Total Maximum Daily Loads for Bacteria in the Malibu Creek Watershed

US Environmental Protection Agency
Region 9

Established by:

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Catherine Kuhlman **Date**
Acting Director
Water Division
EPA Region 9

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1. INTRODUCTION

This document describes the Total Maximum Daily Loads (TMDLs) for coliform bacteria in the Malibu Creek watershed, which includes Malibu Lagoon, Malibu Creek and its tributaries. Malibu Creek and five of its tributaries (Stokes Creek, Las Virgenes Creek, Palo Comado Creek, Medea Creek, and Lindero Creek) exceed the water quality objectives (WQOs) for coliform (LARWQCB, 1996 and 1998). Malibu Lagoon also exceeds the WQOs for coliforms. This TMDL identifies the total allowable bacterial loads and the associated wasteload and load allocations for bacteria needed to meet the water quality objectives for bacteria in the Malibu Creek watershed.

This TMDL complies 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 wasteload and load allocations for coliform bacteria. The waterbodies addressed in this TMDL are listed in Table 1 and Figure 1.

1.1. 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 objective 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. For the purpose of this document, 303(d) listed water bodies and impaired water bodies are synonymous.

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 the U.S. Environmental Protection Agency guidance (U.S. EPA, 1991). 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 (40 CFR 130.7 and USEPA, 2000).

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 Regional Board identified over 700 waterbody-pollutant combinations in the Los Angeles Region where TMDLs would be required (LARWCQB, 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 more than 700 waterbody-pollutant combinations into 92 TMDL units.

This TMDL addresses Analytical Unit 47 of the Consent Decree which consists of Malibu Lagoon, segments of the Malibu Creek and tributaries listed for coliform bacteria.[1] Table 1 identifies the listed waterbodies, and the number of linear miles of waterbody in Analytical Unit 47 impaired by each. Malibu Beach and Surfrider beach are covered under the Santa Monica Bay Beaches (Analytical unit #48), for which the Regional Board has developed separate TMDLs. The consent decree schedule requires that the Malibu Creek TMDL be completed by March 22, 2003. EPA is establishing this TMDL at the request of the Regional Board in order to meet its obligations under the consent decree because the State was unable to establish this TMDL in time to meet the consent decree deadline. This report presents the TMDL for bacteria and summarizes the analyses performed by EPA and the Regional Board to develop this TMDL.

There are a number of waterbodies in the Malibu Creek watershed that are hydrologically connected to the water bodies listed in the 1998 Water Quality Assessment. These unimpaired or unassessed waterbodies include Hidden Valley Creek, Potrero Canyon Creek, Triunfo Creek, Cheeseboro Creek, and Cold Creek and four lakes (Lake Sherwood, Westlake, Lake Lindero and Malibou Lake). These waterbodies have been considered within the analytical framework of this TMDL because they have the potential to contribute significant coliform loadings to the impaired waterbodies. As discussed below, we have determined that it is necessary to set load allocations and wasteload allocations to limit bacteria discharges to these 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, as well as setting allocations for sources that discharge directly to the downstream impaired segments.

Table 1. Waterbodies within the Malibu Creek watershed that are listed as impaired due to high fecal coliform counts (LARWQCB, 1996)

Waterbody	Extent impaired
Lindero Creek Reach 2 (above Lake Lindero)	4.8 miles
Lindero Creek Reach 1 (Medea Creek to Lake Lindero)	2.2 miles
Medea Creek Reach 2 (above confluence with Lindero Creek)	5.4 miles
Medea Creek Reach 1 (from Malibou Lake to confluence with Lindero Creek	3.0 miles
Palo Comado Creek	7.8 miles
Las Virgenes Creek	11.5 miles
Stokes Creek	5.3 miles
Malibu Creek	9.5 miles
Malibu Lagoon	13 acres

[1] Malibu Lagoon is also listed for swimming restrictions, enteric viruses, and shellfish harvesting advisories. EPA has concluded that implementation of the TMDLs for fecal coliform will be sufficient to address the listing for swimming restrictions. The fecal coliform TMDLs also are intended to address enteric viruses (see EPA, 2003). Shellfish harvesting is not a designated beneficial use of Malibu Lagoon, and the applicable water quality objectives are not designed to address this use. Therefore, these fecal coliform TMDLs are not be designed to address the shellfish harvesting use.

1.2. Environmental Setting: The Malibu Creek Watershed

The Malibu Creek watershed is located about 35 miles west of Los Angeles. The 109-square mile watershed 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; some reaches of the creeks run dry in the summer. During rain storms the runoff from the watershed may increase flows in the creeks dramatically. The natural hydrology of the watershed has been modified by the creation of several dams and man-made lakes, the importation of water to the system for human use which provides most of the base-flow to the system, and the presence of the Tapia WWRF which provides significant dry-weather flow to the system in the winter months but is largely prohibited from discharging in the summer months. Flows from watershed drain into Malibu Lagoon and ultimately into Santa Monica Bay when the entrance to the lagoon is open.

In terms of landuse patterns, about 80% of the land in Malibu Creek watershed is undeveloped. The developed land is a mixture of residential (13%), commercial/industrial (4%) and agricultural (3%) landuses.

The western part of the watershed drains the areas around Hidden Valley, Portero Creek, Westlake and Triunfo Creek (total area about 25,210 acres). These areas are largely undeveloped. There is some limited agricultural landuse, located mostly in Hidden Valley subwatershed. Most of the residential and commercial/industrial land use is in the area around Westlake. Nearly all the runoff from this large watershed area is funneled to Triunfo Creek and ultimately to Malibou Lake. None of the river reaches in this western-most portion of the watershed have been listed for fecal coliform bacterial impairments. However, it is important to note that the waterbodies in these areas were largely unassessed by the Regional Board due to a lack of data which precluded assessment. It is highly probable that the runoff from these areas contributes fecal coliform loadings to the listed segments downstream of Malibou Lake and needs to be considered in TMDL development.

Malibou Lake also receives flows from 15,900 acre area which includes the watersheds associated with Lindero Creek, Medea Creek, Palo Comado Creek and Cheeseboro Creek. Lindero Creek, Medea Creek and Palo Comado Creek are listed for fecal coliform bacteria; Cheeseboro Creek is not. The landuse in these watersheds, while still largely undeveloped, has a higher percentage of residential and commercial land uses especially in the areas around Lindero Creek and Medea Creek watersheds.

Malibou Lake discharges to Malibu Creek, which is listed as impaired for its entire 10-mile length from the Lake to the Lagoon. Malibu Creek also receives flow from Las Virgenes Creek and Stokes Creek, both of which are listed as impaired. Although much of the area in this portion of the watershed is currently undeveloped, there are proposals such as Ahmanson Ranch which would increase the amount of residential development. Landuse at the bottom of the watershed near the lagoon is much more developed, with significant residential and commercial development.

1.3 Summary of Problem

High levels of fecal coliform bacteria in the creeks and lagoon result in exceedance of water quality standards and impair recreational uses within the watershed. High levels in the lagoon also contribute to problems at Surfrider beach.

1.4 TMDL Elements

Guidance from USEPA (2000) identifies seven elements of a TMDL. Sections 1 through 7 of this document are organized such that each section describes one of the elements, with the analysis and findings of this TMDL for that element. The elements are:

1. Problem Identification. This section reviews the evidence used to add the waterbody to the 303(d) list, and summarizes existing conditions using that evidence along with any new information acquired since the listing. 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 the data and information regarding the decision to list each reach, such as the number and severity of exceedences observed.

2. Numeric Targets. For this TMDL, the primary numeric targets are based on the numeric water quality objectives for fecal coliform bacteria that apply to the watershed.

3. Source Assessment. This is a quantitative estimate of point sources and non-point sources of bacteria into the Malibu Creek watershed. The source assessment considers factors such as seasonality and flow which may influence the relative magnitude of contributions from various sources.

4. Linkage Analysis. This analysis demonstrates how the sources of fecal coliform bacteria 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 critical conditions or conditions especially resistant to improvement.

5. Pollutant Allocation and TMDL. Each pollutant source is allocated a quantitative load of fecal coliform bacteria that it may discharge. Allocations are designed such that the waterbody will not exceed numeric targets for fecal coliform bacteria 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 achieved and recommends several implementation measures.

7. Monitoring Recommendations. This TMDL recommends 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.

2. PROBLEM STATEMENT

This section provides a review of the data used by the Regional Board to list the waterbodies within the Malibu Creek watershed for fecal coliforms. 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, it is appropriate to begin this section with a discussion of the applicable water quality standards.

2.1. Applicable Water Quality standards

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 water quality objectives are specified in each of the Regional Board's Basin Plans. The water quality objectives are designed to be protective of the beneficial uses in each waterbody in the region. The Basin Plan for the Los Angeles Regional Board (1994) defines 14 beneficial uses for the Malibu Creek watershed. All the designated beneficial uses must be protected. However, the two beneficial uses most pertinent to coliform bacteria are REC1 and REC2. Table 2 identifies for each of the listed waterbodies the uses (existing or intermittent) that are affected by high coliform levels.

Table 2. Malibu Creek Watershed Beneficial Uses - Not Supported

Watershed	REC1	Rec2
Malibu Lagoon	E	E
Malibu Creek	E	E
Las Virgenes Creek	E	E
Stokes Creek	E	E
Upper Medea Creek	I	I
Lower Medea Creek	E	E
Lindero Creek	I	I
Palo Comado Creek	E	E

Recreational uses for body contact (REC1) and secondary contact (REC2) apply to all the listed waterbodies as either 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) are appropriate to protect recreational uses of the creek. The REC1 standard protects uses where ingestion of water is reasonably possible. The REC2 standard protects uses which occur in proximity to water (such as picnicking, sunbathing, hiking, or boating) where ingestion of water is reasonably possible.

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. This is pertinent to the coliform TMDL because wildlife can contribute bacterial loadings to the watershed. Issues related to the effect of wildlife population on water quality and the potential for competing beneficial uses (REC1 vs WILD) are discussed in more detail in section 2 (Targets).

The Basin Plan contains bacterial standards to protect these recreational uses. Total and fecal coliform bacteria are used to indicate the likelihood of pathogenic bacteria in surface waters. The fecal coliform standard is as follows:

In waters designated for water contact recreation (REC-1), the fecal coliform concentration shall not exceed a log mean of 200/100 ml (based on a minimum of no less than four samples for any 30-day period), nor shall more than 10 percent of total samples during any 30-day period exceed 400/100 ml.

