order to set TMDLs that will meet applicable water quality standards. It is reasonable to provide for some nutrient loading reductions from undeveloped land because nutrient loadings from these lands are likely affected by some controllable factors including atmospheric deposition of nutrients onto land surfaces as well illicit dumping of trash and other material that could yield nutrient loads. Moreover, runoff from some undeveloped areas is channeled to developed areas that are expected to benefit from runoff management practices that should reduce nutrient concentrations. Therefore, actions to control nutrient loads from developed areas should result in some reduction in runoff from undeveloped land areas.

Other sources. This source category includes direct atmospheric deposition to water surfaces, discharges from stormdrains to Malibu Lagoon, fecal material from birds, tidal inflow, groundwater releases, and sediment releases. EPA acknowledges that the proposed load reductions are aggressive (90% in summer). However, we believe these reductions should be feasible because:

- actions to reduce nutrient inputs from other anthropogenic sources should eventually bring about substantial reductions in loadings from groundwater and sediment, and
- direct stormdrain discharges to Malibu Lagoon can be effectively eliminated during the summer season.

c. Margin of safety

The Clean Water Act and federal regulations require that TMDLs provide a margin of safety to account for uncertainty concerning the relationship between pollution controls and water quality responses (see 40 CFR 130.7(c)(1)). The Malibu Creek watershed nutrient TMDLs provide both implicit and explicit margins of safety to account for several types of uncertainty in the analysis. This section discusses analytical factors that are uncertain and describes how the TMDL provides the requisite margin of safety.

Relationship between algae growth and nutrient loading. Although there is strong evidence of excessive algal growth in summer and some evidence of excessive algal growth in winter, the degree of algae-related impairment in winter and the degree to which nitrogen, phosphorus, or both are limiting factors in algae production throughout the year are uncertain.

The summer season TMDLs and allocations account for this uncertainty by setting conservative numeric target values for total nitrogen and total phosphorus. Our review of the available data suggests that there is a closer relationship between nutrient levels and algae production in summer than was observed in the winter. Attainment of these conservative summer target values should ensure that nitrogen and phosphorus are not critical limiting factors in algae production and should result in reductions in algae growth.

The winter season numeric targets, associated TMDLs and allocation are less stringent than the summer because available data and research studies do not clearly demonstrate that nutrient levels are likely to cause excessive algae growth. The TMDLs are designed to ensure implementation of the Basin Plan numeric objective for total nitrogen while acknowledging uncertainty concerning winter algae problems and associated attainment of the narrative objective for biostimulatory effects. The TMDLs account for this winter period uncertainty by incorporating a 20% margin of safety (setting the nitrogen numeric target at 8 mg/l instead of 10 mg/l, which is the applicable numeric objective).

Nutrient loading during the winter period, stream flows, and nutrient loading capacity vary more during the winter period than the summer period because most precipitation related changes in runoff, loads, and flows occurs during the winter period. Winter period loads and flows change quickly in response to unpredictable precipitation events. High velocity stream flows are likely to scour filamentous algae and carry it out of the watershed; these high flows also flush nutrient compounds through the watershed and into the ocean. We are accounting for the uncertainty associated with winter season variability in loads, flows, and loading capacity by setting the winter season TMDLs and allocations on a concentration basis instead of a mass-loading basis.

Studies are currently underway to improve our understanding of the relationship between nutrient levels in the watershed and algal growth. EPA strongly recommends that these studies be completed and additional studies carried out if necessary to characterize the limiting factors that control algae growth in the Malibu Creek watershed. These studies need to focus both on the winter and summer periods. Additional study is needed to reconcile conflicting data and research concerning the degree to which algae growth in the winter period is causing impairment and violation of narrative water quality objectives. Based on results from these studies, the State should consider reviewing and, if necessary, revising the TMDLs, allocations, and/or implementation provisions.

Uncertainty in nutrient loading estimates. Although we used established methods for estimating nutrient loads from different sources including relatively sophisticated modeling tools, it is not certain that these estimates are accurate. To help account for this uncertainty, the watershed loadings were based on a four-year period (1992 -1995) that included a wide range of hydrologic variability, and was coincidentally weighted more toward wet years. This approach yields conservatively high runoff estimates from different land uses.

We also made conservative assumptions in the estimation of loadings from septic systems, effluent irrigation, and golf course runoff. All of the excess nitrogen loads (87%) not utilized by plants from septic systems near Malibu Lagoon were assumed to enter the lagoon. Similarly conservative estimates were made in estimating phosphorus delivery from septic systems. Approximately 10 percent of the phosphorus loads from effluent irrigation and golf course fertilization were assumed to enter waterways, an assumption that is conservative because it is usually assumed that phosphorus compounds are highly sorbed to particles and therefore relatively immobile in soils.