The Regional Board recently updated the bacteria objectives for waters designated as REC-1 to be consistent with EPA criteria guidance which recommends the use of *E. coli* criteria for freshwater and the enterococcus criteria for marine waters (See Regional Board Resolution R01-018 and State Board Resolution 2002-0142). The revisions create objectives for these two new indicators and revise the way in which the objectives for fecal and total coliform bacteria are implemented in freshwater and marine waters, respectively. The revised objectives are summarized in Table 3.

Table 3. Summary of applicable bacteria standards

	Parameter	**Geometeric Mean**	**Single Sample**
Freshwater	Fecal	200	400
	E. coli	*126*	*235*
Marine	Total	1,000	10,000 *or 1,000 if FC/TC > 0.1*
	Fecal	200	400
	Enterococcus	*35*	*104*

The implementation provisions for the water contact recreation bacteria objectives defined in these resolutions are as follows:

The geometric mean values should be calculated based on a statistically sufficient number of samples (generally not less than 5 samples equally spaced over a 30-day period).

If any of the single sample limits are exceeded, the Regional Board may require repeat sampling on a daily basis until the sample falls below the single sample limit or for five days, which ever is less, in order to determine the persistence of the exceedance.

When repeat sampling is required because of an exceedance of any one single sample limit, values from all samples collected during that 30-day period will be used to calculate the geometric mean.

These standards were approved by EPA Region 9 on September 25, 2002.

2.2. Assessment of existing conditions relative to numeric standards

This section describes conditions in the Malibu Creek watershed, which resulted in the inclusion of waterbodies as impaired on the 1998 Section 303(d) List. In performing the assessment of inland waters the Regional Board compared the data to the fecal coliform standard. Because the data was too limited to directly assess compliance with 30-day geometric mean standard of 200/100 ml, the evaluation was based on greater than 10% of the samples exceeding the single sample standard of 400 /100 ml using the entire data set. The Malibu Lagoon listing was based on data from Las Virgenes Municipal Water District (Ambrose *et al*., 1995). Although the Regional Board did not include Triunfo Creek and Cold Creek on the 303(d) list, they are included in this table since they were part of the Regional Board's assessment of conditions in the Malibu Creek watershed. It is also likely that sources discharging in these waterbodies contribute fecal coliform loadings to the listed segments downstream and therefore need to be considered as part of our source analysis.

Table 4. Summary of fecal coliform data (counts/100 ml) used in the 1996 listing process (LARWQCB, 1996).

Waterbody Name	Number of Samples	Range
Triunfo Creek	4	ND-2,300
Lindero Creek Reach 1	9	1,700-90,000
Palo Camodo	4	220-30,000
Medea Creek Reach 1	8	23-50,000
Medea Creek Reach 2	4	300-90,000
Las Virgenes	10	40-17,000
Stokes Creek	4	80-14,000
Cold Creek	7	ND-90,000
Malibu Creek	83	ND-14,000

The fecal coliform data from Tapia WRF's NPDES monitoring program is much more limited. We analyzed instream fecal coliform data from three stations: Las Virgenes Creek (70 samples collected between 10/99 to 4/01), Malibu Creek (81 samples collected between 11/97 to 4/01), and Malibu Lagoon (43 samples collected between 8/99 to 11/99). These data were not collected at a frequency which would allow comparison with the geometric mean standard, but can be compared to the single sample standard. For the Las Virgenes station, the median concentration from Las Virgenes was 500/100 ml and about 59% of the samples were above the single sample maximum of 400 counts/100 ml. For Malibu Creek, the median concentration was 230/100 ml and 41% of the samples were above the single sample maximum of 400. For Malibu Lagoon the median concentration was170/100 ml and approximately 33% of the samples were above the single sample maximum of 400.

There is a substantial amount of data on total coliform concentrations in various reaches in the lower portions of the watershed from the Tapia NPDES monitoring program (see Table 5 below). Although these data can not be used to assess compliance with the freshwater standards for fecal coliforms or *E. coli*, they can be used to infer something about the overall level of coliform bacteria in the various tributaries. For perspective, these data were compared to the total coliform standard for marine waters. The mean concentration is consistently greater than 1,000 cfu/100 ml and individual measurements are frequently greater than 10,000 cfu/100 ml.

The fact that high values are seen even at the most upstream stations (R9 and R6) suggests that the coliform problem is widespread and that there are significant sources of coliform bacteria throughout the watershed.

Table 5. Total coliform data from Tapia ambient monitoring program (from January 1987 to December 1999)

REACHES	Station	# of samples	Mean	%>1,000	%>10,000
Upper Malibu Creek	R-9	344	3,132	48	9
Low Las Virgenes Creek	R-6	362	10,818	88	33
Middle Malibu Creek	R-1	402	3,788	57	8
	R-2	402	3,563	58	9
Lower Malibu Creek	R-13	403	3,642	62	9
	R-3	397	1,953	47	3
Malibu Lagoon	R-4	377	1,950	47	4
Estuary	R-11	401	3,629	61	8

2.3. Summary of problem identification

Our review of the data confirms that there are fecal coliform concentrations in the Malibu Creek Watershed which exceed the water quality objective. While the data is insufficient to assess against the 30-day geometric mean, there is sufficient data to indicate that the single sample target of 400/100 ml is regularly exceeded at Las Virgenes, Malibu Creek and Malibu Lagoon. There is also evidence that total coliform concentrations are high (greater than 1,000 counts/100 ml) in Las Virgenes Creek, throughout Malibu Creek, the Lagoon and estuary. There is also sufficient evidence to confirm that the concentrations for total coliform in Malibu Lagoon exceed the standard for marine waters.

3. NUMERIC TARGETS

As discussed above, the Basin Plan bacteria standards were recently revised. The freshwater standard for *E. coli* and fecal coliform now apply to all the creeks in the watershed, while the marine standards for total coliform, fecal coliform, and enterococcus apply to the lagoon. Recognizing that these multiple standards apply in the watershed, however, the analysis and the allocations in this TMDL are based solely on fecal coliform. This decision was made because the 303(d) listings were based on exceedances of the fecal coliform standard. Additionally, there is almost no *E. coli* data to assess compliance with the new freshwater standard and very little enterococcus data to assess conditions for the Lagoon. While there is a substantial data set for total coliform, the total coliform standard only applies to the Lagoon. Because the fecal standard applies to both fresh water and marine, it serves as the common denominator for evaluating the linkage between loadings and water quality. We anticipate that actions targeted toward the reduction of fecal coliforms in the watershed will also reduce concentrations of total coliforms and *E. coli* (since *E. coli* are a subset of the fecal coliforms and fecal coliforms are a subset of the total coliforms). Thus, we expect that actions required to meet the numeric target and the allocations for fecal coliform will result in compliance with the other bacterial objectives.

For these reasons, the primary numeric targets in this TMDL, which were used in our calculation of the TMDL and allocations, are based on fecal coliform. We recognize, however, the importance of the other bacteria standards to human health and the health of the watershed, and we note that in the Santa Monica Beaches bacteria TMDL, the Regional Board has established targets based not only on fecal coliform but also on total coliform and enterococcus. We have determined that it is appropriate to specify that the water quality objectives for E. coli, enterococcus, total coliform, and geometric mean values for fecal coliform as supplemental numeric targets for this TMDL. These supplemental targets were not used in the calculation of the TMDL or the allocations. However, EPA emphasizes the importance of meeting each of the numeric targets. EPA expects that these targets will provide a useful reference in determining the effectiveness of the TMDL in attaining water quality standards, and we recommend that the Regional Board's monitoring measures for this TMDL include monitoring for these other targets, as well as for fecal coliform. Such monitoring will be useful not only in gauging the effectiveness of this TMDL, but also in determining whether any of the water segments should be added to the CWA 303(d) list for failure to meet the various bacteria standards.

TMDL Numeric Targets

	Parameter	**Geometeric Mean**	**Single Sample**
Malibu Creek and Tributaries	Fecal	200	400
	E. coli	*126*	*235*
Malibu Lagoon	Total	1,000	10,000 *or 1,000 if FC/TC > 0.1*
	Fecal	200	400
	Enterococcus	*35*	*104*

In this TMDL we recognize that there are natural sources of coliform bacteria which may not be entirely controllable and that in some instances these sources may contribute bacterial loadings sufficient to cause exceedance of the single sample water quality standard. This becomes a bigger problem when it rains and we acknowledge that not all storm flows may be captured or controlled. Therefore, a reference system/antidegradation approach is used to establish the acceptable frequency of exceedance of the single sample objectives for the Malibu Creek TMDL. The reference system/anti-degradation approach ensures that bacteriological water quality is at least as good as that of a reference system and that no degradation of existing bacteriological water quality is permitted where existing bacteriological water quality is better than that of the selected reference system.

The reference watershed approach is used to set a numeric target for the single sample standard. This is consistent with the intent of the Regional Board. The Regional Board has adopted the following language as part of their implementation procedures for the water quality objectives for bacteria. These implementation procedures have been approved by the Regional Board and State Board. EPA expects that the review process by the Office of Administrative Law and USEPA will be completed in the very near future. Therefore, we are using these implementation procedures in interpreting the fecal coliform water quality procedures for this TMDL. The implementation procedures are as follows:

The single sample bacteriological objectives shall be strictly applied except when provided for in a Total Maximum Daily Load (TMDL). In all circumstances, including in the context of a TMDL, the geometric mean objectives shall be strictly applied. In the context of a TMDL, and at the discretion of the Regional Board, implementation of the single sample objectives in fresh and marine waters may be accomplished by using a 'reference system/antidegradation approach' or 'natural sources exclusion approach.' A reference system is defined as an area and associated monitoring point that is not impacted by human activities that potentially affect bacteria densities in the receiving water body.

These approaches recognize that there are natural sources of bacteria, which may cause or contribute to exceedances of the single sample objectives for bacterial indicators. They also acknowledge that it is not the intent of the Regional Board to require treatment or diversion of natural water bodies or to require treatment of natural sources of bacteria from undeveloped areas. Such requirements, if imposed by the Regional Board, could adversely affect valuable aquatic life and wildlife beneficial uses supported by natural water bodies in the Region.

Under the reference system/antidegradation implementation procedure, a certain frequency of exceedance of the single sample objectives above shall be permitted on the basis of the observed exceedance frequency in the selected reference system or the targeted water body, whichever is less. The reference system/anti-degradation approach ensures that bacteriological water quality is at least as good as that of a reference system and that no degradation of existing bacteriological water quality is permitted where existing bacteriological water quality is better than that of the selected reference system.