These conservative loading estimates were used to estimate the percentage reductions needed to attain the individual allocations during the summer period. Use of conservatively high runoff estimates results in conservative percent reduction estimates for each source category (i.e., implementation of these percentage reductions is highly likely to result in attainment of the individual allocations and the TMDLs).

Additional studies of loadings from nonpoint source categories would be warranted in the future to better characterize loadings during wet weather periods from polluted runoff as well as loads associated with septic system operation.

d. Summary of pollutant allocations

These TMDLs establish seasonal waste load allocations for the Tapia WRP. Seasonal load allocations are established for several source categories including effluent irrigation, commercial/multi-family septic systems in Malibu Lagoon, urban runoff, golf course runoff, livestock/agricultural runoff, and other land uses. During the summer period, large reductions in loads from all anthropogenic sources are needed. During the winter, substantial reductions in Tapia's discharge and modest reductions from other source categories are needed in nitrogen loading to ensure attainment of the concentration-based allocations. Actual reductions attained in winter should be greater since in practice a number of the load reduction efforts proposed in the implementation recommendations (below) are likely to result in year round reductions rather than just summer season reductions.

There is uncertainty in *some* aspects of the TMDL analysis. Implicit and explicit margins of safety are provided to account for these uncertainties. Additional monitoring and studies currently underway and recommended below should help address these areas of uncertainty and provide a basis for considering whether TMDL revisions are warranted.

7. Implementation Recommendations

This section describes the plans, regulatory tools, or other mechanisms by which the waste load allocations and load allocations may be achieved. The main responsibility for water quality management and monitoring resides with the State. EPA fully expects the State to develop implementation and monitoring measures for these TMDLs. Following are EPA's recommendations for implementing these TMDLs.

a. Implementing waste load allocations to permitted point source dischargers

Tapia Water Reclamation Facility. EPA anticipates that the WLAs established in these TMDLs will be implemented through the NPDES permit for the Tapia Water Reclamation Facility. It appears that Tapia needs to substantially decrease nutrient loads in order to meet both its existing winter period effluent limitations and its WLA. The Regional Board will need to determine whether the permit needs to be modified to be consistent with the WLAs and when the modifications would occur. When the permit is next revised, we recommend inclusion of re-opener language that provides to review of the permit if necessary following completion of monitoring and research studies designed to further characterize nutrient and algae issues in the watershed and determine the need for further reductions in nutrient loading from Tapia.

b. Implementing Load Allocations to nonpoint sources.

*Effluent Irrigation***.** The usage of reclaimed water is regulated under water reclamation requirements contained in Regional Board Resolutions 87-86 and 94-055. This should be modified if necessary to be consistent with these TMDLs.

Septic Systems. The highest priority for implementation actions in this source category is commercial septic systems. In particular, actions are needed to ensure that commercial septic systems located in the Malibu Lagoon subwatershed, specifically in the areas of the Malibu Colony Plaza, Cross Creek Plaza, and Malibu Civic Center do not contribute to nutrient loading to the Lagoon. These systems may have been improperly sited and appear to be located adjacent to the lagoon, in a groundwater table with historic levels that do not allow as least 10 feet between the groundwater and septic system.

These commercial septic systems were the focus of Regional Board Resolution 98-023. This resolution provided direction to the Executive Officer to require the submittal of Reports of Waste Discharge for all discharges from multi-family and commercial septic systems located in the Malibu Creek watershed. Therefore, EPA's understanding is that a mechanism for implementation for the septic system Waste Load Allocations (WLAs) derived from these TMDLs has already been established. EPA anticipates that the WLAs developed for these TMDLs will be established as WDR permit limits for the individual septic systems. In addition, the WDRs have specific prohibitions on septic systems within 10 feet of the highest historical groundwater levels. The actual implementation date on the WLAs will depend on implementation schedules established by the Regional Board.

Septic systems that are poorly sited will have options available for meeting the LAs under these TMDLs. One possible method of compliance is pretreatment via Nitrogen Reduction Systems (NRS) of effluent to remove nutrients prior to leachfield discharge (USEPA, 1999b). The principal treatment mechanism for these systems would be biological nitrification-denitrification.

Golf Course Irrigation. Golf courses and users of recycled water can implement management practices to minimize the potential for nutrients entering surface water. Potential management practices may include:

- Applications of fertilizers and recycled water at agronomic rates to ensure that the total nitrogen and phosphorus loads do not exceed the daily vegetative requirements of the turf.

- Use of irrigation systems that will minimize the potential for application of excess recycled water that would result in surface runoff.

- The design of recycled water irrigation systems to cease operation under anticipated storm events.