Under the natural sources exclusion implementation procedure, after all anthropogenic sources of bacteria have been controlled such that they do not cause an exceedance of the single sample objectives, a certain frequency of exceedance of the single sample objectives shall be permitted based on the residual exceedance frequency in the specific water body. The residual exceedance frequency shall define the background level of exceedance due to natural sources. The 'natural sources exclusion' approach may be used if an appropriate reference system cannot be identified due unique characteristics of the target water body. These approaches are consistent with the State Antidegradation Policy (State Board Resolution No. 68-16) and with federal antidegradation requirements (40 CFR 131.12).

The appropriateness of these approaches and the specific exceedance frequencies to be permitted under each will be evaluated within the context of TMDL development for a specific water body, at which time the Regional Board may select one of these approaches, if appropriate.

Arroyo Sequit, located about 10 miles north of Malibu, was chosen as the reference watershed for this TMDL in part for its proximity and similarity to the Malibu Creek watershed. Arroyo Sequit is the least-developed watershed in the area (98% open space), like Malibu Creek it has a freshwater outlet to the beach (Leo Carillo Beach), and there is an existing shoreline station at the beach. Equally important, Arroyo Sequit is also the reference watershed being used in the Regional Board's Santa Monica Bay Beaches Bacteria TMDLs (LARWQCB, 2002b, 2002c) and the Regional Board has established a procedure for setting the acceptable allowable days of exceedances based on the historic exceedance rate at the mouth of this watershed.

The Santa Monica Bay wet weather TMDL allows for 17 exceedance days a year to allow for winter storms, 3 exceedance days during the dry-winter days and 0 exceedance days during dry-summer days. The summer dry period is defined as April 1 to October 31; winter is defined as November 1 to March 31. Winter Wet days are defined as days with greater than 0.1 inch of rainfall and the following 3-days to account for residual rainfall effects. This applies to all the beaches within Santa Monica Bay including Surfrider Beach which is located at the mouth of the Malibu Lagoon.

In order for the Malibu Creek TMDL to be consistent with the Santa Monica Bay Beaches TMDL, we have determined that that the 17 wet-day/3 dry day winter/0 dry day summer modification of the numeric target developed for the Santa Monica Bay Beaches TMDL (LARWQCB, 2002c) is applied to Malibu Lagoon, Malibu Creek and all the tributaries within the Malibu Creek watershed. More details on the application of these numeric targets in this TMDL to identify load reductions are provided in the Section 4 (Linkage Analaysis). In the next section we evaluate potential sources of fecal coliform bacteria to the waters of the Malibu Creek watershed.

4. SOURCE ASSESSMENT

Fecal coliform bacteria may be introduced from a variety of sources including septic systems, runoff, animal wastes, and land-use runoff from both developed and undeveloped areas. An inventory of possible point and nonpoint sources of fecal coliform bacteria to the waterbody was compiled, and both simple methods and computer modeling were used to estimate bacteria loads for those sources. Source inventories were used in the analysis to identify all potential sources within the Malibu Creek watershed; modeling was used to identify the potential delivery of pathogens into the creeks within the watershed.

Fecal coliform loads from the watershed were estimated by using a computer model (Hydrologic Simulation Program – FORTRAN) and supplemental estimates of selected sources (Tetra Tech, 2002). Fecal coliform loadings deposited on land surfaces or in the soil, may be attenuated through sunlight, heat, and decay over time. Transport of coliform bacteria is a result of periodic rainfall and groundwater seepage into the creek system. This source assessment chapter discusses both the raw loading potential of various identified sources as well as the estimated loading to the watershed creeks. The source assessment is provided for both annual and dry-weather (May to October) load estimates. For more detailed information on the source assessment, please refer to the modeling report (Tetra Tech, 2002).

Tapia Waste Water Reclamation Facility. The Tapia WWRF has the capacity to treat and discharge up to 16.1 mgd of tertiarily- treated sewage. 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 (Figure 2). The primary outfall into Malibu Creek is Discharge No. 001, which is located about 0.3 mile upstream of the confluence with Cold Creek. 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.

Currently, discharge to Malibu Creek is not allowed from April 15 to November 15 (Regional Board Order No. 97-135). On average during the winter months the plant discharges 8 to 10 mgd (LVMWD, 1996-2000).

Tapia's permit requires that all the wastewater be chlorinated to at least 2.2 MPN/100 ml for fecal coliform. Although fecal coliforms have not been detected in the effluent, an upper bound on the estimated loadings can be made by multiplying the reported detection limits for fecal coliforms by the average flows. The fecal coliform 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). Based on this analysis the annual fecal coliform loadings from the Tapia plant are on the order of 30 to 60 billion counts per year (Table 6).

Table 6. Average annual fecal coliform loadings (10^9 counts/year) in Tapia effluent (Tetra Tech, 2002)

	1992	1993	1994	1995	1996	1997	1998	1999
Max Conc	<1	<1	<1	<1	<1.1	<1.1	<1.1	<1.1
Average Flow (cfs)	4.76	5.35	4.02	4.80	3.13	3.00	6.44	3.18
Load 10^9 Count/yr	42.2	47.3	35.7	42.8	30.5	29.3	62.9	30.8

The Las Virgenes Municipal Water District (LVMWD) sells approximately 4,000 acre-feet per year of reclaimed wastewater from its Tapia facility that is used for irrigating open space and landscaping (Abramson et al., 1998). The use of reclaimed water is regulated under water reclamation requirements contained in Order No. 87-86 and 94-055. Table 7 summarizes the annual loadings of fecal coliforms from each effluent irrigation operation, estimated by multiplying flows times the concentration/detection limit. These are gross numbers, and do not reflect loadings to receiving water. Indeed, Order No. 87-86 requires that irrigation water shall be retained on the areas of application and not be permitted to escape as surface flows, that reclaimed water shall not be applied at a rate which exceeds vegetative demand, and that special precautions shall be taken to prevent overwatering and to exclude the production of runoff.

Table 7. Annual fecal coliform loads (10^9 counts/year) associated with effluent irrigation in the Malibu Creek Watershed (Tetra Tech, 2002)

Source	1992	1993	1994	1995	1996	1997	1998	1999
Triunfo Sanitation District	5.3	3.4	5.3	6.0	18.0	20.8	13.4	19.9
Western Las Virgenes Municipal Water District	30.0	28.1	24.2	27.2	29.1	37.0	27.2	34.0
Calabasas	11.7	14.7	17.1	16.7	21.3	20.0	15.6	20.7
Las Virgenes Valley	1.4	3.3	3.9	2.9	3.8	2.6	1.9	3.4
Rancho Las Virgenes	1.0	1.1	0.7	0.2	0.9	0.9	0.6	1.2
Rancho Las Virgenes Composting	NA	NA	NA	NA	NA	NA	<0.1	<0.1
Tapia Percolation Beds	11.8	8.3	21.1	27.5	23.2	26.4	NA	NA
Malibu Creek Park	NA	NA	NA	NA	NA	NA	NA	<0.1
Tapia Spray Fields and Wastewater Reclamation Facility	0.6	0.3	0.9	0.3	0.3	10.6	<0.1	<0.1
Tapia Yard	7.0	7.1	7.0	6.2	8.2	NA	NA	NA
TOTAL	62.5	62.9	74.9	80.8	86.0	96.9	45.3	59.3

Tapia is permitted to compost the solid wastes from its treatment facility into fertilizer at their Rancho Las Virgenes Compost Facility (LVMWD, 1994; LA RWQCB, 1997; Abramson et al., 1998). Another portion of the sludge from Tapia may be digested and pumped to their Rancho Las Virgenes Farm for subsurface injection. This activity is regulated under waste discharge requirements contained in Order No. 79-107. Table 8 summarizes the annual loadings from sludge disposal. These have decreased in recent years as composting at Rancho Las Virgenes has come on line.

Table 8. Annual fecal coliform loadings associated with sludge Injection Loads at Rancho Las Virgenes Farm (Tetra Tech, 2002)

Year	Sludge Biosolids Loadings (dry ton/yr)	Fecal Coliform Loading (10^9 counts/year)
1997	307	53,800
1998	90	16,300
1999	1	NA

The loads from Tapia either from direct discharge or indirectly from use of reclaimed water for effluent irrigation or sludge injection are insignificant (<0.1%). Both the direct discharge and reclaimed water are chlorinated so that the effective concentrations of fecal coliforms are less than 1 MPN. Given that concentrations from Tapia are less than 0.5% of the water quality objective for fecal coliform bacteria, flows from Tapia actually provide additional dilutive capacity to the system.

Septic Systems. 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).

There are about 20 commercial septic systems in shopping centers and commercial areas in the vicinity of Malibu Lagoon which discharge an estimated 70,000 to 80,000 gallons of septic effluent per day (LARWQCB, 2000). Several hundred thousands of gallons per day are estimated to be discharged from private residences in the Malibu area of the lower watershed (LARWQCB, 2000). 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 (LARWQCB, 2000). Table 9 presents the total annual fecal coliform loads generated from septic systems in the Malibu Creek watershed.

Table 9. Total annual fecal coliform loads (10^9 counts/year) generated from septic systems (Tetra Tech, 2002)

Subwatershed	Total number of septics	Normal Septics	Failed Septics	Short-Circuited Septics	Comm-erical Septics	Total effluent flow (gal/day)	Fecal coliform Load (10^9 count/year)
Hidden Valley Creek	625	500	125			171,250	1,551,250
Portereo Canyon Creek							
Westlake	60	48	12			16,440	148,920
Upper Lindero Creek							
Lower Lindero Creek							
Upper Medea Creek							
Palo Comado Creek							
Cheeseboro Creek							
Lower Medea Creek	110	88	22			30,140	273,020
Triunfo Creek	820	656	164			224,680	2,036,700
Upper Malibu Creek	95	76	19			26,030	235,790
Upper Las Virgenes Creek							
Lower Las Virgenes Creek	50	40	10			13,700	124,100
Stokes Creek	85	68	17			23,290	210,970
Middle Malibu Creek	50	40	10			13,700	124,100
Cold Creek	300	240	60			82,200	744,600
Lower Malibu Creek	5	4	1			1,370	12,410
Malibu Lagoon							
Above Lagoon	170	136	34			46,580	423,400
Adjacent to Lagoon	30			30		8,220	74,460
Commercial near lagoon	20				20	75,000	678,900
Total	**2420**	**1896**	**474**	**30**	**20**	**732,600**	**6,643,000**

Source: LARWQCB, 2000; NRCS, 1995; Finney, 1995.

When operating normally, septic systems are effective in removing fecal coliform bacteria. However, septic systems can be significant sources of bacteria when the systems fail or are situated close to surface waters or high groundwater tables so that treatment is short-circuited. Normally operating systems were assumed to remove 100% of the fecal coliform bacteria, failing systems to remove 60%, and short-circuited systems to remove none of the bacteria. The Regional Board has estimated that 20 to 30% of the septic systems in the Malibu Creek watershed are failing. The Regional Board also suggested that the residential septic systems in the Malibu Colony and Cross Creek shopping areas adjacent to the Malibu Lagoon are sited so close to the lagoon that very little removal is taking place and that many of these systems are in effect being short-circuited. This conclusion is based on evidence of high pollutant concentrations measured in the shallow groundwater, the limited depths of the leach fields due to the high ground water table and evidence discussed below from the Malibu Technical Investigation (LARWQCB, 2000).

In estimating loads from the failing systems, it was initially assumed that 20% of the systems in the upper watersheds were failing. This number was subsequently adjusted during calibration for seasons, such that the number of septic systems failing ranged from 2.5% during the drier months to 20% during the wetter months. Through calibration of the model for the septic systems near Malibu Lagoon it was estimated that about 20% of the systems were being short-circuited. Based on these assumptions, we estimated that septic systems account for about 18% of the total annual fecal coliform loadings to the Malibu Creek watershed. The septic systems in the Malibu Lagoon subwatershed account for 12% of the total annual loadings to the entire Malibu Creek watershed.

We understand that the City of Malibu is conducting a risk assessment to better characterize the impact of septic systems on groundwater in the Lower Malibu Creek and Lagoon area. Data from this study should provide greater certainty on the estimates of septic system loadings to the Creek and Lagoon.

Runoff from Residential and Commercial Areas. Runoff from residential and commercial areas can be important sources of 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 sources include fertilizer used for lawns and landscaping; organic debris from gardens, landscaping, and parks; trash such as food wastes; domestic animal waste; and human waste from areas inhabited by the homeless. 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 the watering of lawns and the washing down of parking lots and driveways can contribute pollutants between storms. The bacterial loadings from residential runoff were estimated to be 3,150,000 billion counts per year. The bacterial loadings associated with commercial and industrial were on the order of 2,550,000 billion counts per year.

Horse and Livestock. Manure produced by horses, cattle, sheep, goats, birds, and other wildlife in the Malibu Creek watershed are sources of both nutrients and coliforms. 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.

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 (NRCS, 1995).

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 has also occurred on the Rancho Las Virgenes property of the upper Las Virgenes Creek subwatershed.

Estimates of fecal loads produced by horse and livestock can be estimated by multiplying he number of animals in the watersheds by a per unit fecal production load (Table 10 and 11).

Table 10. Gross annual fecal loads (10^9 counts/year) associated with horse manure (Tetra Tech, 2002).

Subwatershed	Number of Horses	Fecal coliform loads (10^9 counts/year)
Hidden Valley Creek	920	140,890
Portereo Canyon Creek	40	6,132
Westlake		
Upper Lindero Creek		
Lower Lindero Creek	5	767
Upper Medea Creek	20	3,066
Palo Comado Creek	100	15,330
Cheeseboro Creek		
Lower Medea Creek	140	21,462
Triunfo Creek	160	24,528
Upper Malibu Creek		
Upper Las Virgenes Creek	15	2,300
Lower Las Virgenes Creek	5	767
Stokes Creek	45	6,899
Middle Malibu Creek	30	4,600
Cold Creek	115	17,630
Lower Malibu Creek		
Malibu Lagoon	100	15,330
Total	**1695**	**259,880**

Table 11. Gross annual fecal coliform loads (10^9 counts/year) associated with livestock manure (Tetra Tech, 2002)

Subwatershed	Cattle	Sheep/Goats	Fecal coliform (10^9 counts/year)
Hidden Valley Creek	250		9,490,000
Upper Las Virgenes Creek	15		569,400
Upper Las Virgenes Creek		200	876,000
Total	**265**	**200**	**10,950,000**

The values in tables 10 and 11 present gross fecal coliform loads from horse and other livestock manure, respectively, in the Malibu Creek watershed. They do not reflect the actual net loadings to the creeks. In our model, the gross horse loads were 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 (ASAE, 1998). Because horse and livestock loads occur as non-point sources in the model, there is a buildup of the bacteria during the dry periods and thus reduced contribution of the bacteria to the stream reaches during these periods. Based on these assumptions, our best estimate of net loadings to the creeks is 3,220 billion counts per year. This represents about 0.5% of the total loadings to the Malibu Creek watershed.

Wildlife. Wildlife wastes contribute to the nutrient and bacterial loads from the large undeveloped portions of the watershed, and may be the only source of bacteria from these areas. Over 75 percent of the entire Malibu Creek watershed is undeveloped wildland consisting primarily of chaparral, scrub, and woodlands, with smaller areas of grasslands and forests. 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) (NRCS, 1995). We have no direct estimates of populations or the loading rates associated with these animals. However, the values for bacterial loadings associated with runoff from undeveloped land provide an indirect estimate of wildlife contribution. It is estimated that runoff from chapparal/sage scrub lands contributes 37,700 billion per year, runoff from grasslands contributes 2,690 billion per year, and runoff from woodlands contributes 809 billion per year.

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 have previously been suggested to be an important source of the elevated coliform levels in the lagoon (Warshall et al., 1992). Table 12 presents the annual bacteria loads produced by waterfowl near Malibu Lagoon. The loads were reduced to 35% of these loads during model calibration. This reduction in bird loads can be explained by the fact that the birds do not spend all their time in the lagoon.

Table 12. Annual bacterial loads (10^9 counts) produced by waterfowl near Malibu Lagoon.

Month	Bird Population	Fecal coliform
January	1000	75,330
February	1500	102,060
March	1630	122,788
April	400	29,160
May	300	22,599
June	320	23,328
July	230	17,326
August	200	15,066
September	400	29,160
October	750	56,498
November	780	56,862
December	1100	82,863
Annual Total		**633,040**

Source: Topanga-Las Virgenes Resource Conservation District; ASAE, 1998.

Golf Courses. Golf courses can be a source of bacteria since the typical fertilization and watering rates are generally high. Golf courses also attract large numbers of Canada geese. The bacteria may be transported to waterways in storm 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 mile 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 (Tetra Tech, 2002). Based on our analysis, the runoff of fecal coliform bacteria associated with golf courses is negligible (less than 1%). It should be pointed out that waterfowl loads were not evaluated for the lakes since bird counts were not available.

Tidal Inflow to Lagoon. Tidal inflow loads of bacteria were calculated from estimated tidal inflow rates from the UCLA study (Ambrose et al., 2000) and fecal coliform concentrations in coastal waters measured during the Malibu Technical investigation (LARWQCB, 2000). The average concentration for fecal coliform at beach surf zone stations was 69 counts per 100 ml. From this number annual loading associated with tidal inflow was estimated to be 16,100 billion counts per year. This is a relatively small percentage (0.2%) of the annual loadings to the lagoon.

Dry weather storm drain loads to Malibu Lagoon. Three major storm drains discharge to Malibu Lagoon. These are the Civic Center drain, the Cross Creek Road drain, and the Malibu Colony. It is estimated that the fecal loading from the Malibu Colony storm drain was 4.8 x 10^7/day. These high concentrations from these storm drains may result in localized exceedances of water quality standards. However in terms of annual loadings, these drains contribute a very small fraction (<1%) of the loads to the lagoon.

Summary of source assessment. The results of our source assessment are summarized in Tables 13 and 14. These values represent our best estimates of potential sources from the watershed to the creeks. Surface runoff loads from residential and commercial areas are clearly the largest sources. Most of these loadings are associated with storms. However dry-weather urban runoff also contributes a significant fraction. Failing septic systems also provide a significant fecal contribution, especially to the lagoon. Birds are another significant source of fecal coliforms to the lagoon. These are the major contributors to the total watershed on an annual basis. During the dry season, urban runoff is still the largest source of fecal coliforms, but the loads associated with birds and failing systems are comparable in magnitude. Because there are differences in the types of land-use activities that occur in each of the subwatersheds, the relative contribution of the different sources will also vary among the different subwatersheds. The data in Table 14 provide insight on the relative source contributions by watershed.

The values in Tables 13 and 14 do not by themselves provide enough information to allocate load reductions among the various sources. A model has been developed to relate loadings to concentrations in the creek and lagoon system. The model integrates this information on potential loadings with assumptions about the timing and delivery of these loadings relative to instream flows and instream processes to predict water quality (Section 4).

Table 13. Summary of sources (note the numbers are order of magnitude approximations)

Potential sources	**Total annual loadings (10^9 counts/year)**
Runoff from residential landuses	3,000,000
Runoff from commercial/ industrial landuses	3,000,000
Septic systems	300,000
Birds	200,000
Undeveloped areas/Wildlife	40,000
Horses and livestock	30,000
Tidal inflow	20,000
Imported water	5,000
Tapia	60
Dry-weather storm drains at Malibu Lagoon	20
Irrigation and sludge disposal	10

Distribution of average annual fecal coliform loads by watershed and source 1992 – 1995 (From Tetra Tech, 2002)

	Commercial/Industrial	High/Medium Density Res.	Low Density Residential	Rural Residential	Agriculture/Livestock	Vacant	Chaparral/Sage	Grasslands	Woodlands	Golf Courses	Septic	Sludge	Effluent Irrigation	Tapia	Imported Water	Lagoon drains	Birds	Tidal Inflow	Total
Hidden Valley	0.3	0.1	0.6	0.2	0.4	0.0	0.1	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1
Potrero Canyon Creek	0.3	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9
Westlake	14.5	10.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.6
Upper Lindero Creek	1.5	5.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1
Lower Lindero Creek	3.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.8
Upper Medea Creek	3.5	10.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.4
Palo Comado Creek	3.1	0.3	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4
Cheeseboro Creek	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Lower Medea Creek	0.1	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Triunfo Creek	0.3	0.6	0.7	0.4	0.0	0.0	0.1	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6
Upper Malibu Creek	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Upper Las Virgenes Creek	1.1	2.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6
Lower Las Virgenes Creek	7.1	3.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.9
Stokes Creek	0.6	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
Middle Malibu Creek	0.2	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Cold Creek	0.1	0.0	1.0	0.6	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9
Lower Malibu Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Malibu Lagoon	1.5	0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	7.6	0.2	12.2
Total	38.9%	41.5%	5.3%	1.5%	0.5%	0.0%	0.6%	0.0%	0.0%	0.0%	3.8%	0.0%	0.0%	0.0%	0.1%	0.0%	7.6%	0.2%	100.0%

5. LINKAGE ANALYSIS

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 use of a hydrodynamic and water quality model to determine the loadings of bacteria that are acceptable to achieve 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.