Some of the management strategies outlined above have been proposed by the Ahmanson Ranch Specific Area Plan for implementation in the master planed community for Ahmanson Ranch (VCRMA, 2002). The BMPs outlined above are administrative BMPs, which will involve changes in operational practices, but not necessarily result in capital expenditure.

*Horses and Livestock***.** Load reductions are proposed for horse stables and livestock pastures. It is estimated that 40% of the manure is already removed from stables. Additional manure management measures will be needed to implement the allocations. Additional BMPs may also be necessary to mitigate the impacts from this source category. For examples, measures could be taken to keep animals away from the streams in Hidden Valley and other tributaries, and manure could be removed more frequently from stables. It is important to ensure that manure from stables is managed properly throughout the year and that animal waste is not allowed to runoff into streams at any time.

8. Monitoring Recommendations

Follow-up monitoring and evaluation is recommended to validate the TMDL, and to assess whether the implementation measures are adequate to attain water quality standards.

a. Water quality monitoring

A watershed-scale monitoring program should be established at key compliance points along the river. Samples should also be collected at the upstream and downstream ends of the listed tributaries. Sample results should be compared to the numeric in-stream targets identified in Section 2c for dissolved oxygen, ammonia, nitrate, total nitrogen, percent algal cover and Chlorophyll *a*.

Much of this data is already being collected as part of the Tapia WRP monitoring program. However there is only limited data available for the upper portion of the watershed and selected tributaries of Malibu Creek. EPA recommends that these watersheds be surveyed in order to more fully understand the natural conditions, and how the impaired waterbodies compare to natural conditions. Heal the Bay has a network of monitoring stations throughout the watershed including a number of potential reference sites. These sites should be considered in future monitoring and assessment plans for the watershed.

The Malibu Creek Advisory Committee, Modeling and Monitoring Subcommittee has developed a Watershed-Wide Monitoring Program (1999). The program addresses the watershed-scale monitoring needed to evaluate the effectiveness of the TMDLs. The data could be used to provide further verification of the model and refine the TMDLs as appropriate.

b. Pollutant source monitoring

Monitoring of pollutant sources is needed to ensure that required reductions are being achieved and if necessary, to refine the allocations presented in these TMDLs.

Treated and reclaimed wastewater. Tapia WRP should continue to monitor effluent concentrations of nitrogen and phosphorus for the purpose of verifying loads to the watershed. Tapia WRP should also continue to monitor the quality and quantity of reclaimed water used in the system. Special monitoring should be conducted to evaluate the quantity and quality of reclaimed water that re-enters the system via surface runoff or through groundwater.

Septic systems. According to the Regional Board, the WDRs will have a monitoring program component to estimate concentrations from the septic systems. In addition, we recommend special studies be conducted for better certainty in the number of septic systems and the distribution of the systems within the Malibu Creek watershed.

Horses and livestock. Monitoring is needed to ensure that recommended load reductions are being achieved. This could be established through random inspections of horse and livestock facilities.

Monitoring of urban sources. A special monitoring program should be established to evaluate effectiveness of actions to reduce both dry and wet weather urban runoff.

c. Special studies—Recommendations

There are uncertainties in the numeric target and winter wet season impact of source loading from the treatment plant to Malibu Lagoon. The following studies are recommended to address these uncertainties.

Extent of algal impairment. EPA recommends studies to investigate the current extent of impairment due to excessive algal growth in the creek by surveying algal biomass and species composition at multiple sites within the creek. This data will provide information regarding the present degree of excessive algal biomass in the stream as well as determining any relationships between land uses, water column nutrient concentrations, and resulting impacts on stream periphyton biomass and communities.

Limiting factor analysis. EPA recommends further study to assess whether total nitrogen or total phosphorus or other parameters such as flow and light limit algal growth in the Malibu Creek watershed. This information will assist Regional Board staff in determining watershed specific nutrient targets which are linked to algal nutrient requirements.

Fate of nutrients in Malibu Lagoon. These TMDLs are based on the assumption that the summer nutrient concentrations control algal abundances. Another critical assumption is that summer period nutrient concentrations are related to summer period loadings. This may not be the case in the Lagoon where some fraction of the total nitrogen and phosphorus loadings may be retained in the sediments and ultimately serve as a source of nutrients during summer periods when algae is more abundant. Thus, EPA recommends a study to determine if the expected upstream reductions in nutrient loadings do not result in desired improvements in water quality in the lagoon.

d. Summary of TMDL Monitoring

The TMDL monitoring program should be designed to provide information that will assure that water quality objectives are being met throughout the watershed and to refine the source loading estimates. These efforts will provide information on the success of the TMDLs to address the nutrient related problems in the creek, lagoon and listed tributaries. Information generated by this program may be used by the Regional Board to revise the TMDLs, NPDES permits, WDRs, and other control actions if necessary.

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