5.1. Model description

Receiving water quality models were used to predict fecal coliform concentrations in the listed creeks and lagoon in the watershed. The models were used to establish the relationship between pollutant loads from the all potential sources within Malibu Creek watershed and the in stream water quality targets for the listed reaches (Tetra Tech, 2002).

HSPF was selected since it could be linked directly with the watershed and stream modeling framework. For the purpose of analysis, the Malibu Creek watershed was divided into 18 subwatersheds. The source loadings data from each these subwatersheds were treated as inputs at the appropriate location within the network of tributaries and creeks that were modeled as part of Malibu Creek watershed (Figure x). The following stream reaches within the Malibu Creek watershed were included in the model: Hidden Valley Creek, Portrero Canyon Creek, Upper Lindero Creek, Lower Lindero Creek, Upper Medea Creek, Palo Comado Creek, Cheeseboro Creek, Lower Medea Creek, Triunfo Creek, Upper Malibu Creek, Upper Las Virgenes Creek, Lower Las Virgenes Creek, Stokes Creek, Middle Malibu Creek, Cold Creek, Lower Malibu Creek and Malibu Lagoon. The following lakes were also considered as part of the stream network: Westlake Lake, Lake Sherwood, Lake Lindero and Malibou Lake.

Calibration of the model involved a comparison of historical receiving water data (baseline conditions) with predicted receiving water concentrations (simulated conditions) from the model. The model predictions were compared to actual in-stream concentrations at five locations within the watershed where there was existing data: Upper Malibu Creek (R9), Middle Malibu Creek (R2), Lower Malibu Creek (R3), Malibu Creek at the Lagoon (R4) and Malibu Lagoon (R11). The nature of the calibration process and the parameters adjusted to achieve calibration are detailed in the modeling document (Tetra Tech, 2002).

The model results were evaluated for the critical condition (See Section 4b) and then used to evaluate the bacterial load reductions that would be required to ensure that water quality standards are met at each of the listed reaches (See Section 4c).

5.2. Critical Conditions and Seasonality

Bacterial loadings to the system vary seasonally. Therefore the issue of critical conditions and seasons is not straightforward. During most of the year, when flows in the creek system and to the lagoon are fairly low, there are limited amounts of water available for dilution. Under these conditions, small and localized loadings can result in exceedances of water quality standards. On the other hand the largest bacterial loads are delivered during winter storm events. The relationship between storm loads and water column concentrations during these storm events is not linear and may vary between storms. The effect of storm water runoff is to dramatically increase the instream concentrations. This increase typically extends one to two days after the rain event. Based on our analysis of source loadings and water quality, we have determined that the bacterial concentrations in the creeks and lagoon are highest during wet-weather.

To establish the critical condition for the wet rainy days, we used rain data from 1993. Based on data from the Regional Board's Santa Monica Bay TMDL this represents the 90th percentile year for rain. Use of this wet year provides a conservative estimate of loadings from runoff. Consistent with the Santa Monica Bay TMDL, wet days were defined as days with rain greater than 0.1 inch plus the three following days. For the critical year (1993) we identified 69 wet days and 296 dry days. This TMDL differs slightly from the Santa Monica Bay TMDL in that we have used the 1993 calendar year (January 1 to December 31) rather than the modified storm year (April 1 to October 31). However, we believe the net effect of this difference on the TMDL is negligible.

5.3. Application of the model to link loadings to water quality.

The model was used to examine the relationship between loadings and the numeric targets identified in Section 2. Seven critical compliance points were identified at major tributaries and the Malibu Creek mainstem consistent with listed reaches, modeling output points, and available monitoring data (Figure 2). The Lower Medea Creek location is inclusive of upstream tributaries and listed reaches Lindero Creek, Medea Creek, and Palo Comado Creek. Lower Las Virgenes Creek is inclusive of Upper Las Virgenes and Stokes Creek. Although it is not listed as impaired, a compliance point was established at the bottom of the Triunfo Creek watershed to address the contribution of fecal coliform loadings from the western part of the watershed to the listed water bodies downstream of Triunfo Creek. Malibu Creek is shown as Upper, Middle, and Lower to identify the loading and reduction needs for each major segment of the creek in relation to entry points of the major tributaries (i.e., Las Virgenes and Cold Creek). The compliance point in Malibu Lagoon is inclusive of the local drainage, all upstream drainage delivered by Malibu Creek, and net tidal inputs.

For each of the seven compliance points, the relationship between loads and water quality was derived based on examination of the estimated daily fecal coliform loads against the daily flow-weighted loading capacity of the receiving waters for the critical wet year (1993). The flow-weighted loading capacity, known as a load duration curve, is calculated by multiplying the daily flow times the single sample standard of 400 CFU/100 ml. The daily loadings for the critical wet-year (1993) predicted by the model were evaluated against the flow-weighted daily load capacity (Figures 4-1 to 4-7). The peaks above the load-duration curve indicate potential exceedance days. The area under the peaks but above the curve reflects the magnitude of the excess load.

The model results indicate a significant number of days of exceedance during the critical year (Table 15). Most of these exceedance days are associated with the rain-days. Indeed, the model suggests that every storm greater than 0.1 inch has the potential to cause exceedances of the single sample standard. The predicted number of wet-day exceedance days far exceeds the 17 days allowance for wet days.

In comparison, there were relatively few dry-day exceedances in the creeks. The exceedance days predicted by the model vary by watershed but range from 3 to 12 days. The higher numbers were associated with the Triunfo Creek and Upper Malibu Creek watersheds. In contrast to the creeks, the number of exceedance days predicted for the lagoon (42 days) far exceeds the 3 day allowance for dry days.

Table 15. Predicted number of exceedance days of the single sample standard of 400 counts/day based on 1993 flows. Excess exceedances were calculated by subtracting allowable number of days for wet days (17) and dry days (3) from the wet and dry day exceedances

Watershed Compliance Point	Total exceedance days	Wet day exceedances	Dry Day exceedances	Excess wet day exceedances	Excess dry day exceedances
Triunfo Creek	79	67	12	50	9
Lower Medea Creek	71	63	8	46	5
Lower Las Virgenes Creek	37	34	3	17	0
Upper Malibu Creek	82	66	16	49	13
Middle Malibu Creek	72	65	7	48	4
Lower Malibu Creek	71	65	6	48	3
Malibu Lagoon	107	65	42	48	39

The model results were used to estimate the reductions in annual loadings that would be required to meet the water quality standards in both wet days and dry days for the critical wet-year (1993). The fecal coliform contributions associated with the 17 largest wet-day loads and the 3 largest dry-day loads were subtracted from the existing loads. We then estimated the loads associated with the excess exceedance days and the load reductions that would be required to meet the single sample standard. We first examined the loadings reductions required to meet the dry-day target (Table 16).

Table 16. Dry-day critical condition analysis. Model predictions of annual loads (10^9 counts/year) and reductions required to meet the single sample standard on all but 3 dry-days during critical year (1993).

Watershed Compliance Point	Annual Load (1993)	Annual dry-Day Load	Adjusted dry-day Load (- 3 days)	Required reduction of dry-day loadings	Percent reduction required to meet standard
Triunfo Creek	1,052,697	8,242	7,257	196	3%
Lower Medea Creek	1,889,668	16,688	3,468	115	3%
Lower Las Virgenes Creek	853,843	7,730	3,211	0	0%
Upper Malibu Creek	2,226,010	18,368	15,689	944	6%
Middle Malibu Creek	3,534,204	38,015	24,443	1,261	5%
Lower Malibu Creek	3,602,402	28,189	27,978	211	1%

Malibu Lagoon	3,651,826	129,494	33,133	1,448	4%
	16,810,650	246,726	115,179	4,175	

Based on this analysis is appears that the dry-day targets can be met with fairly modest load reductions, on the order of 3 to 6%. However, more significant reductions in the wet-day loads are needed to meet the wet-day targets (Table 17). The estimates of the required wet-weather reductions range from 53 to 88%. On average wet-weather loads will have to be reduced by 65% to meet the wet-weather targets in this TMDL.

Table 17. Wet-day critical condition analysis. Model predictions of annual load reductions (10^9 counts/year) required to meet the single sample standard all but 17 wet days during the critical year (1993)

Watershed Compliance Point	Existing Annual Load	Annual wet-day Load	Adjusted wet-day load (- 17 days)	Required reduction of wet-day loadings	Percent reduction required to meet standard
Triunfo Creek	1,052,697	1,044,455	277,142	148,114	53%
Lower Medea Creek	1,889,668	1,872,981	522,924	458,841	88%
Lower Las Virgenes Creek	853,843	846,113	163,523	124,572	76%
Upper Malibu Creek	2,226,010	2,207,642	560,413	346,755	62%
Middle Malibu Creek	3,534,204	3,501,821	928,385	633,738	68%
Lower Malibu Creek	3,602,402	3,564,387	961,166	618,976	64%
Malibu Lagoon	3,651,826	3,090,204	999,226	653,910	65%
	16,810,650	16,127,603	4,412,779	2,984,906	

We did not calculate the reductions required to meet the geometric mean value of 200 counts/100 ml since the relationship between loadings and a running 30-day geometric mean is non-linear and there are multiple combinations of load reduction scenarios that could be used to meet the geometric mean. Furthermore although the effect of storm loads on instream concentrations may be large, the effect is short term (3 days). Use of wet-day loadings in the calculation of the geometric mean would skew the results, and not be indicative of the average concentration in the creeks and lagoon during the dry days.

It is clear that most (>95%) of the annual fecal coliform loadings to the Malibu Creek watershed and most of the exceedances that occur over a year are associated with wet-weather runoff during rain days. However, it is not possible to define a single number for the wet-day loading capacity because the flows associated with storms and the loadings generated in storm water runoff vary tremendously in different storm seasons, among storms in a single storm season and even over the course of a single storm. The load-duration curves are a useful tool for displaying the daily flow-weighted loading capacity and establishing the annual load reduction requirements needed to meet water quality standards. We used the model to evaluate loadings during a critical wet-year (1993). The load-duration curves were used to quantify the excess loadings and identify the load reductions needed to meet the standard during the critical year. The required reductions varied by location but ranged from 0 to 6% dry days and averaged 65% for rain days. We are applying these reductions, which reflect conditions during the critical wet year (1993), to the TMDL. Allocations are being based on a 6% reduction in dry-weather loadings and a 65% reduction in wet-weather loadings.

6. TMDLs AND ALLOCATIONS

Each pollutant source category is allocated a quantitative load for fecal coliforms. Allocations are designed such that the waterbody will not exceed numeric targets for fecal coliform bacteria in any of the listed 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.

In Section 4, we established the load reductions needed to meet water quality objectives for fecal coliform under critical conditions. In this section, we allocate these load reductions to both point and non-point sources.

The wasteload and load allocations are based on the source assessment information presented in Section 3, which represents the average loadings from various sources from 1992 to 1995 expressed as both annual and dry-season (May to October) loadings. This is different from the dry-day and wet-day concept used in the linkage analysis, but consistent with the approach used in the source assessment. We believe that the annual and seasonal time scales are appropriate for setting allocations since it is likely that any actions taken to implement reductions will operate of over these longer time scales. The translation of a rain-day allocation to an annual allocation is justified since the rain days contribute more than 95% of the wet-weather loadings.

The targeted reductions are expressed in terms of percent reduction of both dry-season (May-October) and annual loadings. The 6% dry-day reduction is applied to the average dry-season loadings and the 65% wet-day reduction is applied to the average annual loadings. This is done because the source loadings based on average loadings (1992-1995) are more representative than the source loadings based on a single year (1993). The application of reductions based on the critical year (1993) to the average annual loadings (1992-1995) also provides an additional margin of safety to ensure that the water quality objectives will be met.

The load and wasteload allocations are presented in Tables 18 and 19. The sums of these allocations, as indicated in Tables 18 and 19, constitute the TMDLs. Note that the target percentage reduction figures in column 4 of each table are provided for information only—the specific allocations which sum to the TMDLs are being established by EPA.

6.1. Waste Load Allocations

EPA regulations require that a TMDL include wasteload allocations (WLAs), which identify the portion of the loading capacity allocated to existing and future point sources (40 CFR 130.2(h)).

The Tapia WWRF effectively disinfects the tertiary treated wastewater, so the fecal loadings are small and are not likely to increase fecal coliform concentrations. Indeed the effluent from Tapia actually provides additional dilutive capacity to the creek system. Waste load allocations are appropriate however because of the potential impact to the downstream lagoon system. WLAs for the Tapia plant are based on the existing permit limits. The design flow for Tapia is 16.1

mgd (app. 25 cfs). The permit limits for fecal coliform bacteria are set at 2.2 CFU/100 ml. During the winter months the total maximum daily allocation for Tapia is 1.35 billion counts per day. Although Tapia is prohibited from discharging during the summer months (April 15 to Nov 15), they do have a provision which allows up to 2.5 cfs in flows during these months if needed for flow in the creek. This would allow a daily allocation of 0.13 billion counts per day. The annual waste load allocation is 265 billion counts per year.

6.2. Load Allocations

Load allocations are being established for the commercial and multi-family septic systems in the area around Malibu Lagoon. The waste being discharged to the septics is being required to meet the REC1 water quality standard of 200 CFU per 100 ml. It is anticipated that in the leach field the fecal coliform concentrations will be further reduced by more than 99%. It has been estimated that with these actions, the annual loadings in the lagoon would be decreased from 158,000 billion counts per year to 21,800 billion counts per year. This represents an 86% reduction in the annual loadings to Malibu Lagoon and a 55% reduction in annual loadings to the entire watershed (from 247,000 billion counts per year to 111,000 billion counts per year).

Table 18. Dry season fecal coliform allocations (10^9 counts/6 months) by source category based on 1992-1995

Source Category	Existing Loads	% of Existing Load	Target Reduction (%)	Load Allocation
Point				
Tapia Discharge	12	0%	0	24
Nonpoint				
Runoff from residential lands	171,000	30%	6	160,740
Runoff from commercial areas	184,000	32%	6	172,960
Agriculture/Livestock	81	0%	50	41
Dry Weather Urban Runoff	2,610	0%	6	2,453
Septic Systems	105,000	18%	65	36,750
Effluent Irrigation/Sludge	2	0%	0	0
Background Nonpoint				
Birds	108,000	19%	0	108,000
Runoff from undeveloped lands	723	0%	0	723
Tidal	2,580	0%	0	2,580
Other	692	0%	0	692
Total TMDL	**574,700**	**100%**	**16%**	**484,961**

Table 19. Annual fecal coliform allocations (10^9 counts/6 months) by source category based on 1992-1995.

Source Category	Existing Loads	% of Existing Load	Target Reduction (%)	Load Allocation
Point				
Tapia Discharge	59	0%	0	265
Nonpoint				
Runoff from residential lands	3,160,000	50%	69	979,600
Runoff from commercial areas	2,550,000	40%	69	790,500
Agriculture/Livestock	35,600	1%	50	17,800
Dry Weather Urban Runoff	5,220	0%	69	1,618
Septic Systems	246,000	4%	65	86,100
Effluent Irrigation/Sludge	21	0%	0	0
Background Nonpoint				
Birds	250,000	4%	0	250,000
Runoff from undeveloped lands	43,200	1%	0	43,200
Tidal	16,100	0%	0	16,100
Other	18	0%	0	18
Total TMDL	**6,306,218**	**100%**	**65%**	**2,185,201**

A load reduction of 50% was applied to agriculture and livestock based on recommendations from the Regional Board.

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). Stormwater and dry-weather urban flows and storm water flows are usually considered point sources under the general stormwater NPDES permits for Los Angeles County and Ventura County. Allocations are being established to deal with stormwater discharges covered under the MS4 stormwater permit. Approximately 90% of the total annual loadings are associated with runoff from areas with residential and commercial/industrial land uses. The allocations are based on a 6% reduction of dry-season loadings and a 65% reduction of the annual loadings to the system. To achieve the 65% wet-weather target reduction, the allocations for the annual stormwater runoff from residential and commercial/industrial landuse categories are based on a 69% reduction target. To meet the 6% reduction in land use in the listed segments above Malibu Lagoon, the allocations for dry-season runoff associated with residential and commercial industrial landuse categories are based on an 8% reduction target.

Load allocations of zero are set for effluent irrigation and sludge injection since the wastewater used for irrigation and injection is chlorinated and it is assumed that there are no bacterial loadings to surface waters from this source.

No load reduction was given to birds since they are a natural part of the system and are not controllable. At the present time, we believe that the allocations described above are sufficient to meet the objectives. However, it may prove that the birds in Malibu Lagoon are sufficient alone to cause an exceedance. If this proves to be the case, we will recommend that the Regional Board consider re-evaluating the TMDL using the natural source exclusion for implementing the water quality standard.

6.3. Margin of Safety

The Margin of Safety was derived from the use of several conservative assumptions during model analysis. These include:

- The watershed loadings were based on the 90th percentile year for rain (1993). This should provide conservatively high runoff from different land uses.
- The load reductions established in this TMDL were based on reduction required during the critical year. This adds a margin of safety for more typical years.

6.4. Summary of pollutant allocations

This TMDL places a waste load allocation for the Tapia discharge based on effluent limitations and flow restrictions in the permit for wet and dry periods. The loadings from Tapia represent at most 1% of the total allowable allocation to the system. No WLAs are set for effluent irrigation or sludge injection since it is assumed that these loadings do not make it to the surface waters. An allocation is also being placed on the commercial and multi-family septic systems in Malibu.

General load allocations have been provided which identify load reduction by source. Although localized load reductions may vary based on subwatershed, these allocations provide a basin-wide summary of the expected load reduction needs by source type. The loads presented here were derived from the 4-year average (1992-1995) of the simulation period, for all loads entering the Malibu system. Future monitoring and assessment may result in refining these estimates and subsequent load allocations.

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 Regional Board is primarily responsible for implementation of the TMDL and is expected to develop the appropriate implementation measures. EPA recommends the following measures.

7.1. Implementing waste load allocations to permitted point sources

Tapia Water Reclamation Facility As required by EPA regulations, the NPDES permit limits for the Tapia Water Reclamation Facility will need to be consistent with the waste load allocations established in this TMDL. The renewal of the NPDES permit for TWRF is scheduled to follow the establishment of this TMDL. The actual implementation date will depend on a compliance schedule adopted by the Regional Board.

Stormwater and urban runoff. As discussed in Section 6, it will be necessary to determine the specific discharge areas that are covered under the NPDES stormwater permits. As required by

EPA regulations, the NPDES permit limits for the Los Angeles and Ventura County MS4 permits will need to be consistent with the waste load allocations established in this TMDL. Modest reductions in dry-weather urban runoff are necessary to meet the dry-day targets identified in this TMDL. This might be accomplished through simple source reduction efforts such as education and the use of BMPs. If this is not enough, then other options such as diversion and treatment of dry-weather runoff may be appropriate. The control of wet weather runoff is likely to require more significant actions such as the construction of retention ponds to retain and possibly treat some fraction of the stormwater flows. The actual implementation date will depend on a compliance schedule adopted by the Regional Board.

7.2. Implementing load allocations for non-point sources

The Regional Board has recommended the following actions to implement bacterial source reduction measures necessary to achieve this TMDL:

- Regulation of commercial and multi-family septic systems
- Fencing of pasture land to prevent the direct access of livestock to streams
- Increasing the manure removal from horse and livestock stables from 40% to 80%
- Source reduction to minimize dry weather urban runoff
- Storm drain diversion and small regional treatment facilities for dry weather runoff
- Construction of diversion, retention and subsequent routing of wet-weather storm runoff to treatment facilities

Septic systems. The sites targeted for reduction by the Regional Board are 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. These systems have been improperly sited. These septic systems are 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.

Commercial multi-family septic systems located within the aforementioned commercial centers were the focus of Los Angeles 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, an implementation mechanism for the septic system Load Allocations (LAs) derived from this TMDL has been established. It is anticipated that the LAs developed for this TMDL 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 LAs will depend on a compliance schedule adopted by the Regional Board. The Regional Board has indicated that systems which are poorly sited will have options available for meeting the LAs under this TMDL.

Residential septic systems were not targeted for load reductions by the Regional Board since many of them are dispersed in rural areas. The residential septic systems in Malibu Colony produce about 1% of the bacterial loads produced by the commercial septic systems, so they are not targeted for reductions by the Regional Board.

Horses and Livestock. Horses and livestock contribute a relatively small contribution to the total annual load in the watershed. However in specific watersheds they do contribute a larger percentage of the dry weather loadings (e.g., Hidden Valley Creek, Upper Las Virgenes Creek) Therefore, BMPs should be considered to minimize the impacts from this source category. For examples, measures could be taken to keep animals away from the streams in Hidden Valley, and manure could be removed more frequently from some stables. It has been estimated that 40% of the manure is already being removed from stables. The Regional Board has recommended that this number be increased to 80%. This is a 50% reduction over the existing practice.

8. MONITORING RECOMMENDATIONS

Follow-up monitoring and evaluation is recommended to validate the TMDL, and to assess whether the water quality standards are being attained. In addition, specific TMDL elements should be evaluated to determine if they are accurate and effective (EPA, 1999).

8.1. Water quality monitoring

EPA recommends that a watershed scale-monitoring program be established at key compliance points along the creek. We recommend that samples sites be located at seven key compliance points and at the upstream and downstream ends of the listed tributaries. Sample results should be compared to the numeric in-stream targets identified in Section 3. This includes fecal coliform and E. coli in the creeks, and total coliform, fecal coliform and enterococcus in the lagoon.

Although there is good data on total coliform concentrations in the lower reaches of the watershed, there is only limited data available for the upper portion of the watershed and selected tributaries of Malibu Creek. In addition, there is relatively little information on the concentrations of fecal and almost no data on *E.* coli anywhere in the watershed. These data are needed to refine the reference watershed approach. 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. The program addresses the watershed-wide monitoring required for the TMDL. The data could be used to provide further verification of the model and refine the TMDL as appropriate.

8.2. Pollutant source monitoring

Septic systems. It is anticipated that the WDRs will have a monitoring program component to estimate concentrations of bacteria coming from these systems. In addition, we recommend that a special study be conducted to get better certainty in the number of septic systems and the distribution of the systems within the Malibu Creek watershed. We anticipate that the City of Malibu's risk assessment of decentralized systems in high priority areas in the City will provide information to refine the load estimates for fecal coliform from septic systems to the Creek and Lagoon.

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

Birds. Monitoring is needed to determine the contribution of birds to the lagoon loadings. The operative question is whether or not water quality standards can be achieved because of bird population. If it is determined that bird loadings alone are sufficient to cause exceedances of bacterial standards, then the Regional Board should consider pursuing a natural source exclusion for Malibu Lagoon.

Urban runoff. Monitoring is needed to confirm that the reductions in dry-weather and wet-weather runoff from commercial /industrial and residential land uses specified under this TMDL are being achieved.

8.3. Special studies

We recommend that studies be conducted:

- to evaluate whether or not a natural source exclusion is needed for Malibu Lagoon.
- to determine runoff from undeveloped areas to evaluate if reference approach is appropriate for upper watersheds.
- to determine the relationship between E. coli and fecal coliform concentrations.

8.4. Summary of TMDL Monitoring

We recommend that a TMDL monitoring program 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 TMDL to address the coliform problems in the creek, lagoon and listed tributaries. The Regional Board could also use the information generated by this program to consider whether separate listings and TMDLs are needed for E. coli or enterococcus and/or to revise the coliform TMDL if necessary.

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10. FIGURES

Figure 4-1. Model run for Triunfo watershed.

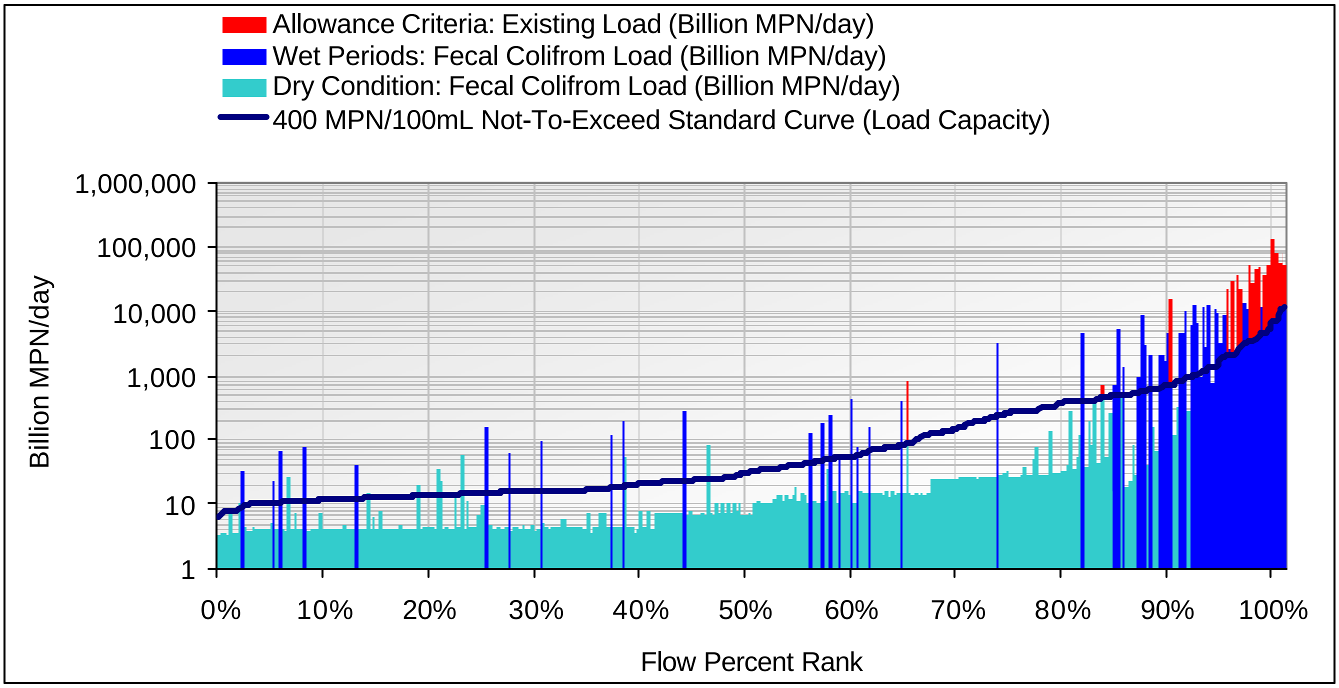

Figure 4-2. Model run for Lower Medea Creek.

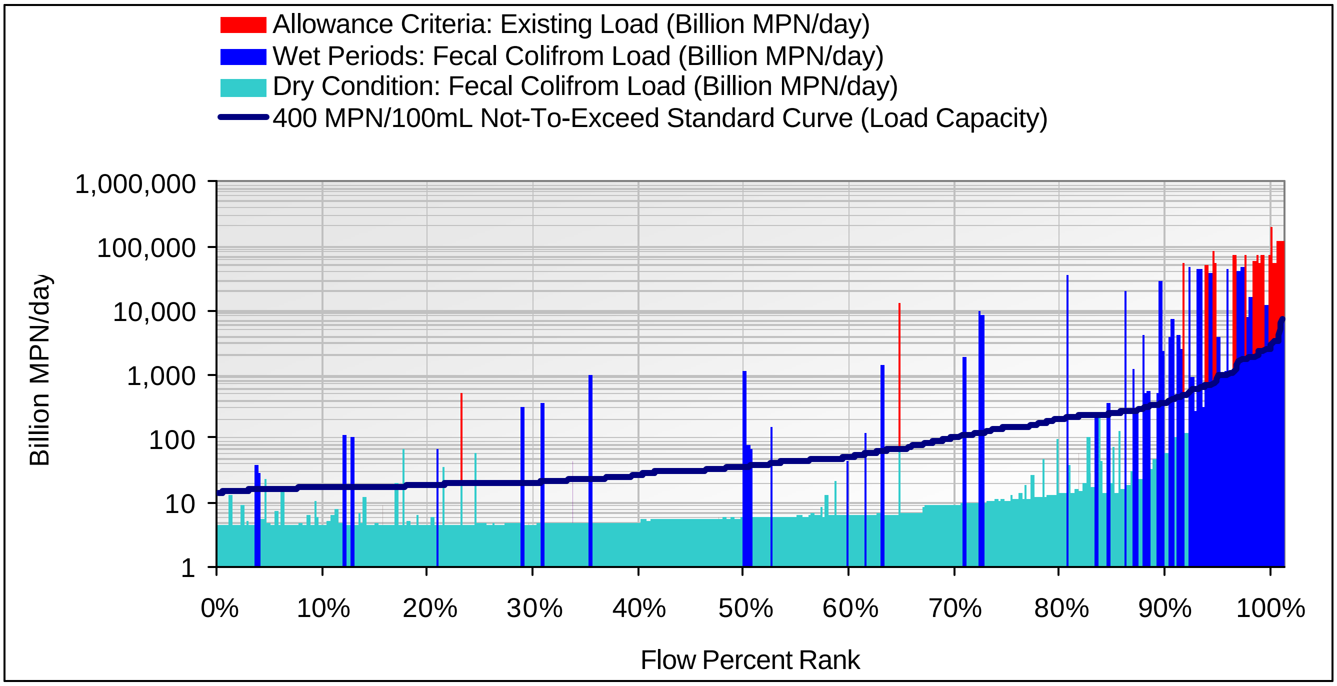

Figure 4-3. Model simulation for Lower Las Virgenes Creek

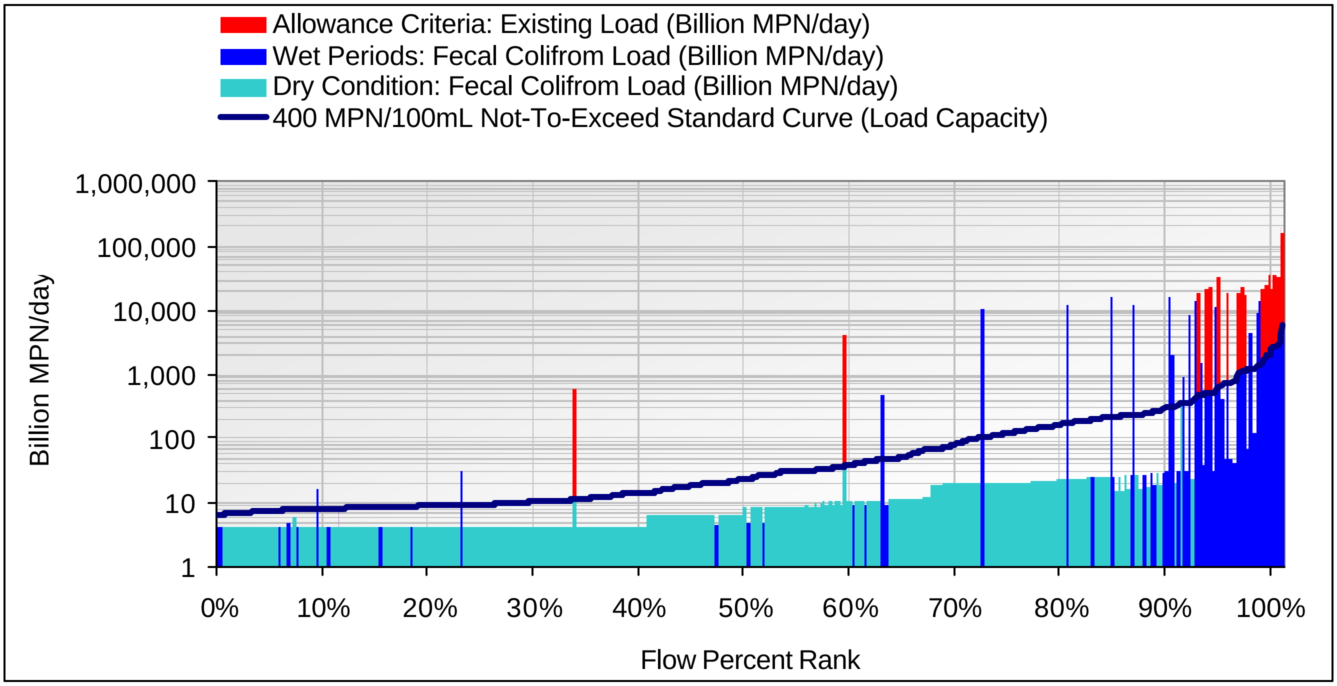

Figure 4-4. Model simulation for Upper Malibu Creek.

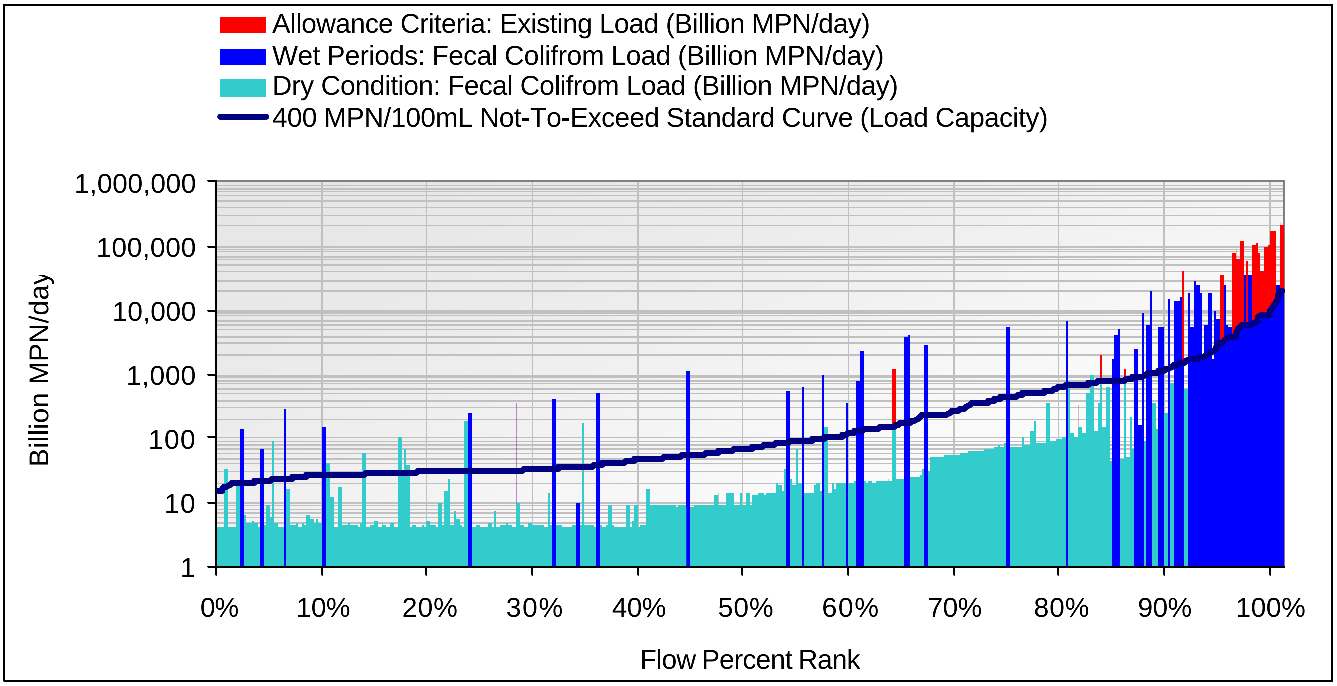

Figure 4-5. Model simulation for Middle Malibu Creek.

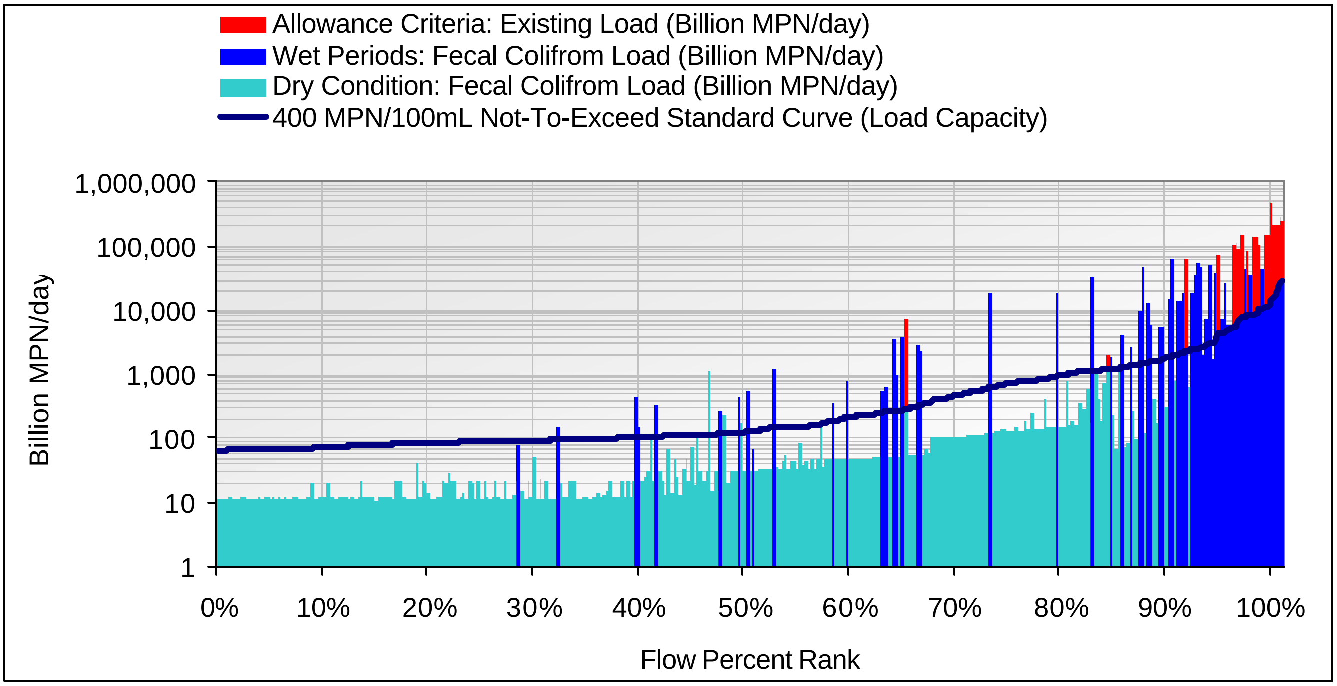

Figure 4-6. Model simulation for Lower Malibu Creek.

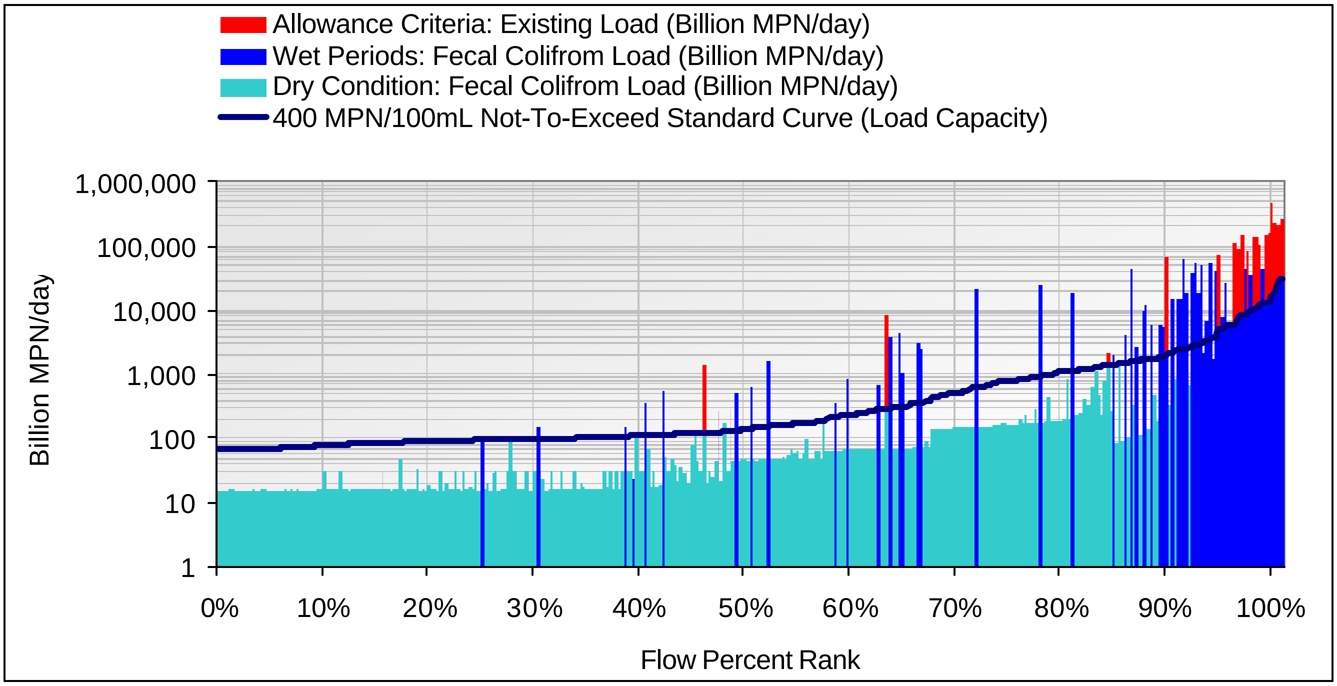

Figure 4-7. Model simulation for Malibu Lagoon.